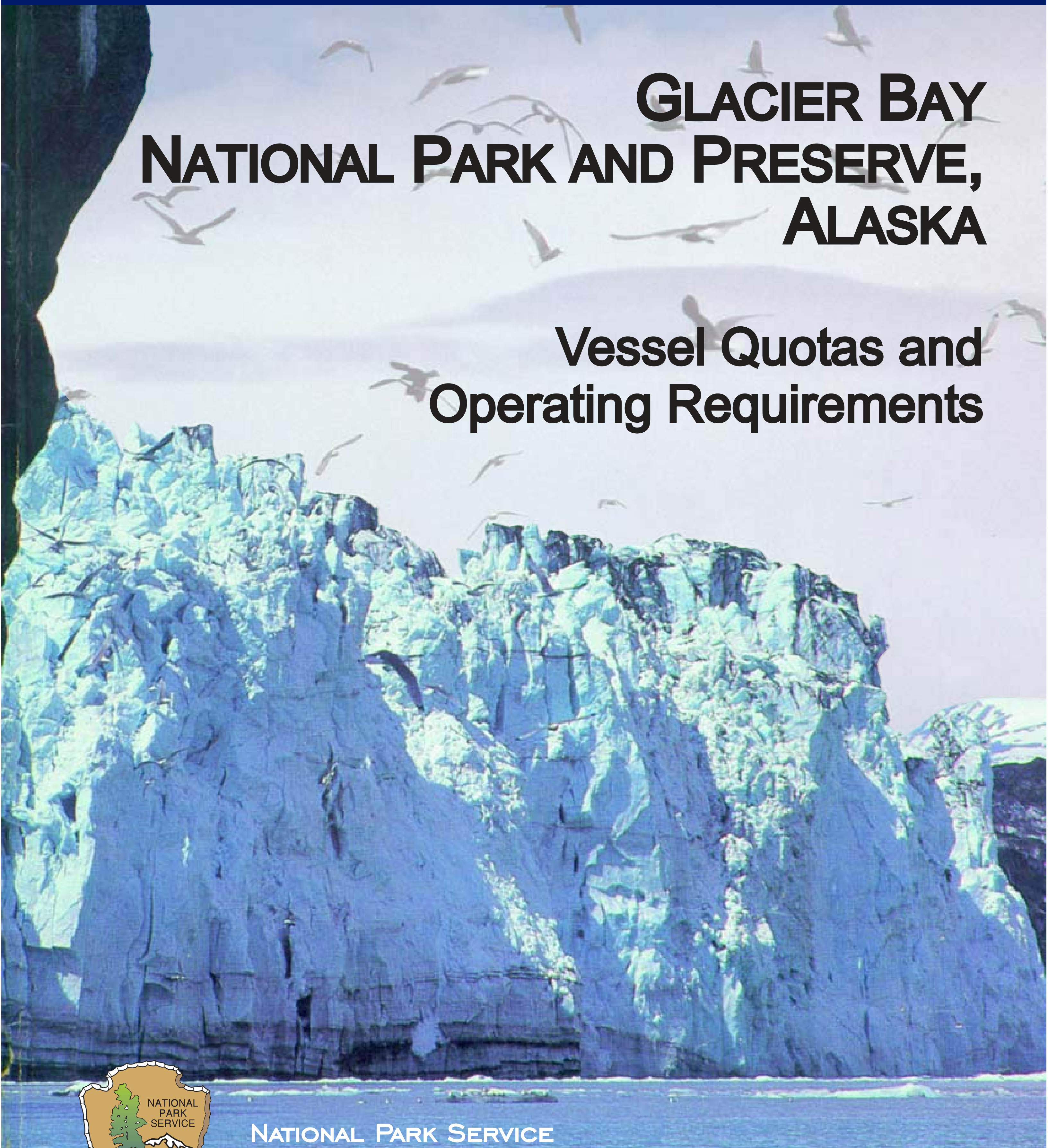
DRAFT ENVIRONMENTAL IMPACT STATEMENT



GLACIER BAY NATIONAL PARK AND PRESERVE, ALASKA

Vessel Quotas and Operating Requirements

NATIONAL PARK SERVICE

NATIONAL PARK SERVICE
Department of the Interior

GLACIER BAY NATIONAL PARK AND PRESERVE, ALASKA
UNITED STATES DEPARTMENT OF THE INTERIOR

United States Department of the Interior

NATIONAL PARK SERVICE
Glacier Bay National Park and Preserve

March 14, 2003

Dear Reader:

The National Park Service (NPS) has prepared a Draft Environmental Impact Statement (DEIS) for Vessel Quotas and Operating Requirements in Glacier Bay National Park and Preserve. This DEIS describes five alternatives for establishing motorized vessel quotas and associated operating requirements within the park. The DEIS was prepared in response to direction by the United States Congress as well as new operational needs since 1996.

We invite your comments on the DEIS. Your ideas and suggestions will help set vessel quotas and operating requirements that protect park resources and provide for visitor use and enjoyment.

Commenting: Specific comments on the alternatives and analysis will be most helpful. Based on your comments, a final EIS will be prepared followed by a decision. We anticipate a decision no later than January 1, 2004. Please send your written comments to:

> Glacier Bay National Park and Preserve Vessel DEIS
> C/O Nancy Swanton
> EIS Project Manager
> 2525 Gambell Street
> Anchorage, Alaska 99503-2892

In addition, you may submit comments on the park's website at http://www.nps.gov/glba. Click on "Vessel Management Draft EIS" under "News and Events."

Open Houses/Public Hearings: The NPS will host informational open houses/public hearings in mid-April 2003 in the following locations: Anchorage, Juneau, Hoonah, Gustavus, Pelican, Elfin Cove, and Seattle. These meetings will be designed to facilitate dialogue between you and the NPS regarding your questions and comments on the DEIS. An informational open house will precede each public hearing. Details on time and place of the open houses/public hearings will be available on the park's website, published in local newspapers, announced on local radio, and posted in local post offices.

This is an important opportunity for you to comment on the DEIS for Glacier Bay National Park and Preserve. We look forward to receiving your comments.

Tomie Patrick Lee
Superintendent

Glacier Bay National Park and Preserve
Vessel Quotas and Operating Requirements
Draft Environmental Impact Statement

National Park Service, Alaska Region
United States Department of the Interior March 2003

Cover Photograph by Mark Kelley

Draft Environmental Impact Statement

Glacier Bay National Park and Preserve
Vessel Quotas and Operating Requirements
Alaska

Lead Agency: National Park Service

This draft environmental impact statement (EIS) analyses five alternatives for quotas (limits) and operating requirements for cruise ships and tour, charter, and private vessels within Glacier Bay and Dundas Bay. A decision is needed to set the maximum level of vessels while protecting park resources and values. The lead agency in this decision is the U.S. Department of the Interior, National Park Service (NPS). The Responsible Official is the NPS Regional Director, Alaska Region, Robert Arnberger.

Glacier Bay National Park and Preserve is a marine-oriented park and preserve located in Southeast Alaska, near Juneau. It is a popular destination because of its spectacular scenery, including tidewater glaciers and abundant wildlife. The purpose and need for the decision are to provide opportunities for people to visit the park while protecting park resources.

Alternatives 1, 2, and 3 would incorporate current operating requirements, yet they differ in the number of vessels that would be permitted to enter Glacier Bay. The quota season for these alternatives would be June 1 through August 31. Under alternatives 4 and 5, the quota season would be extended to May 1 through September 30, vessel quotas would be initiated for Dundas Bay, and several new operating requirements would be established to protect park resources. Alternative 4 would maintain the current daily quotas for cruise ships and slightly reduce the daily quotas for the other three vessel classes. Alternative 4 also would reduce seasonal use days for cruise ships, tour vessels, and charter vessels, but would slightly increase seasonal use days for private vessels. Alternative 5 would maintain current vessel quotas from June 1 to August 31, and would extend the seasonal use day limits to May and September for cruise ships. The other vessel classes would maintain the June-through-August quota season. The Park Service has selected Alternative 3 as the preferred alternative. Alternative 4 is the environmentally preferred alternative.

Under all alternatives, vessel traffic would emit air and water pollution, disturb marine birds and mammals (including the threatened humpback whale), and affect experiences for some visitors who travel in non-motorized vessels (such as kayaks) and hike along the shorelines. Collisions with humpback whales and other marine mammals could occur.

Upon completion of the EIS, the Regional Director will sign and implement a record of decision that sets entry quotas and operating requirements for cruise ships and tour, charter, and private vessels in Glacier Bay and Dundas Bay.

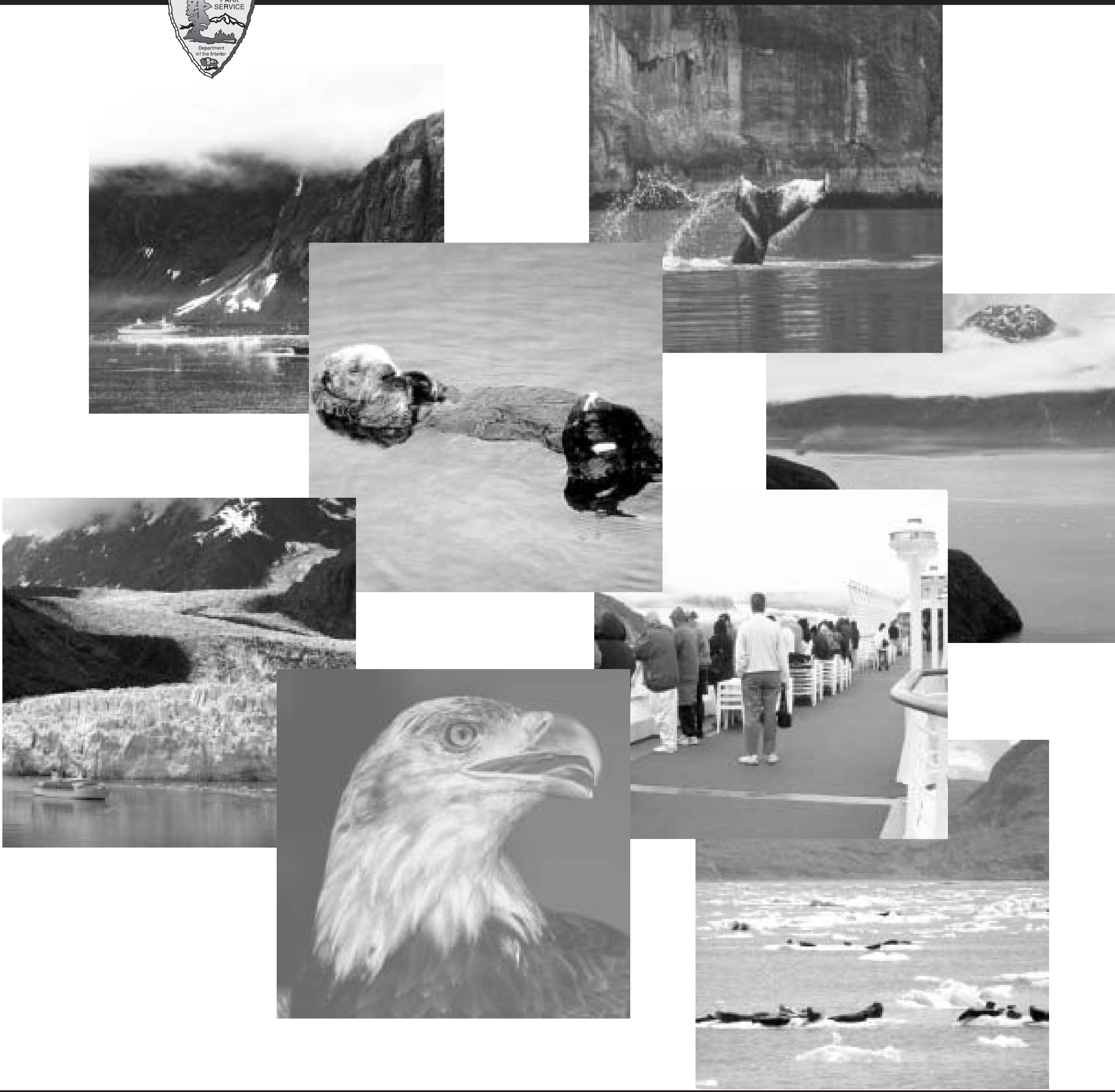
The comment period for the draft EIS will end 60 days after the notice of availability is published in the *Federal Register*. Comments should be submitted to:

Nancy Swanton
National Park Service, Alaska Support Office
2525 Gambell St., Anchorage, AK 99503

For additional information, visit the project website at http://www.nps.gov/glba.

U.S. Department of the Interior, National Park Service — Glacier Bay National Park and Preserve

SUMMARY



GLACIER BAY

NATIONAL PARK AND PRESERVE, ALASKA

VESSEL QUOTAS AND OPERATING REQUIREMENTS • DRAFT ENVIRONMENTAL IMPACT STATEMENT

SUMMARY

The National Park Service (NPS, also "the Park Service" or "Service") proposes to establish new or keep existing quotas (limits) and operating requirements for four types of motorized watercraft – cruise ships, and tour, charter, and private vessels – within Glacier Bay and Dundas Bay in Glacier Bay National Park and Preserve. This draft environmental impact statement (EIS) was prepared, as required, under the National Environmental Policy Act (NEPA) of 1969 and regulations of the Council of Environmental Quality (CEQ; 40 Code of Federal Regulations [CFR] 1500). It describes a reasonable range of alternatives and the existing conditions and contains a detailed analysis of environmental consequences of the alternatives.

PURPOSE AND NEED FOR ACTION

The purpose for the action is to address the continuing demand for motorized watercraft access into Glacier Bay and Dundas Bay in a manner that ensures continuing protection of park resources and values while providing for a range of high-quality recreational opportunities for visitors. The Park Service seeks to develop a system of vessel quotas and operating requirements for the park and preserve that will guide management of vessel traffic in the park.

The need for action stems from legislation enacted in 2001, wherein the U.S. Congress directed the Park Service to set the maximum level of motorized vessel entries based on the analysis in this EIS. Reevaluation of vessel quotas and operating requirements is required to address the continuing demand for vessel entries and park visitation. The Park Service desires, through this planning process and this EIS, to comprehensively address issues and concerns associated with vessel management and the park's marine environment.

THE ALTERNATIVES

Introduction

The National Park Service is considering five alternatives for achieving the objectives and needs described in the previous section. Each alternative defines different entry quotas (limits) and/or operating requirements for cruise ships, tour vessels, charter vessels, and private vessels. Because this environmental impact statement is responding to a very narrow set of needs related specifically to managing commercial and private motorized vessels used for visitor recreational purposes, the alternatives considered have many elements in common.

Alternatives 1, 2, and 3 differ only in the number of vessels permitted to enter Glacier Bay. Alternative 1 would maintain the current quotas (also called the "no-action" alternative). Alternative

2 would decrease vessel quotas from current quotas, setting them at those levels in effect prior to 1996, and alternative 3 (the NPS preferred alternative) is the current quota, plus an allowance for additional cruise ships (totaling up to two per day, every day, from June through August).

Alternative 4 (the environmentally preferred alternative) prescribes vessel quota numbers that were in effect prior to 1985, plus revised operating requirements, while alternative 5 prescribes existing vessel quota numbers with revised operating requirements.

Operating requirements for alternative 4 differ slightly from those in alternative 5, but both alternatives include:

- new restrictions for use of wilderness waters by cruise ships and tour vessels
- increased protection for harbor seal haul-out areas in John Hopkins Inlet (in response to major population declines)
- a revision of designated whale waters to more accurately reflect current whale use

Alternative 1: No Action

Alternative 1 is the no-action alternative. The current quotas and operating requirements for all vessel types would remain in effect under this alternative. Table S-1 lists the specific vessel quotas.

TABLE S-1: SUMMARY OF VESSEL QUOTAS FOR GLACIER BAY UNDER ALTERNATIVE 1, JUNE 1 - AUGUST 31

Vessel Class	Daily Entries	Seasonal Entries	Seasonal-Use Days
Cruise ship[a]	2	139	139
Tour vessel[a]	3	276	276
Charter vessel	6	312	552
Private vessel	25	468	1,971

a. Cruise ships and tour vessels are limited to a maximum of two per day and three per day, respectively, year-round.

Alternative 2

Under alternative 2, Vessel quotas would be those authorized in 1985. Vessel classes would continue to be defined under the existing regulations. Current operating requirements would remain in effect (see table S-2).

TABLE S-2: SUMMARY OF VESSEL QUOTAS FOR GLACIER BAY UNDER ALTERNATIVE 2, JUNE 1 - AUGUST 31

Vessel Class	Daily Entries	Seasonal Entries	Seasonal-Use Days
Cruise ship[a]	2	107	107
Tour vessel[a]	3	276	276
Charter vessel	6	271	511
Private vessel	25	407	1,714

a. Cruise ships and tour vessels are limited to a maximum of two per day and three per day, respectively, year-round.

Alternative 3: NPS Preferred Alternative

Alternative 3 would optimize visitor-use opportunities via cruise ship in Glacier Bay by potentially increasing cruise ship seasonal-use days. This alternative is identical to alternative 1 except that seasonal entry quotas for cruise could increase from 139 to 184 (which would allow for two cruise ships per day every day between June 1 and August 31) contingent upon environmental studies (see table S-3).

TABLE S-3: SUMMARY OF VESSEL QUOTAS FOR GLACIER BAY UNDER ALTERNATIVE 3, JUNE 1 - AUGUST 31

Vessel Class	Daily Entries	Seasonal Entries	Seasonal-Use Days
Cruise ship[a]	2	139 (potentially up to 184)	139 (potentially up to 184
Tour vessel[a]	3	276	276
Charter vessel	6	312	552
Private vessel	25	468	1,971

a. Cruise ships and tour vessels are limited to a maximum of two per day and three per day, respectively, year-round.

Alternative 4: Environmentally Preferred Alternative

Alternative 4 would allow the lowest level of entries across all vessel classes, except private vessels, and would provide revised operating requirements. Tables S-4 and S-5 summarize vessel quotas for Glacier Bay and Dundas Bay respectively, under alternative 4.

TABLE S-4: SUMMARY OF VESSEL QUOTAS FOR GLACIER BAY UNDER ALTERNATIVE 4, MAY 1 – SEPTEMBER 30

Vessel Class	Daily Vessel Quota		Seasonal Entries	Seasonal-Use Days	
	June - Aug	May and Sept	June – Sept	June – Aug	May and Sept
Cruise ship[a]	2	2	NA	92	61
Tour vessel[a]	2	2	NA	184	122
Charter vessel	5	5	NA	460	305
Private vessel	22	22	NA	2,024	1,342

a. Cruise ships and tour vessels are limited to daily vessel quota year-round.

NA = not applicable

TABLE S-5: SUMMARY OF VESSEL QUOTAS FOR DUNDAS BAY UNDER ALTERNATIVE 4, MAY 1 – SEPTEMBER 30

Vessel Class	Daily Vessel Quota	Seasonal Entries	Seasonal-Use Days
Cruise ship	Not permitted	NA	NA
Tour vessel[a]	Not permitted	NA	NA
Charter vessel[a]	3	NA	459
Private vessel	No limit	No limit	No limit

a. Cruise ships and tour vessels are limited to daily vessel quota year-round.

NA = Not applicable

Alternative 5

Alternative 5 would maintain the current daily vessel quotas for all vessel types in Glacier Bay. Seasonal-use days for cruise ships would be extended into May and September. Vessel quotas would be initiated for tour and charter vessels in Dundas Bay. Operating requirements would be revised. Tables S-6 and S-7 summarize vessel quotas for Glacier Bay and Dundas Bay, respectively, under alternative 5.

TABLE S-6: SUMMARY OF VESSEL QUOTAS FOR GLACIER BAY UNDER ALTERNATIVE 5, MAY 1- SEPTEMBER 30

Vessel Class	Daily Vessel Quota		Seasonal Entries	Seasonal-Use Days	
	June - Aug	May and Sept		June - Aug	May and Sept
Cruise ship[a]	2	2	NA	139	92
Tour vessel[a]	3	3	NA	276	183
Charter vessel	6	No limit	NA	552	No limit
Private vessel	25	No limit	NA	2,300	No limit

a. Cruise ships and tour vessels are limited to daily vessel quota year-round.

NA = not applicable

TABLE S-7: SUMMARY OF VESSEL QUOTAS FOR DUNDAS BAY UNDER ALTERNATIVE 5, JUNE 1 – AUGUST 31

Vessel Class	Daily Vessel Quota	Seasonal Entries	Seasonal-Use Days
Cruise ship[a]	Not permitted	NA	NA
Tour vessel	0 in upper Bay[a] 1 in lower Bay [b,c]	NA	0 in upper Bay 153 in lower Bay [b,c]
Charter vessel	No limit	NA	276
Private vessel	No limit	No limit	No limit

a. Cruise ships and tour vessels are not allowed on a year-round basis.
b. Upper Dundas Bay is wilderness waters; the lower Bay is non-wilderness waters.
c. The quota season June 1 through August 31 applies.

NA = Not applicable

AFFECTED ENVIRONMENT

The topics addressed in the affected environment section were selected based on federal law, regulations, executive orders, NPS management policies, National Park Service subject-matter expertise, and concerns expressed by other agencies or members of the public during scoping and comment periods.

Physical Environment

Fjord Dynamics and Oceanographic Processes. The most significant physical aspect of Glacier Bay is that it is a recently deglaciated fjord in southeast Alaska. The north end of the Bay's main body divides into two fjord systems known as the East and West Arms. Muir Inlet is included in the East Arm.

Soundscape. The park's soundscape includes both naturally occurring and human-made sounds.

When evaluated against the natural soundscape in a park, human-caused sound is considered “noise”. At present, much of the human-generated sounds in the park originate from motorized vessels and, therefore, these sounds are most prevalent over the water, under the water, and along the shoreline.

Air Quality. Air emission sources within the park include exhaust from fuel combustion during vessel operations, fuel combustion for heating of buildings at Bartlett Cove, fuel use by vehicles in the park, and occasional campfires. The greatest source of emissions within the park is marine vessel traffic, and includes nitrogen oxides, sulfur oxides, and particulate matter.

Water Quality. Glacier Bay water quality is affected by a number of factors, including run-off, sedimentation, tidal variations, large-scale mixing and up-welling zones, and the overall complex topography of the area. The consensus among researchers is that water quality in the Bay is generally good. Potential pollution sources in the Bay include motorized vessels, glacial sediment loading, and runoff from developed areas adjacent to the Bay.

Biological Environment

Threatened and Endangered Species. Two species, both marine mammals, are resident seasonally and/or year-round within Glacier Bay and Dundas Bay and are listed as threatened or endangered under the Endangered Species Act. The central north Pacific stock of humpback whales is listed as endangered. The eastern stock of Steller sea lions is listed as threatened. It should be noted that Kittlitz’s murrelets are listed as threatened in other parts of the United States and Canada and are under review by the USFW.

Marine Mammals. Marine mammals that inhabit the park seasonally or year round other than the two marine mammals listed as threatened or endangered include: minke whale, harbor porpoise, Dall’s porpoise, killer whale, harbor seal, and sea otters.

Marine Birds and Raptors. The bird community of Glacier Bay proper and Dundas Bay is typical of southeastern Alaska. Marine birds (birds that spend most or all of their life near and in marine areas) are the most common type of bird in the planning area and most relevant to this environmental impact statement. Of these, the most sensitive to vessel traffic are colonial nesting seabirds, murrelets, molting waterfowl, raptors, shorebirds, and seaducks.

Marine Fishes. Four pelagic fish species, including capelin, walleye pollock, Pacific herring, and northern lampfish, account for approximately 90 percent of the total number of identified fish in the park. The demersal fishes (bottomfish) found in the park are members of the skates, sculpins, and flatfishes. Five species of salmon and steelhead trout occur in the waters of the park.

Coastal/Shoreline Environments and Biological Communities. Glacier Bay's southern portions have the most beaches; the shorelines in these areas are more mature than the remainder of the Bay. Farther north, the shoreline structure is less mature with fewer beaches and little vegetation. The shoreline vegetation found in the middle and northern portions of the Bay comprises those species that colonize areas after a disturbance. At the terminus of the glaciers, exposed bedrock overlain by fine sediment is prevalent due to the active dumping and grinding by the glacier. The vegetation is sparse and includes hardy pioneer species. Water temperature, salinity, amount of suspended sediment, and ice scour are key factors controlling biological community development and all of these variables are directly related to the proximity of the site to tidewater glaciers. In general, community diversity in rocky intertidal communities close to tidewater glaciers is very low.

Human Environment

Cultural Resources.

Archaeological Resources. Archaeological resources that have been found, or can be expected to occur, in the park are diverse and include: petroglyphs and petrographs, culturally modified trees, rock shelters, villages, forts, fishing sites and weirs, hunting and gathering sites, stone cairn formations, mining camps, canneries, trading posts, log cabins, trails, horticulture sites, buried sites, major/multi-component sites, cemeteries or burials, and intertidal and wet zones.

Ethnographic Resources. A Park Service preliminary assessment of the park has identified approximately 15 sites that may qualify as traditional cultural properties.

Cultural (or Ethnographic) Landscapes. The Park Service has compiled two Cultural Landscapes Inventories in the park at Bartlett Cove and Dundas Bay. Both areas may be eligible for listing in the National Register for Historic Places. They are components of a larger ethnographic landscape that encompasses the entire park and preserve.

Visitor Experience. For this environmental impact statement, five major visitor groups are defined: 1) cruise ship passengers; 2) tour vessel passengers; 3) charter vessel passengers; 4) private vessel visitors; and 5) backcountry visitors. In 2001, nearly 383,000 visitors traveled through Glacier Bay aboard cruise ships, tour vessels, charter vessels or private vessels and other modes. Eighty-five percent of park visitors are cruise ship passengers.

Vessel Use and Safety.

Vessel Traffic. Cruise ships in Glacier Bay generally follow a predictable pattern after they enter the park. Most cruise ships arrive at the mouth of Glacier Bay from the east through Cross Sound and travel north through the Bay. They typically proceed seaward down the West Arm to Glacier Bay. Most vessels continue their outbound voyage down Glacier Bay leaving the park between 4:00 and 8:00 p.m.

Tour, charter, and private vessels are capable of entering remote inlets and harbors within Glacier Bay, although there are typical routing patterns. The primary anchorages for tour, charter, and private boats within Glacier Bay are: North and South Sandy Cove, Blue Mouse Cove, Reid Inlet, Berg Bay, Geikie Inlet, Tidal Inlet, Russell Island Passage, Johnson Cove, Goose Cove, Adams Inlet, Sebree Cove, North and South Fingers Bay, and Beardslee Island Entrance. There is a legislated provision for a daily passenger ferry from Juneau to Bartlett Cove.

Vessel Safety. Since the Vessel Management Plan was implemented in 1996, no cruise ships have been involved in collisions or groundings. A crab boat, fishing in the winter, sank, and one tour vessel has grounded. In a separate incident, another tour vessel struck an iceberg in Tarr Inlet and suffered hull damage. There was no oil spill associated with this incident. Twenty-one other vessels (mostly private vessels) have grounded, but with only minor damage reported. Other types of accidents commonly reported include vessels going adrift or dragging anchor, and minor collisions.

Wilderness Resources. Approximately 2,658,186 acres of Glacier Bay National Park's total of 3,283,168 acres are designated as part of the National Wilderness Preservation System. These wilderness resources include most of the land in the park and five marine wilderness waterways: the Beardslee Islands, Dundas Bay, the Hugh Miller/Scidmore Complex, Adams Inlet, and Rendu Inlet. The Glacier Bay Wilderness offers some of the most unique resources in all of the National Wilderness Preservation System. Calving tidewater glaciers, temperate rainforest, plant diversity, and terrestrial and marine wildlife including threatened and endangered species, provides an unparalleled intact ecosystem.

Local and Regional Socioeconomics. Communities neighboring Glacier Bay National Park include relatively small villages, native communities, and larger towns that rely on tourism, government, and the fishing, forest products, and mining industries as a basis for their economies. The nearest town to the park is Gustavus, and the town's economy is heavily supported by NPS employment, commercial fishing, tourism, and government. Other nearby communities include: Elfin Cove, a vital service center for recreational and commercial marine vessels, supported by commercial fishing and tourism; Hoonah a predominantly Alaska Native community, supported by commercial fishing, timber, government, and emerging tourism; Pelican, supported by commercial fishing; Haines, a center for commercial fishing, construction, tourism, and government; Yakutat, a predominantly Alaska Native community dependent on commercial fishing, fish processing, sport fishing, and tourism; Juneau, the service, supply, and transportation center for northern southeast Alaska; Skagway, a vital transportation and tourism center, and; Sitka, supported by commercial fishing, tourism, and government.

ENVIRONMENTAL CONSEQUENCES

The environmental impact statement evaluates the environmental consequences of the five alternatives in Glacier Bay and Dundas Bay by considering direct, indirect, and cumulative effects:

- **Direct effects** are those effects that result from the action and occur at the same time and place.
- **Indirect effects** are those reasonably foreseeable effects caused by the action, but that may occur later in time or farther removed in distance from the location of the direct effect.
- **Cumulative effects** can result from individually minor, but collectively significant, actions taking place over a period of time.

Effects Thresholds. Thresholds help establish the basis for understanding the severity and magnitude of the effects. Under each element of the environment, effects thresholds are defined using four categories of significance: *negligible*, *minor*, *moderate*, and *major*. A major effect indicates that the alternative could result in impairment to the existing environment. An impairment is an effect that would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values.

Mitigation Measures. This environmental impact statement also identifies and discusses mitigation measures, which are specific methods for avoiding, minimizing, rectifying, reducing, or compensating for an alternative’s adverse effect(s).

An overview of the environmental consequences of the five alternatives for each environmental resource/topic area is provided below.

Physical Environment

Soundscape. Vessel noise would intrude on the natural soundscape on the surface and underwater. Shoreline areas would be subjected to vessel noise, potentially interfering with visitor enjoyment of the natural soundscape. Under current vessel use, vessel noise is prevalent in the underwater soundscape. One study found that during peak use in August, nearly 70% of sound samples taken contained vessel noise. Overall, vessel noise is considered consistent with park resources and values because motorize vessels have been and will remain a necessary way to provide access to the park. Access for public enjoyment and understanding of park resources is one of the primary purposes of the park.

Under alternative 2, fewer cruise ships, charter, and private vessels would reduce human-caused sounds, particularly along shorelines, where private vessels are more likely to travel. Alternative 3 could allow an increase of up to 184 cruise ships. During the summer, the underwater soundscape would be subjected to four cruise ship passings each day, every day, during summer, as two cruise ships travel up and then down the Bay. Other vessel levels and operating requirements and associated human-caused noise would be the same as alternative 1. Under alternative 4, the East Arm of Glacier Bay and lower Dundas Bay would be improved by limiting charter vessels and eliminating tour vessels. Alternative 4 also reduces cruise ship noise by reducing speeds to 13 knots throughout Glacier Bay and by reducing the number of cruise ship by 33% (an average use of one cruise ship per day). Alternative 5 would also set speed limits for cruise ships at 13 knots. However, under alternative 5 private vessels would increase vessel noise along shorelines and in the more remote places of Glacier Bay.

Air Quality. Under certain weather conditions (calm with a temperature inversion), stack emissions would be visible and could linger for several hours. Under alternative 2, fewer cruise ships would reduce the frequency of haze or stack emissions. Under alternative 3, studies would be need to demonstrate that air quality would not be significantly degraded before increasing cruise ships. A 32% increase in cruise ships would greatly increase the frequency of visible stack emissions. Under alternative 4, speed restrictions on cruise ships and lower vessel numbers would reduce emissions and visible plume events. Closure of the east arm to tour vessels could improve visibility there. As with alternative 4, alternative 5 would include speed restrictions that would reduce air emissions, but visible plumes are still expected to occur under certain weather conditions. Under alternative 5, increased private vessels would increase air emissions near shorelines.

Water Quality. Effects would be minor since water quality impacts from spills would be short-term, localized, and the spill response capability is high. A large spill in ice-filled waters is unlikely, but would be a major effect since spill response would not be possible. The effects under alternative 2 would be not discernable from alternative 1. Effects related to discharge of bilge water and vessel grounding or collision would be incrementally lower due to the reduced number of cruise ships.

Under Alternative 3, should cruise ship numbers be increased, then an associated increase in inadvertent discharges into the water would occur. The risk of a major accident would increase, but still remain very low. Effects on water quality from alternative 4 would be similar to alternative 1 but, due to the lower vessel numbers, would result in a lower level of discharges. Risks of a large spill in Dundas Bay would be reduced by prohibiting tour vessels in that area. Effects of alternative 5 would be similar to alternative 1.

Biological Environment

Threatened and Endangered Species. Vessel traffic would continue to adversely affect both humpack whale and Steller sea lions. Effects would be at the level of individual and not the population. Humpback whales would continue to be disturbed by the sight and sounds of vessels. Collisions with cruise ships would be rare but, over time, would be unavoidable. Existing regulations to protect whales and sea lions would remain in place. Under alternative 2, fewer cruise ships would lower exposure to noise and risk of collisions. Under alternative 3, increasing cruise ship numbers would increase associated noise exposure and risk of collisions. Under alternative 4, the combination of reducing summer cruise ship numbers and speed would greatly reduce noise exposure and the risk of collision. Humpback whales would still be exposed to vessel noise from private vessels, which would slightly increase. Restrictions in Dundas Bay would benefit whale use there. Alternative 5 also includes speed reductions for cruise ships, which would greatly reduce noise and the risk of collision. Increasing private vessels would increase non-lethal injuries to humpback whales. Such events are expected to be rare but unavoidable.

Marine Mammals. Vessel traffic may contribute to reported declines in harbor seal populations. Effects on minke whales would be similar to those described for humpback whale. Other marine mammals would avoid vessel traffic but would otherwise not be harmed. Effects under alternative 2 would be similar to alternative 1 but would include a slightly decreased chance of distribution shifts or animal collisions due to lower vessel numbers. With alternative 3, disturbance would increase if cruise ship numbers are increased. Still, populations are expected to remain stable. Alternative 4 would result in a much lower frequency of disturbance due to speed limits, vessel reductions, and restrictions at Dundas Bay and the East Arm. Additional protection for harbor seals in Johns Hopkins inlet would reduce effects. Expanding seasonal restrictions would increase protection during early and late summer. Under alternative 5, increasing private boats would increase disturbance to marine mammals. Expanding seasonal restrictions would increase protection during early and late summer.

Marine Birds and Raptors. Vessel traffic in Sitakaday Narrows, Reid Inlet, the East Arm, Dundas Bay, and other areas would continue to disturb murrelets, molting waterfowl, and breeding harlequin ducks. The amount of disturbances would decline slightly under alternative 2. Under alternative 3, overall effect would be similar to alternative 1, but the amount of disturbances would increase if cruise ship numbers were increased. The reduced vessel traffic of alternative 4 would provide a corresponding reduction in vessel disturbance on marine birds. With the increases in private vessels under alternative 5, disturbance to molting waterfowl, murrelets, and harlequin ducks would increase.

Marine Fishes. Under all alternatives, vessel traffic could displace some fish, but overall, the current level of vessel traffic has not been found to seriously disrupt fish populations.

Coastal/Shoreline Environments and Biological Communities. Effects to shoreline would be minor because current vessel traffic does not cause significant erosion of shorelines. Individual beaches may experience some erosion and sediment suspension from vessel traffic. Effects are similar among all alternatives, with the exception that sediment erosion, re-suspension, or relocation would be slightly greater than current conditions under alternative 5 due to an increase in private vessels.

Human Environment

Cultural Resources. Effects to archaeological and historic resources would be negligible because resources would remain eligible for the National Register of Historic Places. Effects to ethnographic resources would be moderate since the project would potentially affect the integrity of traditional cultural properties. The effects of alternative 2 are not discernable from alternative 1. Under alternative 3, increasing cruise ship numbers to 2 per day, every day, during the summer would eliminate opportunities to undertake traditional activities in the central portions of Glacier Bay without the presence of a cruise ship. Conversely, alternative 4 would increase such opportunities. Effects to cultural landscapes would be moderate under alternative 5 because it would allow more private vessels.

Visitor Experience. Backcountry visitors would be exposed to the sight, sound, and occasionally smells of motorized vessels. Such exposure could lead to potential loss of opportunity to experience solitude. Alternative 2 would cause a major loss in the opportunity for passengers to experience Glacier Bay proper, with a reduction in available cruise ships. Under alternative 3, charter and private vessel passengers and backcountry visitors could experience a loss of opportunities for solitude due to increased cruise ship traffic, but opportunities to visit the park could increase.

Under alternative 4, reduced cruise ship and tour vessel entries would reduce opportunities to visit the park. Under alternative 5, effects would be moderate due to fewer numbers of cruise ships allowed in May and September, but increases in private vessels would detract from wilderness experience for backcountry visitors.

Vessel Use and Safety. Under all alternatives, controls on vessel entry strictly limit the density of vessels in Glacier Bay, but limited congestion would continue to occur at Bartlett Cove and Tarr Inlet. Eliminating tour vessels from Dundas Bay under Alternative 4 would eliminate the current risks associated with operating large vessels in relatively shallow areas. Under both alternatives 4 and 5, formally defining cruise ship routes would reduce the risk of groundings and potential fuel spills. Reducing cruise ship speed would further reduce the currently low risk of accidents.

Wilderness Resources. Effects would be minor for most areas and moderate for concentrated use areas, such as Johns Hopkins and Tarr Inlets, where vessel noise and air pollution would be heightened. Most effects would occur along shorelines. Increasing cruise ships to 184 under alternative 3 during summer would reduce the naturalness of wilderness near the tidewater glaciers, where cruise ships spend most of their time while at Glacier Bay. Reduced vessel numbers under alternative 4 would reduce vessel exposures to wilderness. Reducing cruise ship speed limits would reduce vessel emissions and noise, but would also increase the time cruise ships are within Glacier Bay. Under alternative 5, effects would be similar to alternative 1, but with increased protection to Dundas Bay. As with alternative 4, reducing speed limits would reduce vessel emissions and noise, but would also increase the time cruise ships are within Glacier Bay.

Local and Regional Socioeconomics. Effects to the economies of neighboring communities and Southeast Alaska would be negligible, as would the effects to Glacier Bay-dependant businesses. Alternative 2 would cause some decrease in income and employment for communities with economic linkages to Glacier Bay. In addition, local spending associated with private vessels would be reduced. Alternative 3 would provide additional revenues due to increase in cruise ships; effects on local communities would be negligible with the exception of Gustavus, which would benefit from increased park revenues. Under alternative 4, effects would be minor to moderate due to income and employment decrease related to vessel decreases and reduced local spending associated with private vessels. Moderate effects would be expected for Gustavus where personal income reductions would be expected to be between 5% and 10%. Under alternative 5, effects would be similar to alternative 1; changes to Dundas Bay management could have a minor positive effect on commercial users.

TABLE OF CONTENTS

GLACIER BAY

NATIONAL PARK AND PRESERVE, ALASKA

VESSEL QUOTAS AND OPERATING REQUIREMENTS • DRAFT ENVIRONMENTAL IMPACT STATEMENT

TABLE OF CONTENTS

CHAPTER 1. PURPOSE AND NEED

Section Page

CHAPTER 3. AFFECTED ENVIRONMENT

CHAPTER 4. ENVIRONMENTAL CONSEQUENCES

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER 1

PURPOSE AND NEED

GLACIER BAY NATIONAL PARK AND PRESERVE, ALASKA

VESSEL QUOTAS AND OPERATING REQUIREMENTS • DRAFT ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 1. PURPOSE AND NEED

1.1 INTRODUCTION

The National Park Service (NPS, also "the Park Service" or "the Service") proposes to establish new or keep existing quotas (limits) and operating requirements for four types of motorized watercraft — cruise ships, and tour, charter, and private vessels — within Glacier Bay and Dundas Bay in Glacier Bay National Park and Preserve (see figure 1-1; see subsection 1.1.3). This draft environmental impact statement (EIS) was prepared, as required, under the National Environmental Policy Act (NEPA) of 1969 and regulations of the Council on Environmental Quality (CEQ; 40 Code of Federal Regulations [CFR] 1500). It describes a reasonable range of alternatives and the existing conditions and contains a detailed analysis of the environmental consequences of the alternatives. This chapter describes the underlying purpose and need for the action; presents background information related to the history of vessel management; presents an overview of applicable regulations; and summarizes issues identified by the Park Service, government agencies, organizations, businesses, and the public.

1.1.1 Purpose

The purpose for the action is to address the continuing demand for motorized watercraft access into Glacier Bay and Dundas Bay in a manner that ensures continuing protection of park resources and values while providing for a range of high-quality recreational opportunities for visitors. The Park Service seeks to develop a system of vessel quotas and operating requirements for the park and preserve that will guide management of vessel traffic in the park. Implementation of the vessel quotas and operating requirements may require promulgation of regulations, revising 36 CFR 13.65.

1.1.2 Need

The need for action stems from legislation enacted in 2001, wherein the U.S. Congress directed the Park Service to set the maximum level of motorized vessel entries based on the analysis in this EIS. Measures to address vessel traffic were implemented in 1979. Temporary regulations went into effect in 1980 and permanent regulations were promulgated in 1985 to respond to concerns about the effects motor vehicles have on the endangered humpback whale *(Megaptera novaeangliae)*. Since then, concerns have broadened to encompass potential effects on other biota, the physical environment, and the visitor experience. Reevaluation of vessel quotas and operating requirements is required to address the continuing demand for vessel entries and park visitation. The Park Service desires, through this planning process and this EIS, to comprehensively address issues and concerns associated with vessel management and the park's marine environment.

Location Map for Glacier Bay National Park and Preserve

Figure 1-1

National Park Service
U.S. Department of the Interior

Boundary of Glacier Bay National Park & Preserve

Glacier Bay National Park and Preserve
Vessel Quotas and Operating Requirements
Environmental Impact Statement

Prepared by: Ecology and Environment, Inc., February 24, 2003

1.1.3 Geographic Area

Collectively, Glacier Bay and Dundas Bay comprise the planning area in this EIS. Glacier Bay is defined as all contiguous marine waters lying north of an imaginary line between Point Gustavus and Point Carolus. Dundas Bay is defined as all contiguous marine waters north of an imaginary line between Point Dundas and Point Wimbledon (see figure 1-2).

1.2 HISTORY OF VESSEL MANAGEMENT IN GLACIER BAY NATIONAL PARK AND PRESERVE

The Park Service has managed motorized recreational vessels in Glacier Bay for more than 20 years. Serious efforts to manage motorized vessels in Glacier Bay began in the mid-1970s in response to concerns regarding humpback whale populations. Since that time, many decisions and plans have been made setting vessel quotas and operating requirements. To understand the current proposed action and the purposes and need for this action, it is important to understand the major milestones of vessel management at the park.

The following subsections summarize these major milestones. For a more detailed perspective on the history of vessel management at the park, see Catton (1995). Much of the following historical overview is based on Catton (1995) and on a 1995 *Glacier Bay National Park and Preserve Vessel Management Plan and Environmental Assessment* (NPS 1995a; described in subsection 1.2.5), and the 1996 revised environmental assessment (EA) and finding of no significant impact (NPS 1996).

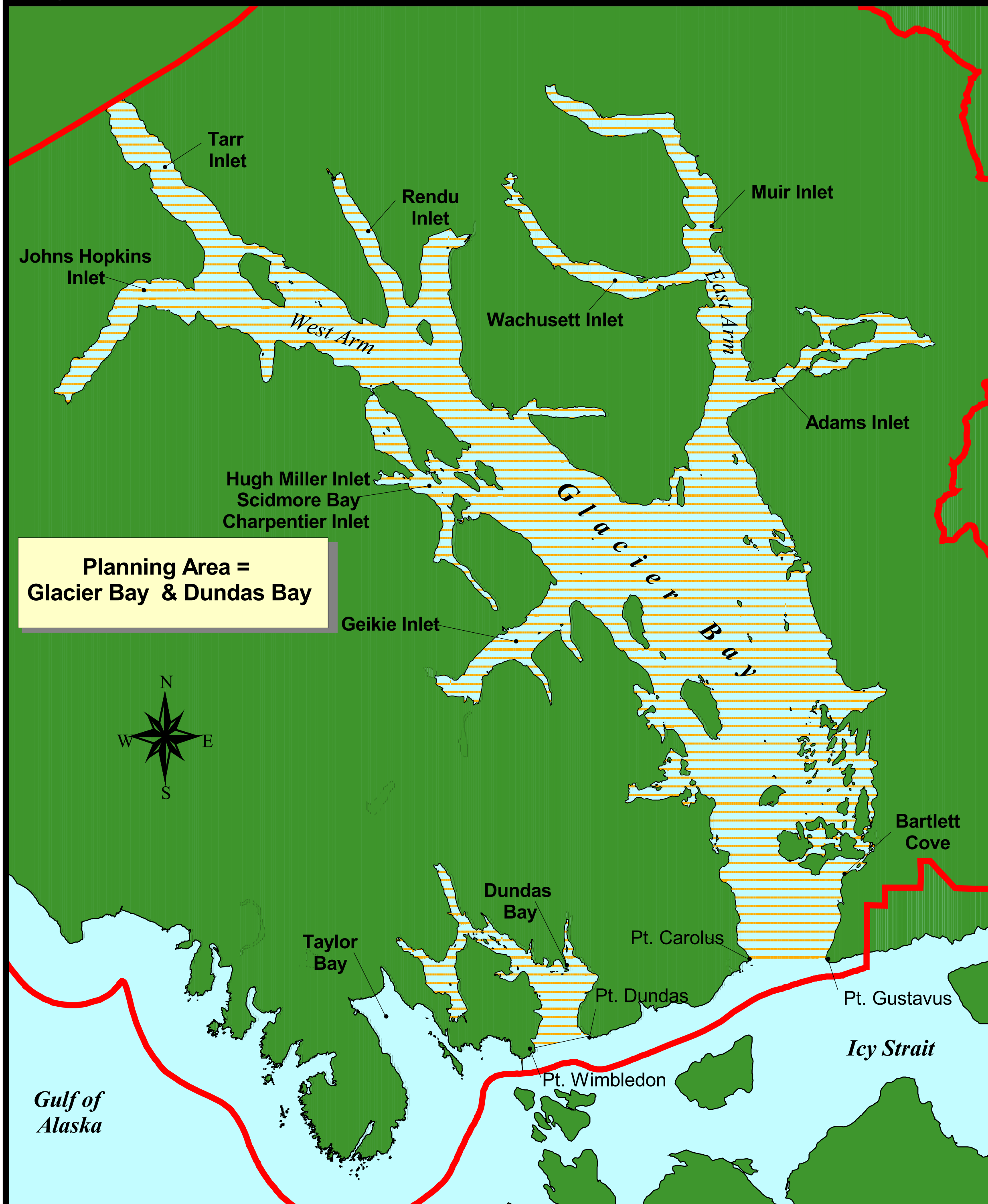
1.2.1 The 1979 Biological Opinion

At the request of the Park Service, consultation under section 7 of the Endangered Species Act (ESA) began in 1979 because vessel traffic in Glacier Bay was implicated when several humpback whales departed from the Bay. The National Marine Fisheries Service (NMFS; now called the National Oceanic and Atmospheric Administration [NOAA] Fisheries) issued a biological opinion (NMFS 1979) concerning the effects of actions proposed by the Park Service to control vessel activity in Glacier Bay National Monument. The National Marine and Fisheries Service concluded that uncontrolled increase of vessel traffic, particularly of erratically traveling charter/pleasure craft, probably had altered the behavior of humpback whales in Glacier Bay and, thus, may be implicated in their departure from the Bay during 1978 and 1979. Therefore, a continued increase in the amount of vessel traffic, particularly charter/pleasure craft, in Glacier Bay would likely jeopardize the continued existence of the humpback whale population frequenting southeast Alaska (NMFS 1979).

Planning Area of the
Vessel Quota and Operating Requirements
Environmental Impact Statement

Figure 1-2

National Park Service
U.S. Department of
the Interior



Planning Area of the Vessel Quota and Operating Requirements Environmental Impact Statement

Boundary of Glacier Bay National Park & Preserve

Glacier Bay National Park and Preserve

Vessel Quotas and Operating Requirements Environmental Impact Statement

5 0 5 10 Miles

Prepared by: Ecology and Environment, Inc., February 24, 2003

In response to the 1979 jeopardy opinion and the reasonable and prudent alternatives the National Marine and Fisheries Service recommended, the Park Service limited vessel traffic to approximately the 1976 level and established restrictions on vessel routing and maneuvering. Vessels were divided into categories based on their size and purpose for being in the Bay. Research was initiated on humpback whale behavioral response to vessels, humpback whale prey type and density, and underwater acoustic conditions.

1.2.2 1983 Biological Opinion

The Park Service reinitiated consultation with the National Marine and Fisheries Service in 1983 by requesting a determination on whether vessel traffic could be increased, and if so, to what extent. In the 1983 opinion, the National Marine and Fisheries Service stated again that "if the amount of vessel traffic in Glacier Bay was allowed to increase without limit or if the existing restrictions on the operation of vessels within the bay were removed, the associated disturbance would be likely to jeopardize the continued existence of the southeast Alaska humpback whale stock." The National Marine and Fisheries Service addressed the question of increasing vessel traffic by stating "that an initial increase of no more than 20% (above the 1976 level) for the large ship and small vessel categories would be prudent." The National Marine and Fisheries Service also recommended that any vessel increases be contingent on monitoring studies of whale presence, noise levels, and prey showing no adverse affects. The opinion stated "a minimum of two years should be allowed for monitoring and evaluating the effects of such an increase before additional increases are proposed." The opinion also allowed for subsequent increases, as long as whale numbers did not fall below the 1982 level (22 whales).

1.2.3 Increases in Vessel Quotas through the Mid- and Late-1980s

The Park Service promulgated new regulations in May 1985. These allowed for up to a 20% increase in vessel quotas above the 1976 level for all vessel classes. The Park Service implemented increases in two increments, and the 20% increase was reached in 1988.

1.2.4 Final Recovery Plan for Humpback Whales

In 1991, the National Marine and Fisheries Service published the *Final Recovery Plan for the Humpback Whale*. In this document a long-term numerical recovery goal was set for humpback whales, along with objectives for achieving the recovery goal. The long-term numerical goal is to increase humpback whale populations to at least 60% of the number existing before commercial exploitation or of current environmental carrying capacity. Both of those levels remain to be determined. In the meantime, the interim goal is a doubling of populations within the next 20 years.

The recovery plan further states that the primary means to an increased population is to “optimize natural fecundity by providing natural feeding opportunities, and reducing death and injury by human activities.” Objectives in the humpback whale recovery plan that are applicable to vessel management include:

1. maintain and enhance current or historical habitats used by humpback whales by reducing disturbance from human-produced underwater noise in important habitats when humpback whales are present and encourage government entities at all levels to correct existing impacts on habitat of humpback whales;
2. identify and reduce direct human-related injury and mortality through an evaluation of the effects of humpback whales from collisions with ships or boats; and
3. measure and monitor key humpback whale population parameters.

1.2.5 The 1993 Biological Opinion

In 1993, the National Marine and Fisheries Service issued a biological opinion based on a 1992 internal Park Service draft proposal for quotas and operating requirements. The biological opinion analyzed the potential effects on the Steller sea lion *(Eumetopias jubatus)*, gray whale *(Eschrichtius robustus)*, and humpback whale. The biological opinion was based on the following level of proposed vessel activity: cruise ships at the rate of two per day for a seasonal total of up to 184, tour vessels at the rate of three per day for a seasonal total of 276, charter vessels at the rate of six per day for a seasonal total of 552, and private vessels at the rate of 25 per day for a seasonal total of 2,300. The National Marine and Fisheries Service recommended continued monitoring and study of humpback whale movement, distribution, abundance, and feeding ecology, and study of how vessel presence alters the behavior and/or distribution of humpback whales. The National Marine and Fisheries Service concluded that the Park Service’s draft management plan would not adversely affect the Steller sea lion population, gray whales, or the central North Pacific humpback whale population. Further, the agency concluded that the level of vessel activity described in the plan would not jeopardize the continued existence and recovery of these species. The opinion applied to the 1996 vessel management plan and EA, since the vessel management levels in the plan were equivalent to or less than those described above (see the discussion about this plan below).

1.2.6 The 1996 Vessel Management Plan and Environmental Assessment and the Finding of No Significant Impact (NPS 1996)

In 1991, the Park Service began the development of the first comprehensive vessel management plan, considering the effects on park resources and visitor experience. The 1996 finding of no significant impact provided for increases in cruise ships, charter vessels, and private vessels. It provided for an incremental increase in cruise ships up to 184 over the June through August season (up to two cruise ships per day, every day, over those three months). Any increase would be contingent upon the completion of studies demonstrating that such increases would be consistent with park resources and values. The EA acknowledged that uncertainties existed regarding the environmental consequences of increasing vessel quotas in Glacier Bay.

Based on the EA, the Park Service concluded there would be no significant impacts as a result of the proposed action and issued a finding of no significant impact in March 1996. The Park Service concluded that an EIS was not required and the modified vessel management alternative was implemented, with regulations effective in May 1996.

Research and monitoring programs were initiated to better understand the effects of park vessel traffic on resources and values to protect the park's resources. Research and monitoring programs initiated since the 1995 EA include:

- Steller sea lion/vessel interaction study;
- harbor seal/vessel interaction study;
- U.S. Navy underwater acoustics research;
- whale/vessel interaction study;
- coastal mapping/inventory;
- coastal monitoring protocol;
- ethnographic overview; and
- archeological inventory.

1.2.7 Omnibus Parks and Public Lands Management Act of 1996 (Public Law 104-333)

This act limited the ability of the Park Service to regulate air and water quality, as well as noise generation. Key provisions of the act are as follows:

> *The Park Service may not impose any additional permittee operating conditions in the areas of air, water, and oil pollution beyond those determined and enforced by other appropriate agencies.*
>
> *When competitively awarding permits to enter Glacier Bay, the Park Service may take into account the relative impact particular permittees will have on park values and resources, provided that no operating conditions or limitations relating to noise abatement shall be imposed unless the secretary determines, based on the weight of*

> *the evidence from all available studies including verifiable scientific information from the investigations provided for in this subsection, that such limitations or conditions are necessary to protect park values and resources.*

1.2.8 2001 Decision – U.S. Court of Appeals for the Ninth Circuit

In a May 1997 complaint filed in the U.S. District Court, the National Parks Conservation Association challenged the validity of the Park Service's 1996 finding of no significant impact that authorized the increased entry levels. The District Court upheld the decision made by the Park Service. Following an appeal, the U.S. Court of Appeals for the Ninth Circuit reviewed the evidence and ruled in February 2001 that the portion of the vessel management plan and EA and the implementing regulations that authorized an increase in vessels into Glacier Bay violated the NEPA because an EIS was not prepared. The court determined that uncertainty about the potential effects of increased vessel quotas, as outlined in the EA (see subsection 1.2.5), was itself an indicator of significant impacts as defined under the NEPA. Furthermore, the court determined that the project involved controversy, which is another measure of significance under the act.

The court directed the park to manage vessel entries at those levels in place before the 1996 decision, pending preparation of an EIS. The effective date of the injunction was remanded to the District Court; the injunction became effective in late summer 2001.

1.2.9 Fiscal Year 2002 United States Department of the Interior Appropriations Bill (Public Law 107-63, 105th Congress)

Following the Ninth Circuit Court of Appeals decision, the U.S. Congress, as part of the U.S. Department of the Interior (USDI) Appropriations Act of 2002 (section 130 of Public Law 107-63 [155 Statute 414]), changed the requirements established in the court decision and required the Park Service to:

- prepare and complete an EIS by January 1, 2004, to identify and analyze the effects of the increased vessel use established in 1996.
- set the maximum levels of vessels (motorized watercraft) that enter Glacier Bay based on the EIS.

Congress set the numbers of allowable vessel entries to the levels in effect during the 2000 calendar year, which were 139 cruise ships, 276 tour vessels, 312 charter vessels, and 468 private vessels for the June through August season. On January 18, 2002, the District Court modified the previous injunction. This current level of seasonal entries forms the basis for the no-action alternative (alternative 1) of this EIS.

1.3 LEGAL MANDATES, POLICIES, AND PLANS

The following subsections summarize the most important directives that guide development of this plan.

1.3.1 NPS Organic Act and Redwood Amendment

The Organic Act of 1916 and the 1978 amendment of the NPS General Authorities Act of 1970 provide the overall mandate for management of the national parks. The Organic Act specifies the core NPS mission, including establishing regulations to protect the environment. The act states the responsibilities of the Park Service:

> *The (National Park) service . . . shall promote and regulate the use of the Federal areas known as national parks . . . to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.*

The Organic Act gives the Park Service a mandate to protect resources of national parks and to make conservation of the environment the leading priority when making management decisions regarding national parks. The act also states that one of the fundamental purposes of all parks includes the enjoyment of park resources and values. In situations where a conflict exists between NPS efforts to conserve resources and values versus those providing for enjoyment of them, conservation takes precedence.

Clarifications to the Organic Act of 1916. Congress supplemented and clarified provisions of the Organic Act by the General Authorities Act in 1970, and through enactment of a 1978 amendment to that law, the "Redwood amendment." Congress wanted to strengthen the ability of the U.S. secretary of the interior to protect park resources. The Redwood amendment states:

> *Congress further reaffirms, declares, and directs that the promotion and regulation of the various areas of the National Park System . . . shall be consistent with and founded in the purpose established by section 1 of this title [the Organic Act provision quoted on page 1], to the common benefit of all the people of the United States. The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress.*

Section 1.4 of the Park Service's *2001 Management Policies* (NPS 2001b), described further in the following subsection, formally adopts a single interpretation of the key statutory provisions under the Redwood amendment. This single interpretation is necessary to allow as little ambiguity as possible; to ensure consistency in decision making; and to show the courts that decisions made by the Park Service are logical and reasonable, and thoroughly thought through in accordance with the Organic

Act. Section 1.4 of the NPS management policies states that the no-impairment term of the Organic Act and the no-derogation term of the Redwood amendment define a single standard for management of the national park system, and the terms can be used interchangeably (NPS 2001b).

The clause limiting the exceptions to those “directly and specifically provided for by Congress” has been the subject of much debate as to whether it is to be interpreted broadly to cover all kinds of activities generally authorized by Congress or limited to only those cases where Congress has expressly permitted the threatening activity. Several legal scholars and commenters contend that it is to be construed narrowly to apply only to those situations where Congress has explicitly authorized a threatening activity (Mantell and Metzger 1990). Court decisions have not addressed this issue directly (Mantell and Metzger 2002).

1.3.2 NPS Management Policies

NPS management policies (NPS 2001b) are the basic Service-wide policies of the Park Service. These policies are important factors considered in the effects determinations presented in chapter 4 of this EIS. Adherence to policy is mandatory unless specifically waived or modified by the secretary of the interior, the assistant secretary of the interior, or the NPS director. Policies are defined for the following categories and are available on the NPS website at www.nps.gov/refdesk/mp/:

- land protection.
- natural resource management.
- cultural resource management.
- wilderness preservation and management.
- interpretation and education.
- use of the parks.
- park facilities.
- commercial visitor services.

With regard to NPS management policies, one of the most important factors in preparing an effects analysis in an EIS is the determination of whether an action would result in “impairment” to the park’s resources. Impairment, as it applies to the lands managed by the Park Service, is derived from the text of the Organic Act’s mandate to leave resources “unimpaired for the enjoyment of future generations.” Impairment is defined as an effect that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values. The Park Service can allow certain effects within parks, but not to the extent that would leave resources impaired for future generations (unless Congress explicitly provides for the impairing activity).

NPS policies (NPS 2001b) provide the following guidelines for determining what constitutes impairment:

> *The fact that a park use may have an impact does not necessarily mean it will impair park resources or values for the enjoyment of future generations. Impacts may affect park resources or values and still be within the limits of the discretionary authority conferred by the Organic Act. However, negative or adverse environmental impacts are never welcome in national parks, even when they fall far short of causing impairment. For this reason, the Service will not knowingly authorize a park use that would cause negative or adverse impacts unless it has been fully evaluated, appropriate public involvement has been obtained, and a compelling management need is present. In those situations, the Service will ensure that any negative or adverse impacts are the minimum necessary, unavoidable, cannot be further mitigated, and do not constitute impairment of park resources and values.*

According to NPS policy, an effect could constitute impairment to the extent that it affects a resource or value whose conservation:

- is necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park.
- is key to the natural or cultural integrity of the park or to opportunities for enjoyment of the park.
- is identified as a goal in the park’s general management plan (NPS 1984) or other relevant NPS planning documents.

Before approving a proposed action that could adversely affect park resources and values, an NPS decision maker must consider the effects of the proposed action and determine, in writing, that the activity will not lead to an impairment of park resources and values. If there would be an impairment, the action may not be approved without Congressional action. The determination of whether there would be an impairment is ultimately based on the Park Service decision maker’s professional judgment. The decision maker must consider any EA or EIS required by the National Environmental Policy Act, relevant scientific studies and other sources of information, and public comments.

This EIS includes an evaluation of the potential for each alternative to result in impairment. The Park Service will base its final decision regarding the proposed action’s potential to impair park resources on this evaluation.

An impairment evaluation is presented in “Chapter 4. Environmental Consequences” for each environmental topic contained within the physical and biological environment sections and for two topics within the human environment section — wilderness resources and cultural resources.

1.3.3 Pertinent NPS Director's Orders

Director's orders are part of the NPS Directives System, as are NPS management policies. Director's orders provide legal references, operating policies, standards, and procedures for particular aspects of park planning. Director's Order 12 (NPS 2001a) is most relevant because it provides the guidance necessary to prepare an NPS EIS in compliance with the National Environmental Policy Act.

Two other director's orders are particularly pertinent to vessel management in Glacier and Dundas Bays. "Director's Order 47, Sound Preservation and Noise Management" (NPS 2001c) is important because it provides guidance for regulating noise in the park. This director's order articulates NPS policies that require, to the fullest extent practicable, the protection, maintenance, or restoration of the natural soundscape resource in a condition unimpaired by inappropriate or excessive noise sources. "Director's Order 41, Wilderness Preservation and Management" (NPS 1999a) provides accountability, consistency, and continuity to the Park Service's wilderness management program, and otherwise guides Service-wide efforts in meeting the letter and spirit of the 1964 Wilderness Act. This director's order clarifies, where necessary, specific provisions of the Park Service's management policies (NPS 2001b), and establishes specific instructions and requirements concerning the management of all NPS wilderness areas.

1.3.4 Glacier Bay National Park and Preserve Enabling Legislation

Glacier Bay was designated as a national monument by presidential proclamation in 1925. The presidential proclamations of 1925 and 1939 that established and expanded Glacier Bay National Monument; the Alaska National Interest Lands Conservation Act (ANILCA) of 1980 redesignated the monument as a park and preserve and further expanded it; the NPS Organic Act of 1916, and amendments applicable to all national park areas; and the Omnibus Consolidated and Emergency Supplemental Appropriations Act of 1999 (Public Law 105-277), as amended, provide specific statutory requirements for management of the park and preserve. These mandates include:

- "conserv[ing] the scenery and the natural and historic objects and wildlife therein and . . . provid[ing] for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (NPS Organic Act).
- preserving and protecting the area's tidewater glaciers, vegetation, unique opportunities for scientific study of glaciers and related flora and fauna changes over time, and historic value associated with early explorers and scientists (proclamation).
- preserving lands and waters containing nationally significant natural, scenic, historic, archeological, geological, scientific, wilderness, cultural, recreational, and wildlife values (Alaska National Interest Lands Conservation Act).
- preserving the unrivaled scenic and geological values associated with natural landscapes (Alaska National Interest Lands Conservation Act).

- maintaining sound populations of, and habitat for, wildlife species of inestimable value to the citizens (Alaska National Interest Lands Conservation Act).
- preserving the natural, unaltered state of the coastal rain forest ecosystem (Alaska National Interest Lands Conservation Act).
- preserving wilderness resources and related recreational opportunities (Alaska National Interest Lands Conservation Act).
- maintaining opportunities for scientific research and undisturbed ecosystems (Alaska National Interest Lands Conservation Act).
- allowing the park to remain “[a] large sanctuary where fish and wildlife may roam free, developing their social structure and evolving over long periods of time as nearly as possible without the changes that extensive human activities would cause” (Alaska National Interest Lands Conservation Act).

1.3.5 Park Purposes

Based on the enabling legislation presented in subsection 1.3.4, the purpose of the park and preserve is to preserve its accessible tidewater glaciers, superlative scenic grandeur, historic value, unique opportunities for the study of glaciers and associated plant and animal community succession processes, fish and wildlife populations and their habitats, unaltered and undisturbed ecosystems and opportunities for scientific research, and wilderness resource values and related recreational opportunities. (NPS 2000a)

1.3.6 International Biosphere Reserve and World Heritage Site Designations

In 1986, the park and preserve was designated as an International Biosphere Reserve by the United Nations Educational, Scientific, and Cultural Organization under its Man and the Biosphere Program. Biosphere reserves are protected areas that are internationally recognized. They are established to conserve species and natural communities and to discover ways to use environments without degrading them. The program emphasizes research, resource monitoring, and education.

In December 1992, the United Nations Educational, Scientific, and Cultural Organization also designated the park as a World Heritage Site, a natural site of outstanding universal value to mankind. World Heritage Site designation recognizes the world’s most significant natural and cultural areas. The park and preserve is a part of the Kluane/Wrangell-St. Elias/Glacier Bay/Tatshenshini-Alsek World Heritage Site.

1.3.7 Park Management

Title 36 CFR 13.65, (see appendix A) and the *Glacier Bay National Park and Preserve 2002 Compendium* (NPS 2002as; see appendix B) stipulate park rules and regulations, including current vessel quotas and operating requirements (as amended by Congress). The park compendium outlines many NPS regulations that provide the superintendent with discretionary authority to make designations or impose public use restrictions or conditions. The regulations in 36 CFR 13.65, and the park compendium encompass all aspects of park management. The compendium is reviewed and revised annually.

1.3.8 Omnibus Consolidated and Emergency Supplemental Appropriations Act, 1999 (Public Law 105-277, 1998)

This act, passed in October 1998 and amended in May 1999, specifically addressed commercial fishing activities in the marine waters of the park. This legislation restated closure of wilderness waters to commercial fishing, closed additional non-wilderness areas within Glacier Bay to commercial fishing, and required a phase-out (in progress) of all commercial fishing within Glacier Bay. The law allows existing commercial fisheries to continue in the marine waters of the park outside Glacier Bay under a cooperative NPS/state fisheries management plan consistent with park purposes and values.

1.3.9 Pertinent Park Plans and Their Relationship to This Plan

General Management Plan. The park's and preserve's *General Management Plan* (NPS 1984) sets the overall direction for management of natural and cultural resources, visitor use, land protection, and facility development. The following general management plan objectives pertain to vessel quotas and operating requirements:

1. *Protection of park resources:* Allow ecological processes to continue unimpaired by visitor use. Protect marine and terrestrial wildlife and vegetation from adverse effects of visitor use. Identify marine areas that have special sensitivities for wildlife, solitude, or other values, and develop methods for protecting these special sensitivities.
2. *Provision for visitor use:* Continue recognition of Glacier Bay's waterways as primary access corridors to the area. Ensure visitors have a wide variety of quality and environmentally sound alternatives for experiencing the Glacier Bay story, employing a wide variety of vessel types. Establish vessel operating requirements and limits on the number of vessel entries necessary to protect park purposes and resources.

Wilderness Visitor Use Management Plan. In July 1989, the park adopted a *Wilderness Visitor Use Management Plan* (NPS 1989). The plan establishes wilderness visitor management zones and requirements for access, group size, length of use, and commercial activities. Recreational use associated with vessel traffic, such as tour vessel drop-off points for wilderness visitors, or numbers of commercial sea kayaking trips, is addressed in the plan. This plan was considered in the development of this EIS.

Backcountry Management Plan and Environmental Impact Statement. The Park Service initiated the park backcountry management planning process, which will include an EIS, in fall 2002. The EIS will present alternatives for managing the park's wilderness and backcountry and will address visitor use of wilderness and non-wilderness waters and land. It will consider use via non-motorized vessels, such as kayaks; some aspects of recreational boating; camper vessel drop-offs; and off-vessel activities. The planning process and the EIS will result in a record of decision (ROD) that will direct the course of backcountry management of the park.

Commercial Fishing Compensation Program. Commercial fishing is being phased out of Glacier Bay, but will continue until all the current permit holders cease to fish.

1.3.10 Environmental Regulatory Requirements

In addition to NPS mandates, policies, and plans, the Park Service also must evaluate its proposed action against several federal laws intended to protect the environment. These laws are described in "Chapter 4. Environmental Consequences."

1.4 THE NEPA PROCESS

1.4.1 Scoping

The NEPA is the basic national charter for protection of the environment. NEPA procedures ensure that relevant environmental information is available to government officials and the public before decisions are made and before actions are taken. To achieve these objectives, the NEPA process for "major federal actions" includes scoping, preparation of draft and final EISs, and development of a record of decision. These elements of the NEPA process for the Glacier Bay proposed action are described in detail below.

The Council on Environmental Quality defines scoping as "an early and open process for determining the scope of issues to be addressed in an EIS and for identifying the significant issues related to the proposed action" (40 CFR 1501.7). The intent of scoping is to avoid overlooking important issues that should be analyzed and to de-emphasize less important issues. Comments from any interested persons; affected federal, state, and local government agencies; any affected Native groups; and private industry are invited.

The scoping period began on February 22, 2002, with publication of the notice of intent (NOI) to prepare an EIS. The notice of intent is published in the *Federal Register* and invites industry, government agencies, environmental groups, and the general public to comment on areas of interest or concerns related to the action being proposed. The notice of intent announces the scoping process followed for the EIS. The notice requested that all comments be received by the Park Service by June 7, 2002. During the scoping period, the Park Service published a brochure inviting the public to participate in the scoping process and providing basic information about the NEPA process, the actions and alternatives under consideration, and how the public could participate in the process. The brochure included a comment form, and the Park Service provided electronic versions of both on the park website.

The Park Service hosted public meetings from May 20 through May 30, 2002, in the Alaska communities of Hoonah, Gustavus, Pelican, Elfin Cove, Anchorage, and Juneau, as well as in Seattle, Washington. Meeting participants could review displays, maps, and literature, and speak directly with members of the EIS project team. The team provided an overview of the project at each meeting, followed by an opportunity for the public to make comments and ask questions. The project team recorded the comments received at each meeting. Following the meetings, the Park Service mailed a brochure summarizing the comments received and the anticipated EIS schedule to the individuals who attended the public meetings and others known to be interested in the process.

The Park Service conducted internal scoping meetings at park headquarters on April 19 and May 9, 2002. In addition, the EIS project team met with representatives from the U.S. Geological Survey (USGS) and the USGS Alaska Science Center on May 9, 2002; with representatives from several Alaska state agencies on May 15 and May 28, 2002; and with a representative from the National Marine and Fisheries Service on May 29, 2002.

Based on the information gained through the scoping process — which included NPS staff evaluations and input — major issues, alternatives to the proposed action, and measures that could mitigate the effects of the proposed action were identified for analysis in this EIS. The issues are presented in section 1.5.

1.4.2 Draft Environmental Impact Statement

As required by section 102(2)(C) of the National Environmental Policy Act, an EIS is prepared for any major federal action significantly affecting the quality of the human environment. The draft EIS describes the proposal, the alternatives, and the potentially affected marine and onshore environments; presents an analysis of potential adverse effects on the environment; describes potential mitigating measures to reduce the adverse effects; and presents a record of consultation and coordination with others during EIS preparation.

The document is filed with the U.S. Environmental Protection Agency (EPA), and its availability is announced in the *Federal Register*. Preparation of this draft EIS began in June 2002, the notice of availability for the draft EIS was published in March 2003, and public hearings will be conducted in April 2003. Comments on this draft EIS can be submitted to the Park Service during the public review period.

1.4.3 Final Environmental Impact Statement

Oral and written comments on the adequacy of the draft EIS will be obtained through the public review process and responded to in the final EIS. The final EIS will be filed with the U.S. Environmental Protection Agency and made available to the public. The availability of the final EIS will be announced in the *Federal Register*, and the notice of availability is expected in fall 2003.

1.4.4 Record of Decision

When an EIS is prepared, the ultimate choice of an alternative, mitigation measures, and the decision rationale are documented in the record of decision. Publication of the record of decision will follow a 30-day no-action period after release of the final EIS.

1.5 ISSUES OF CONCERN RAISED DURING SCOPING

1.5.1 Summary of Issues and Topics Evaluated in This Environmental Impact Statement

Issues and impact topics identified during the scoping process form the basis for environmental analysis in this document. A brief description is provided for each issue and impact topic. Issues and topics considered, but not addressed in this document, also are identified. “Chapter 5. Consultation and Coordination” provides more details regarding NPS and public scoping meetings and consultation with other federal and state agencies. The issues of concern raised during scoping regarding topics to be addressed in this EIS include the following:

Soundscape.

- Vessel noise could unacceptably alter the natural soundscape of the park.

Air Quality.

- Increases in vessel quotas could increase the particulate and pollutant load entering the air column and have a detrimental effect on air quality by increasing, thus changing the air quality, visibility, and the presence of haze.
- Increases in vessel quotas could increase the stack emissions and could result in detrimental effects to human health and the environment.

Water Quality.

- Increases in vessel quotas increase the potential for unauthorized releases of marine debris, petroleum, graywater, sewage, oil, ballast, photographic chemicals, dry cleaning solutions, and cleaning solvents. The unauthorized release of marine debris and other contaminants may degrade water quality.
- Increasing the vessel quota increases the potential of small and large oil spills. Current technology is inadequate to clean up oil spills in ice-filled waters.
- Vessels other than large cruise ships may not have the capacity to hold and treat waste. Possible increases in these types of vessels in park waters could result in increased discharges of waste, resulting in degradation of the marine environment.
- The park's zero discharge policy for cruise ships means that they are dumping waste outside the park, resulting in possibly more degradation of the marine environment than otherwise might occur.

Threatened and Endangered Species.

- The sight and noise of vessel traffic alter marine mammal behavior; therefore, any increase in the number of vessels would further disrupt marine mammal behavior.
- Vessel wakes could cause onshore waves that startle sleeping humpback whales.
- Varying vessel speeds need to be evaluated to determine the appropriate speed to protect whales and minimize the effects on threatened and endangered species.
- Increases in vessel traffic could result in increased whale/vessel collisions, and whale mortality or injury could result from such collisions.
- Humpback whales feeding in Bartlett Cove could be disrupted by vessels operating in this area. Vessel requirements should be evaluated to determine if they are effective in protecting whales.

Marine Mammals.

- The sight and noise of vessel traffic alter marine mammal behavior; therefore, any increase in the number of vessels would further disrupt their behavior.
- Varying vessel speeds need to be evaluated to determine the appropriate speed to protect and minimize the effects on whales in non-whale waters.
- Increases in vessel traffic could result in increased whale/vessel collisions, and whale mortality or injury could result from such collisions.
- Whales feeding in Bartlett Cove could be disrupted by vessels operating in this area. Vessel operating requirements should be evaluated to determine if they are effective in protecting whales.

Marine Birds and Raptors.

- The presence of vessels in the marine environment can alter marine bird behavior. Harlequin ducks in Dundas Bay could be disturbed by vessel traffic.
- Waves from vessel wakes could swamp marine bird nests that are in low-lying areas, thus reducing reproductive success and altering marine bird feeding behavior.
- Private and charter vessels that offload visitors onshore could disturb bird colonies, specifically at McBride Glacier, as well as nesting arctic terns and mew gulls in other breeding locations, thus reducing reproductive success.

Marine Fishes.

- Airborne contaminants from ship stacks could be deposited in the marine environment and enter the marine food chains, causing fish mortality through ingestion or dermal contact.
- The presence of artificial light from vessels could alter behavior of marine fish.
- Waves generated by wakes and prop wash could increase turbidity and degrade fish habitat.
- Invasive species on hulls of ships or in unauthorized releases of ballast water could be introduced into the marine environment of the park and could displace native marine fishes.

Coastal/Shoreline Environment and Biological Communities.

- Vessel wakes could erode portions of the shoreline.
- Traffic at popular drop-off locations could be changed, resulting in increased physical disturbances and disturbance of intertidal communities.
- Waves could alter the behavior of terrestrial mammals that feed, roam, or sleep on the shoreline.
- Invasive species on hulls of ships or in unauthorized releases of ballast water could be introduced into the marine environment of the park which could displace native species and alter ecological functioning.

Cultural Resources.

- Air and water pollution could defile elements of Glacier Bay sacred to the Huna-Tlingit, including the glaciers, mountain goats, and harbor seals.
- Waves generated from vessels could erode portions of the shoreline, thus changing the geological composition of the shoreline, and possibly exposing anthropological and archeological resources present in interstadial geologic layers, including preglacial forests.
- Increase in traffic at popular drop-off locations could increase physical disturbances and potential vandalism of anthropological resources.

Visitor Experience.

- The presence of large cruise ships could diminish the experience of visitors from smaller vessels because of the visual effects and loss of wilderness experience.
- Vessel noise could intrude on visitor solitude in Glacier Bay.
- The presence of vessels may provide a backcountry user with a greater sense of security knowing that help is nearby if an emergency occurs.
- The presence of vessels may scare wildlife and thereby diminish the experience of visitors expecting to see wildlife.

Vessel Use and Safety.

- Increasing vessels or vessel speed could increase the risk of vessel-vessel and vesselmarine mammal collisions.
- A 10-knot vessel speed restriction could decrease the maneuverability of large vessels, causing an increased risk to the ship and to visitor safety.
- Smaller vessels are more maneuverable than larger vessels and should be allowed to travel at faster speeds because they could avoid most potential hazards.
- Waves generated from larger vessels could swamp kayaks or small vessels on the water and cause serious injury to the occupants.
- Increasing the user-friendliness of the operating requirements could increase the possibility that vessel operators would adhere to the rules and decrease the possibility of accidents and/or violations of regulations.
- Cruise and tour vessels should have strict protocols and routes to minimize the risk of vessel groundings that could cause resource damage or risks to visitor safety.

Wilderness Resources.

- An increase in vessel quotas could allow more people to experience a wilderness area intimately. In addition, wilderness would be more accessible.
- An increase in vessel quotas could diminish the value of wilderness by increasing the sense of crowdedness.
- The presence of large vessels could diminish the wilderness values.
- Increases in off-vessel activity could result in more trash and degradation of the terrestrial environment.

Local and Regional Socioeconomics.

- Increasing the vessel quota for private and charter vessels and providing access to Dundas and Taylor Bays could improve local economies and lifestyles. Revenues generated from local wildlife viewing and sightseeing charter and tour vessels could replace loss of livelihood resulting from the Glacier Bay commercial fishing phase-out.
- Increasing the number of permits allocated to local owners and operators could benefit the local economy.
- Increasing the vessel quota for tour vessels could benefit the economy of local communities by providing additional entries to local operators. Increased restrictions on local resident access could have detrimental effects to local economies.
- Increasing the vessel quota for private, locally based vessels would benefit inn and lodge operators by increasing their access to Glacier and Dundas Bays for their guests.
- Some people perceive that tourism in Southeast Alaska is leveling out and fewer independent travelers are coming to the park. These conditions, if true, may alter demand and the type of visitor experience preferred.
- The number of charter vessel operators is increasing, which could result in increased demand for permits.

Cumulative Effects. The National Environmental Policy Act mandates that agencies consider all potential effects, including those considered cumulative, as defined in CEQ NEPA regulation 40 CFR 1508.7. A cumulative effect is the effect on the environment that results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions. Existing actions/projects and reasonably foreseeable actions that may contribute to cumulative effects are described in chapter 4.

1.5.2 Issues Considered but Eliminated from Detailed Analysis in This Environmental Impact Statement

The scope of this EIS is necessarily focused on recreational motorized vessel use. Comments related to management of the following resources and topics are considered outside the scope of this document:

- Land-based activities.
- Allocation of cruise, tour, or charter vessel permits. This will be addressed in accordance with NPS regulations and policy.
- Deep benthic environments in Glacier Bay and Dundas Bay. The deep benthic environments within this area are not likely to be affected by cruise ships or other vessel activities addressed in this EIS. These habitats occur well below the depth at which they might be affected by vessel wakes, oil spills, or other activities related to vessel traffic. While vessel noise likely would reach these habitats, most deep benthic animals have no known sensory apparatus for hearing. Additionally, attenuation of the vessel noise with depth is likely to decrease noise levels to below the level at which crabs or other deep benthic animals are affected.
- Restrictions to or providing access into the backcountry (i.e., off-vessel areas). The park's backcountry management plan will address where vessels may land and where they may offload passengers. The backcountry management planning process is underway, and an EIS is being prepared.
- Kayak quotas and operating requirements. This EIS addresses only motorized vessels. Kayak quotas and operating requirements will be addressed in the park's backcountry management plan, which should be underway before or when this EIS is completed.
- Commercial fishing. Issues concerning commercial fishing are addressed in the commercial fishing compensation plan and the commercial fishing EA (NPS 1998). Vessel use associated with commercial fishing is evaluated in the cumulative effects section of this document.
- Administrative vessel use. This EIS addresses recreational vessel use. Administrative vessel use is solely at the discretion of the superintendent, as necessary, to ensure visitor safety; respond to emergency situations; and otherwise implement the park's mission, purposes, and values.

1.6 FEDERAL PERMITS, LICENSES, AND ENTITLEMENT NECESSARY TO IMPLEMENT THE ACTION

No permits are required for the Park Service preferred alternative (alternative 3). Implementation of a vessel quota and operating requirement alternative would require the Park Service to promulgate regulations, revising 36 CFR 13.65.

ALTERNATIVES

GLACIER BAY

NATIONAL PARK AND PRESERVE, ALASKA

VESSEL QUOTAS AND OPERATING REQUIREMENTS • DRAFT ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 2. ALTERNATIVES

2.1 INTRODUCTION

This chapter identifies, describes, and compares five alternatives for achieving the purpose and need for the action described in chapter 1.

These alternatives are the result of discussions with representatives of federal, state, and local agencies; the Hoonah Indian Association, which is the federally-recognized tribal government; interested civic groups; businesses; and the public, as well as discussions among NPS staff.

2.1.1 Terminology and Definitions

Table 2-1 provides a comparison of the terms and definitions used in the alternatives discussion in this environmental impact statement.

2.2 VESSEL QUOTAS AND OPERATING REQUIREMENTS COMMON TO ALL ALTERNATIVES

Because this environmental impact statement is responding to a very narrow set of needs related specifically to managing commercial and private motorized vessels used for visitor recreational purposes (i.e., cruise ships, tour vessels, charter vessels, and private vessels), the alternatives considered have many elements in common. Subsections 2.2.1 and 2.2.2 describe the vessel quotas and operating requirements, respectively, that would remain the same regardless of which alternative is selected.

2.2.1 Vessel Quotas

All alternatives:

- use permits to regulate vessel numbers in Glacier Bay.
- require private vessel operators entering Bartlett Cove to contact park headquarters to obtain an entry permit and receive orientation to the park.
- set quotas (limits) for motorized vessel use of Glacier Bay for cruise ships, and tour, charter, and private vessels.
- allow a maximum of two cruise ships to enter Glacier Bay per day year-round.
- allow for one entry to Bartlett Cove for the ferry service from Juneau — with the sole purpose of accessing park and other authorized visitor services or facilities at, or originating from, the public dock area at Bartlett Cove.

TABLE 2-1: COMPARISON OF DEFINITIONS FOR ALTERNATIVES 1 THROUGH 5

	Alternatives 1-3	**Alternative 4**	**Alternative 5**
Term	**Current regulations apply, and current regulatory language is shown below.**	**Adjustments to the current regulations are shown below; other definitions in the current regulations would continue to apply.**	**Adjustments to the current regulations are shown below; other definitions in the current regulations would continue to apply.**
Charter Vessel	Any motor vessel under 100 tons gross (U.S. System) or 2,000 tons gross (International Convention System) that is rated to carry up to 49 passengers, and is available for hire on an unscheduled basis, except a charter vessel used to provide a scheduled camper or kayak drop-off service.	Any motor vessel of less than 100 tons gross (U.S. Simplified Measurement System) or 2,000 tons gross (International Convention System) engaged in transport of passengers for hire and rated to carry up to 12 passengers overnight or up to 49 passengers for daytime use, except when operating as an administrative vessel. Charter vessels also include any uninspected vessel of less than 200 tons gross (U.S. Simplified Measurement System) and not more than 24 meters (79 feet) in length engaged in transport of passengers for hire, except when operating as an administrative vessel. (Note: uninspected vessels may not carry more than 12 passengers.)	Same as alternative 4.
Cruise Ship	Any motor vessel at or more than 100 tons gross (U.S. System) or 2,000 tons gross (International Convention System) carrying passengers for hire.	Any motor vessel of at least 100 tons gross (U.S. Simplified Measurement System) or 2,000 tons gross (International Convention System) carrying more than 12 passengers for hire, except when operating as an administrative vessel (administrative vessels are those engaged in official government business, including research).	Same as alternative 4.

TABLE 2-1: COMPARISON OF DEFINITIONS FOR ALTERNATIVES 1 THROUGH 5

Term	Alternatives 1-3 Current regulations apply, and current regulatory language is shown below.	Alternative 4 Adjustments to the current regulations are shown below; other definitions in the current regulations would continue to apply.	Alternative 5 Adjustments to the current regulations are shown below; other definitions in the current regulations would continue to apply.
Entry	Each time a motor vessel passes the mouth of Glacier Bay into the Bay; each time a private vessel activates or extends a permit; each time a motor vessel based at or launched from Bartlett Cove leaves the dock area on the way into Glacier Bay, except a private vessel based at Bartlett Cove that is gaining access or egress to or from outside Glacier Bay; the first time a local private vessel uses a day of the seven-use day permit; or each time a motor vessel singularly launched from a permitted motor vessel and operated only while the permitted vessel remains at anchor, or a motor vessel launched and operated from a permitted motor vessel while that vessel is not under way and in accordance with a concession agreement.	NA	NA
Private Vessel	Any motor vessel used for recreation that is not engaged in commercial transport of passengers, commercial fishing, or official government business.	Same as alternatives 1, 2, and 3.	Same as alternatives 1, 2, and 3.
Speed through the Water	The speed at which a vessel moves through the water (which itself may be moving), as distinguished from "speed over the ground."	Same as alternatives 1, 2, and 3.	NA
Speed Over the Ground	NA[a]	NA	Speed measured in relation to a fixed point on the earth.
Tour Vessel	Any motor vessel under 100 tons gross (U.S. System) or 2,000 tons gross (International Convention System) that is rated to carry more than 49 passengers, or any smaller vessel that conducts tours or provides transportation at regularly scheduled ties along a regularly scheduled route.	Any motor vessel of less than 100 tons gross (U.S. Simplified Measurement System) or 2,000 tons gross (International Convention System) engaged in transport of passengers for hire and rated to carry more than 12 passengers overnight or greater than 49 passengers for daytime use, except when operating as an administrative vessel.	Same as alternative 4.

TABLE 2-1: COMPARISON OF DEFINITIONS FOR ALTERNATIVES 1 THROUGH 5

Term	Alternatives 1-3 Current regulations apply, and current regulatory language is shown below.	Alternative 4 Adjustments to the current regulations are shown below; other definitions in the current regulations would continue to apply.	Alternative 5 Adjustments to the current regulations are shown below; other definitions in the current regulations would continue to apply.
Vessel-Use Day	Any continuous period of time in which a motor vessel is in Glacier Bay from 12 midnight on one day to 12 midnight the next day.	When a motor vessel is in Glacier Bay or Dundas Bay operating under its permit for that calendar day.	Same as alternative 4.
Seasonal-Use Days	Not defined in current regulations, but presumed to be the number of vessel-use days allowed during a specific seasonal period.	Same as alternatives 1, 2, and 3.	Same as alternatives 1, 2, and 3.
Daily Vessel Quota	Not defined in current regulations, but presumed to be the number of vessel-use days allowed in an area on any one calendar day.	Same as alternatives 1, 2, and 3.	Same as alternatives 1, 2, and 3.
Administrative Use	Not specifically defined in the current regulations, but presumed to be a motor vessel engaged in official business for the state or federal government. See 13.65(b)(2)(iii). Exceptions from entry permit requirement.	Any motor vessel engaged in official government business.	Same as alternative 4.
Administrative Vessel	Not defined in the current regulations, but presumed to be any vessel involved in administrative use (as with alternatives 4 and 5).	Any vessel involved in administrative use.	Same as alternative 4.
Whale Waters	Any portion of Glacier Bay, designated by the superintendent, having a high probability of whale occupancy, based upon recent sighting or past patterns of occurrence.	Same as alternatives 1, 2, and 3.	Same as alternatives 1, 2, and 3.

TABLE 2-1: COMPARISON OF DEFINITIONS FOR ALTERNATIVES 1 THROUGH 5

Term	Alternatives 1-3	Alternative 4	Alternative 5
	Current regulations apply, and current regulatory language is shown below.	**Adjustments to the current regulations are shown below; other definitions in the current regulations would continue to apply.**	**Adjustments to the current regulations are shown below; other definitions in the current regulations would continue to apply.**
Short-Notice Private Vessel Permits	NA	Permits available to private vessels on short notice. Private vessel operators could obtain one of these permits by making a reservation within 48 hours of when they desire to enter Glacier Bay.	Same as alternative 4.
Bartlett Cove Passenger Ferry[b]	Any motor vessel engaged in the transport of passengers for hire, with sole purpose of accessing park or other authorized visitor services or facilities at, or originating from, the public dock area at Bartlett Cove, as provided in Public Law 105-83, Title I, section 127.	Any motor vessel of less than 100 tons gross (U.S. Simplified System) or 2,000 tons gross (International Convention System) engaged in the transport of passengers for hire, with sole purpose of accessing park or other authorized visitor services or facilities at, or originating from, the public dock area at Bartlett Cove.	Same as alternatives 1, 2, and 3.

a. The term "speed over ground" is referenced in the current regulations, but no definition is provided. It is presumed to be speed measured in relation to a fixed point on the earth.

b. See Title I, section 127, of the Department of the Interior and Related Agencies Appropriations Act of 1998 (Public Law 105-83), which authorizes one entry per day for a passenger ferry into Bartlett Cove from Juneau.

NA = Not applicable.
CFR = Code of Federal Regulations.

In addition, under all alternatives, no permit is required by the following types of vessels for entry into Glacier Bay:

- administrative vessels, vessels operated by the Hoonah Indian Association (i.e. Hoonah tribal members operating under a tribal permit), and research vessels (however, research vessels must obtain a research permit).
- vessels granted safe harbor in Bartlett Cove by the superintendent based on hazardous conditions, such as weather or mechanical problems.
- skiffs launched from a permitted motor vessel and operated while the permitted vessel remains at anchor (and skiffs launched to take photographs for marketing materials in accordance with a valid concessions or commercial use permit).
- commercial fishing vessels otherwise permitted and engaged in commercial fishing.

2.2.2 Operating Requirements

In areas designated as "special-use areas," operating requirements are set to protect resources. Under all alternatives, special-use area designations would remain the same for seabird nesting colonies, island protection regulations, harbor seal and sea lion haul-outs and lower Glacier Bay whale waters. Special-use areas identified in the park and preserve:

- East Arm and West Arm of Glacier Bay.
- areas with wildlife and other sensitive resources.
- Bartlett Cove.
- outer coast waters.
- wilderness waters.

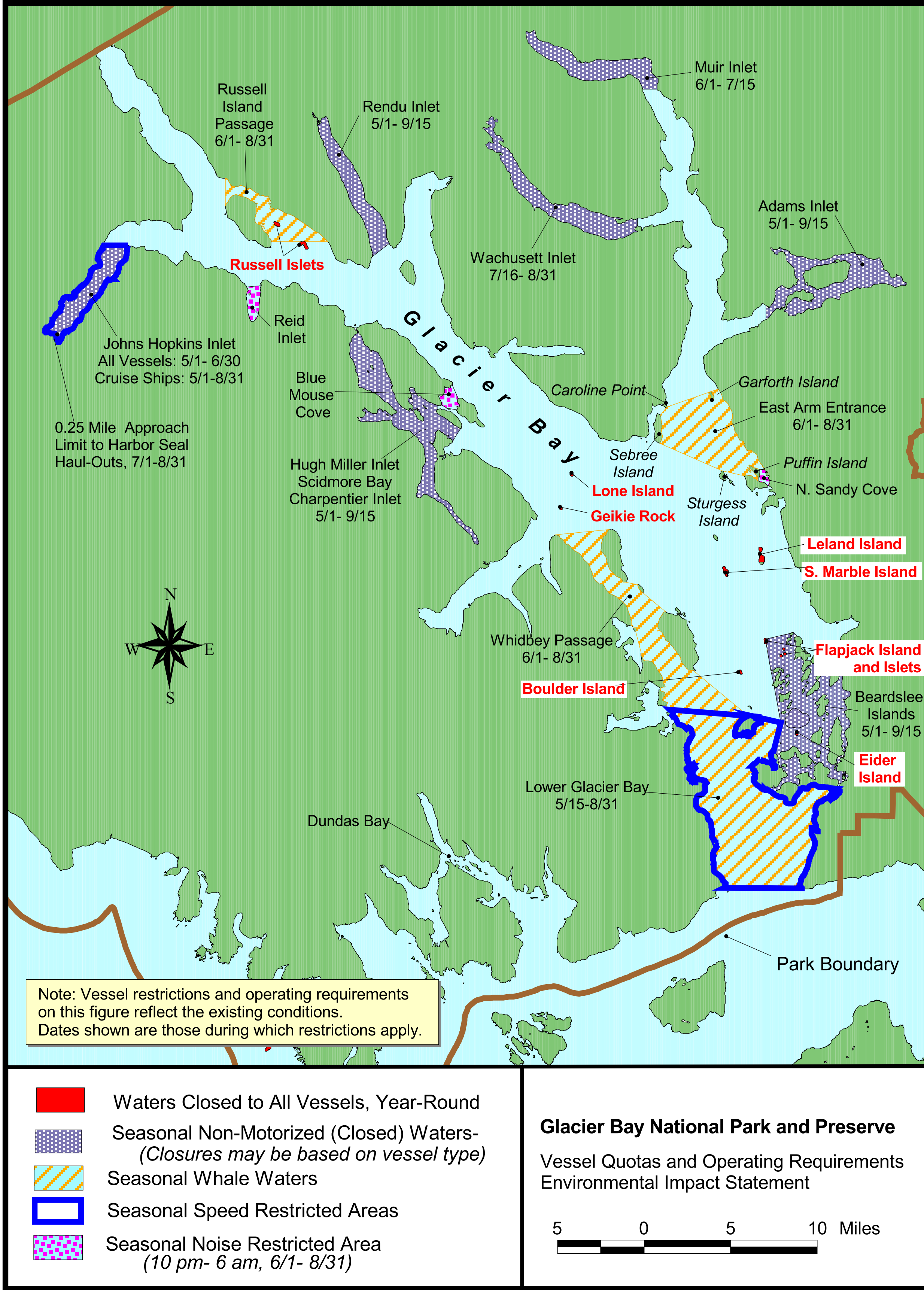
Non-motorized water designations and seasons for closed waters also would remain unchanged for alternatives 1, 2, and 3 (see figure 2-1 and table 2-13). Additional closed waters would be defined for alternatives 4 and 5. In addition, with the exception of speed restrictions, vessel operating restrictions in whale waters would remain the same among alternatives (although the actual waters designated as whale waters would not). Restrictions include the following:

- In designated areas, all motor vessels more than 18 feet long will navigate a mid-channel course and, where possible, maintain a distance of at least 1 mile from the shoreline while in transit through whale waters.
- All vessels are prohibited from operating within 0.25 nautical mile of a humpback whale or pursuing or attempting to pursue humpback whales within 0.5 nautical mile in marine waters within the boundary of the park and preserve.

VESSEL RESTRICTIONS AND OPERATING REQUIREMENTS UNDER ALTERNATIVES 1, 2 & 3

Figure 2-1

National Park Service
U.S. Department of the Interior



2.3 ALTERNATIVE 1: NO ACTION

Alternative 1 is the no-action alternative or the status quo. Vessel quotas and operating requirements considered under this alternative pertain to Glacier Bay. Vessel classes would continue to be defined under the existing regulations. The current quotas, quota season, and operating requirements for cruise ships and tour, charter, and private vessels would remain in effect under this alternative. The current vessel quotas were approved by Congress (Public Law 107-63) in November 2001 and are based on the "modified alternative 5" of the NPS 1996 *Vessel Management Plan and Environmental Assessment* finding of no significant impact (NPS 1996).

2.3.1 Alternative 1 — Vessel Quotas

This alternative would maintain existing visitor-use opportunities in Glacier Bay by continuing the vessel quotas for cruise ships, and tour, charter, and private vessels, authorized by Congress in 2001. Table 2-2 lists the quotas for each vessel class. The current quota season of June 1 through August 31 would remain in effect.

TABLE 2-2: SUMMARY OF VESSEL QUOTAS FOR GLACIER BAY UNDER ALTERNATIVE 1, JUNE 1–AUGUST 31

Vessel Class	Daily Entries	Seasonal Entries	Seasonal-Use Days
Cruise ship [a]	2	139	139
Tour vessel [a]	3	276	276
Charter vessel	6	312	552
Private vessel	25	468	1,971

[a] Cruise ships and tour vessels are limited to a maximum of two per day and three per day, respectively, year round.
See table 2-1 for an explanation of terms.

As indicated in the table above, a maximum of two cruise ships per day would be allowed entry to Glacier Bay; however, the seasonal limit of 139 cruise ship entries would ensure that some days during the season would have fewer than two cruise ship entries. Current exceptions would be maintained, including the exception of private vessels based at Bartlett Cove that are transiting between Bartlett Cove and waters outside Glacier Bay, or a private vessel that is operating in Bartlett Cove in waters bounded by the public and administrative docks. These vessels would require a permit to travel north of Bartlett Cove.

2.3.2 Alternative 1 — Vessel Operating Requirements

Under alternative 1, vessel operating requirements would follow the existing regulations (see appendix A) and the park compendium (see appendix B). The park compendium is a written compilation of designations, closures, permit requirements, and other restrictions imposed by the superintendent under the discretionary authority found in the Code of Federal Regulations.

Vessel Speed. Under alternative 1, vessels would continue to be required to operate at speeds of 20 knots or less and remain mid-channel in designated whale waters. (The superintendent may designate a 10-knot limit in any area because of whale concentrations.) Vessel speed is measured as “through the water” speed, or the speed at which a vessel moves through the water (which itself may be moving), as distinguished from “speed over the ground.” Under alternative 1, vessel speed limits in designated whale waters would be in effect from May 15 through August 31.

Whale Waters. Whale waters are any portion of Glacier Bay designated by the superintendent as having a high probability of whale occupancy, based upon recent sightings or past patterns of occurrence. From May 15 through August 31, the lower Bay, defined in 36 CFR 13.65 (see appendix A) and shown in figure 2-1, would be designated whale waters. From June 1 through August 31, Whidbey Passage, East Arm entrance waters, and Russell Island Passage waters also would be designated whale waters (see appendix A and figure 2-1).

Vessel Routes and Destinations (Including Non-Motorized Waters). Under alternative 1, vessel routes are not defined although cruise ships generally follow the mid-channel of Glacier Bay. Closed waters are identified in figure 2-1 and defined in 36 CFR 13.65 (see appendix A). Many of the waters around rocks and islands are closed for protection of sensitive wildlife species. In addition, for the protection of harbor seals, Johns Hopkins Inlet is closed to cruise ships from May 1 through August 31 and to all vessels from May 1 through June 30. From July 1 through August 31, in Johns Hopkins Inlet, all vessels are required to stay 0.25 nautical mile from seals hauled out on ice.

The areas closed from May 1 through September 15 to provide non-motorized backcountry experiences include Adams Inlet, Rendu Inlet, the Hugh Miller complex, and the Beardslee Island group. Additional closures include Muir Inlet, beginning north of McBride Glacier (June 1 through July 15) and Wachusett Inlet (July 16 through August 31; see figure 2-1). These areas also are defined in appendix A.

2.4 ALTERNATIVE 2

Under alternative 2, vessel quotas would be set to those authorized in 1985 and in effect in 1996. Vessel classes would continue to be defined under the existing regulations as shown in table 2-1. Vessel operating requirements and the quota season would remain the same as those under the no-action alternative. Vessel quotas and operating requirements considered under this alternative pertain to Glacier Bay.

2.4.1 Alternative 2 — Vessel Quotas

Vessel quotas would be in effect in Glacier Bay from June 1 through August 31 (see table 2-3). Current exceptions would be maintained, including the exception of private vessels based at Bartlett Cove that are transiting between Bartlett Cove and waters outside Glacier Bay, or private vessels in Bartlett Cove that are operating in waters bounded by the public and administrative docks. As is currently the case, these vessels would require a permit to travel north of Bartlett Cove.

TABLE 2-3: SUMMARY OF VESSEL QUOTAS FOR GLACIER BAY UNDER ALTERNATIVE 2, JUNE 1–AUGUST 31

Vessel Class	Daily Entries	Seasonal Entries	Seasonal-Use Days
Cruise ship[a]	2	107	107
Tour vessel[a]	3	276	276
Charter vessel	6	271	511
Private vessel	25	407	1,714

a. Cruise ships and tour vessels are limited to a maximum of two per day and three per day, respectively, year round.
See table 2-1 for an explanation of terms.

2.4.2 Alternative 2 — Vessel Operating Requirements

As with alternative 1, vessel operating requirements would follow the existing regulations (see appendix A) and the park compendium (see appendix B). See the description of operating requirements under alternative 1.

2.5 ALTERNATIVE 3: NPS PREFERRED ALTERNATIVE

Alternative 3 represents the vessel management plan completed in 1996. Vessel quotas and operating requirements considered under this alternative pertain to Glacier Bay. Alternative 3 would continue the current vessel quotas, but would provide for potential future increases in cruise ships up to 184. The increases would allow up to two cruise ships per day, every day. The current quota season and operating requirements would be maintained. As with alternatives 1 and 2, the time period when seasonal-use days are defined would be from June 1 through August 31. Vessel classes would continue to be defined under the existing regulations (see table 2-1).

Tour, charter, and private vessel quotas would remain the same as currently allowed. Any increase in cruise ship numbers would be contingent upon the completion of studies that demonstrate the increases would be compatible with the protection of park resources and values. Since 1996, the Park Service has conducted research to determine whether increases are warranted, and each year, the superintendent reviews the research results. To date, the research has not clearly demonstrated that further increases are warranted. Research would continue, with emphasis on air quality, humpback whales, nesting birds, and visitor experience.

2.5.1 Alternative 3 — Vessel Quotas

This alternative would optimize visitor-use opportunities via cruise ship in Glacier Bay by potentially increasing cruise ship seasonal-entry quotas and seasonal-use days (see table 2-4). This alternative is identical to alternative 1, except that the cruise ship seasonal-entry quota could increase from 139 entries per season to 184 entries per season, contingent upon the results of studies demonstrating that an increase in cruise ship traffic would be consistent with protection of the values and purposes of the park. The Park Service has developed comprehensive research and monitoring programs to satisfy informational needs and to quantify environmental effects to determine whether increased quotas for cruise ships are compatible with protection of park resources and values. If the cruise ship vessel quota were increased to 184, two cruise ships would be permitted to enter Glacier Bay every day from June 1 to August 31.

Current exceptions would be maintained, including the exception of administrative traffic and private vessels based at Bartlett Cove. As is currently the case, no permit would be required for private vessels based at Bartlett Cove transiting between Bartlett Cove and waters outside Glacier Bay, or private vessels that are operating in Bartlett Cove in waters bounded by the public and administrative docks.

TABLE 2-4: SUMMARY OF VESSEL QUOTAS FOR GLACIER BAY UNDER ALTERNATIVE 3, JUNE 1–AUGUST 31

Vessel Class	Daily Entries	Seasonal Entries	Seasonal-Use Days
Cruise ship[a]	2	139 (potentially up to 184)	139 (potentially up to 184)
Tour vessel[a]	3	276	276
Charter vessel	6	312	552
Private vessel	25	468	1,971

a. Cruise ships and tour vessels are limited to a maximum of two per day and three per day, respectively, year round.
See table 2-1 for an explanation of terms.

2.5.2 Alternative 3 — Vessel Operating Requirements

As with alternatives 1 and 2, vessel operating requirements would follow the existing regulations (see appendix A) and the park compendium (see appendix B). See the description of operating requirements under alternative 1.

2.6 ALTERNATIVE 4: ENVIRONMENTALLY PREFERRED ALTERNATIVE

Alternative 4 would allow the lowest level of entries across all vessel classes, except private vessels. Alternative 4 would maintain the current daily quotas for cruise ships and reduce slightly the daily quotas for the other three vessel classes. It would reduce seasonal use days for cruise ships, tour vessels, and charter vessels would increase slightly the number of seasonal use days for private vessels for Glacier Bay. The quota season would be lengthened to include May and September for all vessel classes. Seasonal entry quotas would be eliminated. Vessel quotas would be initiated for charter vessels in Dundas Bay. Operating requirements would be modified, including limited closures of certain waters to cruise ships and tour vessels and decrease vessel speed for large vessels.

2.6.1 Alternative 4 — Vessel Quotas

Glacier Bay. Under alternative 4, cruise ship quotas would be set at two per day year round; however, because the season use days would be 92 (June through August) and 61 (May and September) cruise ships would average one per day; on some days there could be none. The daily quota for tour vessels would be two, with seasonal limits of 184 (June through August) and 122 (May and September). The daily quota of charter vessels in Glacier Bay would be set at five, with seasonal use days set at 460 (June through August) and 305 (May and September). Daily quotas for private vessels would be 22. Seasonal use days for private vessels would be 2,024, which is an additional 53 use days, compared to the current situation. Seasonal use limits for private vessels for May and September would be 1,342.

Dundas Bay. Alternative 4 would formalize the current use pattern by prohibiting cruise ships in Dundas Bay. Tour vessels also would be prohibited in Dundas Bay. This alternative would establish a daily quota of three for charter vessels in Dundas Bay from May 1 through September 30. Daily vessel quotas would not be set for private vessels because private vessel use has not been an issue in Dundas Bay, nor does the park believe that it will become an issue over the life of this plan.

Season. Vessel quotas in Glacier Bay and Dundas Bay under alternative 4 would be in effect from May 1 through September 30.

With this alternative, seasonal entries would be eliminated. Currently, when a vessel leaves Glacier Bay, it is not permitted to return without obtaining a new permit. Under alternative 4, with the elimination of seasonal entries, a vessel could leave the Bay and enter again under one permit within a particular calendar day. Seasonal use days would be the product of the daily vessel quota time the number of days in the season (92 for June through August; 61 for May and September).

Tables 2-5 and 2-6 summarize vessel quotas for Glacier Bay and Dundas Bay, respectively, under alternative 4.

TABLE 2-5: SUMMARY OF VESSEL QUOTAS FOR GLACIER BAY UNDER ALTERNATIVE 4, MAY 1–SEPTEMBER 30

	Daily Vessel Quota		Seasonal Entries	Seasonal-Use Days	
Vessel Class	June–Aug	May and Sept	June–Sept	June–Aug	May and Sept
Cruise ship[a]	2	2	NA	92	61
Tour vessel[a]	2	2	NA	184	122
Charter vessel	5	5	NA	460	305
Private vessel	22	22	NA	2,024	1,342

a. Cruise ships and tour vessels are limited to the daily vessel quota year round.

NA = Not applicable.
See table 2-1 for explanation of terms.

TABLE 2-6: SUMMARY OF VESSEL QUOTAS FOR DUNDAS BAY UNDER ALTERNATIVE 4, MAY 1–SEPTEMBER 30

Vessel Class	Daily Vessel Quota	Seasonal Entries	Seasonal-Use Days
Cruise ship	Not permitted	NA	NA
Tour vessel	Not permitted	NA	NA
Charter vessel	3	NA	459
Private vessel	No limit	No limit	No limit

NA = Not applicable.
See table 2-1 for explanation of terms.

Permitting Procedures. Under alternative 4, current park regulations would be changed from “Each private motor vessel must have a permit” to “Permits shall be issued to a designated individual for a specific vessel over a specific period of time.” Permits would be issued to individuals rather than vessels because individuals are responsible for following park regulations.

Under current regulations, private vessels based in Bartlett Cove that enter and exit Glacier Bay do not count as a daily entry (note that traveling up-Bay from Bartlett Cove counts as an entry). The “based in Bartlett Cove” exemption would be eliminated under alternative 4. In its place, 10 private vessel permits (of the 22 daily permits allowed), called “short-term permits,” would be set aside for distribution on a short-notice basis (up to 48 hours). Any individual with a private vessel could obtain one of these permits by making a reservation within 48 hours of when they want to enter Glacier Bay.

2.6.2 Alternative 4 — Vessel Operating Requirements

Vessel Speed. Placing speed limits on vessels is one of the main methods the Park Service uses to reduce the risk of vessels colliding with marine life. Speed limits also reduce noise.

Vessel speed regulations would change in two fundamental ways under alternative 4. First, vessel speed limits would be based on vessel length; a year-round speed limit of 13 knots through the water would be placed on all vessels greater than or equal to 262 feet (80 meters) to reduce risks of vessel collisions with whales. Second, the timeframe for speed limits in whale waters (lower Glacier Bay only) would be extended to May 1 through September 30 (currently May 15 through August 31) to account for the presence of humpback whales throughout the longer period. Motorized vessels less than 262 feet (80 meters) long would be prohibited from operating at more than 20 knots through the water in lower-Bay whale waters. All motor vessels would be subject to operating at no greater than 10 knots through the water when the superintendent has designated a maximum of 10 knots because of the presence of whales. The regulatory language would read:

> *From May 1 through September 30 in the designated whale waters of the lower Bay, as defined above, for vessels less than 262 feet (80 meters) in length, the following is prohibited: 1) Operating at more than 20 knots speed through the water. 2) Operating at more than 10 knots speed through the water, when the superintendent has designated a maximum speed of 10 knots (due to the presence of humpback whales in the area).*
>
> *For vessels 262 feet (80 meters) or greater in length, the following is prohibited: 1) Operating at more than 13 knots speed through the water, everywhere within Glacier Bay proper. 2) Operating at more than 10 knots speed through the water when the superintendent has designated a maximum speed of 10 knots (due to the presence of humpback whales in the area).*

Whale Waters. Whale waters would be lower Glacier Bay waters only from May 1 through September 30 (see appendix A for a detailed description of the boundary). In addition, the superintendent also may designate any portion(s) of Glacier Bay and Dundas Bay as temporary whale waters and impose motor vessel speed restrictions in whale waters (same as the current regulations).

Vessel Routes and Destinations (Including Non-Motorized Waters). Routes for cruise ships in Glacier Bay would be defined to provide more assurance of resource protection, provide a potentially improved backcountry visitor experience, better separate the various vessels in Glacier Bay, and provide an increased margin of safety for avoidance of nearshore collisions. A cruise ship route would be identified using the current typical cruise ship traffic pattern (generally in mid-channel). Non-motorized water designations and seasons would not change.

Cruise ships would be allowed to go into the West Arm, into Tarr Inlet, and up to Jaw Point in Johns Hopkins Inlet. In addition to the closed waters defined for alternatives 1, 2, and 3, cruise ships also would not be allowed into Beardslee Entrance, Dundas Bay, and the East Arm, defined by an imaginary line drawn from southern Sebree Island to the mainland (see figure 2-2).

Tour vessels would not be allowed in the closed waters, as defined in the current regulations (see appendix a). In addition, tour vessels would not be allowed into Beardslee Entrance, Muir Inlet (the East Arm of Glacier Bay north of Muir Point), Berg Bay, and Fingers Bay in Glacier Bay or in Dundas Bay.

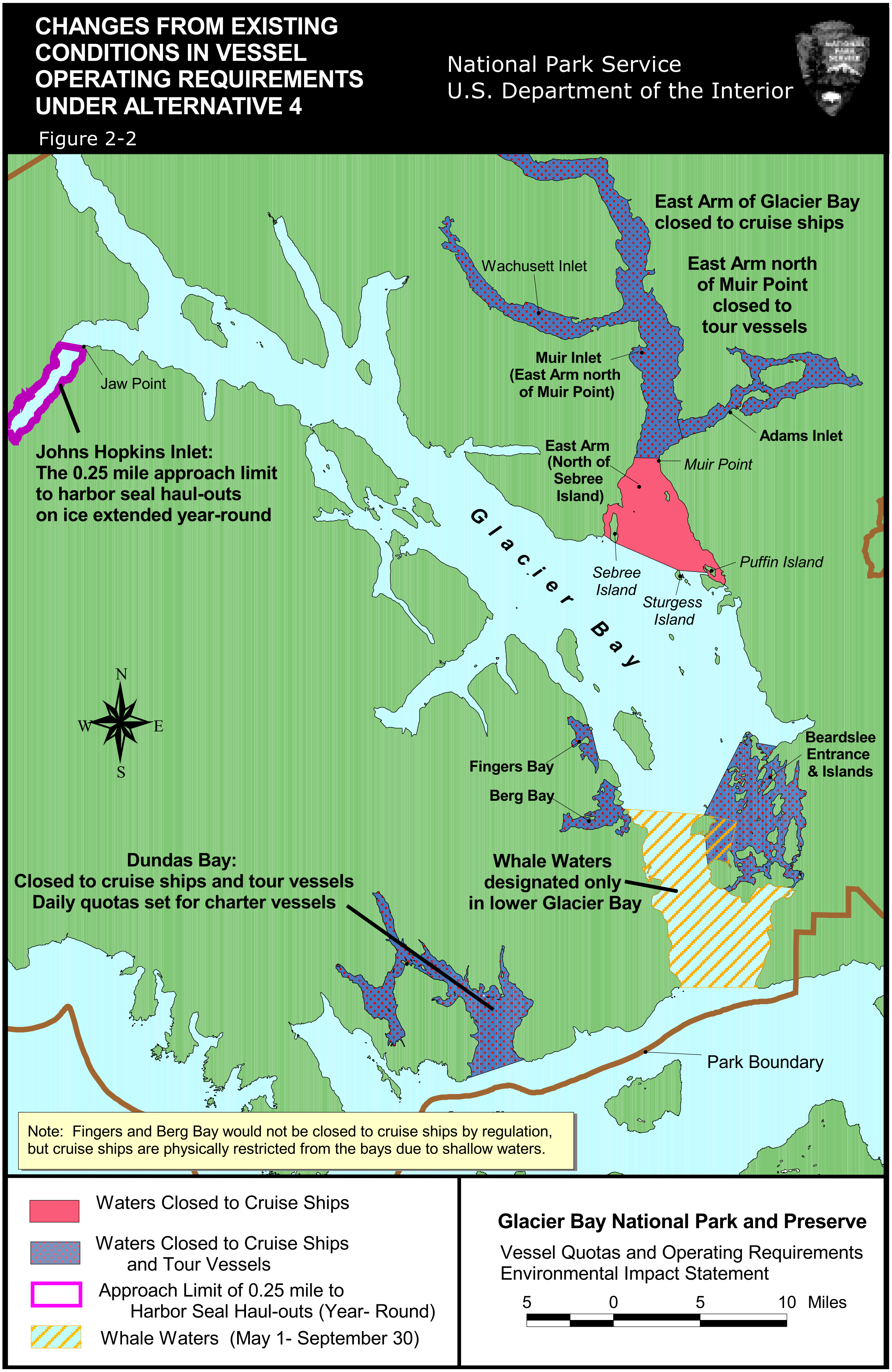
Johns Hopkins Inlet seasonal closure — Current regulations require motorized vessels to maintain a 0.25-nautical-mile distance from harbor seals hauled out on ice in Johns Hopkins Inlet from June 1 through August 31. Under alternative 4, this requirement would apply year-round.

2.7 ALTERNATIVE 5

Vessel quotas and operating requirements under alternative 5 would apply to Glacier Bay and Dundas Bay. Alternative 5 would maintain the current daily vessel quotas for all four vessel types in Glacier Bay. The seasonal use days for cruise ships would be extended into May and September. It would maintain the number of seasonal use days for cruise ships, tour vessels, and charter vessels during the current quota season but decrease the number of seasonal use days for cruise ships during May and September. It would increase the number of seasonal use days for private vessels. Seasonal entry quotas would be eliminated. Vessel quotas would be initiated for tour and charter vessels in Dundas Bay. Operating requirements would be modified, including limited closure of certain waters to cruise ships and tour vessels, decreased vessel speed for large vessels, and use of "speed over ground" as a measure of vessel speed.

2.7.1 Alternative 5 — Vessel Quotas

Glacier Bay. Alternative 5 would maintain current vessel numbers for Glacier Bay from June 1 to August 31 and would extend the seasonal-use day limits to May and September for cruise ships. The number of cruise ships that would be allowed in May and September (92) represents the same proportion of use allowed at present from June through August (139 ships/92 days = 92 ships/61 days). The other vessel classes would maintain the June through August season. Entry limits lower than those allowed under existing requirements are proposed for cruise ships in May and September (see table 2-7). This alternative would maximize private vessel use in Glacier Bay by increasing seasonal-use days for private vessels, compared to existing conditions. As with alternative 4, seasonal entries would be eliminated with this alternative.


CHANGES FROM EXISTING CONDITIONS IN VESSEL OPERATING REQUIREMENTS UNDER ALTERNATIVE 4
Figure 2-2
National Park Service
U.S. Department of the Interior
East Arm of Glacier Bay closed to cruise ships
East Arm north of Muir Point closed to tour vessels
Wachusett Inlet
Muir Inlet (East Arm north of Muir Point)
Adams Inlet
East Arm (North of Sebree Island)
Muir Point
Puffin Island
Sebree Island
Sturgess Island
Jaw Point
Johns Hopkins Inlet: The 0.25 mile approach limit to harbor seal haul-outs on ice extended year-round
Glacier Bay
N
W
E
S
Fingers Bay
Berg Bay
Beardslee Entrance & Islands
Dundas Bay: Closed to cruise ships and tour vessels Daily quotas set for charter vessels
Whale Waters designated only in lower Glacier Bay
Park Boundary
Note: Fingers and Berg Bay would not be closed to cruise ships by regulation, but cruise ships are physically restricted from the bays due to shallow waters.
Waters Closed to Cruise Ships
Waters Closed to Cruise Ships and Tour Vessels
Approach Limit of 0.25 mile to Harbor Seal Haul-outs (Year- Round)
Whale Waters (May 1- September 30)
Glacier Bay National Park and Preserve
Vessel Quotas and Operating Requirements Environmental Impact Statement
5 0 5 10 Miles

Dundas Bay. Cruise ships would not be allowed in Dundas Bay on a year round basis. One tour vessel would be allowed per day in the lower part of Dundas Bay (non-wilderness waters) from June 1 through August 31. Tour vessels would not be allowed within the wilderness waters year round. Seasonal use days for charter vessels would be 276, which represent an average of 3 vessels per day from June through August.

Season. As is currently the case, daily quotas for cruise ships and tour vessels would be in effect year round in Glacier Bay. Seasonal-use days would apply from May 1 through September 30 for cruise ships. Daily quotas and seasonal use days for charter and private vessels would continue to be the existing season of June 1 through August 31, as would the seasonal use days for tour vessels. The season for vessel quotas in Dundas Bay would be June 1 through August 31, although cruise ships would not be permitted year round and tour vessels would not be permitted in wilderness waters (upper Dundas Bay on a year round basis).

Tables 2-7 and 2-8 summarize vessel quotas for Glacier Bay and Dundas Bay, respectively, under alternative 5.

TABLE 2-7: SUMMARY OF VESSEL QUOTAS FOR GLACIER BAY UNDER ALTERNATIVE 5, MAY 1–SEPTEMBER 30

	Daily Vessel Quota		Seasonal Entries	Seasonal-Use Days	
Vessel Class	June–Aug	May and Sept		June–Aug	May and Sept
Cruise ship[a]	2	2	NA	139	92
Tour vessel[a]	3	3	NA	276	183
Charter vessel	6	No limit	NA	552	No limit
Private vessel	25	No limit	NA	2,300	No limit

a. Cruise ships and tour vessels are limited to the daily vessel quota year round.

NA = Not applicable
See table 2-1 for an explanation of terms.

TABLE 2-8: SUMMARY OF VESSEL QUOTAS FOR DUNDAS BAY UNDER ALTERNATIVE 5, JUNE 1–AUGUST 31

Vessel Class	Daily Vessel Quota	Seasonal Entries	Seasonal-Use Days
Cruise ship[a]	Not permitted	NA	NA
Tour vessel	0 in upper Bay[a] 1 in lower Bay[b c]	NA	0 in upper Bay 153 in lower Bay[b c]
Charter vessel	No limit	NA	276
Private vessel	No limit	No limit	No limit

a. Cruise ships and tour vessels are not allowed on a year-round basis.
b. Upper Dundas Bay is wilderness waters; the lower Bay is non-wilderness waters.
c. The quota season June 1 through August 31 applies.

NA = Not applicable
See table 2-1 for an explanation of terms.

Permitting Procedures. Current park regulations would be changed from "Each private motor vessel must have a permit" to "Permits shall be issued to a designated individual for a specific vessel over a specific period of time." Permits would be issued to individuals rather than vessels, because individuals are responsible for following park regulations.

Under alternative 5, the exemption for private vessels based in Bartlett Cove that enter and exit Glacier Bay (these are not currently counted as daily entries) would be eliminated and new "short-term permits" would be issued. Anyone could obtain a short-term permit by making a reservation within 48 hours of when they want to enter Glacier Bay.

2.7.2 Alternative 5 — Operating Requirements

Alternative 5 shares the revisions to operating requirements with alternative 4, with the following exceptions:

1. how vessel speed is defined;
2. the time frame during which speed restrictions are in effect;
3. the time frame during which whale waters are in effect; and
4. access for cruise ships and tour vessels in the East Arm.

Vessel Speed. Vessel speed limits would be similar to those described for alternative 4. The difference would be that speed would be based on "over the ground speed" rather than "through the water speed" for all vessel classes. Ground speed does not account for water currents, but rather is based on the rate of travel in relation to a fixed point on the ground or the bottom of the water body.

Until the proliferation of Global Positioning System (GPS) units in the consumer market, most vessels measured vessel speed with a through-hull or transducer-mounted paddle-wheel device that calculated speed by water passing under the vessel; this is speed "through the water." GPS technology uses signals from high-altitude satellites located in stationary positions over earth. By timing the signals sent by an array of satellites, and by knowing the orbital parameters of the satellites, a GPS can determine a location more accurately than was previously possible. GPS receivers can measure vessel speed in relation to fixed positions on the ground — or speed "over ground."

Most private boaters use GPS technology exclusively and may not have electronic equipment available to measure through-the-water speed. As a result, alternative 5 uses a ground-based, rather than water-based, definition of vessel speed. In many situations, the actual differences are negligible; however, Glacier Bay is known for its rapid currents that measure 8 knots or more in some places. Using ground speed, and traveling against such a current, a vessel's water-based speed would be 8 knots faster than its ground speed, and, moving with such a current, a vessel's water-based speed would be 8 knots slower than ground speed.

The time frame during which vessel speed limits would be effect would be year round for vessels greater than or equal to 262 feet (80 meters) and May 15 through September 30 for vessels less than 262 feet. Prohibited from May 15 through September 30 would be operating a vessel at more than 10 knots speed over the ground when the superintendent has designated that as the maximum speed due to the presence of whales.

Whale Waters. Designated whale waters would be the same as those for alternative 4 (only waters of lower Glacier Bay), except that the effective timeframe would be May 15 through September 30 and, again, speed would be measured over the ground (rather than through the water)

Vessel Routes and Destinations (Including Non-Motorized Waters). Under alternative 5, vessel operators would be under the same requirements as currently exist with respect to vessel routes. Likewise, non-motorized wasters would be the same as currently exist, with the addition of the following: Beardless Entrance and the entrance to Adams Inlet, Dundas Bay would be closed to cruise ships and the wilderness waters of Dundas Bay would be closed to tour vessels (see figure 2-3). As with alternative 4, the required 0.25 mile distance from harbor seals in Johns Hopkins Inlet would be applied year-round.

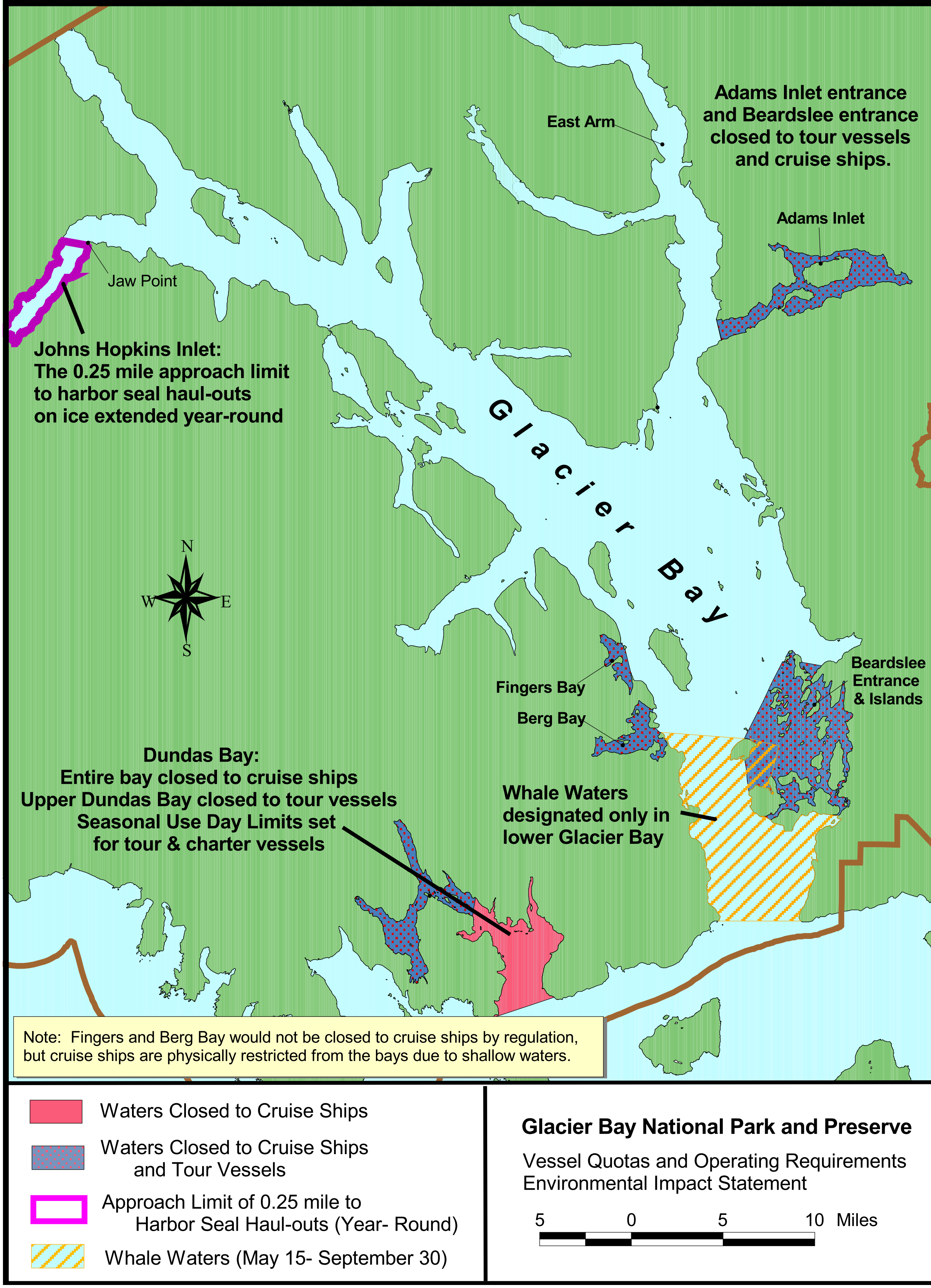
2.8 THE NPS PREFERRED ALTERNATIVE

Alternative 3 is the NPS preferred alternative. The main reason for selecting this alternative is that it provides for maintaining the current level of visitor use while protecting park resources and values. This system has been implemented successfully over the past several years, providing the opportunity for more than 300,000 visitors each year in a manner consistent with park purposes and values.

CHANGES FROM EXISTING CONDITIONS IN VESSEL OPERATING REQUIREMENTS UNDER ALTERNATIVE 5

Figure 2-3

National Park Service
U.S. Department of the Interior



Glacier Bay National Park and Preserve

Vessel Quotas and Operating Requirements
Environmental Impact Statement

Providing opportunities for people to visit the park is one of the main purposes of the park. This alternative maintains the non-motorized waters developed in 1996 to increase non-motorized uses, as well as numerous other measures to protect sensitive areas in the park. Alternative 3 also provides the potential to increase opportunities for visits to the park by increasing cruise ship numbers, contingent upon the completion of studies demonstrating that such increases would be compatible with park resources and values.

2.9 THE ENVIRONMENTALLY PREFERRED ALTERNATIVE

NEPA criteria for the environmentally preferred alternative includes those that:

- fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
- ensure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.
- attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences.
- preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice.
- achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life’s amenities.
- enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Based on these criteria alternative 4 is the environmentally preferred alternative. By allowing the fewest number of cruise ships, tour vessels, and charter vessels, alternative 4 would provide for the lowest number, intensity, and duration of adverse effects to natural resources in Glacier Bay and Dundas Bay.

2.10 ACTIONS CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS IN THIS EIS

The following describes actions raised during scoping that were considered but eventually eliminated from detailed evaluation in this environmental impact statement.

Development of an Open-Access Vessel Corridor to the Bartlett Cove Dock. Local residents requested unlimited access between Icy Strait and the Bartlett Cove Dock, without requiring an entry permit. The Gustavus Dock is in disrepair, and local residents must travel across Icy Strait for fuel and other services. Providing access to Bartlett Cove would provide a convenient and, some believe safer, alternative.

Providing an open-access vessel corridor to Bartlett Cove is counter to park purposes, as well as the purpose and function of Bartlett Cove. The services at Bartlett Cove are intended to support the park's use by park visitors and are not intended to constitute a service stop for the greater Icy Strait area. In addition, the mouth of Glacier Bay is already a high-traffic area where vessels enter and leave the park. It is also an area where wildlife concentrate. Allowing essentially unregulated use in the lower Bay could cause excessive vessel traffic in a sensitive area. In its July 2002 meeting, the Gustavus Community Association voted against formally requesting unlimited access to the Bartlett Cove Dock as part of this environmental impact statement because of concerns about the effects that such a request would have on the fate of the Alaska State Dock at Gustavus.

Restricting Administrative Use. Some people requested the park place limits on administrative vessel use in Glacier Bay. Administrative vessels include research vessels, park vessels, and any other vessels on official business for the state or federal government. This environmental impact statement addresses the use of commercial and private vessels for recreational purposes; administrative vessel use is solely at the discretion of the superintendent to ensure visitor safety; respond to emergency situations; and otherwise implement the park's mission, purposes, and values. Use of NPS vessels is necessary to protect park resources and values.

While restrictions on administrative use of vessels are beyond the scope of this environmental impact statement, the cumulative analysis considers the effects of administrative vessel use on park resources. The scope of this environmental impact statement, as defined by Congress (see subsection 1.2.8), is to identify and analyze the effects of the 1996 increases in the number of vessel entries allowed in Glacier Bay.

Research vessels are managed on a case-by-case basis using a decision matrix (see appendix C). This matrix is used when annual requests for administrative vessel use in the park are received from individuals associated with federal, state, tribal, or private organizations. Administrative vessel use is defined as any vessel use that is not classified as a cruise ship, tour vessel, charter vessel, or private vessel under the standard permit classification system (36 CFR 13.65; see appendix A), or listed as an exception under 36 CFR 13.65(iii). Exceptions to this definition are requests from individuals who have the authority to enforce state or federal regulations within the park.

Requiring Maximum Available Technology or Increasing Pollution Minimization Requirements to Control Cruise Ship Stack Emissions and Improve Air Quality. Section 703 of the November 1996 Omnibus Act (Public Law 104-333) prohibits the Park Service from imposing any vessel operating conditions related to air, water, and oil pollution beyond those enforced by other agencies on permittees. Section 703 also prohibits noise abatement unless scientific information supports a determination that such restrictions are necessary.

Increasing Cruise Ship Numbers above 1996 Levels. The previous vessel management plan and environmental assessment for Glacier Bay, completed in 1996, did not contemplate cruise ship numbers greater than two per day each day during the 92-day peak visitor season from June through August. Any increase in the number of cruise ships to be allowed into Glacier Bay was to be contingent upon studies, an annual review of study results by the superintendent, a determination by the superintendent based on that review, and approval from the NPS director. The Park Service has been unable to implement the previous plan. In addition, study results to date have not provided reason to warrant increasing the limit beyond what was considered in the 1996 plan. The Park Service believes that a measured approach is in the public interest of ensuring protection of park resources. Finally, based on the results of scoping for this current planning effort, which included more than four months for interests and concerns to be voiced no interest was expressed in increasing the daily limit beyond two per day. Thus, the Park Service believes that two cruise ships per day for each of the 92 days of the visitor season constitutes a reasonable upper limit to consider for cruise ships in the current plan.

The Environmental Impact Statement Should Consider the Widest Range of Alternatives, from Banning All Motorized Vessels and Prohibiting Further Vessel Quota Increases to Allowing Only Small Craft or Providing Unlimited Use of Glacier Bay. The Park Service believes that the alternatives identified in the environmental impact statement constitute a reasonable range of alternatives that provide access to the park, provide a range of visitor opportunities, and protect park resources. Banning all motorized vessels or allowing only small craft in Glacier Bay would not meet the Park Service's goal of providing a wide range of opportunities for visitors. Eliminating cruise ships and tour vessels from the Bay would dramatically reduce opportunities to visit the park for most of the visiting public. Providing motorized vessels unlimited access to the Bay would jeopardize park resources and values. These alternatives would not meet the basic objectives for the park.

Eliminate Vessel Quotas and Base Vessel Operating Requirements on Safety Issues. Vessel quotas and operating requirements are essential tools that the Park Service employs to manage vessel use in the park so that mandates defined in the enabling legislation and park purposes are met. The quotas and operating requirements are established to allow visitor access to the park and to protect park resources so that they can be conserved and remain unimpaired for the enjoyment of future generations. Eliminating vessel quotas and basing vessel operating requirements only on safety issues would not provide adequate protection for resources and values for which the park was established.

Expand Whale Waters to Include the Marble Islands and Extend Whale Waters from the Southern Park Boundary to the Eastern Tip of Lemesurier Island and the Western Tip of Pleasant Island. The proposed permanent expansion of the whale waters to include the Marble

Islands is unnecessary under all alternatives because the superintendent has the authority to designate temporary whale waters and impose motor vessel speed restrictions when necessary to protect whales. Permanent designation would unnecessarily limit visitor enjoyment of the park by requiring vessels of more than 18 feet to maintain a distance of 1 nautical mile from shore. Temporary whale waters limit the amount of time this stipulation is in force and thus restrict access to the shore only when it is necessary for the protection of humpback whales. Expanding the whale waters to the eastern tip of Lemesurier Island and the western tip of Pleasant Island, which are beyond the park boundary, is outside the NPS jurisdiction.

Establish Commercial-Free Activity Zones. By law, regulation, and policy, the Park Service limits commercial visitor services to those that are necessary and appropriate for public use and enjoyment, and that are consistent with the preservation and conservation of the resources and values of the unit to the highest practicable degree. No rationale has been provided as to why the commercial visitor services proposed in the plan would fail to meet the requirements.

Allow Self-Regulated, Traditional Use of the Park for Native Alaskans. This EIS pertains to vessel quotas and operating requirements for the four classes of motor vessels (cruise ships and tour, charter, and private vessels) entering the park in Glacier Bay and Dundas Bay. This traditional use of the park by Native Alaskans is beyond the scope of this EIS.

2.11 COMPARISON OF ALTERNATIVES

Each alternative defines quotas and/or operating requirements for cruise ships, tour vessels, charter vessels, and private vessels.

2.11.1 Comparison of Quotas

Quotas define the maximum allowable number of motorized vessels allowed in Glacier Bay and/or Dundas Bay, set by vessel class (i.e., cruise ship, tour vessel, charter vessel, and private vessel). Quotas are set by day and by season. For alternatives 1, 2, and 3 two types of seasonal quotas are used, seasonal entries and seasonal use days (see table 2-1 for definitions). A seasonal limit may result in daily use that is less than the maximum daily use allowed. For example, under existing conditions, a maximum of 2 cruise ships are allowed into Glacier Bay on any given day, year-round. However, from June through August (a 92 day period), 139 cruise ships are allowed into Glacier Bay, for a daily average of 1.5 cruise ships per day. On certain days, no cruise ships enter the Bay.

Alternative 1, the no-action alternative, would maintain the current quotas for Glacier Bay, as established by Congress.

Alternative 2 would decrease vessel quotas from current quotas, setting them at those levels in effect in 1995 (i.e. quotas authorized by 1985 vessel regulations). This would result in:

- a 23% reduction in cruise ship seasonal entries (from 139 to 107).
- a 13% reduction in charter vessel seasonal entries (from 312 to 271) and a 7% reduction in charter vessel seasonal-use days (from 552 to 511).
- a 13% reduction in private vessel seasonal entries (from 468 to 407) and a 3% decrease in seasonal-use days (from 1,971 to 1,714).

Alternative 3 would implement the 1996 Vessel Management Plan. This alternative would maintain the current vessel quotas, and include a provision to allow an incremental increase in cruise ships (totaling up to two per day, every day, from June through August), if studies support that such increases are compatible with protection of park values and purposes. This equates to a potential increase in cruise ship use up to 32% (from 139 to 184). The increased traffic would be absorbed, for the most part, in early and late summer.

Alternative 4 calls for the greatest reduction in cruise ships and tour and charter vessels. Under alternative 4, seasonal limits would change from June through August as follows:

- a 33% reduction in cruise ship seasonal entries (from 139 to 92).
- a 33% reduction in tour vessel daily vessel quota (from 3 to 2) and a 33% reduction in seasonal-use days (from 276 to 184).
- a 17% reduction charter vessel daily vessel quota (from 6 to 5) and a 17% reduction in charter vessel seasonal-use days (552 to 460).
- a 12% reduction in private daily vessel quota (from 25 to 22) but a 3% increase (from 1,971 to 2,024).

In addition, alternative 4 would expand seasonal limits to include May and September, which would result in a 50% reduction in cruise ships and a 33% reduction in tour vessels during May and September as compared to the current situation. Daily limits for charter and private vessels also would be restricted in May in September to 5 and 22 vessels, respectively. Currently, no limits are set for charter or private vessels during May and September.

Finally, daily limits would be reduced for tour vessels (from 3 to 2), charter vessels (from 6 to 5) and private vessels (from 25 to 22). Total seasonal use days for private vessels would increase slightly (2.6%, or an additional 53 use days).

Alternative 5 would maintain existing daily and seasonal use day quotas from June through August, with the exception of private vessels. Seasonal limits would be expanded to include May and September for cruise ships (alternative 4 expanded the season for all vessel classes). While the daily quotas for private vessels would remain the same as currently in place, seasonal use day quotas would increase by 16% (from 1971 to 2300).

Under both alternatives 4 and 5, the way vessel quotas are counted changes in several ways. First, vessel class definitions would be changed to be more consistent with other standard vessel classifications. Second, vessels based in Bartlett Cove would no longer be exempt from permits. This would eliminate the essentially unregulated traffic that currently exists between Bartlett Cove and the mouth of Glacier Bay. One of the reasons this exemption was first established was to avoid the possibility of a vessel based at Bartlett Cove from being stranded outside of Glacier Bay due to the lack of sufficient permits available. This measure would no longer be necessary with alternatives 4 and 5 due to changes, with each of these alternatives that would allow a permitted vessel to leave and return to Glacier Bay without having to get an additional permit. The daily vessel quota would no longer be based on "entries," so that a vessel covered under a permit for any particular day could leave Glacier Bay and then return. Under alternatives 1 through 3, each time a vessel enters Glacier Bay counts toward the daily vessel quota.

Allowing vessels to enter, leave, and reenter Glacier Bay on the same day could shift more use to the lower Bay. However, eliminating the Bartlett Cove exemption would eliminate the currently unregulated traffic (which would now be counted toward the quota). Therefore, these two changes roughly would counteract each other in terms of vessel traffic.

Also, under both alternatives 4 and 5, ten daily permits would be made available to private vessels on a short-notice basis. Private vessel operators could obtain one of these permits by making a reservation within 48 hours of when they desired to enter Glacier Bay (including vessels transiting from Bartlett Cove).

Unlike alternatives 1, 2 and 3, alternatives 4 and 5 would prohibit cruise ships from entering Dundas Bay. Alternative 4 also would prohibit tour vessels from entering Dundas Bay, while alternative 5 would allow tour vessels in the lower Bay, but not in the upper Bay (wilderness waters). Alternative 4 would establish a daily quota of three for charter vessels in Dundas Bay from May 1 through September 30, while alternative 5 sets no daily limit for charter vessels but sets a limit of 276 use days from June through September (for an average of 3 charter vessels per day).

2.11.2 Comparison of Operating Requirements

The 1996 decision to increase vessel numbers also included many measures to reduce or avoid effects on the resources and values of Glacier Bay. These are defined in the form of vessel operating requirements. Many operating requirements established in 1996 to protect sensitive park resources, including humpback whales, other marine mammals, and nesting birds.

These include:

- buffers around nesting birds.
- foot traffic restrictions.
- marine mammal protection areas.
- minimum approach distances for marine mammals.
- non-motorized waters.

These measures were incorporated into the regulations (see appendix A for more details).

Establishment of temporary whale waters are perhaps one of the most important and effective ways of protecting humpback whales while avoiding unnecessary restrictions on visitor use. Park Service staff monitor whale numbers and movements and report concentration areas as they develop. Whale use can be unpredictable, so this method allows for early detection and protection of areas where whales are concentrating. Based on monitoring, the superintendent can and does establish temporary whale waters to protect whales. In temporary whale waters, speed limits are restricted to 10 knots. This system has proven to be an effective way to protect humpback whales while not restricting vessel use unnecessarily. Monitoring humpback whales and establishing temporary whale waters will stay in effect under all alternatives.

The park and preserve’s research and monitoring program provides a tool to identify problems early and to provide a basis for making adaptive management decisions as needed to protect park resources.

Speed Restrictions

Under alternatives 1,2, and 3, speed limits would be set only within designated whale waters of the lower Bay, with a limit of 20 knots measured through the water. Speed is unrestricted elsewhere, although cruise ships and tour vessels generally travel at a slow maneuvering speed in the upper West Arm. When whales begin to congregate in any area, temporary whale waters are established and speed is restricted to 10 knots. In addition, vessels are required to slow to 10 knots or less whenever inadvertently being within one-quarter mile of a humpback whale. Under alternatives 4 and 5, cruise ship speeds would be limited to 13 knots to reduce the likelihood of collisions with whales. Under alternative 5 only, vessel speeds would be changed to measure speed over the ground, rather than through the water. With speed being measured through the water, vessels can move several knots faster (as measured over the ground) when going with the current, and several knots slower when going against the current.

Non-Motorized Waters

The 1996 decision also designated several inlets and other areas off limits to motorized vessel traffic (see figure 2-3). Additional closures are proposed for alternatives 4 and 5 (figure 2-4).

Ferry Vessel Operating Requirements

Under all alternatives, the daily ferry from Juneau mandated by Congress is restricted to the Lower Bay and Bartlett Cove. Under alternatives 4 and 5, additional restrictions are defined to prohibit the ferry from deviating from a direct course between the mouth of Glacier Bay and Bartlett Cove.

Vessel Routes

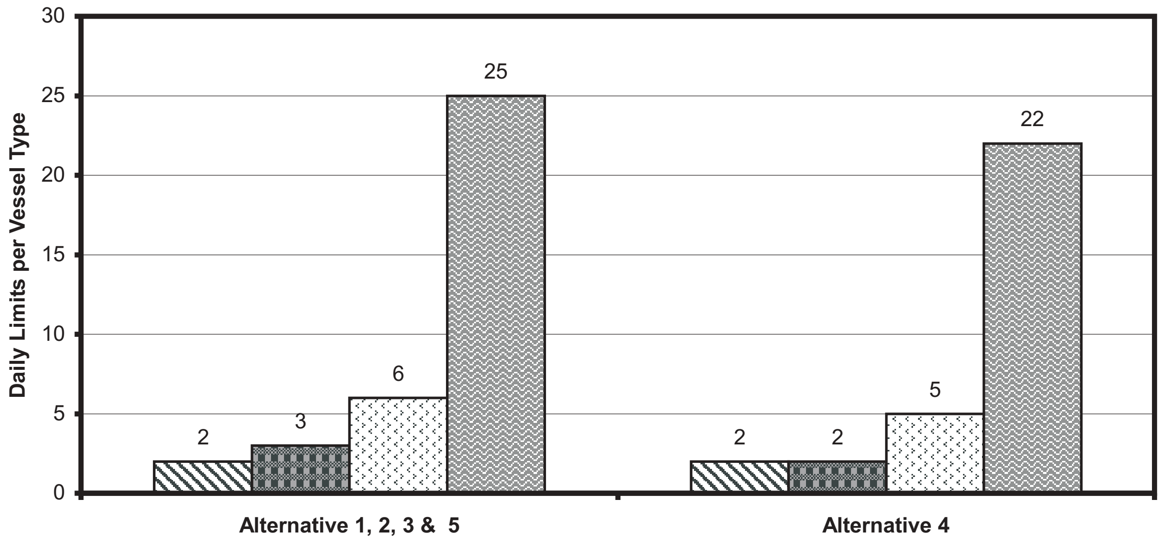
Under alternatives 4 and 5, routes for cruise ships would be defined (typically in mid-channel) to protect coastal resources, provide an improved backcountry visitor experience, protect wilderness values, better separate the various users, and provide an increased margin of safety for avoidance of near-shore collisions. A cruise ship route would be specified using the current typical cruise ship traffic pattern. Non-motorized water designations and seasons would not change.

2.11.3 Comparison of Environmental Effects Among Alternatives

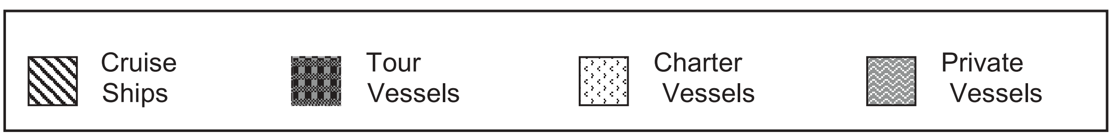
Many of the environmental effects of vessel traffic would be similar among the five alternatives, in terms of overall impact conclusions (i.e., negligible, minor, moderate, or major). In general, most adverse effects would occur in proportion to vessels numbers, speed and distribution, including air emissions and disturbance of wildlife and visitors from vessel traffic. Some beneficial effects increase with increasing vessel numbers, including economic benefits related to the Alaska tourism industry and visitor opportunities to experience the Bay via a motorized vessel.

Alternatives 2 and 4 have lower vessel numbers than the other alternatives (with the exception that alternative 4 allows more private vessel use days). In most cases, the magnitude of environmental effects also would be lower than would be expected for the other alternatives. Alternative 2 would allow the fewest private vessel use days among the alternatives, while alternative 4 would allow the fewest cruise ships (see chapter 2).

FIGURE 2-4: VESSEL QUOTAS IN GLACIER BAY PROPER COMPARED AMONG THE ALTERNATIVES – DAILY VESSEL QUOTA (JUNE 1- AUGUST 31)



Note: The alternatives vary mostly in "Seasonal Use Days" rather than daily limits. With the exception of Alternative 4, all alternatives share the same daily limits, but do not share the same seasonal limits. Also, note that for Alternatives 1, 2, and 3, daily limits are for entry, which is the maximum number of vessels that can enter the Bay in any one day. For Alternatives 4 and 5, daily limits are for "daily vessel quotas," which is the maximum number of vessels allowed in the Bay during any period *between midnight of one day and midnight the next.* The daily and seasonal quotas for private and charter vessels, in Alternatives 1,2,3, and 5 are for June- August; during May & September no quotas are imposed. Daily quotas for charter and private vessels are in effect in May and September for Alternative 4. Daily quotas for cruise ships and tour vessels are year-round for all of the alternatives.



Alternative 3, the NPS preferred alternative, could allow an increase of up to 184 cruise ships, should studies demonstrate that such an increase could be taken consistent with park resources and values. The analysis in Chapter 4 assumes that the 184 vessel level would be reached (Alternative 1 addresses the effects of the current level of 139 vessels). Since 1996, the Park Service has conducted research to determine if increases were warranted. Each year, the superintendent reviews the results of this research. To date, the research has not clearly demonstrated that further increases are warranted. Research will continue, with particular emphasis on air quality, humpback whales, nesting birds, and visitor experience.

Alternative 3 has the highest potential level of cruise ship use. Still, based on the analysis presented in Chapter 4, the level of effect is considered to be consistent with park resources and values. The current level of use has been in place for several years without impairment of park resources or values. This system has worked well over the past several years, providing the opportunity for over 300,000 visitors each year in a manor consistent with park purposes and values. Providing opportunities for people to visit the park is one of the primary purposes of Glacier Bay National Park and Preserve. This alternative maintains the protection measures defined in the 1996 decision (see operating requirements and mitigation measures above). Alternative 3 also provides the potential to increase opportunities to visit the park by increasing cruise ship numbers, contingent upon the completion of studies demonstrating that such increases would be compatible with park resources and values.

Alternative 4 would eliminate tour vessels from Dundas Bay. This would improve visitor experience in this area, as well as protect wildlife. The risk of groundings would also be reduced. Alternatives 4 or 5 would have new operating requirements intended to reduce environmental effects of vessel traffic. Under both alternatives, cruise ships would be required to travel at speeds no greater than 13 knots. This would greatly reduce the potential of cruise ships colliding with humpback or other whales.

Alternative 5 would provide for the most private vessels. Since private vessels tend to be smaller and operators more free to explore, private vessels tend to travel to the more remote waters of Glacier and Dundas Bays. Such use can disturb backcountry users, detract from the naturalness of wilderness, and disturb marine and terrestrial wildlife.

Physical Environment

Soundscape. Under all alternatives, vessel noise (along with sight) would intrude on the natural soundscape, both on the surface and below the water. Vessel noise would be prevalent underwater in any of the alternatives. Likewise, vessel noise would travel to shorelines and interfere with the natural sounds of wind, rain, waves, birds, and rivers and streams. Alternative 3 would cause the most underwater vessel noise, assuming an increase in cruise ships. This alternative would eliminate days when the natural soundscape is not altered by cruise ships during the summer months. Alternatives 4 and 5 would reduce vessel noise because of the requirement that cruise ships travel at 13 knots throughout Glacier Bay.

Air Quality. Under all alternatives, the primary concern related to air quality is the potential for stack emissions for vessels to leave a visible plume and/or create haze. Such events are known to occur intermittently under the current situation, although the frequency of such events is unknown. Air emissions are highly dependent of vessel types and numbers. Cruise ships produce the highest point source emission but also tend to have the highest level of emission control technology. Private vessels emit much less exhaust, but they can travel to the more remote places of Glacier and Dundas Bays.

Alternative 3 would produce the highest annual emissions, increasing the number of times when smoke plumes would be visible. Implementation of alternative 4 would result in a moderate effect, due to lower vessel numbers. The emissions of nitrogen oxides in Glacier Bay under all alternatives except alternative 4 would be above the 250-tons-per-year thresholds; however, based on the size of the area, the fact that all the sources are mobile and dispersed, and using Juneau's air quality for comparison, it is unlikely that these emissions would exceed air quality standards. Proposed speed restrictions and quota changes under alternatives 4 and 5 could reduce visibility problems, although increases to private vessel quotas under these alternatives would off-set some of this improvement.

Water Quality. The potential major effect to water quality would occur in the unlikely event of a large oil or fuel spill. While the analysis determined that such a spill is very unlikely, the addition or reduction in vessels entering Glacier Bay may incrementally increase or decrease, respectively, the likelihood of the event over the long term. Eliminating tour vessels from Dundas Bay would reduce risks of accidents for these vessels in that area, which includes several areas of shallow waters and other navigational hazards.

Biological Environment

Threatened and Endangered Species. All alternatives would cause some individual whales and sea lions to move away from passing vessels in Glacier Bay or Dundas Bay; however, because whale distribution has been shown to be more a factor of prey abundance than avoidance of vessels, overall effects are expected to be at the individual level and, therefore, minor. Collisions with ships would be rare, but cannot be ruled out under any of the alternatives and, over time, is probably inevitable. Killing a humpback whale would be considered a major effect, even though the level of effect would still be at the individual level and would not be sufficiently severe to counter the general increasing trend in humpback whale populations. The risk and potential frequency of such collisions increases with vessel traffic increases, so alternative 3 would have the highest potential level of risk for whale deaths due to vessel strikes. Alternatives 4 and 5 include speed restrictions to 13 knots for cruise ships, a speed that has been shown to greatly reduce the likelihood of ship/whale collisions that result in whale mortality. Alternative 4 also reduces cruise ship numbers by over one-third the amount currently allowed, so the likelihood of collisions with humpback whales is lowest under alternative 4.

Marine Mammals. Under all alternatives, marine mammals would be disturbed by vessel traffic. Vessel traffic would cause individuals to avoid areas of high vessel use. Most marine mammals are highly mobile and able to avoid vessels, but individuals may be struck and injured or killed by vessels. The context of effects is expected to be at the individual level, rather than the population level, with the possible exception of harbor seals, whose populations in Glacier Bay are declining.

Marine Birds and Raptors. Vessel traffic would disturb concentration areas of brood-rearing harlequin ducks, molting waterfowl, and foraging marbled murrelets. These species are particularly sensitive to vessel traffic and are expected to experience potential local population declines. Alternative 5, which has the highest level of private vessel use days, would also have the greatest potential for disturbing shore birds and colonial nesting birds, since these vessels can travel closer to shore than larger vessels.

Marine Fishes. Some fish may avoid areas near vessels, but no major effects are expected.

Coastal/Shoreline Environmental and Biological Communities. Implementation of any of the alternatives would have a minor effect on coastal/shoreline communities.

Human Environment

Cultural Resources. From the perspective of the Huna Tlingit (scoping), vessel traffic affects ethnographic resources in the park by reducing the quality of resources and, thus, degradation of the Huna Tlingit ancestral homeland.

Visitor Experience. Visitor opportunities would change among the alternatives in three primary ways. First, since more than 85% of visitors to Glacier Bay experience the park on a cruise ship, changes in the numbers of cruise ships allowed would greatly affect opportunities for the most common method of viewing the Bay. Second, providing opportunity in the form of cruise ship entry also removes opportunities and reduces the quality of visits for people who wish to experience the Bay without cruise ships. Third, alternative 4 would increase opportunities for solitude and quiet in Dundas Bay and the East Arm of Glacier Bay by closing them to tour vessels. In addition, alternative 4 would limit charter vessels to three per day. Alternative 5 would provide more opportunities for charter vessels to use Dundas Bay by providing flexibility to allow more than three charters on any particular day, so long as an average of three from June to August is not exceeded.

Visitor experience would change among the alternatives in proportion to vessel numbers and distribution. Cruise ships and other vessels can detract from the feeling of solitude and wilderness for some backcountry users, including hikers and kayakers. Alternative 3 has the highest potential to reduce backcountry experiences due to cruise ships. Alternative 5 would also reduce some backcountry experiences due to the increase in private vessel use. Private vessels can travel to more remote places and are the most prevalent vessel type in both Dundas and Glacier Bays. Therefore, they are the most likely to be seen and heard by backcountry visitors.

Vessel Use and Safety. Risks of major vessel accidents resulting in large fuel spills and major loss of life are expected to be very low. However, if a major spill were to occur the effects would likely be major. Occasional groundings with associated small fuel leaks would be expected under any of the alternatives.

Wilderness Resources. The sights and sounds of vessel traffic would change the naturalness of some wilderness areas (which include essentially all shoreline areas of Glacier and Dundas Bays). Alternative 4 would eliminate tour vessel use in Dundas Bay, which would increase the naturalness of shoreline areas.

Local and Regional Socioeconomics. Alternative 2 would reduce direct and indirect spending by cruise lines and passengers, and the associated fees and taxes paid by cruise ship companies. Alternative 3 would benefit local communities and cruise ship ports of call by increasing cruise ship entries. Alternatives 2 and 4 could result in lost employment and local incomes due to the loss of cruise ship revenues and related employment. Alternative 4 would reduce charter and tour vessel entries, as well as associated employment.

Conclusions Regarding Impairment

None of the alternatives analyzed resulted in effects on park resources or values that constitute impairment. In general, only some major impacts can result in impairment, but it is dependent on the context, severity, duration, and timing of the effects. Negligible, minor, or moderate effects are not likely to lead to impairment. The effects of a proposed would be considered impairment if 1) a native species would be lost or could no longer sustain a viable population in the park; 2) ecological processes would be diminished such that they were permanently disrupted in a large portion of the park; 3) resources would be diminished to the point that the public could no longer have the opportunity to enjoy them; and 4) if the park could not attain the goals set out in its management plans (NPS NRPC 2002).

The potential for impairment was evaluated for all the physical and biological resources, and some of the resources in the human environment (cultural and wilderness resources). The other elements of human environment, visitor experience, vessel use and safety, local and regional socioeconomics) are not park resources and therefore not subject to impairment evaluation. None of the effects resulting from the implementation of any of the proposed alternative constituted major effects and none had the context, severity, duration, and timing of effects which would result in impairment.

Ongoing and Potential Future Study Needs

The 1996 Vessel Management Plan (VMP) identified numerous information and management needs associated with determining appropriate levels of vessel traffic and designing mitigation measures to protect resources in Glacier Bay National Park (GBNP). Current and ongoing studies include:

- Humpback whale monitoring to determine temporary concentration areas and need to designate temporary whale waters. The whale monitoring program also identifies population and use trends.
- Steller sea lion monitoring program.
- Harbor seal vessel interaction study.
- Underwater sound monitoring program.
- Visitor surveys.
- Coastal resource inventory.
- Ethnographic overview.

Based on the analysis presented in the EIS, additional studies are needed in the following areas:

- More information is needed regarding vessel noise levels. Both surface and subsurface studies should be completed, including studies evaluating cruise ships traveling at relatively high speeds.
- Air quality studies need to be conducted where stack missions may be causing visible plumes or haze.
- Humpback whale monitoring must continue to identify population trends and to locate concentration areas that warrant designation as temporary whale waters.

- Harbor seal populations should be closely monitored to document recovery or further declines.
- Visitor surveys should be conducted to monitor visitor use and experience.

Many other resource studies are either ongoing or planned, as well as the ongoing scientific research that is a major purpose of Glacier Bay National Park and Preserve.

Figures 2-5 and 2-6 illustrate the changes in vessel operating requirements under alternatives 4 and 5, respectively.

Tables 2-9 through 2-13 summarize and compare the alternatives and associated vessel quotas and operating requirements.

2.12 MITIGATION MEASURES COMMON TO ALL ALTERNATIVES

Included in all of the alternatives are protective measures to ensure that vessel traffic does not significantly affect park resources and values. These measure include:

- non-motorized waters allow visitors an enhanced opportunity to experience wilderness;
- whale waters regulations offer protection for the humpback whale and other threatened and endangered species.
- the Glacier Bay Superintendent may establish and enforce speed restrictions anywhere in the Bay to protect whales.
- seabird nesting closures offer protections of nesting habitat from park visitors and vessel approach.
- harbor seal and Steller sea lion critical areas offer protection for the threatened Steller sea lion and pupping and molting harbor seals.

In addition to these protective measures, alternatives 4 and 5 include specific operating requirements that represent mitigation measures. These measures include, in general, vessel speed restrictions, designated vessel travel routes, and establishment of additional waters closed to motorized vessel use.

FIGURE 2-5: VESSEL QUOTAS IN GLACIER BAY PROPER COMPARED AMONG THE ALTERNATIVES – SEASONAL USE DAYS (JUNE 1-AUGUST 31)

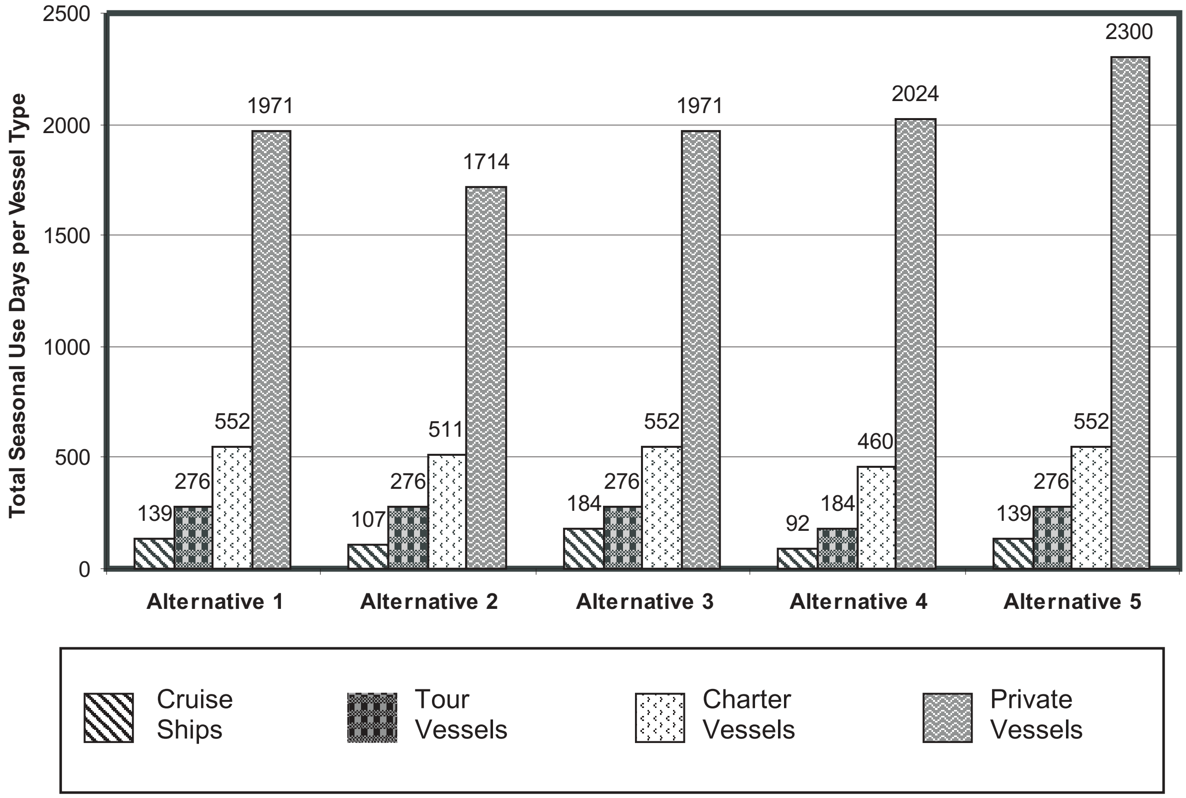


FIGURE 2-6: VESSEL QUOTAS FOR CRUISE SHIPS AND TOUR VESSELS IN GLACIER BAY PROPER COMPARED AMONG THE ALTERNATIVES – SEASONAL USE DAYS (MAY AND SEPTEMBER)

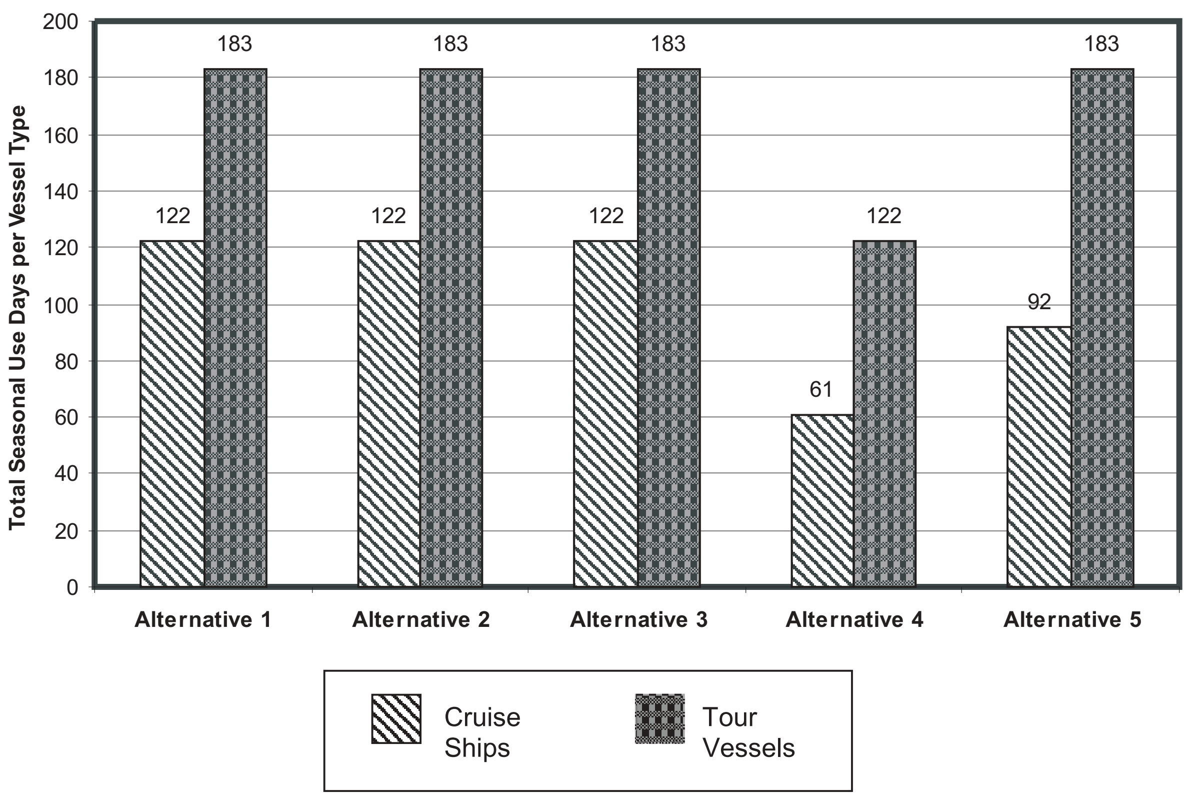


TABLE 2-9: OVERVIEW OF ALTERNATIVES EVALUATED IN THIS ENVIRONMENTAL IMPACT STATEMENT

Alternative	Vessel Quotas[a]	Operating Requirements
Alternative 1 (no action alternative)	For Glacier Bay: Current quotas and quota season (see table 2-10).	Current operating requirements.
Alternative 2	For Glacier Bay: 1985-authorized quotas (those in effect in 1996). Current quota season (see table 2-10).	Current operating requirements.
Alternative 3 (NPS preferred alternative)	For Glacier Bay: Current quotas with a provision to increase seasonal quotas for cruise ships. Current quota season (see table 2-10).	Current operating requirements.
Alternative 4 (environmentally preferred alternative)	For Glacier Bay[b]: Current daily quotas for cruise ships; slightly reduced daily quotas for tour, charter, and private vessels. Reduced seasonal-use days for cruise ships, and tour and charter vessels; slightly increased number of seasonal-use days for private vessels. Quota season lengthened (May 1–Sept 30) for all vessel classes (see table 2-10). For Dundas Bay: Cruise ships and tour vessels not permitted. Vessel quotas initiated for charter vessels. No limits for private vessels (see table 2-11).	Revised operating requirements, including seasonal-entry quotas, not applicable; limited closures of certain waters to cruise ships and tour vessels; decreased vessel speed for large vessels (see table 2-12).
Alternative 5	For Glacier Bay[b]: Current daily quotas and quota season for cruise ships, and tour, charter, and private vessels. Current number of seasonal-use days for cruise ships, and tour and charter vessels during the current quota season. Decreased number of seasonal-use days for cruise ships during May and September. Increased number of seasonal-use days for private vessels (see table 2-10). For Dundas Bay: Cruise ships not permitted. Vessel quotas initiated for tour and charter vessels. No limits for private vessels (see table 2-11).	Revised operating requirements, including seasonal-entry quotas, not applicable; limited closures of certain waters to cruise ships and tour vessels; decreased vessel speed for large vessels; and use of "speed over ground" as a measure of speed (see table 2-12).

TABLE 2-10: COMPARISON OF VESSEL QUOTAS IN GLACIER BAY FOR ALTERNATIVES 1 THROUGH 5

Vessel Class		Alternative 1 [b]		Alternative 2 [b]		Alternative 3 [b]		Alternative 4		Alternative 5	
		June 1 – Aug 31	May and Sept	June 1 – Aug 31	May and Sept	June 1 – Aug 31	May and Sept	June 1 – Aug 31	May and Sept	June 1 – Aug 31	May and Sept
Cruise Ship[a]	Daily Vessel Quota	2	2	2	2	2	2	2	2	2	2
	Seasonal Entries	139	No limit	107	No limit	139 (potentially up to 184)	No limit	NA	NA	NA	NA
	Seasonal-Use Days	139	122	107	122	139 (potentially up to 184)	122	92	61	139	92
Tour Vessel [a]	Daily Vessel Quota	3	3	3	3	3	3	2	2	3	3
	Seasonal Entries	276	No limit	276	No limit	276	No limit	NA	NA	NA	NA
	Seasonal-Use Days	276	183	276	183	276	183	184	122	276	183
Charter Vessel	Daily Vessel Quota	6	No limit	6	No limit	6	No limit	5	5	6	No limit
	Seasonal Entries	312	No limit	271	No limit	312	No limit	NA	NA	NA	NA
	Seasonal-Use Days	552	No limit	511	No limit	552	No limit	460	305	552	No limit
Private Vessel	Daily Vessel Quota	25	No limit	25	No limit	25	No limit	22	22	25	No limit
	Seasonal Entries	468	No limit	407	No limit	468	No limit	NA	NA	NA	NA
	Seasonal-Use Days	1,971	No limit	1,714	No limit	1,971	No limit	2,024	1,342	2,300	No limit

a. Cruise ships and tour vessels are limited to the daily vessel quota year-round.

b. Information is shown for May and September to facilitate comparison with alternatives 4 and 5 where quota season is extended to include May and September (for all classes [alternative 4] and cruise ships only [alternative 5]).

NA = Not applicable.

TABLE 2-11: COMPARISON OF VESSEL QUOTAS IN DUNDAS BAY FOR ALTERNATIVES 1 THROUGH 5

Vessel Class	Quotas	Alternative 1 (No Action)	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Cruise Ship	Daily Vessel Quota	---------------------- No limit[c] ----------------------			Not permitted	Not permitted [b]
	Seasonal Entries	---------------------- No limit[c] ----------------------			NA	NA
	Seasonal -Use Days	---------------------- No limit[c] ----------------------			NA	NA
Tour Vessel	Daily Vessel Quota	---------------------- No limit ----------------------			Not permitted	Not permitted in wilderness waters[b]; 1 in non-wilderness waters [c]
	Seasonal Entries	---------------------- No limit ----------------------			NA	NA
	Seasonal -Use Days	---------------------- No limit ----------------------			NA	Not permitted in wilderness waters [b] 92 in non-wilderness waters [c]
Charter Vessel	Daily Vessel Quota	---------------------- No limit ----------------------			3 [a]	No limit
	Seasonal Entries	---------------------- No limit ----------------------			NA	NA
	Seasonal -Use Days	---------------------- No limit ----------------------			459[a]	276[c]
Private Vessel	Daily Vessel Quota	------------------------------------- No limit -------------------------------------				
	Seasonal Entries	------------------------------------- No limit -------------------------------------				
	Seasonal -Use Days	------------------------------------- No limit -------------------------------------				

a. Vessel quota season is May 1 through September 30.
b. This is a year-round limitation.
c. Vessel quota season is June 1 through August 31.
d. Through the NPS competitive allocation of cruise ship permits, existing cruise ship operators have committed to an itinerary that does not include Dundas Bay; however, there are currently no regulations that prohibit cruise ships from entering Dundas Bay.

TABLE 2-12: COMPARISON OF VESSEL OPERATING REQUIREMENTS FOR ALTERNATIVES 1 THROUGH 5

Requirement Regulation	Alternatives 1, 2, and 3 (Current Regulations)	Alternative 4	Alternative 5[b]
Quota Season	June 1 through August 31[a]	May 1 through September 30[a].	Glacier Bay: June 1 through August 31 for tour, charter and private vessels. May 1 through September 30 for cruise ships. Dundas Bay: June 1 through August 31 for tour vessels in the lower bay, and charter vessels. Year-round for cruise ships in Dundas Bay and for tour vessels in wilderness waters of Dundas Bay.
Speed Restrictions	May 15 through August 31, in the waters of the lower bay whale waters the following is prohibited: (1) Operating a motor vessel at more than 20 knots speed through the water or (2) operating a motor vessel at more than 10 knots speed through the water when the superintendent has designated a maximum speed of 10 knots due to the presence of whales.	Year-round, in Glacier Bay the following is prohibited for motor vessels ≥262 feet (80 meters) in length: Operating at more than 13 knots speed through the water, to reduce risks of vessel collisions with whales. May 1 through September 30, in waters of lower bay whale waters the following is prohibited for motor vessels <262 feet (80 meters): Operating at more than 20 knots speed through the water. May 1 through September 30, in waters of Glacier Bay and Dundas Bay, the following is prohibited: Operating a motor vessel at more than 10 knots speed through the water when the superintendent has designated a maximum speed of 10 knots due to the presence of whales.	Year-round, in Glacier Bay the following is prohibited for motor vessels ≥262 feet (80 meters) in length: Operating at more than 13 knots speed <u>over the ground</u>, to reduce risks of vessel collisions with whales. <u>May 15 through September 30</u>, in waters of lower bay whale waters, the following is prohibited for motor vessels <262 feet (80 meters) in length: Operating at more than 20 knots speed <u>over the ground</u>. <u>May 15 through September 30</u> in waters of Glacier Bay and Dundas Bay the following is prohibited: Operating a motor vessel at more than 10 knots speed <u>over the ground</u> when the superintendent has designated a maximum speed of 10 knots due to the presence of whales.

TABLE 2-12: COMPARISON OF VESSEL OPERATING REQUIREMENTS FOR ALTERNATIVES 1 THROUGH 5

Requirement Regulation	Alternatives 1, 2, and 3 (Current Regulations)	Alternative 4	Alternative 5[b]
Whale Water Geographic Locations	May 15 through August 31: Lower bay waters. June 1 through August 31: Whidbey Passage, East Arm Entrance waters, Russell Island Passage. The superintendent may designate temporary whale waters and impose motor vessel speed restrictions in whale waters (in Glacier Bay).	May 1 through September 30: Lower Glacier Bay waters. The superintendent may designate temporary whale waters and impose motor vessel speed restrictions in whale waters in any portion of Glacier Bay and Dundas Bay.	May 15 through September 30: Lower Glacier Bay waters. The superintendent may designate temporary whale waters and impose motor vessel speed restrictions in whale waters in any portion of Glacier Bay and Dundas Bay.
Measurement of Vessel Speed	Vessel speed is measured “through the water.”	Vessel speed is measured “through the water.”	Vessel speed is measured “over the ground.”
Non-Motorized (Closed) Waters for Cruise Ships	Operating a motor vessel or seaplane in closed waters (as defined in the current regulations) is prohibited.	Same as alternatives 1, 2, and 3 and the following additional closed waters in Glacier Bay: (1) Beardslee Entrance, (2) the East Arm, defined by an imaginary line drawn from southern Sebree Island to the mainland; also Dundas Bay.	Same as alternatives 1, 2, and 3 and the following additional closed waters in Glacier Bay: (1) Beardslee Entrance, (2) entrance to Adams Inlet; also Dundas Bay.
Non-Motorized (Closed) Waters for Tour Vessels	Operating a motor vessel or seaplane in closed waters (as defined in the current regulations) is prohibited.	Same as alternatives 1, 2, and 3 and the following additional closed waters in Glacier Bay: (1) Beardslee Entrance, (2) Muir Inlet defined by an imaginary line drawn from Muir Point west to the mainland, (3) Berg Bay, and (4) Fingers Bay; also Dundas Bay.	Same as alternatives 1, 2, and 3 and the following additional closed waters: in Glacier Bay: (1) Beardslee Entrance, (2) entrance to Adams Inlet, also wilderness waters of Dundas Bay.
Ferry Vessel Operating Requirements	Per Section 127, Public Law 105-83, the ferry is restricted to the sole purpose of accessing the Bartlett Cove dock. The ferry is subject to speed, distance from coastlines, and other operating requirements common to all vessel types.	Same as alternatives 1, 2, and 3 and, in addition can not deviate from a direct course between the mouth of Glacier Bay and Bartlett Cove.	Same as alternative 4.

TABLE 2-12: COMPARISON OF VESSEL OPERATING REQUIREMENTS FOR ALTERNATIVES 1 THROUGH 5

Requirement Regulation	Alternatives 1, 2, and 3 (Current Regulations)	Alternative 4	Alternative 5[b]
Vessel Routes	None except in designated whale waters where: Operators of motor vessels over 18 feet in length will in all cases where the width of the water permits, maintain a distance of at least one nautical mile from shore, and, in narrower areas will navigate in mid-channel: Provided, however, that unless other restrictions apply, operators may perpendicularly approach or land on shore (i.e., by the most direct line to shore) through designated whale waters.	None for tour vessels, charter vessels, and private vessels, except in designated whale waters where operators would be under the same rules as for alternatives 1, 2, and 3. Routes for cruise ships would be defined.	Same as alternatives 1, 2, and 3.
Harbor Seal Vessel Approach Distance in Johns Hopkins Inlet	Cruise ships, tour vessels, charter vessels, and private vessels must maintain a 0.25 nautical mile distance from all harbor seals hauled out on ice in Johns Hopkins Inlet from July 1 through August 31.	Same as alternatives 1, 2, and 3, but on a year-round basis.	Same as alternative 4.
Short-Notice Private Vessel Permits	Not applicable	Ten permits for private vessels would be issued on a short-notice. This number may be adjusted annually through use of the park compendium. Private vessel operators could obtain one of these permits by making a reservation within 48 hours of when they desired to enter Glacier Bay.	Same as alternative 4.
Permit Exemption for Vessels Based in Bartlett Cove	A permit is not required to enter Glacier Bay when a private motor vessel based at Bartlett Cove is transiting between Bartlett Cove and waters outside of Glacier Bay, or is operated in Bartlett Cove in waters bounded by the public and administrative docks.	Entrance and egress exemptions for vessels based in Bartlett Cove are eliminated. A permit is not required for a vessel that is operated in Bartlett Cove in waters bounded by the public and administrative docks.	Same as alternative 4.

TABLE 2-13, SUMMARY OF DIRECT AND INDIRECT EFFECTS BY RESOURCE FOR EACH ALTERNATIVE

ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 5
PHYSICAL ENVIRONMENT				
Soundscape				
Vessel noise would intrude on the natural soundscape on the surface and underwater. Shoreline areas would be subjected to vessel noise, potentially interfering with visitor enjoyment of the natural soundscape. Overall, vessel noise is considered consistent with park resources and values.	Fewer cruise ships, charter, and private vessels would reduce human-caused sounds, particularly along shorelines, where private vessels are more likely to travel.	Assuming 184 cruise ships during the summer, the underwater soundscape would be subjected to four cruise ship passings each day, every day during summer. Other vessel levels and operating requirements and associated human-caused noise would be the same as alternative 1.	The East Arm of Glacier Bay and lower Dundas Bay would be improved by limiting charter vessels and eliminating tour vessels. Reducing cruise ship speeds to 13 knots would greatly reduce underwater noise levels.	Increases in private vessels would increase vessel noise along shorelines and in the more remote places of Glacier Bay.
Air Quality				
Under certain weather conditions (calm with a temperature inversion), stack emissions would be visible and could linger for several hours.	Fewer cruise ships would reduce the frequency of haze or stack emissions.	Studies would need to demonstrate that air quality would not be significantly degraded before increasing cruise ships. A 32% increase in cruise ships would greatly increase the frequency of visible stack emissions.	Speed restrictions on cruise ships and Lower vessel numbers would reduce emissions and visible plume events. Closure of the east arm to tour vessels could improve visibility there.	As with alternative 4, speed restrictions would reduce air emissions, but visible plumes are still expected to occur under certain weather conditions. Increased private vessels would increase air emissions near shorelines.
Water Quality				
Effects would be minor since water quality impacts from spills would be short-term, localized, and the spill response capability is high. A major spill in ice-filled waters is unlikely, but would be a major effect since spill response would not be possible.	Effects not discernable from alternative 1. Effects related to discharge of bilge water and vessel grounding or collision would be incrementally lower due to the reduced number of cruise ships.	Should cruise ship numbers be increased, then an associated increase in inadvertent discharges into the water would occur. The risk of a major accident would increase, but still remain very low.	Similar to alternative 1; could result in a lower level of risk of inadvertent discharge of bilge water. Dundas Bay would benefit with restriction of tour vessels.	Effects would be simlar to alternative 1. Restriciton on tour vessels in Dundas Bay would reduce spill potential in those areas.

TABLE 2-13, SUMMARY OF DIRECT AND INDIRECT EFFECTS BY RESOURCE FOR EACH ALTERNATIVE

ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 5
BIOLOGICAL ENVIRONMENT				
Threatened and Endangered Species				
Vessel traffic would continue to adversely affect both humpack whale and Steller sea lions. Effects would be at the level of individual and not the population. Humpback whales would continue to be disturbed by the sight and sounds of vessels. Collisions with cruise ships would be rare but, over time, would be unavoidable. Existing regulations to protect whales and sea lions would remain in place.	Fewer cruise ships would lower exposure to noise and risk of collisions.	Increasing cruise ship numbers would increase associated noise exposure and risk of collisions.	The combination of reducing cruise summer ship numbers and speed would greatly reduce noise exposure and the risk of collision. Humpback whales would still be exposed to vessel noise from private vessels, which would slightly increase. Restrictions in Dundas Bay would benefit whale use there.	Speed reductions for cruise ships would greatly reduce noise and the risk of collision. Increasing private vessels would increase non-lethal injuries to humpback whales. Such events are expected to be rare but unavoidable.
Marine Mammals				
Vessel traffic may contribute to reported declines in harbor seal populations. Effects on Minke whales would be similar to those described for humpback whale. Other marine mammals would avoid vessel traffic but would otherwise not be harmed. .	Similar to alternative 1, but slightly decreased chances of distribution shifts or animal collisions due to lower vessel numbers.	Similar to alternative 1, but potentially increased disturbance if cruise ship numbers are increased. Populations are expected to remain stable.	Much lower frequency of disturbance due to speed limits, vessel reductions, and restrictions at Dundas Bay and the East Arm. Additional protection for harbor seals in Johns Hopkins inlet would reduce effects. Expanding seasonal restrictions would increase protection during early and late summer.	Increasing private boats would increase disturbance to marine mammals. Expanding seasonal restrictions would increase protection during early and late summer.

TABLE 2-13, SUMMARY OF DIRECT AND INDIRECT EFFECTS BY RESOURCE FOR EACH ALTERNATIVE

ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 5
Marine Birds and Raptors				
Vessel traffic in Sitakiday Narrows, Reid Inlet, the East Arm, and Dundas Bay would continue to disturb murrelets, molting waterfowl, and breeding harlequin ducts.	Overall effects would be similar to alternative 1. The amount of disturbances would decline slightly.	Overall effect would be similar to alternative 1. The amount of disturbances would increase if cruise ship numbers are increased..	Reduced vessel traffic would provide a corresponding reduction in vessel disturbance on marine birds.	Increases in private vessels, which can venture into remote bays and inlets, would increase disturbance to molting waterfowl, harlequin ducks.
Marine Fish				
Vessel traffic could displace some fish, but overall, the current level of vessel traffic has not been found to seriously disrupt fish populations.	Effects not discernable from alternative 1.	Effects not discernable from alternative 1.	Effects not discernable from alternative 1.	Effects not discernable from alternative 1.
Coastal/Shoreline Environment and Biological Communities				
Effects to shoreline would be minor because current vessel traffic does not cause significant erosion of shorelines. Effects to the biological shoreline communities would be minor. Individual beaches may experience some erosion and sediment suspension from vessel traffic.	Effects not discernable from alternative 1.	Effects not discernable from alternative 1.	Similar to alternative 1. Sediment erosion, re-suspension, or relocation would be slightly greater than current conditions due to a slight increase in private vessels.	Similar to alternative 1. Higher private number of vessels would have the potential to alter the shoreline to a greater extent due to vessel wakes.

TABLE 2-13, SUMMARY OF DIRECT AND INDIRECT EFFECTS BY RESOURCE FOR EACH ALTERNATIVE

ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 5
HUMAN ENVIRONMENT				
Cultural Resources				
Effects to archaeological and historic resources would be negligible because resources would remain eligible for the National Register of Historic Places. Effects to ethnographic resources would be moderate since the project would potentially affect the integrity of traditional cultural properties.	Effects not discernable from alternative 1.	Increasing cruise ship numbers to 2 per day, every day, during the summer would eliminate opportunities to undertake traditional activities in the central portions of Glacier Bay without the presence of a cruise ship.	Most effects not discernable from alternative 1. Effects to cultural landscapes would be minor due to longer restricted-entry season, slower vessel speeds, and additional restricted waters.	Most effects not discernable from alternative 1. Effects to cultural landscapes would be moderate because alternative 5 would allow more private vessels..
Visitor Experience				
Effects would be moderate for backcountry visitors because the presence of motorized vessels could lead to potential loss of opportunity to experience solitude.	Effects would be major because a 30% reduction in cruise ships would decrease the opportunity for passengers to experience Glacier Bay proper.	Effects would be minor for charter and private vessel passengers and major for backcountry visitors because of the loss of opportunities for solitude.	Effects would be major to cruise ship passengers due to reduced cruise ship and tour vessel entries, and moderate for backcountry users due to a decrease of 34% in the number of cruise ships.	Effects would be moderate due to fewer numbers of cruise ships, but increases in private vessels would detract from wilderness experience for backcountry visitors.
Vessel Use and Safety				
Effects would be negligible because controls on vessel entry strictly limit the density of vessels in Glacier Bay, but limited congestion would continue to occur at Bartlett Cove and Tarr Inlet.	Effects not discernable from alternative 1.	Risks of vessel accidents would increase, but would remain minor, since overall vessel density would remain low.	Effects would be positive because reduced vessel entries and speed limits would increase vessel safety and decrease vessel traffic. Eliminating tour vessels from Dundas Bay would eliminate the current risks associated with operating large vessels in relatively shallow areas. Formally defining cruise ship	Formally designating cruise ship routes and reducing speeds would further reduce the currently low risk of accidents..

TABLE 2-13, SUMMARY OF DIRECT AND INDIRECT EFFECTS BY RESOURCE FOR EACH ALTERNATIVE

ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 5
			routes would significantly reduce the risk of groundings and potential fuel spills. Reducing cruise ship speed would further reduce the currently low risk of accidents.	
Wilderness Resources				
Effects would be minor for most areas and moderate for concentrated use areas, such as Johns Hopkins and Tarr Inlets, where vessel noise and air pollution would be heightened. Most effects would occur along shorelines.	Effects not discernable from alternative 1.	Increasing cruise ships to 184 during summer would reduce the naturalness of wilderness near the tidewater glaciers, where cruise ships spend most of their time while at Glacier Bay.	Reduced vessel numbers would reduce vessel exposures to wilderness. Reducing cruise ship speed limits would reduce vessel emissions and noise, but would also increase the time cruise ships are within Glacier Bay.	Effects would be similar to alternative 1, but with increased protection to Dundas Bay. As with alternative 4, reducing speed limits would reduce vessel emissions and noise, but would also increase the time cruise ships are within Glacier Bay.
Local and Regional Socioeconomics				
Effects to the economies of neighboring communities and Southeast Alaska would be negligible, as would the effects to Glacier Bay-dependant businesses.	Effects would be minor to moderate due to decrease in income and employment for communities with economic linkages to Glacier Bay. Reduced local spending associated with private vessels. Moderate effects would be expected for Gustavus where personal income reductions would be expected to be between 5% and 10%.	Effects would be positive due to increase in cruise ships; effects on local communities would be negligible with the exception of Gustavus, which would benefit from increased park revenues.	Effects would minor to moderate due to income and employment decrease related to vessel decreases and reduced local spending associated with private vessels. Moderate effects would be expected for Gustavus where personal income reductions would be expected to be between 5% and 10%.	Effects would be similar to alternative 1; changes to Dundas Bay management could have a minor positive effect on commercial users.

CHAPTER 3

AFFECTED ENVIRONMENT

GLACIER BAY

NATIONAL PARK AND PRESERVE, ALASKA

VESSEL QUOTAS AND OPERATING REQUIREMENTS • DRAFT ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 3. AFFECTED ENVIRONMENT

3.1 INTRODUCTION

This chapter describes the existing environment that could be affected by the alternatives in this environmental impact statement and is divided into sections that discuss the physical, biological, and human environment. The topics associated with each environment are as follows:

Physical Environment

- Fjord Dynamics and Oceanographic Processes.
- Soundscape.
- Air Quality.
- Water Quality.

Biological Environment

- Threatened and Endangered Species.
- Marine Mammals.
- Marine Birds and Raptors.
- Marine Fishes.
- Coastal/Shoreline Environment and Biological Communities.

Human Environment

- Cultural Resources.
- Visitor Experience.
- Vessel Use and Safety.
- Wilderness Resources.
- Local and Regional Socioeconomics.

These topics were selected based on federal laws, regulations, executive orders, NPS management policies, NPS subject matter expertise, and concerns expressed by other agencies or members of the public during scoping and comment periods. The conditions described establish the baseline for the analyses of effects found in "Chapter 4. Environmental Consequences."

3.2 PHYSICAL ENVIRONMENT

This section describes the physical environment of Glacier and Dundas Bays, including fjord dynamics, oceanographic processes, soundscape, air quality, and water quality. Subsection 3.2.1, "Fjord Dynamics and Oceanographic Processes," is purely informational; potential effects of the alternatives on these aspects of the physical environment are not discussed in chapter 4.

3.2.1 Fjord Dynamics and Oceanographic Processes

3.2.1 Fjord Dynamics and Oceanographic Processes

Glacier Bay is a recently deglaciated fjord in Southeast Alaska. A fjord is a long, narrow estuary, usually hundreds of meters deep, that is formed by the retreat of a glacier. The glacial retreat leaves a U-shaped valley that is filled by the ocean.

The main body of Glacier Bay is approximately 60 miles long with a 4-mile-wide mouth between Point Gustavus and Point Carolus. The Bay widens to approximately 12 miles at the base of the East and West Arms (see figure 1-2). The Chilkat Range bounds Glacier Bay to the east, the Takinsha Range bounds the Bay to the north, and the Fairweather Mountain Range bounds the Bay to the northwest. The peaks and ridges of the Brady Glacier form the Bay's west boundary. The north end of Glacier Bay's main body divides into two fjord systems known as the East and West Arms. Muir Inlet is included in the East Arm. Glacier Bay (including the two arms) has steep slopes and displays the typical U shape of a glacially formed valley. The sea floor of Glacier Bay, with average depths more than 1,000 feet (305 meters), is often too deep for anchoring vessels. With freshwater inputs from the surrounding watersheds and glaciers, multiple sills, high sedimentation, and large tidal fluctuations, Glacier Bay comprises a complex oceanographic system. The system experiences high variability in salinity, temperature, sediment load, light penetration, and current patterns (NPS 1983; NPS 2002k; Hooge and Hooge 2002).

The movement of water through Glacier Bay is determined by several of the Bay's physical characteristics, including the presence of a single opening to the ocean, a shallow sill entrance at the opening, deeper basins behind the shallow entrance, and multiple embayments and sills backed by deep basins. Figure 3-1 shows the bathymetry of Glacier Bay, as well as the locations of sills (NPS 1983; NPS 2002k; Hooge and Hooge 2002).

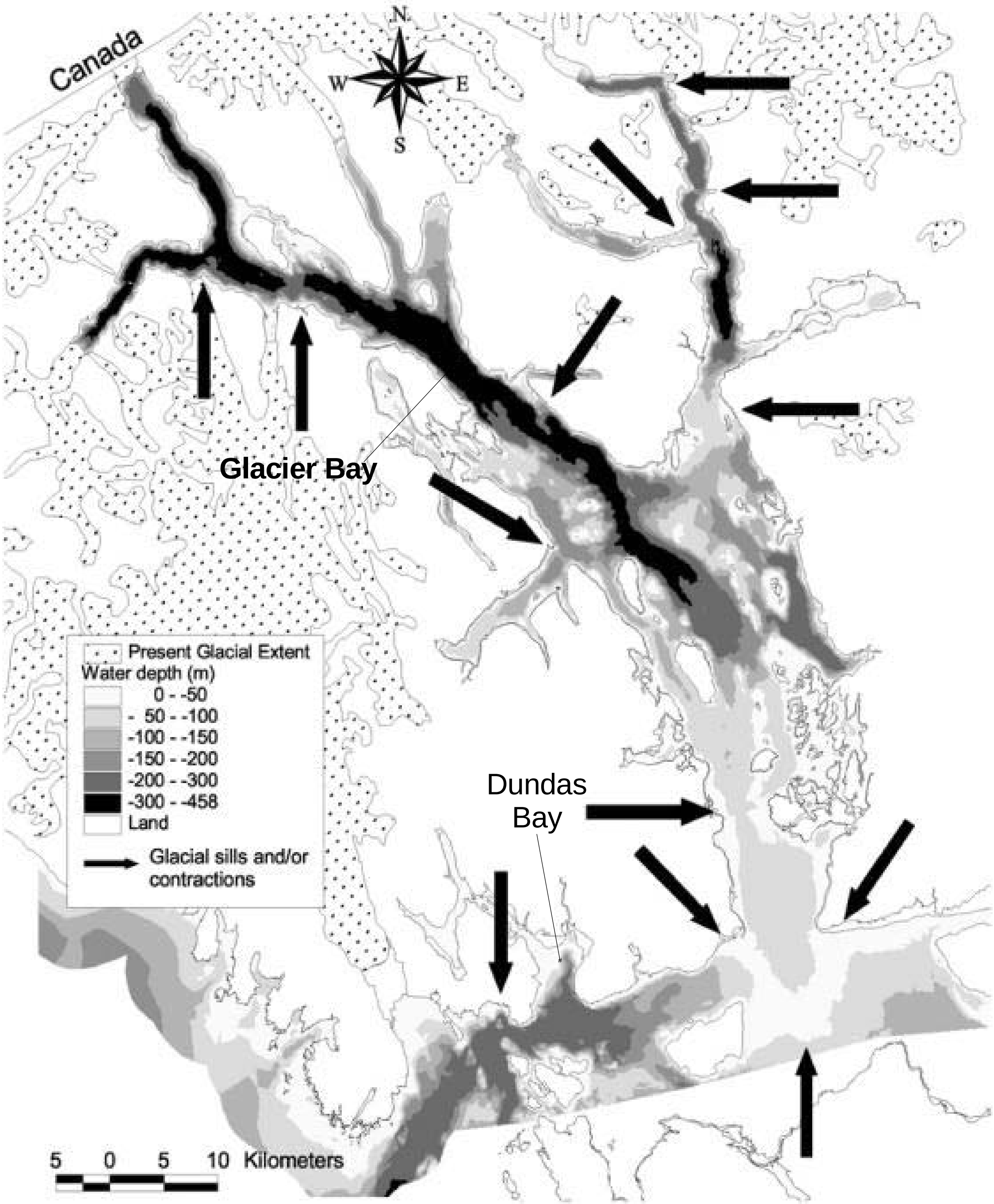
Glacier Bay's water regime also contributes to the complexity of the system. The Bay is a tidally influenced estuary. The tidal range varies throughout the Bay, with the greatest ranges (more than 25.5 feet [7.8 meters]) in the Bay's northern portion. The tidal exchange, in conjunction with the density-driven flow of water between the ocean and the Bay, provides the input for marine water. Freshwater inputs include runoff, creeks and rivers, precipitation, snowmelt, and continuous glacial melting.

Salinity and temperature are two measurable physical parameters that determine the density of a water mass and indicate how water circulates through a water body. Glacier Bay tends to stratify in the summer, but the level of stratification varies through the Bay. Stratification is the layering of water due to differences in salinity or temperature. Tidally induced currents produce more mixing and

BATHYMETRY OF GLACIER BAY PROPER

Figure 3-1

National Park Service
U.S. Department of the Interior



Bathymetry of Glacier Bay proper and adjacent waters, and present extent of glaciation. Numerous contractions and glacial sills are indicated.

Source: Hooge, P.N. and E.R. Hooge 2002 *Fjord Oceanographic Processes in Glacier Bay, Alaska.* Gustavus, AK: U.S. Geological Survey, Alaska Science Center, Glacier Bay Field Station.

Glacier Bay National Park and Preserve

Vessel Quotas and Operating Requirements
Environmental Impact Statement

upwelling near the Bay's entrance than within the main body of the Bay. This entrance area tends to be well mixed and to stratify only during slack water conditions (when the tide is changing direction from high to low or low to high). The salinity generally is higher near the Bay's mouth than at the head of the Bay. This is likely due to the large influx of fresh water at the head of the Bay, as well as the Bay's single point of entry for marine water at the mouth. The mid-Bay region tends to be stratified much of the year because of the input of freshwater runoff, rather than insolation, which causes temperature differences. Figure 3-2 shows winter and summer salinity readings in Glacier Bay in 2000. Hooge and Hooge (2002) state, "Water in the top 10m[eters] is much fresher during summer, when the surface brackish layer is also much narrower and distinct (stratified). Salinities at the bottom of the basins do not change as much, although intermediate-depth waters are most saline during early spring and summer months." The upper arms of Glacier Bay tend to have surface lenses of less saline water. Generally, the salinity and density of water in the upper arms are almost identical to those of the mid-Bay. The sills in the upper arms of Glacier Bay may prevent or enhance mixing with the mid-Bay water.

Temperature tends to follow a pattern similar to salinity, with colder temperatures near the glacier input and warmer temperatures near the Bay's mouth. The waters of Glacier Bay are warmer in the summer and colder in the winter because of seasonal temperature variations (see figure 3-3). A thermocline, which is a region where there is a rapid change in temperature with depth (stratification), often exists in the summer when the sun heats the surface water, but the deeper water remains cool. A double thermocline (four layers of water) often occurs near the glaciers in the upper fjords because of cold freshwater glacial runoff.

The Bay tends to be homogenous in the winter, so thermoclines generally are absent. Hooge and Hooge (2002) frequently reported "pan" ice conditions (freezing of the surface water) during winter surveys in smaller embayments and the upper 6 to 12 miles (10 to 20 kilometers) of the main arms of Glacier Bay.

Internal waves are a naturally occurring process that destabilize stratified layers of water. Internal waves can occur only when the water is stratified. The internal wave causes a vertical oscillation of the water molecules that breaks down the boundary between stratified layers. Internal waves do not affect the shoreline. Hooge and Hooge (2002) state that there is good mixing throughout the water column in the winter, but that stratification can occur in the summer. They found that the first layer of stratification occurs at approximately 10 meters (33 feet), but the Park Service has found that stratification can occur in the first 1 to 2 meters (3.3 to 6.6 feet).

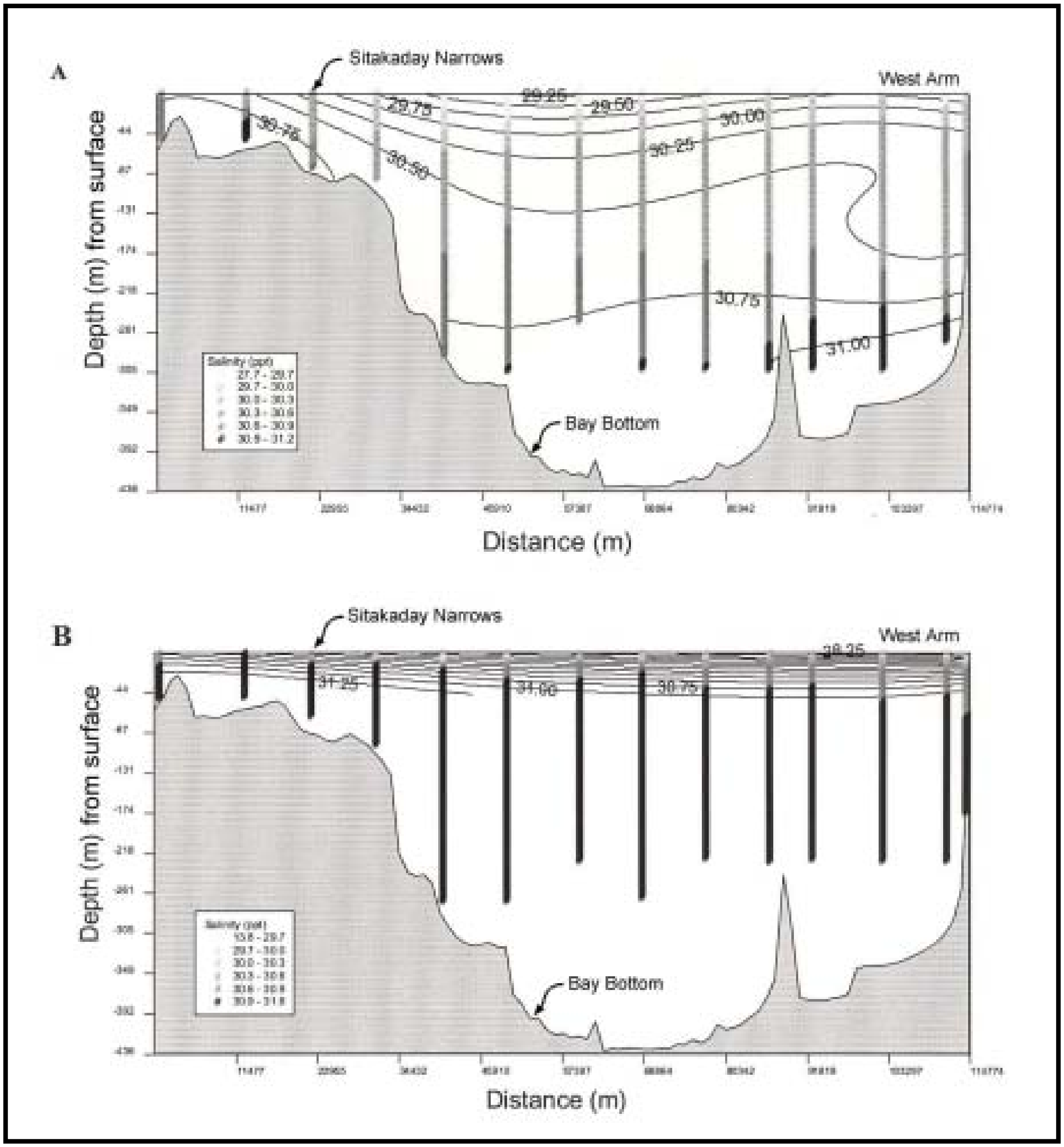


Figure 3-2 Salinity Contours
Salinity contours along the main Glacier Bay-West Arm oceanographic survey line during (A) January 2000 and (B) June 2000. Salinity values are contoured every 0.25 ppt. This figure shows the seasonal variability in salinity in the main body of Glacier Bay to the West Arm. The top figure shows the even mixing that occurs in winter. The lower figure shows the typical layer that develops in summer. The top 10m is fresher during the summer as well as having a narrow and distinct (stratified) brackish layer near the surface. The bay is more saline with depth than what is typical for winter conditions as indicated by the dark lines (darker lines mean more saline or salty water) in (B).

Source: Hooge, P.N. and E.R. Hooge. 2002. *Fjord Oceanographic Processes in Glacier Bay, Alaska.* Gustavus, AK: U.S. Geological Survey, Alaska Science Center, Glacier Bay Field Station.

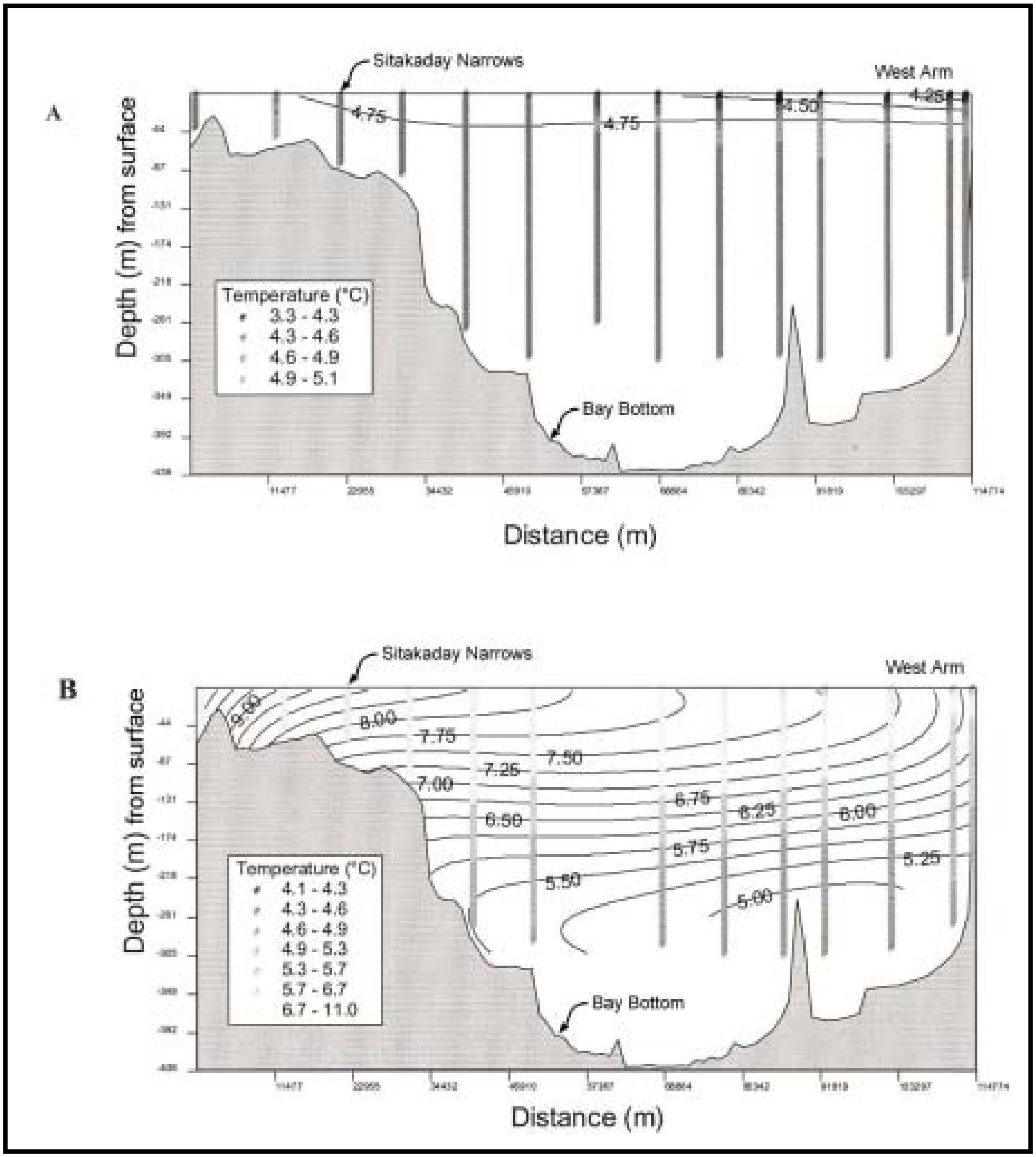


Figure 3-3 Temperature Profiles and Contours
Temperature profiles and contours along the main Glacier Bay-West Arm oceanographic survey line during (A) March 2000 and (B) August 2000. Temperature values are contoured every 0.25°C. This figure shows the seasonal variability in temperature in the main body of Glacier Bay to the West Arm. The top figure shows more even temperatures throughout the water column due to mixing. The lower figure shows how the water sorts out in layers of differing temperature (each layer being called an isotherm) during the summer. The figure also shows the rapid change in temperature with depth known as a thermocline. The Bay is warmer during the summer months, as indicated by the lighter lines (lighter lines mean warmer temperatures) in (B). The Bay is warmer near the mouth and cooler near the glaciers year round.

Source: Hooge, P.N. and E.R. Hooge. 2002. *Fjord Oceanographic Processes in Glacier Bay, Alaska.* Gustavus, AK: U.S. Geological Survey, Alaska Science Center, Glacier Bay Field Station.

Vessels can create internal waves as well, but these waves are shallow (less than 40 feet [12 meters] for the vessels in Glacier Bay) compared to natural internal waves. A vessel creates an internal wave when the hull breaks the plane of the stratified layer. The vessel only affects the volume of water it displaces when moving through the water. The deepest vessel listed in the NPS Vessel Database for Glacier Bay National Park and Preserve (Nemeth 2002) has a draft (depth) of 33 feet (10.1 meters). Most of the cruise ship class has a draft of 25 to 27 feet (7.6 to 8.2 meters). All other vessels will be shallower. Most vessels in Glacier Bay have drafts deep enough to affect only the shallowest stratified layers; however, there are times when a vessel may cause localized mixing of the upper stratified layers along its track line. Localized effects are approximately the same width as the beam of the vessel and trail behind the track. An effect is expected to be short-term because this is a relatively small volume of disturbance compared to the total volume of stratified water in Glacier Bay. The water will tend toward recovery to the original stratified state.

3.2.2 Soundscape

Consistent with "Director's Order 47, Sound Preservation and Noise Management" (NPS 2001c), soundscape refers to the total ambient acoustic environment associated with the park. The park's soundscape includes naturally occurring and human-made sounds. The Park Service considers natural sounds to be vital to the natural functioning of many parks and valuable indicators of an ecosystem's health. Natural sounds also contribute to visitor experience in a park. Because of the importance of natural sound in the park environment, the Park Service considers the natural soundscape to be a resource, similar to air and water. Director's Order 47 articulates NPS operational policies that require, to the fullest extent practicable, the protection, maintenance, or restoration of the natural soundscape resource in a condition unimpaired by inappropriate or excessive noise sources.

Appropriate and Inappropriate Noise. Human-made sound that interferes with visitor enjoyment of park resources or a park's ecological functioning is inappropriate; however, not all sounds are considered inappropriate. For example, activities associated with each park's purpose often are found to be appropriate even though they generate elevated sound levels for areas within a park. However, when activities (inside or outside a park) generate excessive levels of noise, they can jeopardize the natural soundscape resource or the purposes for which the park was created.

Functions of Sound in National Parks. Sound plays an important role in the behaviors and other biological functions of terrestrial and marine organisms. For many animals, sound is used for communication. For example, bird calls and songs during spring are used to establish and defend territories, among other functions. Similarly, the calls and songs of whales and wolves have a variety of functions. Insects also use sound to define territories or attract mates. Other examples of sound as a critical element of animals' functioning include a bat's use of sound (echolocation) to find prey, or its reception of sound as a way to detect predators. Bears foraging in a field are aware of sounds, and often respond to sounds they perceive as possible threats.

Sound is also an important element of the physical environment, although its role in the functioning of physical processes is considerably less than that in the biological realm. Because inanimate objects do not perceive or react to sound, they are affected only by the physical impact of vibration. Examples of natural sounds created within the physical environment include sounds produced by wind passing through trees, claps of thunder, falling water, or the crash of calving glaciers as they tumble into water.

Sound is an important element in the human perception of the natural world. For the Hoonah people, the natural soundscape is an aspect of the spiritual world as well as the physical and biological realms.

Finally, sound is an important aspect of visitor use, especially near park attractions and in natural settings. Natural sounds are very important to many recreational experiences, especially those related to wilderness. As reported to the U.S. Congress in the “Report on the Effects of Aircraft Overflights on the National Park System,” a system-wide survey of park visitors revealed that nearly as many visitors come to national parks to enjoy the natural soundscape (91%) as come to view the scenery (93%). Noise can distract visitors from the tranquility of natural landscapes.

Existing Soundscape in Glacier Bay and Dundas Bay. The following discussion of the existing soundscape in Glacier Bay and Dundas Bay relates to all resource topics evaluated in this environmental impact statement; however, for the purposes of this report, and because sound travels differently in the air and water, this environmental impact statement considers two aspects of the soundscape: the atmospheric soundscape (air above ground and water surfaces) and the underwater soundscape. The natural and human-made sounds in these two soundscapes are described. This discussion is relevant because this environmental impact statement focuses on, among other things, how the soundscape could be affected by changes in vessel quotas and operating requirements. These changes could affect the perceptions of visitors along the shorelines of Glacier Bay who hear passing motorized vessels, or could result in increased disturbance to wildlife exposed to the sounds of motorized vessels.

Atmospheric Soundscape. Natural sounds in the air above Glacier Bay and Dundas Bay include sound created by biological and physical processes:

- breaking waves.
- wind moving across the water; across glaciers; through canyons; across the landscape; and at a microscale, across the ear of an observer.
- animal calls.
- falling rock and ice associated with geological processes, including the movement of glaciers.

Currently, much of the human-made sounds in the park originate from motorized vessels and aircraft; therefore, these sounds are most prevalent over the water and along the shoreline. The sources of these human-made sounds include:

- vessel motors, exhaust, and vessel movement through the water.
- human voices.

- public address systems on cruise ships and tour vessels.
- aircraft overflights, landings, and takeoffs.

Most park visitors detect only the sounds generated in the atmosphere; therefore, it is critical to evaluate areas where visitors congregate to evaluate the variations in soundscape. The Park Service wishes to preserve the natural quietness in areas such as those where tidewater glaciers of Glacier Bay are available to the public. One of the park's purposes, however, is to provide access to these areas; therefore, to fulfill their mission, park administrators must maintain a balance between access to these areas and the resultant sounds produced by motorized vessels in these areas.

The public address systems on cruise ships are one source of human-made sounds in Glacier Bay. All cruise ships and most tour vessels broadcast an interpretive program by an NPS naturalist through their public address systems.

Aircraft noise, which includes the landings and takeoffs of float planes, is another important human-made sound in the park. Aircraft regularly fly over the park for scenic flights and to drop off and pick up passengers, and when traveling through park airspace to other areas. The park does not maintain records of overflights through park airspace.

Underwater Soundscape. While the term "Silent World" has been used to describe the underwater environment, sounds abound there. As with the atmospheric soundscape, the sounds in Glacier Bay's underwater soundscape result from natural and human-made sources (although no sound data are available from Dundas Bay, the following discussion is generally applicable to Dundas Bay). Natural sound sources include wind-generated surface noise, rainfall, sound generated by high tidal currents in restricted channels, and noise from marine life. In the upper Bay, and in Queen Inlet, in particular, glaciers and related processes (e.g., submarine sediment movement) produce strong low-frequency underwater rumbles that resemble thunder and may be seismic events (Malme et al. 1982). As these sounds propagate into the Bay, they occasionally can be heard as far as the Marble Islands and Bartlett Cove.

The human-made components of sound in Glacier Bay mainly are caused by water transportation activities. Cruise ships, tour vessels, charter vessels, fishing vessels, private skiffs, and airplanes contribute to underwater sound levels in areas near Bartlett Cove and other areas where park visitors may be concentrated.

Measurement of underwater noise in Glacier Bay — An underwater noise study was completed by the Naval Surface Warfare Center (NSWC) in December 2002. For that study, a hydrophone was placed in lower Glacier Bay and 5,200 underwater noise samples were collected from that location from August 2000 to June 2002. These samples were analyzed and logged into a database, and statistics were developed for natural and human-made sounds. Although no other recent studies have been conducted to define the park's underwater sound levels, some quantitative analyses of underwater noise in Glacier Bay were undertaken using measurements taken in the 1980s (see appendix C, which contains chapters entitled "Acoustic Concepts and Terminology," "Sound Propagation," "Zones of Influence," and "Marine Mammal Hearing").

Underwater sound measurements were recorded in the 1980s to determine whether Glacier Bay is more or less "noisy" than nearby open water areas. The ambient sound levels from various parts of Glacier Bay were measured by Wenz (1962) and Urick (1983), and were compared to archival data obtained from open water areas (Miles and Malme 1983), such as Bartlett Cove, as shown in figure 3-4. The data for Bartlett Cove were obtained under conditions of very light winds, so the variation in sound level over the two 8-hour measurement periods was due mainly to vessel traffic, rather than differing environmental conditions. The mean sound level from vessel traffic in Bartlett Cove was found to correspond to the wind and wave noise associated with Sea State 4 in open water. Sea State 4 is equivalent to wind speed of about 20 knots, forming moderate waves on the ocean's surface.

This long-term average for Sea State 4 conveys the impression that underwater sound levels are nearly constant; however, Miles and Malme (1983) found that, depending on the duration of the period considered (i.e., from hours to days), there actually are fluctuations in overall sound levels due to humpback whale vocalizations, ship arrivals and departures, and fishing vessel movements, at least for Bartlett Cove (see figure 3-4). These measurements were taken from a graphic-level recording sequence obtained over two 10-minute periods in Bartlett Cove (Miles and Malme 1983).

Figures 3-5 and 3-6 show that the underwater soundscape varies widely throughout Glacier Bay. Sound levels recorded at Station 17 near North Marble Island are lower than Sea State 0 (calm winds, smooth seas) at frequencies above 250 hertz. The low-frequency noise seen in figures 3-5 and 3-6 is from either distant ships or glacier motion. Intermediate levels of sound are seen in the spectrum obtained in Queen Inlet. Glacier rumbles cause the narrow-band peaks in this spectrum. Lastly, the spectrum obtained near Muir Glacier is dominated by the sound of out-gassing from the glacial ice nearby. The high-frequency sounds have a higher sound pressure level than would be obtained by wind and wave noise at Sea State 6 (wind speed about 30 knots forming large waves on the ocean's surface).

Locations of Threatened and Endangered Species

Figure 3-4

National Park Service
U.S. Department of the Interior

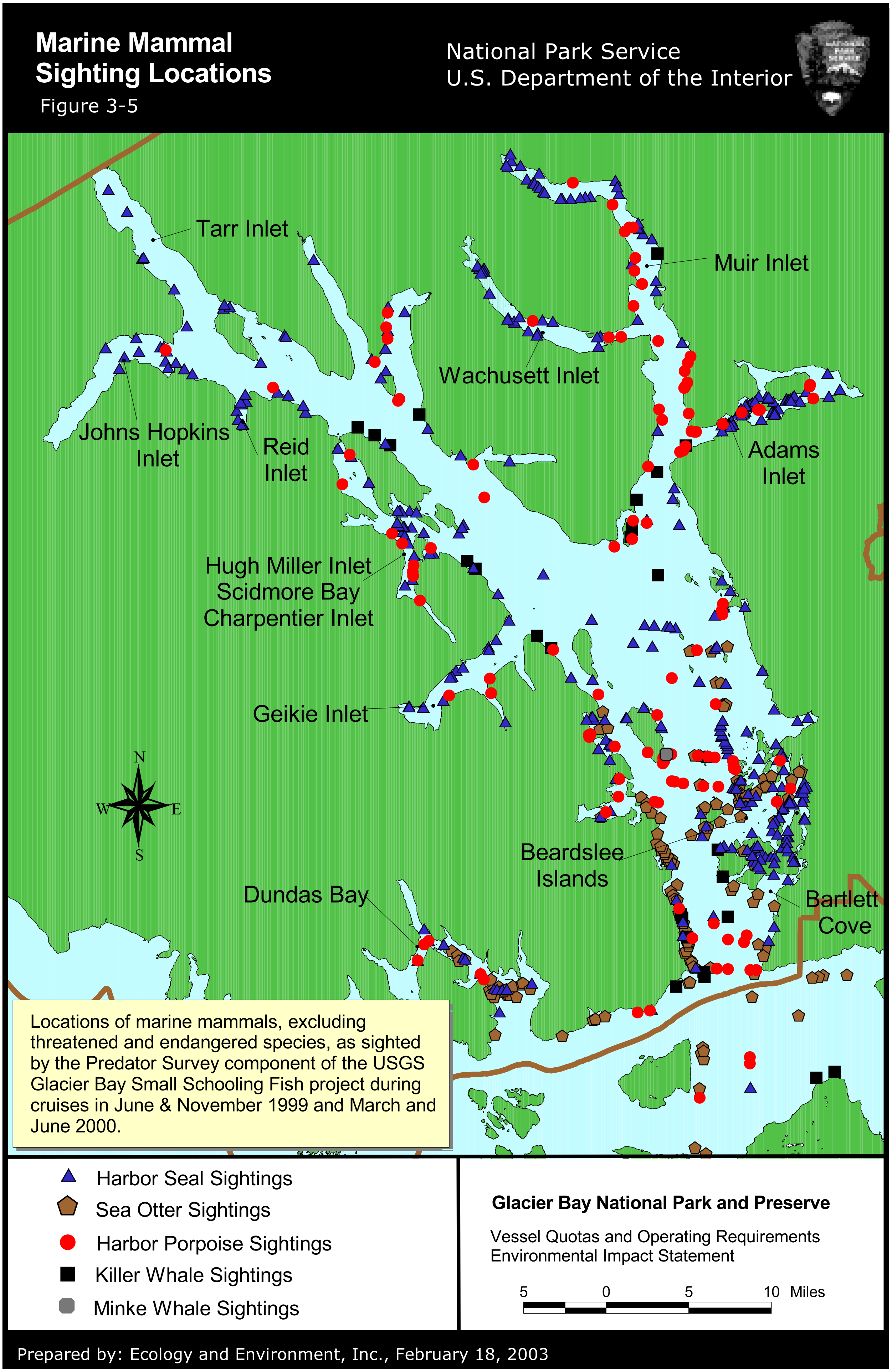
Steller Sea Lion Sightings
Steller Sea Lion Haul-Outs
Steller Sea Lion Sensitive Areas
Humpback Whale Sightings
Humpback Whale Concentration Area

Glacier Bay National Park and Preserve

Vessel Quotas and Operating Requirements
Environmental Impact Statement

5 0 5 10 Miles

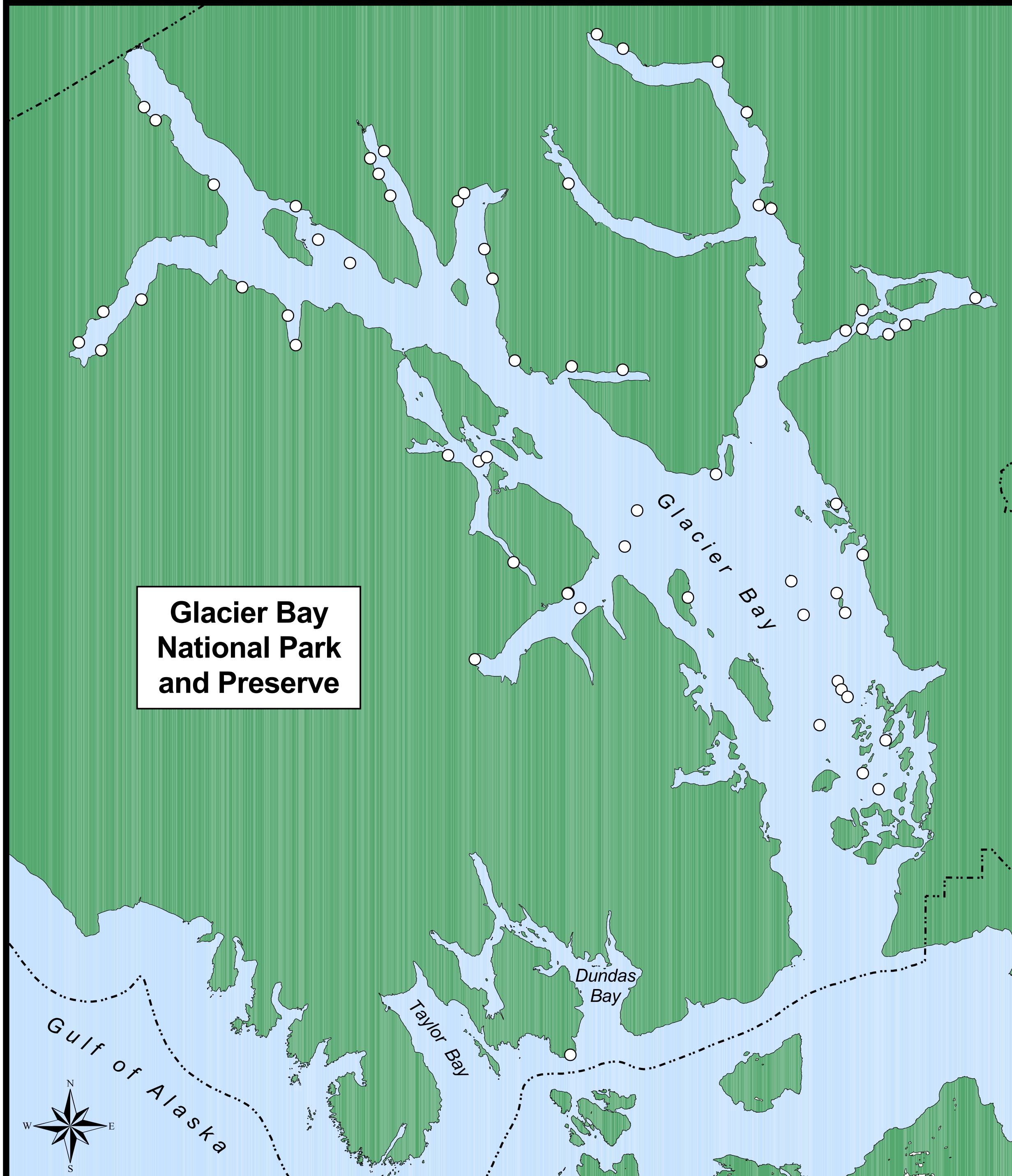
Prepared by: Ecology and Environment, Inc., February 18, 2003


Marine Mammal Sighting Locations
Figure 3-5
National Park Service
U.S. Department of the Interior
Tarr Inlet
Muir Inlet
Wachusett Inlet
Johns Hopkins Inlet
Reid Inlet
Adams Inlet
Hugh Miller Inlet
Scidmore Bay
Charpentier Inlet
Geikie Inlet
N
W
E
S
Beardslee Islands
Dundas Bay
Bartlett Cove
Locations of marine mammals, excluding threatened and endangered species, as sighted by the Predator Survey component of the USGS Glacier Bay Small Schooling Fish project during cruises in June & November 1999 and March and June 2000.
Harbor Seal Sightings
Sea Otter Sightings
Harbor Porpoise Sightings
Killer Whale Sightings
Minke Whale Sightings
Glacier Bay National Park and Preserve
Vessel Quotas and Operating Requirements Environmental Impact Statement
5 0 5 10 Miles
Prepared by: Ecology and Environment, Inc., February 18, 2003

SEABIRD COLONIES

Figure 3-6

National Park Service
U.S. Department of the Interior



Seabird Colony Locations
Park Boundary
Land
Water

Glacier Bay National Park and Preserve

Vessel Quotas and Operating Requirements
Environmental Impact Statement

5 0 5 10 Miles

Prepared by: ABR, Inc. Environmental Research and Services, February 26, 2003

Natural sources of noise in Glacier Bay — The Glacier Bay underwater noise report (NSWC 2002) identifies three main sources of natural underwater noise: wind-generated surface noise, rainfall, and marine life. The dominant source of underwater noise is wind-generated surface noise. According to this study, "in 62% of the usable samples, the 1 kHz [kilohertz] one-third octave band level was controlled by wind noise. The average wind noise level over the entire period was 83 dB [decibels] (1 kHz one-third octave band level)." The maximum noise level recorded was 100 decibels.

Rainfall noise levels averaged 89 decibels, although levels as high as 110 decibels were recorded. This study found that rain was not more prevalent in the winter months; the month with the highest number of samples per day containing rain noise was June 2002 (NSWC 2002).

This study also found that the most common source of marine life sound came from humpback whales. "Humpback whale grunts, groans, whoops, squeaks, and other similar sounds were present in 219 samples, and 24 samples contained humpback whale song sounds. Eighty-two [82] samples contained sounds from other biologic sources such as killer whales. Humpback whale sounds were most common in the August through November time period. Seventy percent of all humpback songs were observed in October 2000. The frequency of occurrence of biologic noise was compared to that of marine vessel noise. Except for October 2000, vessel noise was more common in all months" (NSWC 2002).

Description of noise range for each vessel class — As previously mentioned, the human-made components of underwater sound in Glacier Bay and Dundas Bay are produced mainly by vessel movements. Although the classes of vessels using the Bays can be categorized by type or application, this analysis focuses on vessel size and type. The database used in the 2002 Glacier Bay underwater noise study divides vessel noise into five categories: small vessel, medium vessel, large vessel, multiple types present at the same time, and other types of vessel noise. In the study, small vessels were characterized by high-speed propeller and engine noise and mainly consisted of vessels powered by outboard or inboard/outboard motors. Medium vessel noise was characterized by mid-speed propellers and larger, inboard propulsion plants. Vessels in this category generally ranged from 50 to 200 feet (15 to 60 meters) in length. The large vessel category included vessels more than 200 feet (60 meters) in length (cruise ships and Alaska state ferries fall into this category) and was characterized by slow-speed propellers and low-frequency sound.

The study found that medium vessels were the most common and constituted 62% of vessels observed. "In August 2000 and June 2002, large vessel noise, i.e. large cruise ships, reached an average of about 4 samples per day. . . . On the average, large vessels were slightly louder at the hydrophone than medium and small craft. Large vessels averaged 98 dB, while the average noise levels for medium and small vessel were 93 and 96 dB, respectively. A large vessel logged the highest level, 129 dB. The maximum level for both medium and small vessels was 126 dB" (NSWC 2002). The frequency range for large vessels was found to be typically within the lower end of the spectrum, between 80 and 200 hertz. Medium vessels varied, between 125 and 3,150 hertz, and small vessels typically peaked at frequencies above 800 hertz (NSWC 2002).

The summer months, as expected, were when vessel noise was most common, but even during this time period, 40% of noise samples contained no vessel noise. In October through April, approximately 90% of samples were free of vessel noise. During May and September, 60% of samples had no vessel noise. "On the average, vessel noise levels exceeded wind noise levels. Overall the average vessel noise level was 94 dB, 11 dB greater than the average wind noise" (NSWC 2002).

3.2.3 Air Quality

Ambient air in the park and preserve is not monitored. It is assumed, however, that because of the presence of only a few small emission sources at several locations in the park, air pollutant levels in the park are low, and well below any existing ambient air quality standards.

The Alaska Department of Environmental Conservation (ADEC) conducted air quality monitoring in Juneau from May to July 2001 and August to September 2001. This study determined that ambient air levels of nitrogen oxides (NO_X), sulfur dioxide (SO_2), and particulate matter of 10 microns or less (PM_{10}) are well below state and federal allowable limits. Maximum readings of ambient air concentrations of nitrogen dioxide, sulfur dioxide, and particulate matter of less than 10 microns are between 10% and 40% of the National Ambient Air Quality Standards (NAAQS; ADEC 2001a). Because Juneau has similar air pollution sources, but many more than the park, these findings support the assumption that the park's air pollutant levels do not exceed the National Ambient Air Quality Standards.

Air emission sources within the park include exhaust from fuel combustion during vessel operations, fuel combustion for heating of buildings at Bartlett Cove, fuel use by vehicles in the park, occasional campfires, exhaust from electric power generators, and vessel traffic emissions. Emissions from motorized vessels contain respirable PM_{10} (particulate matter that can be taken into the lungs) and particulate matter smaller than 2.5 microns in diameter ($PM_{2.5}$), carbon monoxide (CO), sulfur dioxide, nitrogen dioxide (NO_2), lead (Pb), and ozone (O_3).

Other trace constituents found in the fuels used by the vessels are negligible and are not considered in this evaluation. Visibility reductions occasionally occur in the park during certain unique weather conditions that trap air pollution within a layer of cold air near the surface.

Meteorological Conditions. Meteorological conditions, such as wind speed and atmospheric stability measurements (determined by difference in temperature at different heights at the same location), provide information about air movement at a location, and influence the dispersion of air pollutant emissions. No meteorological recording station exists within the park to record these specific data; therefore, there are no park-related routine short- or long-term weather data records or climatological statistics that can be used to describe average conditions. Meteorological data from the Gustavus Airport are insufficient to evaluate conditions in the fjords because of the drastic difference in topography.

Based on a 1978 air pollution study, Bensen et al. (1978) concluded that within the fjords, atmospheric mixing is limited because of low wind speeds and temperature inversions. Temperature inversions form because air within a layer from the water surface to approximately 35 to 100 feet (10 to 30 meters) above the water surface is cooler than the air above that layer. This cold air layer develops because low wind speeds limit the ability of the atmosphere to completely mix. Emissions into the cooler air layer within the fjords cannot readily disperse because of low wind speeds, and are trapped below the warmer air above the cooler layer. Bensen et al. (1978) estimated that temperature inversions occurred for at least part of the day on about one-third of all days, and occurred mainly during clear conditions. During temperature inversion and low wind speed conditions, pollution is more likely to remain trapped in the park's fjords.

Existing Air Emissions. Existing air emissions were estimated using 2001 vessel operation data (NPS, Nemeth, electronic mail, October 21, 2002). The estimation method is detailed in appendix D. Table 3-1 presents estimates of daily emissions in the park, using daily maximum quotas. Annual data provided by the park are used to calculate annual emissions. These emissions are distributed from the entrance of Glacier Bay to the heads of the West and East Arms and other side bays and fjords as the vessels move through the Bay. The annual emissions are calculated from the estimated maximum vessel traffic during the operating season (April through October) and expressed in tons per year (see table 3-1). These estimates present the high end of the expected total emissions of the criteria pollutants from vessels operating in Glacier Bay.

TABLE 3-1: 2001 EMISSIONS FROM VESSELS IN GLACIER BAY

Emissions Pounds per Day (lbs/day) (maximum allowable entries)						
Vessel Type	**# entries**	**PM**	**NO_X**	**SO_2**	**CO**	**HC**
Cruise Ships	2	136.01	4,393.30	486.65	511.46	57.50
Tour Vessels	3	23.00	925.84	103.14	98.33	9.38
Charter Vessels	6	7.42	297.51	33.00	35.42	3.70
Private Vessels	25	70.53	2,836.98	315.80	307.51	29.93
Total		236.96	8,453.63	938.59	952.72	100.51
Emissions Tons per Year (TPY)[a]						
Cruise Ships	219	7.45	240.53	26.64	28.00	3.15
Tour Vessels	435	1.25	50.34	5.61	5.35	0.51
Charter Vessels	316	0.20	7.83	0.87	0.93	0.10
Private Vessels	2,004	2.83	113.69	12.66	12.32	1.20
Total		11.73	412.39	45.78	46.60	4.96

a. Includes the season and off-season (May through September).

CO = Carbon dioxide.
HC = Hydrocarbons.
NO_x = Nitrogen oxides.
PM = Particulate matter.
SO_2 = Sulfur dioxide.

Visibility. No historical data regarding visibility within the park, other than personal observations, are available. Daily emission totals, visible plumes of smoke from vessel stacks, and weather conditions contribute to reductions in visibility. During temperature inversions or days with low winds, stack emissions do not dissipate quickly and can result in long plumes from vessel stacks that block views. Visible vessel emissions can produce haze within the park.

3.2.4 Water Quality

This subsection describes Glacier Bay's current water quality and the physical conditions that affect marine water quality in the park.

Natural Factors Affecting Water Quality in the Park. Water quality is affected by many factors, including runoff, sedimentation, tidal variations, large-scale mixing and upwelling zones, and the overall complex underwater topography or bathymetry of the area. These factors cause high variability in salinity, temperature, sediment, productivity, light penetration, and current patterns (Hooge and Hooge 2002). In addition, the year-round glacial meltwater input (water from the melting of glacial ice when it contacts the ocean) is thought to stimulate estuarine circulation even through the winter (Hooge and Hooge 2002).

Existing Water Quality. Conclusions regarding overall water quality for Glacier Bay are limited. No data are available to assess the current or historical water quality of Dundas Bay. No water body in the park is on the Alaska Clear Water Action list, which identifies impaired waters in need of action to recover water quality, and none are included on the list of impaired water bodies as regulated under section 303(d) of the Clean Water Act (CWA).

The NPS Water Resources Division (WRD) created a database inventory of existing water quality data for Glacier Bay collected from 1963 to 1993. According to a summary report of the database, the results of the water quality criteria screening indicated that turbidity exceeded the WRD screening limit for the protection of aquatic wildlife; however, high turbidity exceeding WRD turbidity standards is normal in many glacial meltwater stream systems within the park. Additional conclusions about the overall quality of Glacier Bay are not provided (NPS 1995b).

Water quality parameters — Water quality data collected in the park include information regarding salinity, temperature, and turbidity from 1992 to 2000 (Hooge and Hooge 2002). Water quality information for Dundas Bay is not available. Conclusions regarding the available water quality data include the following:

- **Salinity**. Salinity is a measure of the total dissolved solids in water. Salinity in Glacier Bay ranges from 3.8 to 31.9 parts per thousand (ppt). Salinity generally increases from the head of Glacier Bay to the mouth. The least saline waters were found near tidewater glaciers, and the most saline waters were at depth near and just outside the mouth of Glacier Bay. By comparison, the average ocean salinity is 35 parts per thousand. Variations can be caused by river runoff, ice formation, and precipitation.
- **Temperature**. Surface water temperature is highly variable from the mouth of Glacier Bay to its headwaters, with ranges of 1.9 to 12.2 degrees Celsius (°C), respectively, and varies with the season. Deeper waters experience less variation than do surface waters and range from 4.5 to 5.75°C. Pan ice frequently forms on the surface of smaller embayments of the upper 10 to 20

kilometers of the West and East Arms in the winter months. A recent study describes a warming trend of the Bay of up to 2°C on average. This warming trend could be a result of increased temperatures in the Gulf of Alaska. The increase in temperature is consistent with increased glacial melting in the winter, and may in part account for the differences in circulation, mixing, and renewal noted in this recent study, as compared with research conducted in the 1960s. The recent study identifies the Bay as characterized by renewal and mixing events throughout the year (Hooge and Hooge 2002).

- **Turbidity**. Turbidity is the cloudiness of water resulting from suspended particles, including silts and clays, microorganisms, and chemicals. Although highly variable, background turbidity levels of at least 5 to 15 millivolts (mV) were found throughout Glacier Bay and in Icy Straight. Much higher turbidity levels were detected immediately adjacent to the tidewater glaciers of the upper East and West Arms— up to 231 millivolts in the West Arm and up to 531 millivolts in the East Arm. This turbidity is attributed primarily to turbid glacial meltwater inputs. Peak sediment discharges occurred in August and September, with the fewest discharges occurring in October and May. Sedimentation rates in Glacier Bay were among the highest rates ever recorded.

3.3.1 Threatened and Endangered Species

3.3 BIOLOGICAL ENVIRONMENT

3.3.1 Threatened and Endangered Species

This subsection addresses the two species, both marine mammals, that are resident seasonally or year-round within Glacier Bay and Dundas Bay and that are listed as threatened or endangered under the Endangered Species Act (ESA) of 1973. The central North Pacific stock of humpback whales occurs seasonally and is listed as endangered. The eastern stock of Steller sea lions uses a haul-out (Marble Island) in Glacier Bay, may use one rookery (Graves Rock) along the outer coast of the park, and is listed as threatened. The United States Geological Survey identified habitat used by schooling fish predators in Glacier Bay, including humpback whales and Steller sea lions. Humpback whale and Steller sea lion concentration areas, sensitive areas, haul-outs, and sightings are identified on figure 3-4.

Each of the following subsections regarding the humpback whale and the Steller sea lion includes discussions of their respective population and status, reproduction and recruitment, and natural history. One concern of this environmental impact statement is the effects that sounds generated by vessels have on these species and the other marine mammals in Glacier Bay, so the natural history subsections include discussions of the sounds that each species makes.

The sounds created by marine mammals are a good indication of frequencies important to those species. “Marine Mammal Hearing,” the last subsection within subsection 3.3.1, is applicable to the humpback whale and Steller sea lion, as well as to the species in subsection 3.3.2, “Marine Mammals.”

Humpback Whale *(Megaptera novaeangliae)*.

Population, status, distribution, and demographics **—** Humpback whales are baleen whales that occur in all ocean basins (Rice 1998). Their range extends from Disko Bay in northern Greenland to the pack-ice zone around the Antarctic continent. Commercial whalers heavily exploited humpbacks throughout their range. In 1955, the International Whaling Commission (IWC) prohibited commercial hunting of humpbacks in the North Atlantic, and in 1965, their protection was extended to the North Pacific and Southern Hemisphere populations. Humpback whales were declared an endangered species in 1973, and all populations remain endangered.

The humpback population before commercial exploitation is estimated to have been more than 125,000 worldwide (Rice 1978, NMFS 1991). Commercial whalers heavily exploited humpbacks until the middle of the 20th century. American whalers alone killed 14,164 to 18,212 humpbacks from 1805 to 1909 (Best 1987), and the total North Pacific kill is estimated to be 28,000 (Rice 1978).

By the time the IWC moratorium on commercial whaling occurred after the 1965 hunting season, the worldwide population of humpbacks was estimated to have declined to fewer than 5,000 (Baker et al. 1993). Currently, there is no reliable estimate of the total worldwide population of humpback whales, although the population may be between 10,000 and 12,000 (Braham 1984).

A recent study (Calambokidis et al. 1997) estimated the total North Pacific humpback whale population to be 6,000 to 8,000, well above the 1,400 estimated in the 1960s. Genetic studies (Baker et al. 1993) and photo-identification studies (Calambokidis et al. 1997, 2001) indicated that individual humpback whales tend to return to the same summering and wintering areas year after year. Humpbacks identified at some feeding areas also showed a preference for particular wintering areas: whales feeding in Southeast Alaska (including Glacier Bay) tended to migrate to Hawaii, while whales feeding off California migrated to Mexico (Calambokidis et al. 1997, 2001).

The limited movements of whales between wintering and feeding areas, and the genetic differences among whales utilizing different feeding areas, make it inappropriate to treat the North Pacific as a single population of humpbacks. Calambokidis et al. (1997) concluded that there are at least three populations of humpback whales in the North Pacific: those wintering off Hawaii, Japan, and Mexico. While fidelity to wintering areas is currently the most defensible way to subdivide the North Pacific population, there is also fidelity to feeding areas. Identifiable populations or subpopulations may be associated with those feeding areas (Calambokidis et al. 1997).

Humpback whales were first observed near the mouth of Glacier Bay in 1899, and were reported intermittently throughout the Bay by the 1950s and 1960s (Vequist and Baker 1987). The Park Service has monitored the humpback whale population of Glacier Bay each year since 1985 to document the number of individuals, residence times, spatial and temporal distribution, reproductive parameters, feeding behavior, and human/whale interactions (Doherty and Gabriele 2001). These data are used to form NPS policies regarding when and where vessel operating restrictions in whale waters are needed during the summer visiting season. The NPS whale monitoring program covers most of Glacier Bay and Icy Strait.

Humpback whales are found throughout Glacier Bay and Dundas Bay (see figure 3-4). Feeding congregations often use specific areas such as Bartlett Cove, Sitakaday Narrows, Whidbey Passage, and the East Arm (Doherty and Gabriele 2002). Whale sightings in areas where NPS personnel do not routinely survey (e.g., non-motorized waters) are reported by park visitors and staff on an opportunistic basis; therefore, the presence of whales in these areas is probably under-reported.

The whales that inhabit the park are part of the Southeast Alaska feeding herd; Straley (1994) estimated this herd to be 404, but it could range from 350 to 458 (95% confidence interval of 350 to 458). Site fidelity to the Glacier Bay area is high. Approximately 70% of the whales identified in the Glacier Bay area have been re-sighted in the Glacier Bay / Icy Strait area (Gabriele 1995). The number of whales that used the park and Icy Strait from 1985 to 2001 ranged from 41 to 104 (Doherty and Gabriele 2001). The humpbacks typically move between Glacier Bay and Icy Strait and other areas of Southeast Alaska (Baker 1986; Baker et al. 1990; Straley 1994).

The total 2001 count of 97 whales using Glacier Bay and Icy Strait is the second highest recorded since 1985, despite a low number of survey hours in the study areas (Doherty and Gabriele 2001); however, relatively few whales (45) were seen in the park, while more whales were recorded in Icy Strait (82) than ever before (Doherty and Gabriele 2001). This suggests that whales may have moved from the park to Icy Strait during 2001, presumably because of differences in prey availability (Doherty and Gabriele 2001).

Reproduction, recruitment, and calf return **—** Humpback whales give birth and are presumed to mate on their Hawaii wintering grounds. Calambokidis et al. (1997) indicate that whales found in Glacier Bay and Dundas Bay calve in Hawaii. Female humpbacks typically reproduce at one- to two-year intervals, although calving intervals vary substantially (Glockner-Ferrari and Ferrari 1990; Straley 1994). Calf survivability is difficult to determine because the color patterns of a calf's flukes and body change between seasons and it is often difficult to identify a specific calf from one year to the next; however, the maximum calf mortality rate has been estimated to be 0.150 to 0.241 (Gabriele et al. 2001). Comparison of the estimate for the central North Pacific stock of 6,000 to 8,000 humpbacks (Calambokidis et al. 1997) to the 1981 estimate of 1,407 (Baker and Herman 1987) suggests that the stock increased from the early 1980s to the late 1990s. The estimate by Baker and Herman (1987) is questionable, however, because of small sample size; therefore, while these data appear to support an increasing humpback population in the central North Pacific stock, it is not possible to accurately assess the rate of increase (NMFS 2001a).

Natural history (prey and prey dynamics, temporal and spatial use patterns, and use of sound) **—** Whales in the park typically feed alone or in pairs, mainly on small schooling fishes such as capelin *(Mallotus villosus)*, juvenile walleye pollock *(Theragra chalcogramma)*, sand lance *(Ammodytes hexapterus)*, and Pacific herring (*Clupea pallasii*; Wing and Krieger 1983; Krieger and Wing 1984). Several stable "core groups" commonly are found feeding at Point Adolphus, Bartlett Cove, and Pleasant Island Reef (Baker 1985b; Perry et al. 1985; Gabriele 1997). Whales in the park tend to feed below the surface. Lunge feeding, bubblenet feeding, and other surface feeding modes that were commonly seen in the 1970s (Jurasz and Jurasz 1979) are now rarely seen (Baker 1985b; Gabriele

1995). Very few direct observations of humpback whales consuming their prey have been made, because this typically happens underwater; however, in 2001, humpbacks were photographed feeding on sand lance in Adams Inlet (Doherty and Gabriele 2001). The results of studies conducted during commercial whaling operations identified a wide range of prey species for humpbacks in the North Pacific (Frost and Lowry 1981).

The availability of humpback whale prey in terms of distribution and abundance appears to vary considerably both spatially and temporally within the park and other areas of Southeast Alaska within and between years (Vequist and Baker 1987). Such variations are probably caused by many physical and biological factors. Most likely, the variability in humpback whale abundance and occupancy time in the park is driven by the variability in prey availability. Following a record-high number of whales (62) recorded in the park during 1998 (Doherty and Gabriele 2001), the number of whales recorded within Glacier Bay declined to a low of 45 in 2001. Concurrent studies of small schooling fish in Glacier Bay (Robards et al. 1999; J. Piatt, pers. com., in Doherty and Gabriele 2001) indicated that prey species, including capelin, were “surprisingly absent” from the Bay during that same time period, although data regarding the abundance and distribution of forage fish in Glacier Bay and Icy Strait are not collected annually.

The number of whales using the park typically rises in mid-June, peaking in July and August. Abundance is lower in May and September, and lowest from October through April. In 2001, however, whale activity did not concentrate in the lower Bay until late August, and Bartlett Cove was not used as heavily as it had been in most of the several previous years (Doherty and Gabriele 2001). By contrast, humpback use of Icy Strait far exceeded that documented for previous years.

Male humpback whales sing long, complex songs on their wintering grounds (Payne and McVay 1971). These songs are likely associated with reproduction (Tyack 1981). Song elements range from less than or equal to 20 hertz to 4 or 8 kilohertz, with estimated source levels ranging from 144 to 174 decibels relative to 1 micropascal (dB re 1 μPa; Thompson et al. 1979). The songs are shared by all singing whales while on the breeding grounds and may serve to attract reproductive females, or they may be a form of competitive behavior with other whales. Humpback songs have also been recorded on feeding grounds in Stellwagen Bank in the North Atlantic (Mattila et al. 1987), as well as in Southeast Alaska (McSweeney et al. 1989), and have occasionally been recorded on the high-latitude summer feeding grounds in late summer or early fall (Mattila et al. 1987; McSweeney et al. 1989; Gabriele et al. 2001). The songs heard on the summering grounds are generally condensed versions of songs heard during the winters surrounding the summer feeding season. The function of songs on the summer feeding grounds is unknown. Gabriele et al. (2001) suggest that the increase in song frequency in fall may correspond with the beginning of hormonal activity in male humpbacks associated with the migration to the wintering grounds. Although songs appear to be rare in summer, they increase in frequency in fall, and are heard in pelagic waters as whales make their migration to wintering grounds (Mattila et al. 1987).

Humpback whales also have been recorded uttering stylized rhythmic vocalizations identified as “feeding calls” (Jurasz and Jurasz 1979) and “cries” while feeding cooperatively in Southeast Alaska (Cerchio and Dahlheim 2001). Feeding calls range from 236 to 1,219 hertz (Cerchio and Dahlheim 2001) and are similar within series, but different between series (Cerchio and Dahlheim 2001). It has been suggested that these calls may serve to manipulate prey distribution by creating a broad band of frequencies to which the prey may be sensitive (e.g., scaring fish into tighter groups). The calls also may be assembly calls, but not to coordinate feeding (Baker 1985b). Researchers have also concluded that the cries carry signature information (Sharpe et al. 1998).

Humpbacks also produce sounds associated with agonistic behavior (aggressive, negative behavior, such as fighting, threatening, and fleeing) in social groups on the wintering grounds. These sounds extend from 50 hertz to approximately 10 kilohertz. These sounds may elicit response from humpbacks up to 5.5 miles (9 kilometers) away (Tyack and Whitehead 1983).

All information regarding hearing in baleen whales (which include humpbacks) is based on behavioral observations, anatomical evidence, and extrapolations from other marine mammal hearing characteristics. Field observations of the responsiveness of baleen whales to sounds can set an upper bound for detection thresholds; however, it is not possible to clarify the whales’ reactions to sounds at levels lower than those that elicited a response. The whales either could detect the sounds but simply did not overtly respond, or may not have detected the lower-level sounds at all. Humpback whales reacted to calls from other humpbacks at levels as low as 102 dB re 1 μPa, and bowhead whales fled from an approaching boat when the noise level was 90 dB re 1 μPa (Frankel et al. 1995; Richardson and Greene 1993).

Baleen whales are probably able to hear low-frequency sounds, including infrasounds (less than 20 hertz), and react to sounds from members of their same species that range from 20 hertz (fin whales) to 550 hertz (humpback whales; Watkins 1981; Frankel et al. 1995). Humpback, gray, and bowhead whales react to airgun pulses and underwater playbacks of low-frequency (50 to 500 hertz) human-made sounds (Richardson et al. 1995). Anatomical evidence also suggests that baleen whales are adapted to hear low-frequency sounds (Ketten 1998). The upper bounds of baleen whale hearing are not as high as those of odontocetes. Humpback whales reacted to sonar signals at 3.1 to 3.6 kilohertz and broadband clinkers centered around 4 kilohertz (Lien et al. 1990, 1992; Maybaum 1993). Watkins

(1986) reported that baleen whales react to sonar sounds up to 28 kilohertz, but not to sounds 36 kilohertz and above.

Steller Sea Lion *(Eumetopias jubatus)*.

Population, status, distribution, and demographics — Steller sea lions occur in the coastal and immediate offshore waters of the North Pacific. They are distributed from the Bering Strait along the Aleutian Islands, the Kuril Islands, and the Okhotsk Sea to Hokkaido, Japan, in the western Pacific, and along the coast of North America to the Channel Islands off Southern California in the eastern Pacific (Rice 1998). Two stocks of Steller sea lions are recognized in U.S. waters, based on differences in population dynamics (York et al. 1996) and mitochondrial DNA sequence distribution (Bickham et al. 1996). Cape Suckling (144º W longitude, 308 miles [495 kilometers] west of Gustavus, Alaska), located in the north-central Gulf of Alaska between Prince William Sound and Icy Bay, forms the boundary between these two stocks, dividing them into eastern and western populations (Loughlin 1997). Sea lions from the eastern U.S. stock are most likely to enter Glacier Bay and Dundas Bay, although members of the western stock can travel the distance to the park and have been observed within Glacier Bay. Aerial and ground-based surveys suggest that the minimum population size of the eastern U.S. stock of Steller sea lions is 31,005 (Angliss et al. 2001a). Matthews (1993a) documented that more than 1,100 sea lions (approximately 9% of the Southeast Alaskan population at the time) used haul-outs in Glacier Bay and along the park's outer coast. The U.S. Geological Survey identified a haul-out on South Marble Island and several "sensitive areas," or areas where a number of sea lions may haul out for up to a few weeks at a time, in some years (see figure 3-4).

Steller sea lions were declared a threatened species throughout their range in 1990. In 1997, the western stock was listed as endangered (Loughlin et al. 1992; 62 *Federal Register* 30772, June 5, 1997) as a result of the precipitous decline in the Alaskan population from 140,000 in 1956 to between 60,000 and 68,000 in 1985 (Merrick et al. 1987). World-wide, the population dropped from between 240,000 and 300,000 to 116,000 (Loughlin et al. 1992) during a 30-year period. The decline in numbers has been greatest for the western stock, with some breeding rookeries in the Aleutians declining as much as 87% between 1960 and 1989 (Loughlin et al. 1992). There has been no associated decline in the eastern stock, with the number of Steller sea lions in Southeast Alaska showing increases by as much as 70% between 1960 and 1989 (Loughlin et al. 1992). Although Kruse et al. (2001) have reported that abundance of the eastern stock may be the highest ever recorded and that reevaluation of the threatened listing is warranted, the eastern stock is still listed as threatened (Angliss et al. 2001a).

Reproduction and recruitment — Steller sea lions are the largest member of the family *Otariidae* (eared seals) and show pronounced sexual dimorphism, with males being two to three times larger than females. Adult males average 1,250 pounds (566 kilograms; maximum 2,470 pounds [1,120 kilograms]), and the average length is 111 inches (282 centimeters), while adult females average 580 pounds (263 kilograms; maximum 770 pounds [350 kilograms]) with an average length of 90 inches (228 centimeters; Calkins and Pitcher 1982; Loughlin and Nelson 1986).

During the breeding season, adult sea lions use some haul-outs as rookeries where adult males establish territories, breeding occurs, and pups are born. Breeding adults occupy rookeries from late May to early July (NMFS 1992). Males become sexually mature at three to seven years and physically mature around 10 years of age. Physically mature males may gain and hold a territory for up to seven years (NMFS 1992). Females become sexually mature at three to six years and may produce young into their early 20s. Most females breed annually. Copulation occurs approximately 11 to 14 days postpartum, but implantation is delayed until late September to early October. Pups are born from late May to early July. Pups are usually weaned by the end of their first year, but may continue to nurse until age three (Lowry et al. 1982). Females frequently return to the same pupping site within the rookery in successive years, although the site may or may not be in the same territory within the rookery.

The pregnancy rate of mature females in the Gulf of Alaska in April and May 1985 was 60%, a rate slightly lower than the 67% recorded between 1975 and 1978 (NMFS 1992). A decline in juvenile survival appears to be an important cause of the declines in western Alaskan stocks of Steller sea lions. Declines in the numbers of juvenile sea lions have been reported at many Alaskan rookeries and haul-outs since the 1980s (Merrick et al. 1987; Loughlin et al. 1992); however, the ultimate causes of the decline in survival are not yet understood.

Natural history — Steller sea lions haul out on beaches and rocky shorelines of remote islands, often in areas exposed to wind and waves (NMFS 1992). Sometimes haul-outs with gently sloping beaches that are protected from waves are used as rookeries (NMFS 1992). There are three known rookeries in Southeast Alaska: Hazy Island and White Sisters Island near Sitka, and Forrester Island near Dixon Entrance (Calkins et al. 1996). Recently, up to 49 pups were seen in June 2000 and 2001 on Graves Rock along the park's outer coast; this area may be a new rookery (Raum-Suryan and Pitcher 2000; Raum-Suryan 2001).

During the non-breeding season, sea lions may disperse great distances from the rookeries. For example, juvenile sea lions branded as pups on Forrester Island, located west of Prince of Wales Island, have been observed at South Marble Island in the park (Mathews 1996) — a distance of more than 200 miles south of the park — and some juveniles from the western stock have been observed at South Marble Island and Graves Rock within the park (Raum-Suryan 2001).

Killer whales and sharks probably prey on Steller sea lions, although the effect of these predators is not known (NMFS 1992). Natural mortality is highest for pups, and includes drowning, starvation, crushing by males, disease, predation, and aggression from females other than the mother.

Steller sea lions eat a variety of fishes and invertebrates. In Alaska, walleye pollock is the principal prey item, followed by Pacific cod, octopus, squid, herring, flatfishes, and sculpins. Harbor seals, spotted seals, bearded seals, ringed seals, fur seals, and sea otters are occasionally eaten by adult male Steller sea lions (Gentry and Johnson 1981; Lowry et al. 1982; Pitcher and Fay 1982; NMFS 1992).

No information regarding the frequency, composition, or source levels of Steller sea lion calls exists. Only California sea lion calls have been recorded and analyzed, and these are thought to be generally consistent with those of Steller sea lions. California sea lion males bark incessantly while defending territories on rookeries. Barks have most energy at less than 1 kilohertz. Females bark at intruders in their territory, and squeal, belch, and growl. Females exchange calls with new pups for several hours after birth. Mothers and pups are then able to recognize one another by their calls (Trillmich 1981). Female belches and growls have most energy between 0.25 and 4 kilohertz, female/pup attraction calls are 1 to 2 kilohertz, and the pup's bleat is 0.25 to 6 kilohertz (Peterson and Bartholomew 1969). Male Steller sea lions roar and hiss to defend rookery territories, and females defend birthing territories with barks and growls.

Underwater sounds of California sea lions are generally associated with social situations (Schusterman et al. 1966). Most underwater sounds are barks that are produced while the head is above the surface. Most of the energy is at frequencies below 2 kilohertz, and is similar in water and air (Schevill et al. 1963). When submerged, California sea lions produce barks, whinny and buzzing sounds, and click trains (Schusterman et al. 1966). Steller sea lions are said to produce clicks, growls, snorts, and bleats under water (Poulter 1968).

Marine Mammal Hearing. Sound and the way in which humpback whales and Steller sea lions perceive it are important factors by which the effects of altering the vessel quota and operating requirement strategies will be evaluated. This subsection describes the factors affecting marine mammals' hearing and how marine mammals hear. This information is applicable to all marine mammals and therefore is applicable to subsection 3.3.2. Table 3-2 includes definitions of terms related to underwater acoustics that are used throughout this subsection.

TABLE 3-2: UNDERWATER ACOUSTICS TERMS

Hertz (Hz)	A unit of frequency equal to one cycle per second that is abbreviated as Hz. The usual metric prefixes apply (1,000 hertz is equal to 1 kilohertz).
Low-frequency sound	Below 1,000 Hz. Typical low-frequency underwater sounds are made by large ships as well as the vocalization of marine animals. To the human ear in air, 262 Hz sounds like middle C on the musical scale (Richardson et al. 1995).
Mid-frequency sound	1,000 Hz to 10,000 Hz. Natural underwater mid-frequency sounds are typically created by marine mammals (mainly dolphins) and precipitation.
High-frequency sound	Above 10,000 Hz. Natural underwater high-frequency sounds are typically created by snapping shrimp and echolocation of marine mammals.
Sound intensity	Sound measurements can be expressed in two forms: intensity and pressure. The intensity of a sound is the average rate of energy transmitted through a unit area in a specified direction, expressed in Watts per square meter (W/m^2). Acoustic intensity is rarely measured directly. Instead, when acousticians refer to intensities or powers, they derive them from ratios of pressures. To present sound measurements as ratios of pressures that can be compared to one another, a standard reference pressure needs to be used in the denominator of the ratio. The American National Standard and the international (metric) standard is to use 1 micropascal (µPa) as the reference pressure for underwater sound and 20 µPa as the reference pressure for airborne sounds.

Factors affecting marine mammal hearing — The hearing abilities of marine mammals (and other animals) are functions of the following (after Richardson et al. 1995):

- absolute hearing threshold — the level of sound that is barely audible in the absence of significant ambient noise.
- frequency and intensity discrimination — the ability to discriminate among sounds of different frequencies and intensities.
- directional hearing — the ability to localize sound direction at the frequencies under consideration.
- auditory masking — the ability or inability to distinguish target sounds from ambient noise.
- motivation — the psychological state of the animal may influence whether the sound is detected, and whether the animal reacts.
- individual variation — the variation in hearing sensitivity between individuals.

Following are summaries of the above items; each of these topics is described in depth in appendix C.

Absolute hearing threshold — Odontocetes or toothed whales (in Glacier Bay and Dundas Bay, these include the killer whale, harbor porpoise, and Dall's porpoise) generally have very acute hearing at the middle frequencies, with lower sensitivity at low and high frequencies. The best frequencies for seven species of odontocetes range from approximately 8 to 90 kilohertz (Richardson et al. 1995).

Pinnipeds in the *Phocidea* family (fur seals, which include the harbor seal found in Glacier Bay and Dundas Bay) generally hear from 1 kilohertz to between 30 and 50 kilohertz, with thresholds between 60 and 85 dB re 1 μPa (Richardson et al. 1995). Sensitivity for most phocids remains good until approximately 60 kilohertz, after which sensitivity is poor (Richardson et al. 1995).

Underwater sensitivity at the high- and low-frequency ends for pinnipeds in the *Otariidae* family (which includes the Steller sea lion found in Glacier Bay and Dundas Bay) is generally lower than that for phocids, but there is little difference in the middle frequencies (Richardson et al. 1995). The high-frequency limit for most otariids appears to be approximately 36 to 40 kilohertz (Schusterman 1981), and sensitivity in the 100-hertz to 1-kilohertz range appears to be lower than that for phocids.

Pinnipeds respond to airborne sounds as well as underwater sounds. Otariids apparently are more sensitive to airborne sounds and appear to detect higher-frequency airborne sounds more than phocids. The high-frequency limit of airborne sounds for otariids is similar to the underwater limit of 36 to 40 kilohertz, whereas for phocids, the upper limit appears to be around 20 kilohertz, considerably lower than the 60-kilohertz limit under water. Sensitivity to airborne sounds for otariids and phocids deteriorates as the frequency goes below 2 kilohertz.

Mysticetes or baleen whales include the humpback and minke whales found in Glacier Bay and Dundas Bay. It is not known how well baleen whales use low-frequency sound, but the anatomy of their auditory organs suggests that they may have good low-frequency hearing.

Frequency and intensity discrimination — The ability to differentiate between two signals of different frequency and intensity is important in detecting sound signals amidst background noise. This ability is also important for detecting calls from the same species, prey, and predators. Odontocetes (toothed whales) apparently have very good frequency discrimination and may be able to detect intensity differences as small as 0.35 to 2 decibels (Johnson 1971). No information is available for mysticetes. There is little data regarding the ability of pinnipeds to detect differences in intensity, but it is believed that pinnipeds have less precise frequency discrimination than odontocetes.

Directional hearing — The ability to localize sounds may be important for interactions among social marine mammals, and for prey detection by echolocation or passive signal detection. In mysticetes, the auditory organs are isolated from the skull, enhancing the ability to localize sound. There is some indirect evidence that baleen whales have the ability to localize sounds at frequencies of a few hundreds to tens of hertz (Richardson et al. 1995). Baleen whales sometimes orient and swim toward distant calling from others of their species (Watkins 1981; Tyack and Whitehead 1983), or swim directly away from predator calls (Malme et al. 1983) or industrial noise (Richardson et al. 1995).

Odontocetes also have very good ability to localize sound, as might be expected based on knowledge of their echolocation abilities.

Pinnipeds' auditory structures are fused to the skull, which suggests a reduced ability to localize underwater sounds. Accordingly, pinnipeds have less precise abilities to localize sounds than odontocetes, but pinnipeds have other adaptations for hearing in-air and underwater sounds.

Auditory masking — Normal background noise (natural and human-made) may mask other sounds, interfering with the ability of an animal to detect a sound signal. In general, the masking effect of background noise is reduced if the noise either comes from a direction other than that of the target or is omnidirectional (Richardson et al. 1995).

In general, marine mammals that localize sounds reduce the effect of masking through directional hearing. That is, masking is not as severe for important sounds that come from directions different from those of the noise. In order to reduce masking, marine mammals may shift the frequency of their calls from a "noisy" frequency band to one with less ambient noise (Lesage et al. 1999), increase the length of calls (Miller et al. 2000), change the duration of elements in calls (Norris 1999), or increase the number of specific calls (Lesage et al. 1999) or elements within calls (Serrano and Terhune 2001).

Motivation and individual variation — In addition to the physical factors that influence marine mammal hearing, individual variation in hearing abilities and differences in motivation will influence the effects of sound on marine mammals. Reactions of marine mammals to sounds vary considerably. For example, some humpbacks show little or no reaction to vessels within distances at which other humpbacks have shown obvious reactions. Krieger and Wing (1984, 1986) determined that humpbacks are less likely to react to vessels while actively feeding than when resting or engaging in other activities. Small humpback pods, or pods with calves, were more likely to react to vessels than were larger pods or pods without calves (Bauer et al. 1993). Thus, the motivation (behavioral state, whether sound is perceived as a threat) will affect how or whether marine mammals will react to sound, regardless of the species involved.

3.3.2 Marine Mammals

This subsection describes those marine mammals that inhabit the park seasonally or year-round other than the two marine mammals listed as threatened or endangered: the humpback whale and Steller sea lion (see subsection 3.3.1). Each marine mammal species identified in table 3-3 is described in the following subsections, including information about its status in the park and its range, abundance, and natural history. Sightings of each species made during the USGS predator surveys are shown in figure 3-5.

TABLE 3-3: MARINE MAMMAL SPECIES, OTHER THAN THREATENED AND ENDANGERED SPECIES, KNOWN TO INHABIT THE WATERS OF GLACIER BAY NATIONAL PARK AND PRESERVE

Common Name	Scientific Name
Cetaceans (Whales and Dolphins)	
Minke Whale	*Balaenoptera acutorostrata*
Harbor Porpoise	*Phocoena phocoena*
Dall's Porpoise	*Phocoenoides dalli*
Killer Whale	*Orcinus orca*
Pinnipeds (Sea Lions and Seals)	
Harbor Seal	*Phoca vitulina richardsi*
Marine Fissipeds	
Sea Otter	*Enhydra lutris*

Minke Whale *(Balaenoptera acutorostrata)*. Minke whales are small baleen whales (up to 31 feet [9.5 meters] long in the North Pacific) that inhabit all oceans of the world from the high latitudes to near the equator (Leatherwood et al. 1982). Two minke whale stocks are recognized in U.S. waters — the Alaskan stock and the California/Oregon/Washington stock (Angliss et al. 2001a). No population estimates exist for the Pacific population as a whole or for the Alaskan stock; however, an estimate of 936 minke whales was made for the central Bering Sea during July through August 1999 (Angliss et al. 2001a). It is not known whether the minke whales in Southeast Alaska are from the Alaskan stock or California/Oregon/Washington stock.

Females in the North Pacific reach sexual maturity at approximately 24 feet (7.3 meters) in length; males reach sexual maturity between 21 and 23 feet (6.4 and 7 meters; Horwood 1990). The timing of conception and birthing in minke whales in the North Pacific is not precisely known. There appear to be two peaks of conception — February through March and August through September (Horwood

1990). Gestation time is estimated to be 10 months (Best 1982), resulting in birthing peaks from December through January and June through July (Horwood 1990).

There are several studies of minke whale feeding from the North Pacific and none of quantitative significance from the eastern North Pacific (Horwood 1990). Stomach contents of minke whales taken in the Japanese Minke fishery indicate that minke whales feed on a variety of fishes and invertebrates (Tamura and Fujise 2000). Minke whales killed in the northwest Pacific fed mainly on Japanese anchovy, Pacific saury, and walleye pollock (Tamura and Fujise 2000). Krill (euphausids and copepods) also made up a large part of the stomach contents in some areas (Tamura and Fujise 2000).

In Glacier Bay, minke whale sightings (see figure 3-5) of between five and eight individuals annually were reported between 1996 and 1999 (Gabriele and Lewis 2000). Sightings were concentrated in Sitakaday Narrows and in central Icy Strait. One minke whale was sighted north of Strawberry Island, and there are anecdotal reports of minke whales in the upper West Arm (Gabriele and Lewis 2000).

Because baleen whales, including the minke whale, have rarely been held in captivity, sounds created by baleen whales have generally been recorded in the wild. Most baleen whale sounds are dominated by low frequencies, generally below 1 kilohertz, although a few recordings of clicks with dominant frequencies from 16 to 25 kilohertz have been recorded near minke, fin, and blue whales (Beamish and Mitchell 1973; Thompson et al. 1979; Beamish 1979). However, these high-frequency sounds are thought to have been either from odontocetes in the area or from recording artifacts (Richardson et al. 1995).

Harbor Porpoise *(Phocoena phocoena)*. Harbor porpoises in the eastern North Pacific range from Point Barrow, Alaska, to Point Conception, California, inhabiting shallow coastal waters (Rice 1998; Angliss et al. 2001a). Angliss et al. (2001a) estimated that there are approximately 43,000 harbor porpoises in Alaskan waters divided into three recognized stocks, although it is difficult to determine the true stock structure of harbor porpoise populations in the eastern North Pacific (NMFS 2000a). Dahlheim et al. (2000) estimated that up to 35,500 harbor porpoises inhabit Alaskan waters, based on aerial surveys conducted between 1991 and 1993. The Southeast Alaska stock inhabits waters from the northern border of British Columbia to Cape Suckling, Alaska; the Gulf of Alaska stock occurs from Cape Suckling to Unimak Pass; and the Bering Sea stock occurs from the Aleutian Islands and all waters north of Unimak Pass. Individuals from the Southeast Alaska and Gulf of Alaska stocks, with population estimates of 10,508 and 21,451, respectively, may enter Glacier Bay or Dundas Bay.

Harbor porpoises appear to reproduce annually (Read and Hohn 1995) or biannually (Hohn and Brownell 1990). Reproduction is thought to be strictly seasonal, with parturition, ovulation, and conception occurring in the spring or summer (Read and Hohn 1995). This species seems to be shorter-lived than most odontocetes (toothed whales), because most of the individuals for which age data have been recorded in various locations have been less than 10 years old. Locations have included the Gulf of Maine (Read and Hohn 1995), the Bay of Fundy (Read and Gaskin 1990), California (Hohn and Brownell 1990), the United Kingdom (Lockyer and Walton 1994), and Greenland (Kinze et al. 1990). An abandoned harbor porpoise calf, estimated to be two days old, was found in Glacier Bay in July 1993 (Matthews 1993b). The age of the calf indicated to scientists that the calf may have been born in the park.

Harbor porpoises are known to feed on a multitude of fishes, including herring, hake, lantern fish, capelin, and various species of cephalopods (Palka et al. 1996). A report of opportunistic sightings of harbor porpoises in the park (Gabriele and Lewis 2000) suggests that harbor porpoise numbers within the park may be declining. Gabriele and Lewis (2000) reported that harbor porpoises were distributed throughout lower to mid-Glacier Bay and Icy Strait, most often in waters less than 230 feet (70 meters) deep, but were also seen in waters more than 328 feet (100 meters) deep (see figure 3-5).

Harbor porpoises are odontocetes (toothed whales), as are Dall's porpoises and the killer whales (discussed in the following subsections), all of which are found in or near the park. Odontocetes produce three broad types of sounds — tonal whistles; short-duration pulsed sounds; and less distinct pulsed sounds such as cries, grunts, and barks. Odontocetes that produce whistles tend to be social, gathering in large groups of up to thousands of individuals, while non-whistling odontocetes tend to be non-social or gather in small groups of a few individuals (Tyack 1986; Herman and Tavolga 1980).

Most odontocetes' whistles have most of their energy below 20 kilohertz and can vary greatly in frequency structure. Some odontocetes may use special, unique whistles as "signature calls" that may carry some information about the sender. Whistles also may serve to coordinate activity, such as feeding in large, dispersed groups (Norris and Dohl 1980; Würsig and Würsig 1980). Clicks and pulsed sounds are typically short bursts of sound (50 to 200 microseconds in length) that can range in frequency from 0.1 to 200 kilohertz (Watkins 1980; Santoro et al. 1989). Clicks have been demonstrated to be used for echolocation in several species of odontocetes, and numerous other species produce echolocation-type sounds, although they have not been proven to echolocate. Echolocating odontocetes produce forward-directional, pulsed sounds of high frequency (12 to 150 kilohertz), short duration (50 to 200 microseconds), and high intensity (up to 220 to 230 decibels standardized at 1 micropascal at 1 meter).

Dall's Porpoise *(Phocoenoides dalli)*. Dall's porpoises inhabit deep waters over the continental shelf and the oceanic basin in the North Pacific Ocean (Rice 1998; Angliss et al. 2001a). The Alaskan population of Dall's porpoise is managed as a single stock ranging from Southeast Alaska to the northern Bering Sea, and is estimated to be 83,400 with a minimum population size of 76,874 (Angliss et al. 2001a). The only gaps in distribution in Alaskan waters are in the upper Cook Inlet and the shallow waters of the eastern Bering Sea (Angliss et al. 2001a). Throughout their range, Dall's porpoises are present in all months of the year (Angliss et al. 2001a). Dall's porpoises were seen in Icy Strait six times between 1994 and 1999, but never in Glacier Bay (Gabriele and Lewis 2000).

Very little information about reproduction of Dall's porpoise in the eastern North Pacific is available; most information comes from animals taken in small whale fisheries in the western Pacific. Dall's porpoises probably calve yearly (Jefferson 1989; Ferrero and Walker 1999), with a summer calving peak from June through August, and perhaps a smaller peak in March (Jefferson 1989). Ferrero and Walker (1999) estimated the peak of calving for Dall's porpoises in the central North Pacific to be in July. Females reach sexual maturity when they are approximately 68 inches (172 centimeters) long and between 3.8 and 4.4 years; males reach sexual maturity at 71 inches (180 centimeters) and 4.5 to 5 years (Ferrero and Walker 1999). Males and females reach physical maturity at 7.2 years (Ferrero and Walker 1999).

A variety of prey items has been recorded for Dall's porpoises. In the nearshore waters of Washington, British Columbia, and the Gulf of Alaska, Dall's porpoises fed heavily on capelin, Pacific herring, and cephalopods. In the southern Sea of Okhotsk, north of Japan, Dall's porpoises have been found to feed on Japanese pilchard, walleye pollock, and the *Berryteuthis* squids (Walker 1996).

Killer Whale *(Orcinus orca)*. Killer whales inhabit all oceans and contiguous seas from the Arctic to the Antarctic, though they are generally more abundant nearshore and toward the poles of both hemispheres (Rice 1998). There are no reliable estimates for the world-wide population of killer whales. The total number of killer whales estimated to inhabit Southeast Alaskan waters is 318 (99 resident, 219 transient).

Killer whales in Southeast Alaska can be divided behaviorally and ecologically into three types: residents, transients, and offshore (Bigg et al. 1990; Ford et al. 1994; Black et al. 1997; Dahlheim et al. 1997). Resident-type killer whales usually feed on fish (Olesiuk et al. 1990), travel in pods of 10 to 50 individuals (identified by biologists using a system of letters and numbers), vocalize more, and have smaller home ranges than transient killer whales. Two resident pods (identified as AF and AG) are known to frequent the Glacier Bay / Icy Strait area (see figure 3-5). These pods contain 42 whales and 24 whales, respectively (Dahlheim et al. 1997). Two other pods (AP: 30 whales [September 1989], and AZ: 23 whales [May 1994]) have been seen once in the Icy Strait area (Dahlheim et al. 1997). Several transient pods and assemblages are known to travel through Southeast Alaska and may enter Glacier Bay (Dahlheim et al. 1997). Transient killer whales mainly feed on marine mammals, including seals, sea lions, and other whales; travel in smaller pods of one to 15 individuals; and are rarely seen in association with resident whales (Olesiuk et al. 1990). Offshore killer whales appear to be rare in Alaskan waters (Dahlheim et al. 1997), and little is known about this type, although they appear to be more closely related genetically, morphologically, behaviorally, and vocally to the resident-type than to the transient-type killer whales (Black et al. 1997; Hoelzel et al. 1998).

Female killer whales reach sexual maturity when they are 15 to 16 feet (4.6 to 4.9 meters) long, or about 15 years of age (Olesiuk et al. 1990). Female killer whales are thought to reach reproductive senescence at about 40 years; i.e., the female is beyond her reproductive age. Males appear to reach sexual maturity between 15 and 21 years of age, and reach maximum size at about 21 years (Olesiuk et al. 1990). Females typically give birth to a single calf every two to 12 years, with a mean of 5.3 years (Oliseuk et al. 1990). Twins are rare; Oliseuk et al. (1990) estimate the twinning rate to be 1.5%. The fecundity rate (the proportion of females that produce viable calves each year) for the British Columbia population was estimated to be 0.224 (Olesiuk et al. 1990). The calving period has been determined from stranded newborns, observations of births, and records of fetuses in whaling data. In Prince William Sound, most new calves are seen in spring, but a birth was observed in July, and a newborn was stranded near Homer, Alaska, in January (Matkin and Saulitis 1994).

Harbor Seal *(Phoca vitulina richardsi)*. Harbor seals range from Baja California; north along the western coasts of the United States, British Columbia, and Southeast Alaska; west through the Gulf of Alaska and the Aleutian Islands; and in the Bering Sea north to Cape Newenham and the Pribilof Islands. Angliss et al. (2001a) identified three stocks in Alaska: the Southeast Alaska stock, Gulf of Alaska stock, and Bering Sea stock. More recent genetic evidence was noted, however, indicating a need to reassess these boundaries. Angliss et al. (2001a) estimated 35,226 individuals in the Southeast Alaska stock (from the Alaska/Canada border to Cape Suckling). Trend estimates for Sitka, Ketchikan, and Glacier Bay indicate that the Southeast Alaska stock had been increasing since at least 1983 (Small et al. 1997); however, from 1992 through 1998, overall harbor seal abundance in Glacier Bay declined between 34% and 50% depending on the availability of haul-out substrate (Mathews and Pendleton 2001).

Harbor seals inhabit estuarine and coastal waters, hauling out on rocks, reefs, beaches, and glacial ice flows (see figure 3-5). They are generally non-migratory, but move locally with the tides, weather, season, and food availability, and to find suitable habitat for reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969; Bigg 1981a). Juvenile harbor seals can travel significant distances (326 miles [525 kilometers]) to forage or disperse, whereas adults were found within 118 miles (190 kilometers) of the tagging location in Prince William Sound (Lowry et al. 2001). The smaller home range used by adults in the Sound is suggestive of a strong level of site fidelity (Lowry et al. 2001; Pitcher and Calkins 1979; Pitcher and McAllister 1981). The level of site fidelity that may apply to the Southeast Alaska stock and the interchange between seals using haul-outs within Southeast Alaska and Glacier Bay are unknown.

Female harbor seals give birth to a single pup while hauled out on shore or on glacial ice flows. The mother and pup remain together until weaning occurs at three to six weeks (Bishop 1967; Bigg 1969). Little is known about breeding behavior in harbor seals. When molting, seals spend most of the time hauled out on shore, glacial ice, or other substrates.

Harbor seals consume a wide variety of fishes, cephalopods, and crustaceans in estuarine and marine waters (Sease 1992). Pitcher (1980) reported that harbor seals feed on numerous fish species from a variety of families, including *Gadidae* (cods), *Clupeidae* (herring), *Cottidae* (sculpin), *Pleuronectidae* (righteye flounders), *Salmonidae* (salmon and trout), and *Osmeridae* (smelt).

In a study of harbor seal scat and stomach samples, Jemison (2001) reported differences in harbor seal diets from different locations in Alaska. The most frequently occurring prey species identified from scat in Southeast Alaska were walleye pollock *(Theragra chalcogramma)* and arrowtooth flounder *(Atheresthes stomias)*. In the Kodiak Archipelago, the most frequently occurring prey species were Irish lord *(Hemilepidotus)* and sand lance *(Ammodytes hexapterus)*. In the Bering Sea, sand lance, rock sole *(Lepidopsetta)*, various flounder species (family *Pleuronectidae*), sculpin (family *Cottidae*), yellowfin sole *(Pleuronectes asper)*, rainbow smelt *(Osmerus mordax)*, and tomcod *(Microgadus proximus)* were the most commonly occurring prey identified in scat samples. Prey items from stomach samples collected in Southeast Alaska and Prince William Sound were similar; the most commonly occurring prey were herring, cephalopods, and pollock.

Harbor seals spend considerable time hauled out on land, although much social behavior occurs under water as well. Males produce repeated call trains of low-frequency (less than 4 kilohertz) underwater pulses, including roars, grunts, and creaks (Hanggi and Schusterman 1994). Calls from pups are individually distinct and broadcast simultaneously in air and under water when the pup's head is in the air. Females use their pups' calls in air and under water to recognize and maintain contact with their pups. Pup calls in air are centered around 350 hertz (Ralls et al. 1985), while underwater calls are at higher frequencies (Richardson et al. 1995).

Sea Otters *(Enhydra lutris)*. Before commercial exploitation, the world-wide population of sea otters was estimated to number between 150,000 (Kenyon 1969) and 300,000 (Johnson 1982), and occupied coastal areas from Hokkaido, Japan, around the North Pacific rim to central Baja California, Mexico (Rotterman and Simon-Jackson 1988). Commercial exploitation reduced the total sea otter population to as low as 2,000 in 13 locations (Kenyon 1969). In 1911, sea otters received protection from the North Pacific Fur Seal Convention and otter populations recovered quickly (Kenyon 1969). More than 90% of the world-wide sea otter population now lives in Alaskan waters (Rotterman and Simon-Jackson 1988). There are an estimated 54,523 sea otters in three stocks in Alaskan waters: the southwestern stock with 23,967, the southcentral stock with 21,749, and the southeastern stock with 8,807 (U.S. Fish and Wildlife Service [USFWS] 2002a).

Sea otters were reintroduced into Southeast Alaska between 1965 and 1969, when 412 otters were transplanted from Amchitka Island and Prince William Sound, including 25 that were moved to Cape Spencer in the park and preserve. Otters were not reported in Glacier Bay until 1995. Between 1995 and 2000, the number of otter sightings in Glacier Bay increased from five to 554 annually (Bodkin et al. 2001). The increase in the Glacier Bay population is far greater than the maximum growth rate expected for sea otters, and probably results from reproduction of females in the Bay coupled with immigration of adults and juveniles from outside the Bay. Concentrations of sea otters within Glacier Bay occur in the vicinity of Sita Reef and Boulder Island, and between Point Carolus and Rush Point (see figure 3-5; Bodkin et al. 2001).

Sea otters usually give birth at four years of age; thereafter, 85% to 90% of females pup annually, and their reproductive cycle is approximately 12 months (Jameson and Johnson 1993). It is predicted that the otter population in Glacier Bay likely will continue to increase, and that the increasing otter population may have profound effects on the benthic community structure and function of the Glacier Bay ecosystem.

Sea otters generally occur in shallow (less than 115 feet [35 meters]), nearshore waters in areas with sandy or rocky bottoms, where they feed on a wide variety of sessile and slow-moving benthic invertebrates (Rotterman and Simon-Jackson 1988). Foraging studies in Glacier Bay indicate that sea otter diets consist of 40% clams, 21% urchins, 18% mussels, 4% crabs, and 17% other and unidentified food items (Bodkin et al. 2001).

Sea otters spend much of their time in water, but underwater sounds have not been studied. Airborne sounds of adult sea otters include whines, whistles, growls, cooing, chuckles, snarls, and screams (Kenyon 1981). Otters may also produce sounds by vigorously kicking and splashing while at the water's surface (Calkins and Lent 1975). Calls between mothers and pups appear to be important for maintaining contact (Sandegren et al. 1973). Most of the energy in mother and pup calls is between 3 and 5 kilohertz.

3.3.3 Marine Birds and Raptors

3.3.3 Marine Birds and Raptors

This subsection describes the bird community of Glacier Bay and Dundas Bay, which is typical of Southeast Alaska. Following are the common marine-oriented bird groups:

- loons and grebes.
- shearwaters and storm-petrels.
- cormorants, jaegers, gulls, and terns.
- alcids (murres, guillemots, murrelets, and puffins).
- waterfowl.
- hawks and eagles (raptors).
- shorebirds.
- herons.
- kingfishers.
- crows and ravens.

Common and scientific names in this environmental impact statement follow the conventions of the American Ornithologists' Union (AOU 1998, 2000).

Marine birds are birds that spend most or all of their life near and in marine areas and are the most common type of bird in the planning area. Of these, the most important in terms of sensitivity to vessel traffic are colonial nesting seabirds, molting waterfowl, murrelets, raptors, shorebirds, and seaducks.

Murrelets, scoters, and glaucous-winged gulls are very common year-round. In summer, these are joined by large numbers of black-legged kittiwakes, and in winter, by large numbers of goldeneyes, mergansers, and murres (Conant et al. 1988; Piatt et al. 1991; Agler et al. 1995; USFWS 1996).

The terrestrial avifauna comprises inhabitants of the large coastal rain forest that stretches from the Pacific Northwest to Kodiak Island, Alaska, and includes such characteristic species as blue grouse, rufous hummingbird, and hermit thrush.

None of the bird species found within the park are listed as threatened or endangered under the Endangered Species Act of 1973 (USFWS, Brockman, pers. com., May 29, 2002). One breeding species (Kittlitz's murrelet) is being considered for protection under this act. The marbled murrelet is listed (since 1992) as a threatened species in California, Oregon, Washington, and British Columbia.

Colonial Nesting Seabirds. Sixty-six seabird colonies are located within Glacier and Dundas Bays (see figure 3-6). Colonies of more than 500 birds are found on South Marble Island and at Margerie Glacier. Colonies of 100 to 499 birds are located throughout Glacier Bay and are found in Hugh Miller Inlet, on Eider Island, on Flapjack Island, and on Gloomy Knob. The remaining colonies are small and scattered around the coastlines of Glacier Bay and Dundas Bay. The most abundant breeding colonial birds in the planning area are black-legged kittiwakes (more than 4,500 birds), glaucous-winged gulls (more than 2,200 birds), and pigeon guillemots (1,000 birds; see table 3-4). Other species of substantial numbers within Glacier Bay and Dundas Bay include pelagic cormorant, mew gull, arctic tern, and tufted puffin.

TABLE 3-4: COLONIAL NESTING BIRDS BREEDING IN GLACIER BAY AND DUNDAS BAY

Species	Estimated number of birds
Pelagic Cormorant	142
Parasitic Jaeger	present
Mew Gull	"hundreds"
Herring Gull	20
Glaucous-Winged Gull	2,223
Black-Legged Kittiwake	4,600–4,800
Arctic Tern	"hundreds"
Common Murre	30
Pigeon Guillemot	1,000
Tufted Puffin	110
Horned Puffin	28

Source: NPS 1995a; USFWS 2002c; NPS, Kralovec, electronic mail, July 30, 2002.

Murrelets. Glacier and Dundas Bays support one of the highest populations, if not the highest, of Kittlitz's murrelets world-wide (van Vliet 1993; Day et al. 1999); however, populations have declined in the park and elsewhere (USGS, Drew, pers. com., May 10, 2002). The U.S. Fish and Wildlife Service is considering listing the Kittlitz's murrelet as threatened under the Endangered Species Act. Kittlitz's and marbled murrelets nest in the planning area.

Both are small, brownish or grayish seabirds. Nesting numbers are not known for either species, but are likely in the order of a few thousand (less than 5,000) of Kittlitz's murrelets and several thousand (more than 5,000) of marbled murrelets (Piatt et al. 1991).

Kittlitz's murrelets are unique in that they specialize in foraging near glaciers, glacial ice, and turbid glacial water (Day and Nigro 2000; Day et al. in review), resulting in a very limited distribution (Day et al. 1999). Because this species depends on glacial ice and is representative of this unique ecological system, it is a key park resource.

During summer, Kittlitz's murrelets forage in scattered locations within Glacier Bay and Dundas Bay, with concentrations occurring in the Beardslee Inlet / Sitakaday Narrows area; Berg Bay; Geikie Inlet; the Hugh Miller / Scidmore Inlet complex; Rendu Inlet; Muir Inlet, in general; Wachusett Inlet; the northeastern part of the main body of Glacier Bay; and outer Dundas Bay (see figure 3-7).

Raptors. Five species of marine-oriented raptors have been recorded within Glacier Bay and Dundas Bay: osprey, bald eagle, sharp-shinned hawk, northern goshawk, and peregrine falcon. The osprey, bald eagle, and peregrine falcon feed on fishes and birds and mammals that feed on marine life or live along the coast. The sharp-shinned hawk and northern goshawk feed only on birds that may occur along the coast. Osprey are rarely sighted in Glacier Bay or Dundas Bay and therefore are not addressed further in this document.

Of these species, bald eagles are of particular interest because they feed and nest along shorelines and are probably the most marine-oriented of the five species of raptors. In 1967, the Southeast Alaska breeding bald eagle population was estimated at 8,000 (King et al. 1972). Recent surveys (through 1997) have indicated that the population has stabilized (Jacobson and Hodges 1999). Little information regarding the estimated population size of bald eagles within Glacier Bay or Dundas Bay is available. Cain (1982, cited in Kralovec 1994a) counted 439 eagles and located 197 nests in Glacier Bay (the exact area surveyed was not discussed by Kralovec). The most recent estimate is 291 nests, not all active, in Glacier Bay (NPS, Kralovec, electronic mail, July 30, 2002).

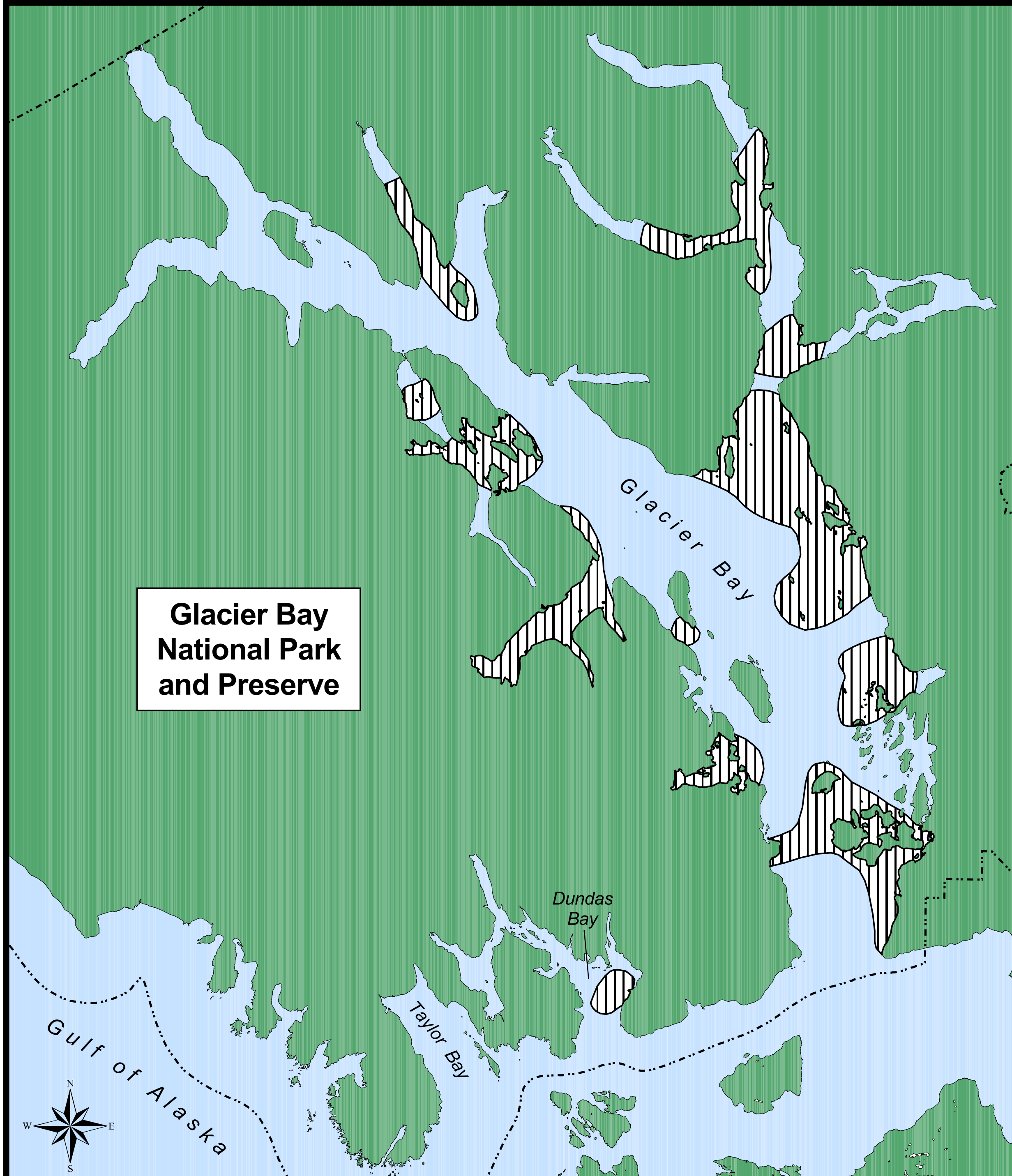
Within Glacier Bay, bald eagles nest primarily in deciduous trees (73%), secondarily in conifers (23%), and little in snags (4%; Kralovec 1994a). Figure 3-8 illustrates the locations of known bald eagle nest sites in Glacier Bay.

Shorebirds. Shorebirds are of interest because they feed and nest along the coast or in nearby coastal marshes; in most cases, they are obligate users of the shoreline. Of the approximately 35 species of shorebirds recorded in Glacier Bay and Dundas Bay, nine have been recorded as breeding or suspected of breeding (Paige 1986). The breeding species are from three species groups: plovers (semipalmated plover and possibly killdeer), oystercatchers (black oystercatcher), and scolopacid shorebirds (greater and lesser yellowlegs and solitary, spotted, and least sandpipers).

CONCENTRATIONS OF MARBLED AND KITTLITZ'S MURRELETS

Figure 3-7

National Park Service
U.S. Department
of the Interior



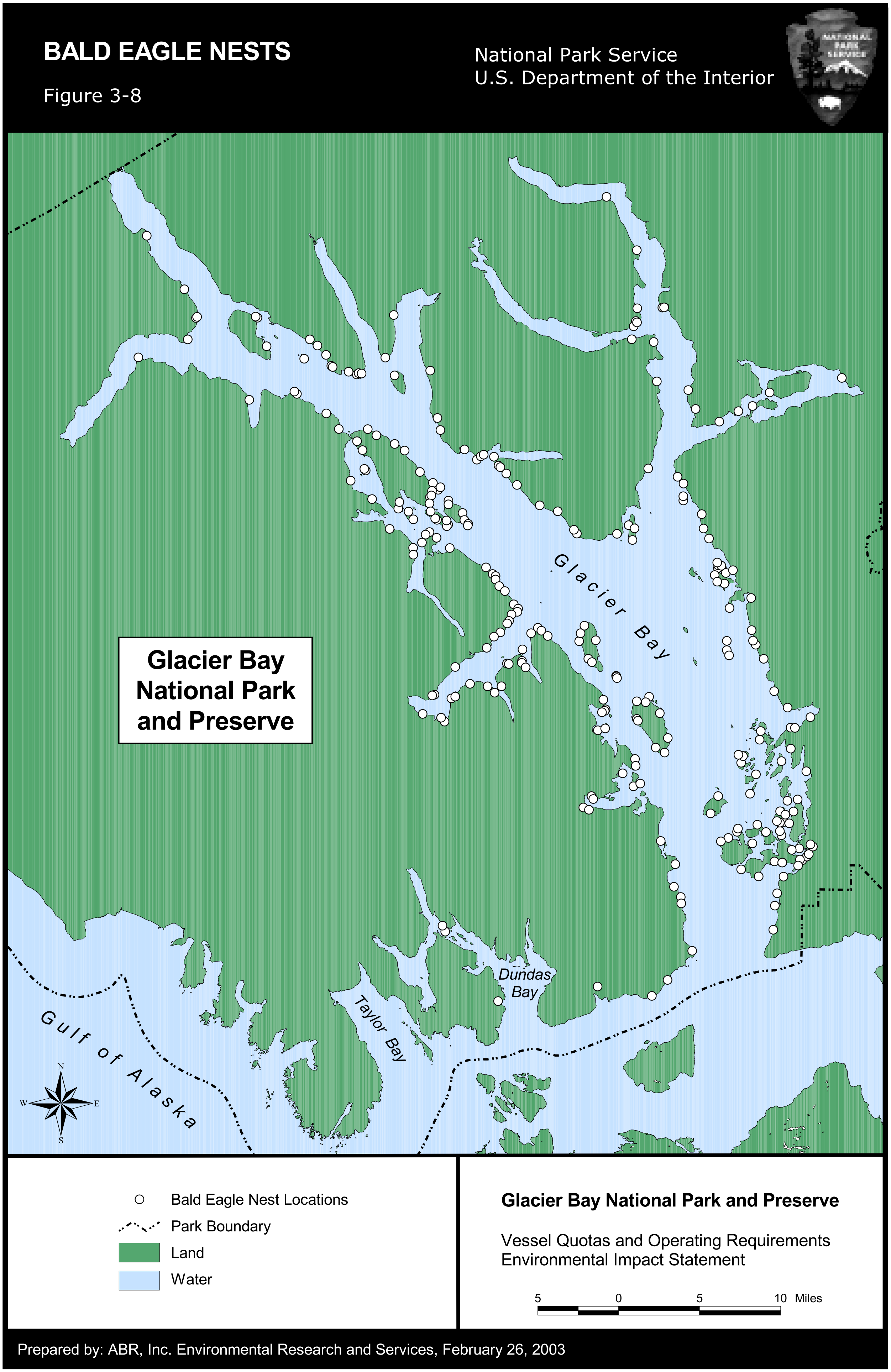
Concentrations of Marbled and Kittlitz's Murrelets
Park Boundary
Land
Water

Glacier Bay National Park and Preserve

Vessel Quotas and Operating Requirements
Environmental Impact Statement

5 0 5 10 Miles

Prepared by: ABR, Inc. Environmental Research and Services, February 26, 2003


BALD EAGLE NESTS
Figure 3-8
National Park Service
U.S. Department of the Interior
Glacier Bay National Park and Preserve
Glacier Bay
Dundas Bay
Taylor Bay
Gulf of Alaska
N
E
S
W
Bald Eagle Nest Locations
Park Boundary
Land
Water
Glacier Bay National Park and Preserve
Vessel Quotas and Operating Requirements Environmental Impact Statement
5
0
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10 Miles
Prepared by: ABR, Inc. Environmental Research and Services, February 26, 2003

Of the nine breeding species found within the park, the black oystercatcher is probably the most unique. This bird is large, distinctive (black with a bright red clothespin-shaped bill), and noisy, and is an easily spotted shorebird along the coast of Alaska. The estimated population of black oystercatchers within Glacier Bay and Dundas Bay is 270 (USFWS 2002). Large numbers of black oystercatchers also concentrate in the park during late summer (August and September) to stage during fall migration (van Vliet 2002).

Little is known about post-breeding concentrations of black oystercatchers in Glacier Bay and Dundas Bay. Wik (1967) counted 124 oystercatchers in Geikie Inlet in late August 1967. In the 1990s, van Vliet (2002) counted 300 to 600 oystercatchers in Geikie Inlet in late summer and suggested that this may be the world's largest concentration of this species.

Seaducks. Seaducks are diving ducks that spend most of their lives at sea, with some even nesting along the coast and raising their young on salt water. Of the 13 species of seaducks recorded in Glacier and Dundas Bays, six are thought to breed in the area (Paige 1986). This group includes harlequin duck, Barrow’s goldeneye, and common and red-breasted mergansers. All raise their young on salt water. The most common breeding species seen on salt water in Glacier Bay and Dundas Bay are harlequin duck, Barrow’s goldeneye, and common merganser. Nearly one-half of the seaducks in Glacier Bay in the summer are white-winged and surf scoters, although they do not breed in the Bay (USGS, Bodkin, pers. com., May 10, 2002).

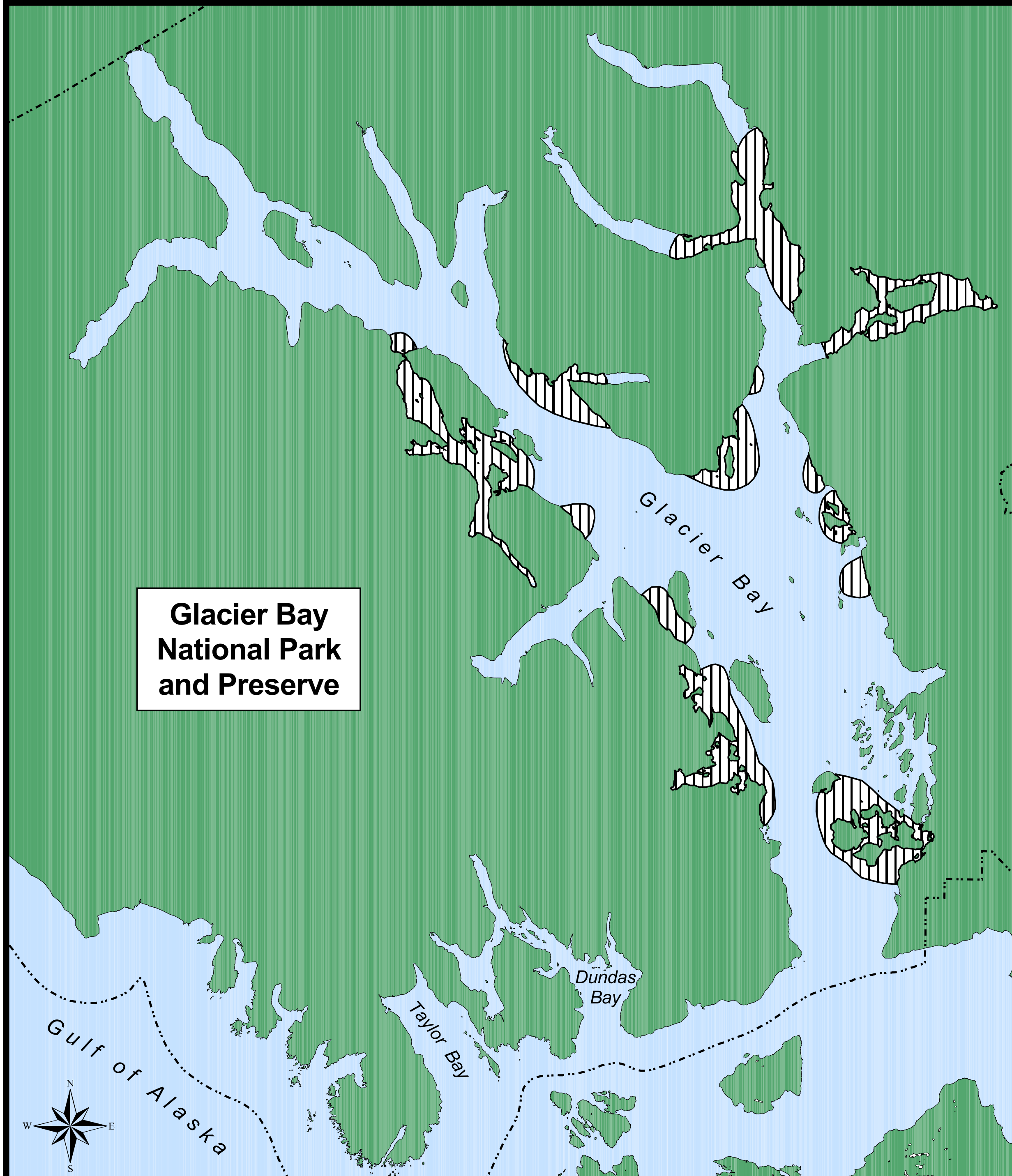
Molting Waterfowl. Waterfowl, including seaducks, use Glacier and Dundas Bays’ protected coves for molting and resting during mid- to late summer (June through September; Duncan and Climo 1991; USGS, Bodkin, pers. com., May 10, 2002). The molt is a time of great energetic stress on waterfowl. Molting occurs after birds have successfully reared their young, and involves the shedding and regrowth of feathers, including the major flight feathers. Molting imposes high energetic costs because all of the body feathers are replaced at once, and most waterfowl fatten before beginning the molt. Molting birds are extremely sensitive and easily disturbed (Welty 1975; Bellrose 1976).

In Glacier and Dundas Bays, the main molting species include Canada goose, harlequin duck, long-tailed duck, white-winged and surf scoters, Barrow’s goldeneye, and common and red-breasted mergansers (Climo and Duncan 1991; Duncan and Climo 1991; NPS 1995a; USGS 2002a). The total population of molting seaducks in the summer is 22,000 to 23,000, including surf and white-winged scoters (7,000 birds, respectively), common mergansers (4,200 birds) and harlequin ducks (1,200 birds; USGS, Bodkin, pers. com., May 10, 2002). These species concentrate particularly in the areas of Adams Inlet, Wachusett Inlet, central and lower Muir Inlet, the Hugh Miller / Scidmore Inlet complex, Tidal Inlet, Berg Bay, the Beardslee Islands, and Rendu Inlet (see figure 3-9; Climo and

CONCENTRATIONS OF SUMMERING WATERFOWL

Figure 3-9

National Park Service
U.S. Department of the Interior



Concentrations of Summering Waterfowl
Park Boundary
Land
Water

Glacier Bay National Park and Preserve

Vessel Quotas and Operating Requirements
Environmental Impact Statement

5 0 5 10 Miles

Prepared by: ABR, Inc. Environmental Research and Services, February 26, 2003

Duncan 1991; Duncan and Climo 1991; USGS 2002c; USGS, Bodkin, pers. com., May 10, 2002; USGS, Drew, pers. com., May 10, 2002; USGS, Litzow, pers. com., May 10, 2002).

3.3.4 Marine Fishes

This subsection describes marine fishes that occur in Glacier and Dundas Bays, with separate discussions for pelagic and demersal fish. These discussions include lists of the fish species found in Glacier and Dundas Bays and detailed descriptions of the most abundant species. A description of the various salmon species that occur in Glacier and Dundas Bays follows these discussions.

Relatively little baseline data exist for the status and distribution of marine fishes in Glacier and Dundas Bays. Fish found by Lenz et al. 2001 in Glacier Bay National Park and Preserve are listed in table 3-5.

TABLE 3-5: FISH FOUND IN GLACIER BAY NATIONAL PARK AND PRESERVE

Common Name	Scientific Name
Pacific Hagfish	*Eptatretus stouti*
Salmon Shark	*Lamna ditropis*
Pacific Sleeper Shark	*Somniosus pacificus*
Roughtail Skate	*Bathyraja trachura*
Big Skate	*Raja binoculata*
Longnose Skate	*Raja rhina*
Starry Skate	*Raja stellulata*
Wolf-Eel	*Anarrhichthys ocellatus*
Pacific Herring	*Clupea pallasii*
Capelin	*Mallotus villosus*
Eulachon	*Thaleichthys pacificus*
Pink Salmon	*Oncorhynchus gorbuscha*
Chum Salmon	*Oncorhynchus keta*
Chinook Salmon	*Oncorhynchus tshawytscha*
Coho Salmon	*Oncorhynchus kisutch*
Sockeye Salmon	*Oncorhynchus nerka*
Steelhead/Rainbow Trout	*Oncorhynchus mykiss*
Cutthroat Trout	*Oncorhynchus clarki*
Dolly Varden	*Salvelinus malma*
Atlantic Salmon	*Salmo salar*
Pacific Cod	*Gadus macrocephalus*
Walleye Pollack	*Theragra chalcogramma*
Rougheye Rockfish	*Sebastes aleutianus*
Pacific Ocean Perch[1]	*Sebastes alutus*
Redbanded Rockfish	*Sebastes babcocki*
Shortraker Rockfish	*Sebastes borealis*

TABLE 3-5: FISH FOUND IN GLACIER BAY NATIONAL PARK AND PRESERVE

Silvergray Rockfish	*Sebastes brevispinis*
Dusky Rockfish	*Sebastes ciliatus*
Yellowtail Rockfish	*Sebastes flavidus*
Shortbelly Rockfish	*Sebastes jordani*
Quillback Rockfish	*Sebastes maliger*
Black Rockfish	*Sebastes melanops*
China Rockfish	*Sebastes nebulosus*
Tiger Rockfish	*Sebastes nigrocinctus*
Yelloweye Rockfish	*Sebastes ruberrimus*
Harlequin Rockfish	*Sebastes variegatus*
Silverspotted Sculpin	*Blepsias cirrhosus*
Coastrange Sculpin	*Cottus aleuticus*
Spinyhead Sculpin	*Dasycottus setiger*
Buffalo Sculpin	*Enophrys bison*
Red Irish Lord	*Hemilepidotus hemilepidotus*
Brown Irish Lord	*Hemilepidotus spinosus*
Bigmouth Sculpin	*Hemitripterus bolini*
Shaggy Sea Raven	*Hemitripterus villosus*
Northern Sculpin	*Icelinus borealis*
Pacific Staghorn Sculpin	*Leptocottus armatus*
Great Sculpin	*Myoxocephalus polyacanthocephalus*
Sailfin Sculpin	*Nautichthys oculofasciatus*
Tidepool Sculpin	*Oligocottus maculosus*
Tadpole Sculpin	*Psychrolutes paradoxus*
Soft Sculpin	*Psychrolutes sigalutes*
Smooth Lumpsucker	*Aptocyclus ventricosus*
Pacific Spiny Lumpsucker	*Eumicrotremus orbis*
Kelp Greenling	*Hexagrammos decagrammus*
Rock Greenling	*Hexagrammos lagocephalus*
Masked Greenling	*Hexagrammos octogrammus*
Whitespotted Greenling	*Hexagrammos stelleri*
Lingcod	*Ophiodon elongatus*
Sablefish	*Anoplopoma fimbria*
Alaskan/Threespine Stickleback	*Gasterosteus aculeatus*
Pacific Saury	*Cololabis saira*
Searcher	*Bathymaster signatus*
Northern Ronquil	*Ronquilus jordani*
Pacific Pomfret	*Brama japonica*
Jack Mackeral	*Trachurus symmetricus*
Kelp Clingfish	*Rimicola muscarum*
Crescent Gunnel	*Pholis laeta*

TABLE 3-5: FISH FOUND IN GLACIER BAY NATIONAL PARK AND PRESERVE

Quillfish	*Ptilichthys goodei*
Snake Prickleback	*Lumpenus sagitta*
Pacific Sandfish	*Trichodon trichodon*
Prowfish	*Zaprora silenus*
Northern Smoothtongue	*Leuroglossus schmidti*
Pacific Sand Lance	*Ammodytes hexapterus*
Northern Lampfish	*Stenobrachius leucopsarus*
Arrowtooth Flounder	*Atheresthes stomias*
Slender Sole	*Eopsetta exilis*
Petrale Sole	*Eopsetta jordani*
Flathead Sole	*Hippoglossoides elassodon*
Pacific Halibut	*Hippoglossus stenolepis*
Starry Flounder	*Platichthys stellatus*
Yellowfin Sole	*Plewonectes stellatus*
Rock Sole	*Lepidosetta bilineata*

[1] Lenz et al. (2001) does not list this species as "present in park"; however, it does have essential fish habitat in the park.

Source: Lenz et al. (2001).

Pelagic Species. Pelagic species live and feed in the open sea; they are associated with the surface or middle depths of a body of water (FishBase 2003). Pelagic fishes include the salmon species during their oceanic phase, as well as the various forage fishes and other mid-water and surface-dwelling species. Thirty-one species were found in mid-water trawls, 12 of which previously had not been documented for Glacier and Dundas Bays (Litzow et al. 2002). Pelagic species were often a dominant group among the fish collected in beach seines in the West and East Arms, and the lower and middle portions of Glacier Bay (Robards et al. 2002). Samples from the lower Bay in June 1999 contained mostly pink salmon (85%), with the rest made up of demersal fishes. The catches in August 2000 contained only 20% pink salmon, with an additional 39% coming from herring and sand lance. Samples from the middle Bay in June 1999 contained at least 91% pelagic species, while pelagic fish in the August 2000 sampling comprised at least 98% of the catch. Samples from the West and East Arms typically contained greater percentages of demersal fishes mixed with the pelagic species, and the samples from June and July 2000 also contained greater proportions of demersal fishes in all areas sampled. An exception was the East Arm in August 2000, where 90% of the catch was pelagic species, with sand lance predominating.

Litzow et al. (2002) listed capelin, walleye pollock, Pacific herring, and northern lampfish *(stenobrachius leucopsarus)* as the most common pelagic species caught in Glacier Bay, accounting for 89% of the mid-water catches.

Capelin **—** Capelin has been reported as the most abundant species caught in mid-water trawls in Glacier and Dundas Bays (Litzow et al. 2002). Capelin, a type of smelt, has an elongated, slender body, and is typically found from the surface to a depth of 655 feet (200 meters). Capelins migrate to nearshore areas to spawn on sandy beaches. They appear to spawn in upper Glacier Bay, as large numbers of young-of-year capelin were caught in these areas (Robards et al. 2002). Capelins are a very important prey item for a broad range of fishes, marine mammals, and seabirds (Sturdevant 1999).

Walleye Pollock **—** The walleye pollock also is a common species reported from mid-water trawls in Glacier and Dundas Bays (Litzow et al. 2002). The walleye pollock is a member of the cod family *(Gadidae)*. Although found in open water, pollock are also commonly reported from bottom trawls. Walleye pollock also have been reported from beach seines in several park locations, with high concentrations in upper Glacier Bay (Robards et al. 1999); however, they were seldom captured in beach seines in 1999 and 2000 by Robards et al. (2002). Most pollock netted by Robards et al. (1999) were larval. Pollock feed on various crustaceans, herring, and sand lance. They are one of the most important commercial species in the North Pacific Ocean and Bering Sea. Pollack are also an important prey species of humpback whales.

Pacific herring **—** Pacific herring are fairly common species caught in mid-water trawls in Glacier and Dundas Bays. Pacific herring is a schooling species found in coastal and offshore waters and is important to commercial and subsistence fisheries in Alaska and western Canada (Litzow et al. 2002). Herring are seasonally abundant along the coast of Alaska. Adult Pacific herring have been reported from beach seines at several locations along the shorelines in the middle region of Glacier Bay (Robards et al. 1999). Herring spawn along the coastline in intertidal and shallow subtidal zones (Mecklenburg et al. 2002) by depositing eggs on eelgrass, seaweed, rocks, pilings, or other substrates (Clemens and Wilby 1961). The nearest known major spawning ground is at Auke Bay, approximately 50 miles east of Glacier and Dundas Bays (O'Clair and O'Clair 1998). The Alaska Department of Fish and Game (ADFG) has not identified any locations within park waters for herring spawning (O'Clair and O'Clair 1998). When abundant, they form an important part of the diets of large predatory fishes and marine mammals, such as humpback whales.

Northern lampfish **—** Northern lampfish are members of the lanternfish family *(Myctophidae)*. Lampfish are equipped with photophores and other luminous tissue that can produce a variety of colors and light patterns. They are of particular importance as forage fish because of a very high fat content, which may be as high as 10 times the fat level of other forage fishes, such as capelin or sand lance (Van Pelt et al. 1997, cited in Robards et al. 2002). Lampfish are typically found in deeper water during the day and rise toward the surface at night. They occasionally are found in salmon stomachs (Clemens and Wilby 1961). They may also be an important prey source to predators in Glacier Bay because of unique oceanographic conditions (Robards et al. 2002). Apparently because of either high turbidity or high productivity near some glacier faces, they are found in the near-surface water column during the day, where they are more available to predation, especially by birds.

Other pelagic species **—** Other pelagic species in Glacier Bay and Dundas Bay include two additional forage fishes: eulachon *(Thaleichthys pacificus)* and Pacific sand lance *(Ammodytes hexapterus)*. Eulachon are members of the smelt family, and enter large rivers to spawn in fresh water. They are preyed upon by Chinook salmon, fur seals, and a variety of other marine vertebrate predators. The Pacific sand lance feed on plankton and in turn are preyed upon by salmonids, lingcod, halibut, and many other fish species (Clemens and Wilby 1961). They tend to live in clean sandy substrates, coming out of the sand to feed. Sand lance were found throughout Glacier Bay, with the highest concentrations in the middle region, followed by the upper region (Litzow et al. 2002).

Demersal Species. Demersal fishes are found lying on the bottom or living on or near the bottom and feeding on benthic organisms (FishBase 2003). Most demersal fishes found in Glacier Bay and Dundas Bay are members of the skates, cods, rockfishes, sculpins, and flatfishes. Most of these fish lack a swim bladder, leaving them negatively buoyant.

Skates **—** Skates (family *Rajidae*) are demersal members of a group of vertebrates with a skeleton of cartilage rather than bone, and have been found in Glacier and Dundas Bays (Lenz et al. 2002; Litzow et al. 2002). The *Rajidae* is a large skate family whose members inhabit marine waters nearly world-wide, but are most common in cold temperate to tropical regions (Mecklenburg et al. 2002). Skates live on the bottom in waters near shore to depths of more than 9,840 feet (3,000 meters). They feed on benthic invertebrates and fishes. The longnose skate *(Raja rhina)* has been reported in Glacier and Dundas Bays (Litzow et al. 2002). This species is usually found at depths from 180 to 1,150 feet (55 to 350 meters) on muddy or sandy bottoms. They likely feed on clams and other large invertebrates that may be found on soft substrates. The roughtail, big, and starry skates are found in park waters, while the Aleutian, Bering, and Alaska skates are probably found in the park, but their presence has not been confirmed (Lenz at al. 2002).

Cod **—** Members of the cod family found in the park include Pacific cod *(Gadus macrocephalus)* and walleye pollock. The Pacific cod is a schooling species, typically found over sand or gravel bottoms in 150 to 600 feet (46 to 183 meters) of water. They typically move to deep water for spawning in the late fall and winter, then return in spring to shallower water for feeding. Common prey items include crustaceans and fish. The walleye pollock is discussed in the pelagic fishes subsection because they are often found in mid-water.

Rockfish — Rockfish are members of the family *Scorpaenidae*. Approximately 30 rockfish species in the genus *Sebastes* inhabit Alaskan waters; they usually populate rocky areas in shallow to moderately deep water, although some species may be found in silty and sandy areas (Mecklenburg et al. 2002). They are a free-swimming species, but are often found close to substrate. Little is known of the breeding habits of rockfishes in Glacier and Dundas Bays, but the presence of larger individuals of some rockfish species in the Bays, and the fact that many species of rockfishes have internal fertilization (Clemens and Wilby 1961) suggest that spawning may occur in the Bay. Four species of rockfishes — rougheye *(Sebastes aleutianus)*, vermilion *(S. miniatus)*, yelloweye *(S. ruberrimus)*, and quillback *(S. maliger)* rockfishes — have been identified in park waters (Litzow et al. 2002; Bishop et al. 1995; NPS 1998a). The rougheye rockfish is found in areas with gently sloping substrates and boulders, and on seamounts. The vermilion rockfish is found on rocky reefs and seamounts, usually deeper than 590 feet (180 meters; Mecklenburg et al. 2002). The yelloweye and quillback rockfish are the most commonly reported rockfish from longline catches in Glacier Bay and adjacent waters (Bishop et al. 1995; NPS 1998a). Other species of rockfishes may also be found in Glacier and Dundas Bays, but are likely to be more common in other areas of the park along the outer coast. Large rockfish often prey upon smaller ones, and many rockfish species are sought after in commercial and sport fisheries in Southeast Alaska, but few are known to occur in Glacier Bay or Dundas Bay.

Sculpins — Numerous species of sculpins in several families have been reported for Glacier and Dundas Bays (Litzow et al. 2002). Sculpins are found from shallow tidepools to waters of considerable depth. Six species of sculpins were reported from bottom trawls in Glacier and Dundas Bays during summer 2001: spinyhead sculpin *(Dasycottus setiger)*, thorny sculpin *(Icelus spiniger)*, armorhead sculpin *(Gymnocanthus galeatus)*, blackfin sculpin *(Malacocottus kincaidi)*, northern sculpin *(Icelinus borcalis)*, and ribbed sculpin (*Triglops pingelii*; Litzow et al. 2002). Yellow and brown Irish lords (*Hemilepidotus jordani* and *H. spinosus*) were the most common sculpins caught in longline surveys (Bishop et al. 1995).

Spinyhead sculpin are found on soft bottoms, usually at depths ranging from 165 to 985 feet (50 to 300 meters), although they also may be found in shallower and deeper waters (Mecklenburg et al. 2002). The northern and blackfin sculpin also are reported to be present, but are not common (Litzow et al. 2002). The remaining sculpin species reported by Litzow et al. (2002) for Glacier and Dundas

Bays are in the family *Cottidae*, the largest of the sculpin families. Lenz et al. (2002) lists more than 50 species of cottids as either present or probably present in Glacier and Dundas Bays. The thorny sculpin is found at bottom depths of 30 to 770 meters, although more commonly from 150 to 350 meters. The armorhead sculpin is found on soft bottoms near shore to a depth of 580 meters, although it is most common at depths between 50 and 165 meters (Mecklenburg et al. 2002). The ribbed sculpin is found on sand, pebble, gravel, and rocky bottoms, most frequently at depths of 20 to 150 meters.

Flatfish — The flatfishes in Alaska are in two families: the small family *Paralichthyidae*, which includes sand flounders (or sanddabs), and the larger *Pleuronectidae* (or righteye flounders), which includes flounders, sole, and halibut. Flatfish have highly compressed bodies. Pacific halibut *(Hippoglossus stenolepis)* is the only commercially important flatfish in Glacier Bay. Lenz et al. (2002) list 20 species of flatfishes as present or probably present in Glacier and Dundas Bays. The most common species reported in bottom trawls in Glacier and Dundas Bays were rex sole *(Glyptocephalus zachirus)*, flathead sole *(Hippoglossoides elassodon)*, rock sole *(Lepidopsetta bilineata)*, slender sole *(Lyopsetta exilis)*, and Dover sole (*Microstomus pacificus*; Litzow et al. 2002).

Because of its commercial value, the Pacific halibut is the most high-profile demersal fish species in the park area. Halibut are found on a variety of bottom types. Bishop et al. (1995) reported a significantly higher abundance of halibut on rock and sand substrates than other substrate types in Glacier Bay. Halibut range from shallow water to depths of 1,100 meters, although they are usually found in depths shallower than 300 meters (Mecklenburg et al. 2002). Bishop et al. (1995) reported that halibut in park waters occurred over the entire depth range of their sampling (0 to 325 meters) and that length increased with increasing depth for fish caught from 0 to 250 meters, and decreased thereafter. Young halibut feed mainly on small crustaceans, and as the fish mature, the diet changes to a wide variety of fish species (Hooge and Taggart 1996). Halibut also feed on crabs, clams, squid, and other invertebrates (Clemens and Wilby 1961). Tagging studies in Glacier and Dundas Bays indicate an age-related shift in home range patterns (Hooge et al. in prep.). Juvenile halibut move widely, although often still within the Glacier Bay and Dundas Bay area, while large, sexually mature fish exhibit smaller home ranges, which are often less that 0.5 square kilometer. Occasionally, large halibut alter their pattern of small-home-range use and travel widely before returning to a more sedentary pattern; a few individuals appear to never establish home ranges. More than 95% of halibut tagged in park waters were recaptured within Glacier Bay, indicating a high degree of site fidelity.

Pacific Salmon Species. Five species of salmon occur in the waters of the Glacier Bay and Dundas Bay area. The steelhead trout *(Oncorhynchus mykiss)*, a rainbow trout that spends much of its life in salt water, also is found in the waters of Glacier Bay. These species occur along the Pacific coast of

North America, from Southern California to the Arctic coastline of Alaska (Mecklenburg et al. 2002; Groot and Margolis 1991; Morrow 1980). These are anadromous species that spend most of their lives in marine waters, but spawn in fresh water. Salmon are important components of the commercial, subsistence, and sport fisheries in Alaska.

Chinook salmon **—** Chinook, or king, salmon *(Oncorhynchus tshawytscha),* is the largest-bodied species of the group. Any occurring in Glacier Bay or Dundas Bay are presumably foraging or moving through the area, because they are not known to breed in the streams in either Glacier Bay or Dundas Bay (ADFG 2002a). Orsi and Jaenicke (1996) identify Southeast Alaska marine waters as an important nursery area for "an amalgam of pre-recruit Chinook salmon stocks originating from Oregon to Alaska." The relative importance of the park's marine waters in this respect is not well known.

Coho salmon **—** Adult coho salmon *(O. kisutch)* were identified in almost one-third of the streams in Glacier and Dundas Bays (ADFG 2002a). Coho salmon return to natal streams to spawn from mid-summer to winter depending on geographic location. Coho salmon generally spawn in short coastal streams, including several that drain into park waters. Timing for the spawning in park streams is not well known. The fry feed on a variety of food types, including terrestrial insects, aphids, mites, beetles, spiders, and zooplankton. As the young fish grow, they consume larger prey that may include young sockeye salmon. Generally, coho salmon spend one to two years in fresh water before moving to the sea. As the young fish move into the sea, they remain close to shore, feeding on crustaceans. As they grow larger, they move offshore and feed on larger prey, particularly herring and sand lance. In the southern part of their range, coho salmon generally stay close to the shore, while northern populations spread out across the North Pacific and Bering Sea. After two to three years in the ocean, they return to natal streams to spawn.

Pink salmon **—** Pink salmon *(O. gorbuscha)* migrate to spawning streams between June and September, depending on geographic location. Spawning is typically in tidal areas at the mouths of streams or in streams near the coast. Fry emerge from the gravel in the spring and almost immediately migrate downstream to marine waters. At first, they remain near the coast or in estuaries, where they feed on copepods and larvacean tunicates. As they become larger, pink salmon feed on amphipods, euphausiids, and fish. Pink salmon from the southern part of the range tend to remain closer to the coast during the marine portion of their lives than Alaskan populations, which range across most of the northeast Pacific Ocean. After about 18 months at sea, the adults return to natal streams, although pink salmon demonstrate less site fidelity to natal streams than other salmonid species (Morrow 1980). Use of intertidal areas and streams entering Glacier and Dundas Bays for spawning has been documented for pink salmon, but the extent of use is not well known; however, most park streams accessible to salmonids probably contain pink salmon (Soiseth and Milner 1995).

Sockeye salmon **—** Sockeye salmon *(O. nerka)* were identified in one-fourth of the streams in Glacier and Dundas Bays (ADFG 2002a). They typically spawn in lake habitats or in streams connected to lakes. Most fry rear one to two years in lake systems before smolting and emigrating to the marine environment. While in fresh water, the fry feed on ostracods, cladocerans, and insect larvae. Once in marine waters, they stay close to shore and feed on zooplankton, insects, and small fish. As they grow, the young fish move out to sea and feed on fish, especially sand lance. They typically return to their natal lake or stream to spawn at four or five years of age.

Chum salmon **—** Chum salmon *(O. keta)* were found in almost one-half of the streams in Glacier and Dundas Bays (ADFG 2002a). They generally spawn later than other salmonids, with spawning activity peaking in September and October (Morrow 1980). In most populations, chum salmon do not migrate far upstream and only one run per season is evident. Young chum fry emerge from the spawning gravels during the winter and begin their migration downstream. They remain close to shore for several months after reaching salt water, feeding on small crustaceans, terrestrial insects, and young herring. As they grow, their diet changes to copepods, tunicates, euphausiids, squid, and various fish species. Adult chum salmon return to spawn after three to five years at sea.

Essential Fish Habitat. Essential fish habitat (EFH) is defined in the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 94-265) as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (see table 3-6). Essential fish habitat is designated by the NOAA Fisheries for species managed under existing fishery management plans to assist in maintaining sustainable fisheries (see figure 3-10).

TABLE 3-6: SPECIES WITH ESSENTIAL FISH HABITAT IN GLACIER BAY AND DUNDAS BAY

Common Name	*Scientific Name*
Skate	*Raja spp.* and *Bathyraja spp.*
King Salmon[a]	*Oncorhynchus tshawytscha*
Sockeye Salmon[a]	*O. nerka*
Coho Salmon[a]	*O. kisutch*
Pink Salmon[a]	*O. gorbuscha*
Chum Salmon[a]	*O. keta*
Pacific Cod	*Gadus macrocephalus*
Rougheye Rockfish	*Sebastes aleutianus*
Yelloweye Rockfish	*S. ruberrimus*
Shortraker Rockfish	*S. borealis*
Dusky Rockfish	*S. ciliatus*
Pacific Perch	*S. alutus*
Sculpin	*Cottidae* family
Walleye Pollock	*Theragra chalcogramma*
Sablefish	*Anoplopoma fimbria*

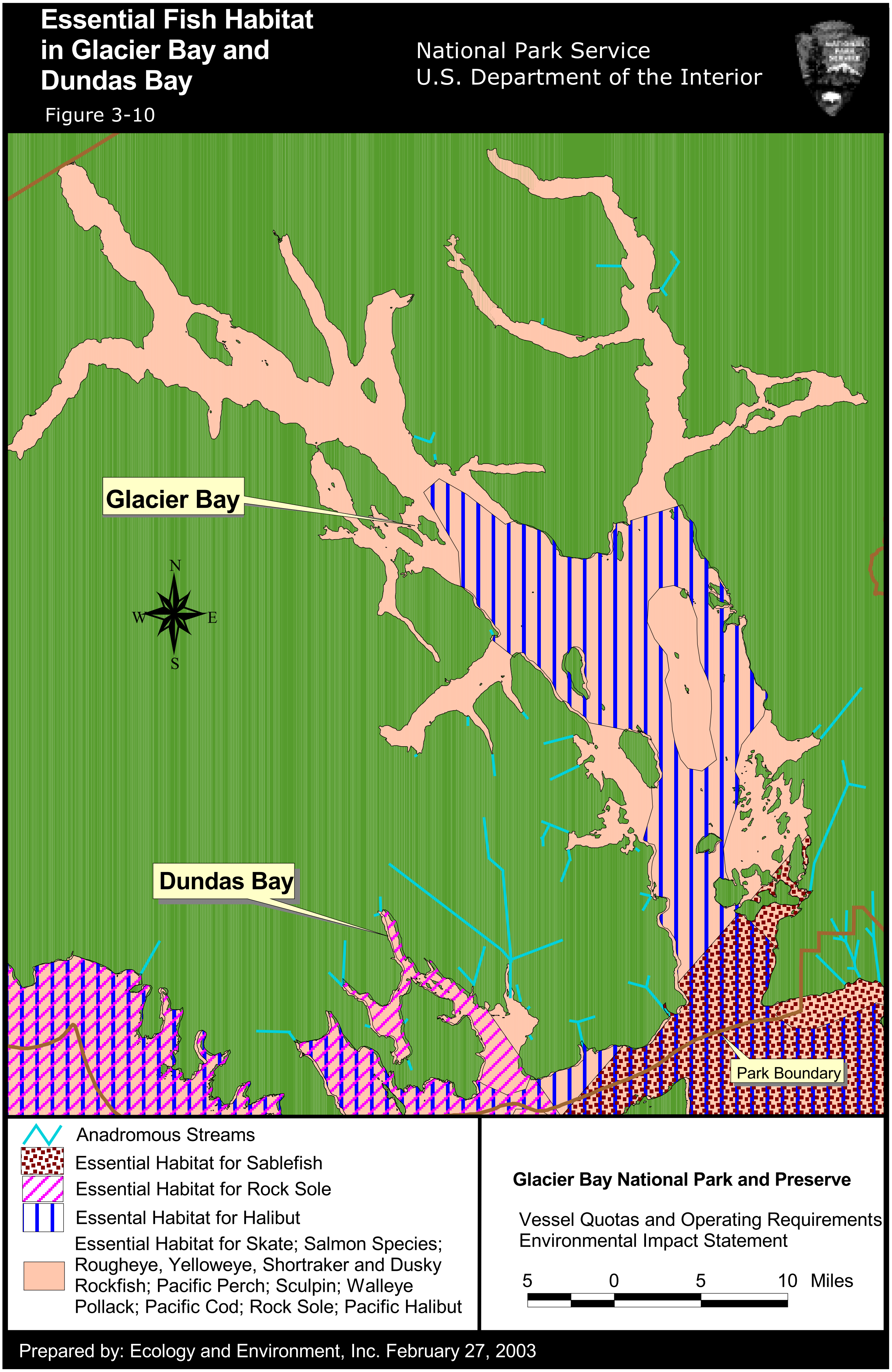
TABLE 3-6: SPECIES WITH ESSENTIAL FISH HABITAT IN GLACIER BAY AND DUNDAS BAY

Rock Sole	*Lepidopsetta bilineata*
Pacific Halibut[b]	*Hippoglossus stenolepis*

[a] Salmon species do not have essential fish habitat because they are managed by the Alaska Department of Fish and Game, not the NOAA Fisheries; they do have important habitat in Glacier Bay.

[b] Halibut do not have essential fish habitat because they are managed by the International Pacific Halibut Commission, not the NOAA Fisheries; they do have important habitat in Glacier Bay.

Source: NOAA Fisheries 2003.



Essential Fish Habitat in Glacier Bay and Dundas Bay
National Park Service
U.S. Department of the Interior
Figure 3-10
Glacier Bay
Dundas Bay
N
E
S
W
Park Boundary
Anadromous Streams
Essential Habitat for Sablefish
Essential Habitat for Rock Sole
Essental Habitat for Halibut
Essential Habitat for Skate; Salmon Species; Rougheye, Yelloweye, Shortraker and Dusky Rockfish; Pacific Perch; Sculpin; Walleye Pollack; Pacific Cod; Rock Sole; Pacific Halibut
Glacier Bay National Park and Preserve
Vessel Quotas and Operating Requirements Environmental Impact Statement
5 0 5 10 Miles
Prepared by: Ecology and Environment, Inc. February 27, 2003

3.3.5 Coastal/Shoreline Environmental and Biological Communities

3.3.5 Coastal/Shoreline Environment and Biological Communities

This subsection describes the physical composition of the Glacier Bay and Dundas Bay shorelines and then discusses the biological communities that inhabit these shorelines.

Coastal Geomorphology. The coastal geomorphology of Glacier Bay was shaped by the glaciers that formed the Bay. The last glacial advance in Glacier Bay started approximately 4,000 years ago and is known as the Little Ice Age. Around 750 A.D., Glacier Bay was completely covered by a glacier that was more than 4,000 feet (1,219 meters) thick and an estimated 20 miles (32 kilometers) or more wide. During this time, the glacier extended more than 100 miles to the St. Elias Mountain Range. As recently as 250 years ago, ice or ice-generated outwash (material deposited by melting glaciers) covered the entire watershed from the headlands through the Sitakaday Narrows. The glacial retreat continues today on the Bay's east and southwest sides; however, Johns Hopkins and Gilman Glaciers on the western side of Glacier Bay are advancing (NPS 1983; Hooge and Hooge 2002).

Glaciers are not the only powerful force acting on the Glacier Bay shoreline. While glaciers originally shaped the Bay, powerful and large low-pressure weather systems from the Gulf of Alaska dominate the climate. Seasonal storms bring wind and waves that change the shore structure and material size. The dominant wind direction for the Gustavus Airport is northwest-southeast, which roughly corresponds to the north-south wind direction expected in the main body of Glacier Bay. Wind requires sufficient duration, intensity, and fetch (open water) in order to create waves. The main body of Glacier Bay has "open water" fetches that are similar to the open ocean, where there are no obstructions to the wind, such as trees or mountains. Glacier Bay also has many narrow passages or inlets that are not oriented to the wind direction. In these cases, wave growth is fetch limited and large waves often cannot be generated, regardless of the intensity or duration of a storm.

Dundas Bay also was formed by glacial advances and retreats. It is likely that the Brady Glacier once covered the Dundas Bay area; however, Dundas Bay has been free of ice for much longer than Glacier Bay, as is evident with forests more than 400 years old. One archeological site is 800 years old, which indicates that Dundas Bay has been free of ice for at least that amount of time. Today, Dundas Bay is largely influenced by glacial meltwater and is considered shallow for larger vessels. Dundas Bay also is subject to the large low-pressure weather systems from the Gulf of Alaska (NPS 2002k; Geiselman et al. 1997).

In addition, less frequent events can act on the shoreline. These include earthquakes, tsunamis, and landslides. Rebound also alters the sea level. Rebound occurs after a glacier retreats. A glacier may grow to several thousand feet thick, and, over many thousands of years, the weight of the ice compresses the Earth's crust beneath it. As the glacier melts and retreats, this weight is removed, and the land mass gradually rebounds. This slow process may take several hundreds or thousands of years. The rate of rebound in Glacier Bay is 2 inches per year, greater than the region's average rebound rate of 1 inch per year (NPS 2002k).

Much of Dundas Bay also has a north-south orientation, similar to Glacier Bay. Dundas Bay is very windy, which would be expected in the main channel because of the orientation of the channel and the wide mouth that would not limit wind exposure to the Bay. Daily tidal fluctuations alone subject the coastline to the same amount of energy as that of an average windstorm on a typical coastal site (an average windstorm is a wind event at an energy level that has an expected frequency of returning every two years).

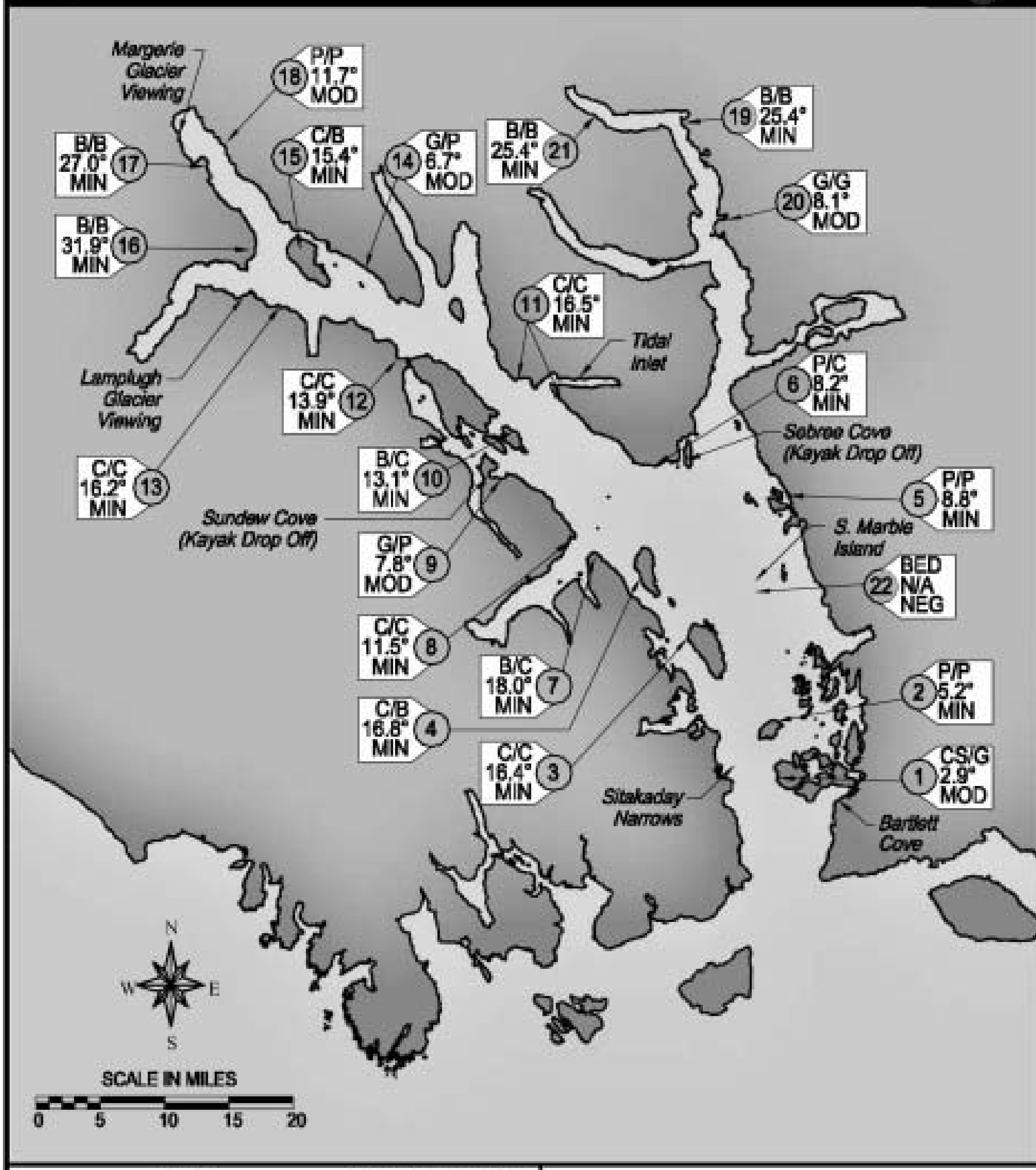
The recent and relatively rapid deglaciation of Glacier Bay over the past 250 years has resulted in a wide range of shoreline structure in a relatively short distance. The shoreline structure ranges from bedrock to a beach. For coastal geomorphological purposes, the shoreline vertical gradient ranges from the extreme low waterline to the extreme high waterline (up to 25 feet or 7 to 8 meters). According to the NPS coastal resources inventory, the shoreline slopes range from very gentle (3 to 9 degrees) to very steep (vertical in locations). Tidal ranges in the Bay are up to 25 feet (7.6 meters; Sharman et al. 2002).

The coastal geomorphological structure of Glacier Bay is complex. Figure 3-11 shows the substrate type, slope, and erosion potential for 22 selected sites within Glacier Bay. The Bay's southern portions have the most beaches containing sands with small particle sizes and mature vegetation (see figure 3-12). From an ecological and geomorphic perspective, shorelines in these areas are more mature than the remainder of the Bay. Farther north, toward the head of the Bay, the shoreline structure is less mature, with fewer beaches or only small pocket beaches; more exposed rock outcrops; and little, if any, vegetation (see figures 3-13 and 3-14). The shoreline vegetation found in the middle and northern portions of the Bay includes a significant component of pioneer species, those species that colonize areas after a disturbance. At the terminus of the glaciers, exposed bedrock overlain by sediment is prevalent because of the active dumping and grinding by the glacier (see figure 3-15). The vegetation in periglacial areas is sparse and restricted to hardy pioneer species.

Shoreline Characteristics at 22 Selected Sites in Glacier Bay

National Park Service
U.S. Department of the Interior

Figure 3-11



KEY
2 P/P 5.2° MIN — Primary Substrate/ Secondary Substrate; Shore Slope in Degrees; Substrate Erodability Potential; Site Number

ABBREVIATIONS	
BED	Bedrock
B	Boulder
C	Cobble
G	Granule
P	Pebble
CS	Coarse Sand
N/A	Not Available
NEG	Negligible
MIN	Minor
MOD	Moderate

Glacier Bay National Park and Preserve

Vessel Quotas and Operating Requirements
Environmental Impact Statement

Prepared by: Peratrovich, Nottingham & Drage, Inc., February, 2003

Figure 3-12 Example of Mature Beach in Glacier Bay.
Gravel and sand beach with mature vegetation.

Figure 3-13 Example of a Less Mature Beach in Glacier Bay.
Gravel and cobble beach with boulders.

The beaches of Glacier Bay's eastern shores comprise smaller particles than those of the western shores. The eastern shores contain sands, gravels, and pebbles, with shallow-sloping beaches, ranging from 3 to 9 degrees. The western shores of the Bay's main body and of the West Arm contain beaches dominated by cobbles, boulders, and bedrock, and the shoreline is steeper than the eastern shore, with typical slopes ranging from 12 to 32 degrees.

Dundas Bay generally has gently sloping shores (approximately 14 degrees), but does contain some steep slopes (80 degrees). The size of sediment also tends to be smaller in Dundas Bay than in Glacier Bay, with wider beaches, especially along the far northeast and southwest shores. These wide beaches mostly comprise silt and fine sand.

Biological Communities. Intertidal biological communities are exposed to the air for part of each tidal cycle, and submerged for the remainder of the cycle. Glacier Bay's shoreline habitats are a combination of rocky and soft substrates that can be separated by wave shock exposure and tidal elevation (Ricketts and Calvin 1968; O'Clair and O'Clair 1998). The shoreline community lives in the intertidal zone between the highest and lowest tides. This runs in Glacier Bay from approximately 21 feet above mean lower low water (MLLW) to approximately 5 feet below mean lower low water. Mean lower low water is the average of the lower of the two daily low tides, making it the tidal elevation below which the water surface seldom falls. Sharman et al. (1995) found that water temperature, salinity, amount of suspended sediment, and ice scour are key factors controlling intertidal biological community development, and that all of these variables are directly related to the proximity of the site to tidewater glaciers. In general, community diversity in rocky intertidal communities close to tidewater glaciers is very low. The amount of time since glacial retreat from the site appears to be of little importance.

Habitat types in this discussion are limited to rocky and soft types, rather than a more elaborate separation, such as that described by Ricketts and Calvin (1968), which includes such sub-groups as mud flats and sand flats among the soft bottom types. Many of the rocky substrates have well-developed communities that are easy to recognize because they form obvious bands across a uniform tidal height. Soft substrate communities may be well developed despite lower visibility, because of unstable, shifting surfaces and a predominance of infaunal organisms (organisms that live within the sediments, such as clams and worms).

Figure 3-14 Bedrock Shoreline.

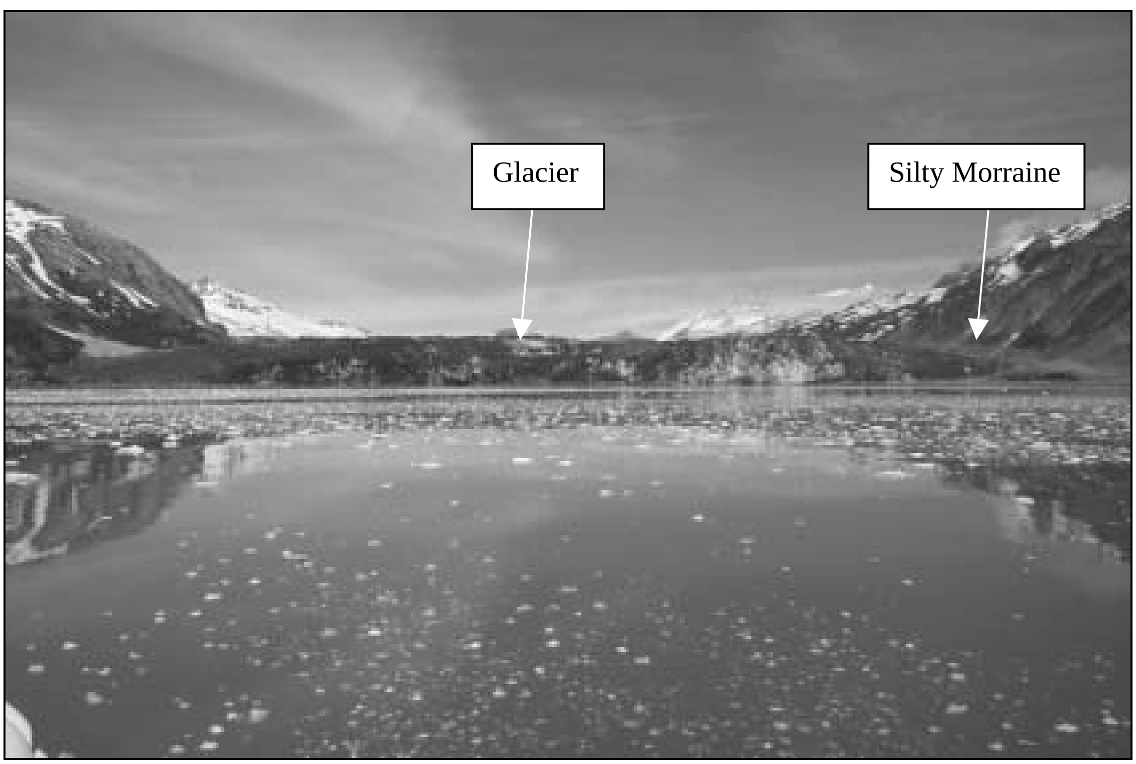


Figure 3-15 Glacier Terminus with Silty Lateral Morraines.

Rocky intertidal — Rocky intertidal shorelines are dominated by stable rock surfaces, either bedrock or cobbles and boulders large enough to remain static during normal storm events. Rocky intertidal substrate consists of greater than 1% bedrock or greater than 75% cobble and boulders with a slope of 60 degrees or less (Irvine et al. 2001).

Three intertidal levels have been identified for rocky intertidal substrates in Southeast Alaska (O'Clair and O'Clair 1998). The upper intertidal at Auke Bay, 50 miles east of the park, runs from approximately 21 feet (6.4 meters) above mean lower low water to 15 feet (4.6 meters). This elevation band is often dry because of extended periods above the tide level. The mid-intertidal range, between 15 feet (4.6 meters) above mean lower low water and 8 feet (2.4 meters) above mean lower low water, is seldom above the water surface long enough to dry completely. This zone is covered by tides regularly, with both high tides normally inundating it. The low intertidal level ranges from 8 feet (2.4 meters) above mean lower low water to 5 feet (1.5 meters) below mean lower low water. Moderate (neap) tides may not uncover this zone, and it is almost always wet when uncovered during the low tides. These habitats and their tidal heights are similar to those found in Glacier and Dundas Bays.

The following biological discussion of the species inhabiting Glacier Bay is based mainly on the Coastal Resources Inventory (Sharman et al. 2002). Additional information comes from O'Clair and O'Clair (1998) and Irvine et al. (2001). Typically, few species inhabit the upper intertidal, because of the harsh conditions present, the difficulty of adapting to freshwater and seawater conditions, desiccation, and the large temperature changes that occur over the course of a typical tide change. The most common algae are the stringy green *Enteromorpha intestinalis* and encrusting "sea tar" spores of the red alga, *Mastocarpus papillatus*. The most common invertebrates are a small snail, the Sitka periwinkle *(Littorina sitkana)*, and an isopod *(Ligia pallasii)*.

Rockweed *(Fucus gardneri)*, barnacles (the common acorn barnacle, *Balanus glandula*; the northern rock barnacle, *Semibalanus balanoides*; the thatched barnacle, *S. cariosus*; and the little brown barnacle, *Chthamalus dalli*), and Pacific blue mussels *(Mytilus trossulus)* dominate the mid-intertidal shorelines of Glacier Bay (Sherman et al. 2002; Irvine et al. 2001). Barnacles were found in 97.6% of the shoreline segments of Glacier Bay that were cataloged, while mussels were identified in 95.9% of the segments. Rockweed was identified in 97% of the segments. All of these organisms permanently attach themselves to rocky substrate. Species locations across the mid-intertidal zone are controlled by the frequency with which they are wetted by the tides and by wave action. They typically form pronounced vertical bands of one or more species across the mid-intertidal zone.

Rockweed forms a short canopy that provides protection for other algae and for a wide variety of invertebrates. It is resistant to drying and can tolerate a wide salinity range from nearly fresh water to undiluted sea water. Its high tolerance to physical stressors makes rockweed particularly suitable to colonize the intertidal zone of Glacier Bay. Rockweed's most common grazers are periwinkles (*Littorina sitkana* and *L. scutulata*) and the rockweed isopod *(Idotea wosnesenskii)*. Other algae typically found in the mid-intertidal zone include several species of green algae (*Enteromorpha* spp. and *Ulva fenestrata*) and brown algae (sea moss, *Endocladia muricata*; rockweed brush, *Odonthalia spp.*; and Oregon pine, *Neorhodomela oregona*). Compared to rockweed, the distribution of these algae is patchy and total biomass is much less.

Barnacles are found from the upper reaches of the intertidal zone to the subtidal zone, but most commonly occur in the mid-intertidal. Species location is determined by physical conditions within their range. The common acorn barnacle is found in the high to mid-intertidal, the northern rock barnacle is found in the mid-intertidal, the thatched barnacle is found from the mid-intertidal into the shallow subtidal, and the little brown barnacle is found from the high intertidal to the low intertidal. All barnacles are active filter feeders, sweeping their cirri (feeding arms) through the water to collect minute food particles suspended in the water when covered by the tide. They are common prey for snails, sea stars, ribbon worms, and occasionally bears.

Large beds of Pacific blue mussels are found in the mid-intertidal zone. The mussel's foot produces elastic (byssal) threads that it uses to attach to rocks or other hard surfaces, such as wharf pilings. The upper edge of their vertical range is limited by water coverage and feeding time during inundation, over each tidal cycle. The lower edge is most likely limited by predators, many of which live in the low intertidal zone or even subtidally and move upward to feed during high tides. Among the mussel's predators are several sea stars (the mottled star, *Evasterias troschelii*; the six-armed star, *Leptasterias spp.*; and probably the sunflower star, *Pycnopodia helianthoides*). Other predators include snails (*Nucella lamellosa* and *N. lima*), various crabs, surfperches, diving ducks, shorebirds, gulls, crows, and mammals (sea otter, *Enhydra lutris*; river otter, *Lutris canadensis*; mink, *Mustela vison*; and occasionally black bear, *Ursus americanus*).

The mid-intertidal zone contains a wide variety of other invertebrates. In addition to the dominant invertebrate species already discussed, the most common invertebrates found in the intertidal environment include anemones, snails, worms, crabs and other arthropods, sea stars, and clams. One anemone *(Anthopleura artemisia)* is frequently encountered. Table 3-7 lists the most common snails, worms, clams, and crustaceans.

TABLE 3-7: COMMON SNAILS, WORMS, CLAMS, AND CRUSTACEANS FOUND IN THE MID-INTERTIDAL ENVIRONMENT IN GLACIER BAY NATIONAL PARK AND PRESERVE

Common Name	Scientific Name
Snails	
Sitka periwinkle	*Littorina sitkana*
checkered periwinkle	*L. scutulata*
file dogwinkle	*Nucella lima*
frilled dogwinkle	*N. lamellosa*
barnacle-eating onchidoris	*Onchidoris bilamellata*
northwest onchidella	*Onchidella borealis*
Pacific falselimpet	*Siphonaria thersites*
Worms	
many-eyed ribbon worm	*Amphiporus angulatus*
purple ribbon worm	*Paranemertes peregrina*
pile worm	*Nereis vexillosa*
scale worm	*Harmothoe imbricata*
tusk worm	*Pectinaria granulata*
tubeworms	order *Sabellida*
Clams	
hiatella clams	*Hiatella spp.*
Pacific littleneck clam	*Prototheca staminea*
butter clam	*Saxidomus gigantea*
tellina clams	*Macoma spp.*
nuttall cockle	*Clinocardium nuttallii*
mya clams	*Mya spp.*
Crustaceans	
crabs	*Hemigrapsus spp.*
hermit crabs	*Pagurus spp.*
isopods	*Idotea wosnesenskii*
amphipods	*Spinulogammarus subcarinatus*

The shield limpet *(Lottia pelta)* is the most common limpet. Other snails, other limpet species, top snails, whelks, and chitons may also be locally abundant. Several worms are common in the mid-intertidal zone, mostly on or in sand or gravel beneath cobbles and boulders. Worms are common and important members of the biological community. The most common echinoderm is the six-rayed sea star, *Leptasterias hexactis*. The clams are found in quiet areas with sufficient soft sediment to bury themselves.

The low-intertidal zone is dominated by encrusting coralline algae and kelps. The dominant coralline alga in the area has been tentatively identified as rock crust, *Lithothamnion phymatodeum* (O'Clair and Lindstrom 2000). Another dominant alga is *Alaria marginata,* the heavy ribbon kelp. In some areas, these two species may provide almost complete coverage of the low intertidal zone. The coralline alga directly covers most available substrate, including invertebrates and some algae, while the ribbon kelp provides an overstory that maintains habitat for many species of algae and invertebrates. Other common algae include green algae (sea lettuce, *Ulva fenestrata / Ulvaria obscura*, *Enteromorpha spp.*, and *Acrosiphonia spp.*) and red algae (*Porphyra spp.*, *Palmaria spp.*, *Neorhodomela spp.*, *Mastocarpus papillatus*, and *Polysiphonia/Pterosiphonia spp.*). Another common, but not dominant, marine plant is the red alga cup and saucer *(Constantinea rosa-marina)*, which occurs as scattered individual plants.

The most common invertebrates in the low intertidal zone include sponges, anemones, snails and other gastropods, bryozoans, worms, amphipods (beach hopper) and other arthropods (crabs and shrimps), echinoderms (sea stars, sea cucumbers, and urchins), and tunicates. The most common sponges, snails, worms, and echinoderms are listed in table 3-8.

TABLE 3-8: COMMON SPONGES, SNAILS, WORMS, AND ECHINODERMS FOUND IN THE LOW-INTERTIDAL ENVIRONMENT IN GLACIER BAY NATIONAL PARK AND PRESERVE

Common Name	Scientific Name
Sponges	
crumb-of-bread sponge	*Halichondria panice*
boring sponge	*Cliona celata*
red volcano sponge	*Acarnus erithacu*
purple encrusting sponge	*Haliclona permollis*
Snails	
black Katy	*Katherina tunicata*
lined chiton	*Tonicella lineata*
ringed blind limpet	*Cryptobranchia concentrica*
plate limpet	*Tectura scutum*
puppet margarite	*Margarites pupillus*
variegated lacuna	*Lacuna variegata*
Columbian cucumber sucker	*Vitriolina columbiana*
shag-rug aeolis	*Aeolidia papillosa*
Worms	
serpulids	*Pseudochitinopoma occidentalis*
spirorbids	*Paradexiospira vitrea*
pile worm	*Nereis vexillosa*
Echinoderms	
mottled star	*Evasterias troschelii*
morning sun star	*Solaster dawsoni*
daisy brittle star	*Ophiopholis aculeata*
green sea urchin	*Strongylocentrotus droebachiensis*
Alaska tar-spot cucumber	*Cucumaria vegae*
white sea cucumber	*Eupentacta pseudoquinquesemita*

The sponges are found in the low intertidal, especially near the lower boundary, as well as in subtidal habitats. The Christmas anemone *(Urticina crassicornis)* is the most common anemone. Of the few other anemone species that occur, most are *Anthopleura spp*. Several of the clam species also are found in the low intertidal (hiatella, Pacific littleneck, and butter clam), where there is sufficient fine sediment. Amphipods and other arthropods are represented by the pink beach hopper *(Maera danae)* and the stout coastal shrimp *(Heptacarpus brevirostris)*.

Soft substrates — The soft intertidal substrates in Glacier Bay are areas of net sediment deposition (more sediment settles than is removed by currents or wave action). These substrates occur in areas protected from strong currents or high waves and in the vicinity of stream mouths. The sediment source may be direct settling from the water column, or the sediment may arrive from longshore transport of sediments deposited elsewhere.

Invertebrates dominate the soft substrates in the intertidal zone. The lack of stable surfaces large enough for attachment severely limits the colonization of algae on these shorelines. Where present, the most common algae are rockweed and sugar kelp *(Laminaria saccharina)*. Clams and worms are typically the most common invertebrates, both groups living in the sediments. Bodkin and Kloecker (1999) reported 10 species of clams in Glacier Bay. Seven of the species identified were fairly common to abundant and are listed in table 3-9.

TABLE 3-9: COMMON CLAMS FOUND IN THE SOFT SUBSTRATE ENVIRONMENT IN GLACIER BAY NATIONAL PARK AND PRESERVE

Common Name	Scientific Name
heart cockle	*Hiatella arctica*
Macoma clam	*Macoma balthica*
Macoma clam	*M. nasuta*
softshell clams	*Mya spp.*
Pacific littleneck clam	*Prototheca staminea*
butter clam	*Saxidomus gigantea*
fuzzy clam	*Pseudopythina compressa*

Only one California sunset clam was found during the Bodkin and Kloecker (1999) study. Several of these clams, particularly the heart cockle, the butter clam, and the Pacific littleneck clam, are collected occasionally by recreational fishers in many areas because of their size; however, the *Macoma* species, which are typically much smaller, are the most abundant members of the group.

A separate study by Mueller (1973), reported in Bodkin and Kloecker (1999), listed four additional species of clams from Glacier Bay. They identified *Axinopsida serricata*, *Nuculana minuta*, *Panomya* *ampla*, and Greenland cockle *(Serripes groenlandica)*. Data regarding worm and other burrowing species found in the park are limited.

Robards et al. (1999) reported large catches of invertebrates in beach seine nets at several soft sediment sites within the park. They reported numerous amphipods from beach seine nets near Carroll Glacier and numerous euphausiids (krill) from the nets close to the Grand Pacific and Reid Glaciers. These crustaceans are likely to be important food sources for forage fishes and other marine fishes in upper Glacier Bay and are known to be important humpback whale prey. Eelgrass *(Zostera marina)* was the only vascular marine plant found on soft substrates, and it was very uncommon, occurring in only 0.3% of the sections of the cataloged shoreline.

3.4.1 Cultural Resources

3.4 HUMAN ENVIRONMENT

3.4.1 Cultural Resources

This subsection describes the cultural resources (e.g., archeological resources, historic structural and ethnographic resources, and the cultural landscapes) for the park and preserve. This discussion does not represent a comprehensive description of the park, but focuses on the information necessary to assess potential effects of the alternatives on archeological sites, historic structures, ethnographic resources, and cultural landscapes in Glacier and Dundas Bays.

The administrations at all national parks, including those established mainly for their natural or recreational resources, have responsibilities to identify "historic properties" potentially affected by undertakings (NPS et al. 1995). The data regarding existing cultural resources include information from the Alaska Heritage Resource Survey (AHRS) from the Alaska Office of History and Archaeology (Alaska Department of Natural Resources [ADNR] 2002), as well as existing literature, and NPS inventories and literature.

Archeological Resources. The Park Service defines archeological resources as "the remains of past human activity and records documenting the scientific analysis of these remains" (NPS 1997a). For the purposes of this analysis, archeological resources refer to prehistoric Native American cultural resources including lithics, faunal material, and features (e.g., house pits and hearths), and historic archeological resources of Native American and Euro-American origins (e.g., the remains of Tlingit occupation, the remains of canneries or salteries and their associated artifacts [fallen structures, fish traps, pilings, and boats], the remains of homesteads and their associated artifacts [fallen cabins, stoves, and outhouses], the remains of mining and associated artifacts [fallen structures, mine shafts, and equipment], the remains of fox farming [fallen structures and fences], the remains of agriculture [garden plots or fields and equipment], and other fallen structures or cultural remains).

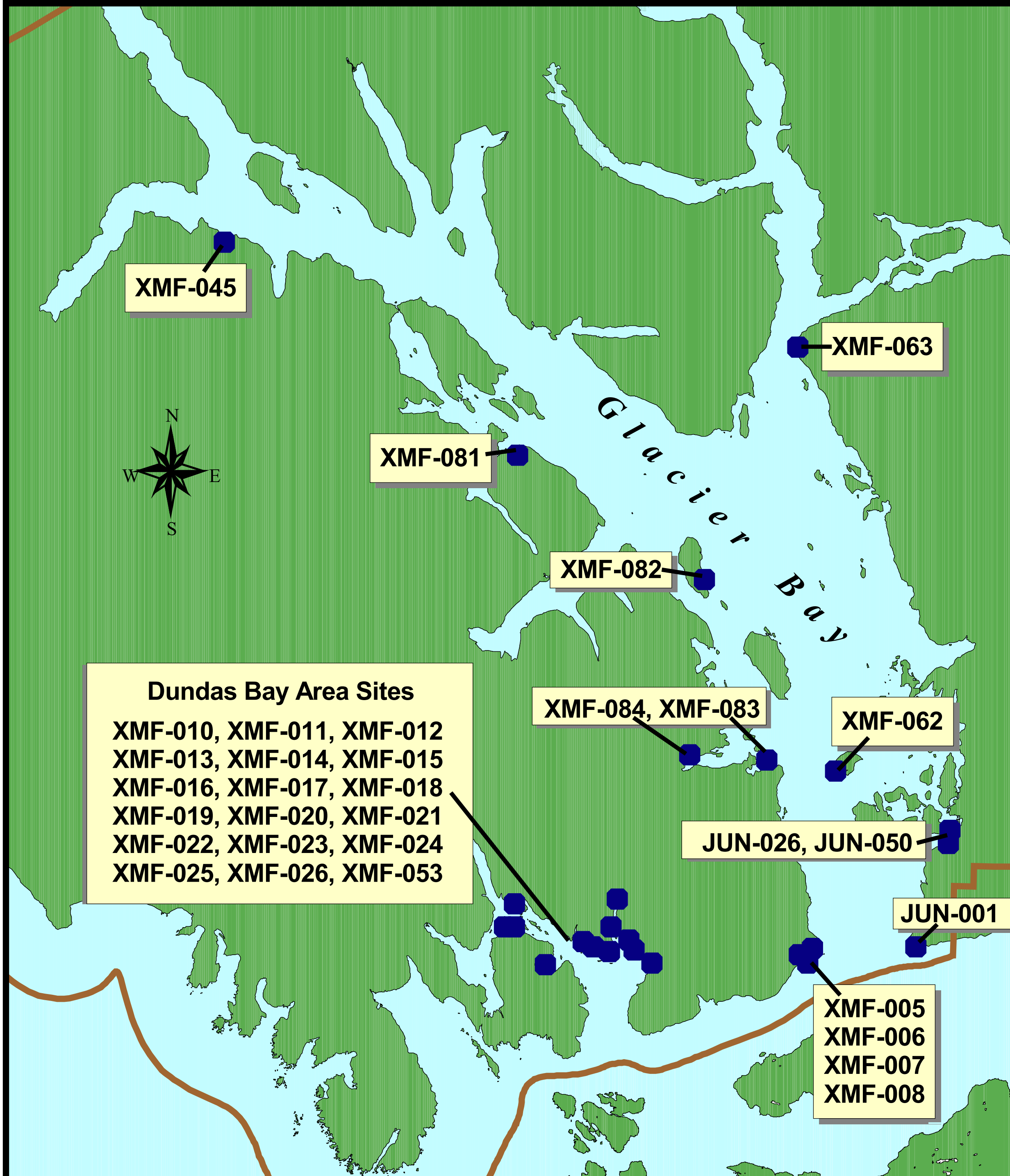
The locations of the archeological resources in Glacier Bay and Dundas Bay are identified in figure 3-16. Archeological resources that have been found, or can be expected to occur, in the park are diverse and include:

- petroglyphs and petrographs.
- culturally modified trees.
- rock shelters.
- villages (defensive and open layout).
- forts.
- fishing sites and weirs.

AHRS Archaeological Sites in Glacier Bay and Dundas Bay

Figure 3-16

National Park Service
U.S. Department of the Interior



Alaska Heritage Resource Survey (AHRS) Sites

Glacier Bay National Park and Preserve Boundary

Source: Alaska Department of Natural Resources. 2002. Alaska Heritage Resource Survey. Anchorage, AK: Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation, Office of History and Archaeology.

Glacier Bay National Park and Preserve

Vessel Quotas and Operating Requirements
Environmental Impact Statement

5 0 5 10 Miles

Prepared by: Ecology and Environment, Inc., for Stephen Braund and Associates, Inc., February 27, 2003

- hunting and gathering sites (e.g., camps, processing sites, lookouts, kill sites, and plant gathering areas).
- stone cairn formations.
- mining camps.
- canneries.
- trading posts.
- log cabins.
- trails.
- horticulture sites.
- buried sites.
- major/multi-component sites.
- cemeteries or burials.
- intertidal or submerged cultural remains (Schoenberg 1999).

Geologic dynamics — glacier advance and retreat, and isostatic depression and rebound — make finding archeological sites difficult. Glacier advance and retreat (e.g., the Little Ice Age peaking in approximately 1750) have potentially removed any evidence of archeological sites before 400 years ago in Glacier Bay. Isostatic rebound (the rising of land after the removal of glacial weight as the glacier retreats) in lower Glacier Bay has resulted in the land lifting at a rate of 1.2 to 1.6 inches (3 to 4 centimeters) per year. For example, previously coastal landforms such as the “Spruce Terrace,” a post-Little Ice Age beach remnant located 9 to 16 feet (2.7 to 4.9 meters) above modern sea level, are receding from the coast because of this rebound (Mann and Streveler 1997, cited in Schoenberg 1999). Many of these landforms have not been surveyed for archeological sites, but have the potential to contain sites dating from the early Holocene (e.g., 9,000 years ago) through the historic period. Dundas Bay, Icy Strait, Excursion Inlet, and the outer coast of the park were not glaciated during the Little Ice Age, and landforms that could have supported human occupation and activity in coastal areas have survived (Mann and Streveler 1997). Because of the park’s maritime nature, archeological sites likely would be found along or near the coastlines. Exceptions include Tlingit ceremonial sites situated on several mountaintops (below 3,000 feet [914 meters] in elevation), Euro-American mining and fur trapping sites, and trails or trade routes.

The following discussion summarizes prehistoric Native American and historic Euro-American and Tlingit archeological resources in the park in Glacier and Dundas Bays (see table 3-10). Identified sites are followed by AHRS numbers in parentheses that, for ease of locating the sites, correspond to codes in table 3-10 and figure 3-16.

Prehistoric resources — Humans have occupied the Glacier Bay area for thousands of years (Ackerman 1968). The oldest dated site in the park vicinity is Ground Hog Bay. The site was occupied beginning 9,000 years ago and is located on the north shore of Icy Strait between Excursion Inlet and Lynn Canal approximately 30 miles (48 kilometers) southeast of present-day Gustavus (Ackerman 1968).

The only dated prehistoric site within the park is *Xakwnoowu* (XMF-053; see table 3-10 and figure 3-16). This site shows almost continuous occupation for the past 800 years, with one date suggesting an earlier occupation 6,400 years ago (Crowell 1995). Several fort platforms on a hill above the historic component of the village of *L'istee* (XMF-013) on the east shore of the Dundas River (see table 3-10 and figure 3-16) may be prehistoric in age, although they have not been firmly dated. Because of increased conflict in the Northwest Coast cultural area around 1,300 years ago, Tlingits began to build forts and defensive village sites in Southeast Alaska (Schoenberg 1999). Three of these types of sites in the park (a fort/village [XMF-053] and two forts [XMF-083 and XMF-082]) occurred between 200 and 400 years ago (Schoenberg 1999; see table 3-10 and figure 3-16).

Protohistoric/historic Tlingit resources — Additional coastal villages and camps are located in Glacier and Dundas Bays, range in age from protohistoric (at or before the time of European contact) to the early 20th century, and include:

- Lester Island Village/*Gatheeni* (JUN-026).
- Point Carolus (XMF-005).
- Carolus River Village (XMF-007).
- Dundas River Village/*Listi*/*Tlistee* (XMF-013).
- Dundas Bay Rock Shelter (XMF-018).
- Tlingit Smokehouse / Dundas Bay Cemetery (XMF-016).
- Berg Bay Village (XMF-084; see table 3-10).

Historic Euro-American Resources.

European Exploration. European explorers who visited the Glacier Bay region between 1741 and 1794 included Alexei Cherikof, James Cook, Jean-Francoise de Galaup, Comte Le Perouse, and George Vancouver. There are no known records of exploration in and around the waters of Glacier Bay between 1795 and 1867 (Kurtz 1995). The late 19th and early 20th centuries were a period of American exploration and scientific investigation in the Glacier Bay area. Early scientific expeditions used Huna Tlingit guides and reported Huna Tlingit subsistence camps throughout the Bays. One archeological remnant of this era of American exploration and scientific investigation is a base camp near Muir Glacier (John Muir Cabin [XMF-063]), built in 1890 by John Muir and Harry F. Reid.

Resource Utilization. Resource utilization in Glacier Bay has included mining, commercial and subsistence fishing, hunting, plant and egg gathering, timber harvesting, fox farming / fur harvesting, and agriculture/horticulture. Hard rock gold mining within the confines of the current park occurred mainly in the area between Reid Inlet and Lamplugh Glacier. The Leroy Mine (Parker Prospect, Mount Parker Mine [XMF-045]) was operated from the mid-1930s through the 1940s (see table 3-10 and figure 3-16). In the first half of the 20th century, mining operations also occurred on Willoughby and Francis Islands, at Blue Mouse Cove, at Sandy Cove, near Beartrack Cove, and in Dundas Bay. Remnants of some of these mining operations are still visible (e.g., rusted machinery, collapsing structures, and piles of mine tailings; Kurtz 1995). Remnants of the commercial fishing industry include:

- the Bartlett Bay Packing Company (JUN-026, JUN-050) operated from 1883 to 1910.
- a cannery at Dundas Bay (XMF-025) operated from 1890 to the 1930s.
- several fish traps (XMF-019, XMF-023, and XMF-024) and boats (XMF-026) associated with the Dundas Bay Cannery that have washed ashore.

Evidence of the importance of subsistence fishing among the Huna Tlingit includes numerous smokehouses that range in age from historic to modern and include Carolus River Smokehouses 1 and 2 (XMF-006 and XMF-008).

Homesteading. Homesteaders settled in the vicinity of the park at either Strawberry Point (Gustavus) or Dundas Bay beginning in 1914. Homesteaders at Gustavus noted the presence of a Huna Tlingit smokehouse on the Salmon River and a ceremonial house located at Point Gustavus. Remnants of homesteads in Glacier Bay include three different homesteads used by William Horseman (Doc Silvers) and his wife from 1928 through the early 1940s (XMF-021 and XMF-022) and several structures dating from the early 1930s to 1964 used by Stanley Harbeson (XMF-010, XMF-011, and XMF-014). Remains of the Silvers and Harbeson homesteads are currently visible. Homesteaders established fox farms on Beardslee, Strawberry (XMF-062), Cenotaph, and Willoughby Islands in the 1920s. Much of the Beardslee Islands enterprise is still visible (Kurtz 1995). Homesteaders sometimes evicted Huna Tlingit from their traditional use areas. Huna Tlingit applied for more than 20 allotments in what eventually became the national monument, and they maintained cabins and smokehouses on many of them (e.g., White Cabin [XMF-012]; see table 3-10 and figure 3-16).

TABLE 3-10: ALASKA HERITAGE RESOURCE SURVEY AND NATIONAL PARK SERVICE ARCHEOLOGICAL SITES IN GLACIER AND DUNDAS BAYS

AHRS #	Site Name	Location	Site Type	Period/Date	Citation
JUN-001	Wuckitan Sib House	Pt. Gustavus (Strawberry Point)	reported lineage house, but not located by Ackerman	Historic, Tlingit	Ackerman 1965:1-2 Ackerman 1968:90 Crowell 1995; SAIP
JUN-026	Lester Island Village (Bartlett Cove, Bushmann Saltery, *Gatheeni*)	South shore of Lester Island	Bushmann Saltery AD1883-1910; cemetery (7 graves); village (4 rect. pits); garden plot	Historic, Tlingit/ Euro-American (AD pre-1885-1900)	Ackerman 1964:2-5 Ackerman 1968:89 Sealaska 1975:766-767 NPS Archeological Survey 002-93-GLBA Kurtz 1995:46
JUN-050	Bartlett Cove Pilings and Site	Bartlett Cove	warehouse; pilings (55); saltery installed by Bushmann (1899)-never completed	Historic, Euro-American (AD1899)	Ackerman 1968:91, Figure 25 NPS Archeological Survey 002-93-GLBA Kurtz 1995:48
XMF-005	Point Carolus	Southwest of Pt. Carolus	2 large oval pits, poss. cache pits	Historic	Ackerman 1964:17 Ackerman 1968:89
XMF-006	Carolus River Smokehouse 1	Near mouth of Carolus River	smokehouse, collapsed building	Historic, Tlingit	Ackerman 1964:14 Ackerman 1968:89
XMF-007	Carolus River Village	Carolus River	three log cabins, smokehouse, historic debris, axe-cut trees	Historic, Tlingit	Ackerman 1964:6-14 Ackerman 1968:89 Sealaska 1975:751
XMF-008	Carolus River Smokehouse 2	Carolus River	smokehouse ruin on pilings w/ assoc. historic items	Historic, Tlingit	Ackerman 1964:14-17 Ackerman 1968:89
XMF-010	Harbeson Cabin 2 (Dundas Bay Cabin)	East shore of Dundas Bay	cabin (modern)	Historic	Ackerman 1964:17 Ackerman 1968:89
XMF-011	Harbeson Cabin 1	Northeast shore of Dundas Bay	cabin, mink pens, salmon smoking shed	Historic	Ackerman 1964:17 Ackerman 1968:89
XMF-012	White Cabin	Northeast shore of Dundas Bay	cabin, river punt	Historic, Tlingit	Ackerman 1964:17 Ackerman 1968:89
XMF-013	Listi (Dundas River Village) ("Tlistee" [DeLaguna])	Dundas River	outdoor fire pit; possible sweatbath; 2 houses; concrete grave capstone (AD1917); historic artifacts	Historic, Tlingit (late 1880s)	Ackerman 1968:8-11 Ackerman 1964:17, 23 Sealaska 1975:758-759 NPS Archeological Clearance Survey Form 001-87-GLBA DeLaguna, F. 1990b:Fig. 1, p. 204
XMF-014	Harbeson Trail Cabin	East bank of Dundas River (N end of XMF-013)	cabin and assoc. artifacts	Historic	Ackerman 1968:89 Ackerman 1964:17 NPS Archeological Clearance Survey Form 001-87-GLBA
XMF-015	Dundas River Cemetery (Christian cemetery)	Near mouth of Dundas River	27 graves w/ gravestones, grave fences, and collapsed grave houses	Historic, Tlingit (AD1901-1928)	Ackerman 1968:89 Ackerman 1964:21-27 Sealaska 1975:756-757

TABLE 3-10: ALASKA HERITAGE RESOURCE SURVEY AND NATIONAL PARK SERVICE ARCHEOLOGICAL SITES IN GLACIER AND DUNDAS BAYS

AHRS #	Site Name	Location	Site Type	Period/Date	Citation
XMF-016	Tlingit Smokehouse (Dundas Bay Cemetery)	Dundas River	log pilings for a house (central hearth), historic items, burial	Historic, Tlingit (AD1900s)	Ackerman 1968:89 Ackerman 1964:17-23 Sealaska 1975:754-755
XMF-017	Olsen Cemetery	Near mouth of Dundas River	cemetery (3 burials)	Historic, AD1919	Ackerman 1968:89 Ackerman 1964:17
XMF-018	Dundas Bay Rock Shelter (Canoe Rock Shelter)	Near mouth of Dundas River	rock shelter, dugout canoe	Protohistoric/ Historic, Tlingit	Ackerman RE 1968:89 Ackerman 1964:27-30
XMF-019	Dundas Bay Fish Trap 1	Near mouth of Dundas River	floating fish trap (Dundas Bay Cannery)	Historic, Euro-American	Ackerman 1968:89 Ackerman 1964:31
XMF-020	Old Dundas River	West of Dundas River	small shack w/ wood burning stove; gasoline drum; historic litter; log foundation	Historic	Ackerman 1968:89 Ackerman 1964:29
XMF-021	Doc Silver Cabin 1	Near Dundas River	cabin and dock	Historic, Euro-American	Ackerman 1968:89 Ackerman 1964:31
XMF-022	Doc Silver Cabin 2	Near Dundas River	cabin site and flagpole	Historic, Euro-American	Ackerman 1968:90 Ackerman 1964:31
XMF-023	Dundas Bay Fish Trap 2	Near Dundas River	floating fish trap and heavy pilings (Dundas Bay Cannery)	Historic, Euro-American	Ackerman 1968:90 Ackerman 1964:31
XMF-024	Dundas Bay Fish Trap 3	Near Dundas River	floating fish trap and heavy pilings (Dundas Bay Cannery)	Historic, Euro-American	Ackerman 1968:90 Ackerman 1964:31
XMF-025	Dundas Bay Cannery	West shore of Dundas Bay	cannery (sheds, docks, boilers, steamboats, company houses)	Historic, Euro-American AD1890-1930s	Ackerman 1968:90 Ackerman 1964:31
XMF-026	Beached Boats	West shore of Dundas Bay	equipment, boats (Dundas Bay Cannery)	Historic, Euro-American	Ackerman 1968:90
XMF-045	Leroy Mine (Parker Prospect, Mount Parker Mine)	East of Lampugh Glacier	Gold Mine Camp - sealed mine shaft	Historic, Euro-American AD1937-1952	ADP 3330-6N file Kurtz 1995:41-43
XMF-053	Village/Fort, Tlingit	Dundas Bay	village/fort w/ middens	Prehistoric/ historic (6420+/-120BP - 120+/-50BP)	Crowell 1995; SAIP
XMF-062	Strawberry Island Fox Farm	Strawberry Island	fox farm (frame house, log house, barn, fox pens, skinning and cooking sheds)	Historic, Euro-American AD1927	Ackerman 1964:5 Ackerman 1968:91 Kurtz 1995:57-58

TABLE 3-10: ALASKA HERITAGE RESOURCE SURVEY AND NATIONAL PARK SERVICE ARCHEOLOGICAL SITES IN GLACIER AND DUNDAS BAYS

AHRS #	Site Name	Location	Site Type	Period/Date	Citation
XMF-063	John Muir Cabin	Muir Point, below mouth of Adams Inlet	pre-fabricated cabin John Muir research base	Historic, Euro-American AD1890	Ostrogorsky, M. AHRS Site Card Gilbert, GK 1910 (Harriman AK Series Vol. III) Kurtz 1995:20-27
XMF-081	Surveyor Camp	Hugh Miller Inlet	camp	Historic, Euro-American AD1906-1908	Howell 1997 survey, cited in Schoenberg 1999
XMF-082		Drake Island	fort platform	Historic	Howell 1997 survey, cited in Schoenberg 1999
XMF-083	Fort Tlingit (X'atadaa Noowu)	Berg Bay	fort platform	Historic	Howell 1997 survey, cited in Schoenberg 1999
XMF-084	Berg Bay Village	Berg Bay	2 houses	Historic (late 1890s-early 1900s)	Howell 1997 survey, cited in Schoenberg 1999

Sources: 1) AHRS files, Office of History and Archeology, Anchorage, Alaska
2) Schoenberg 1999 (DRAFT): Appendix

SAIP = System-Wide Archeological Inventory Program.

Historic Structures. Historic structures are the remains of material assemblies that comprised the structures that housed humans and their activities in the historic past (NPS 1997a). These resources are those buildings still standing; if collapsed or otherwise open to the elements, they fall into the archeological resources category. The park's policy on historic structures is based on the 1984 general management plan (NPS 1984). The general management plan outlines a policy of "benign neglect," directing NPS personnel to allow all historic structures in the park to deteriorate naturally, eventually to be reclaimed by the landscape. It also recommends that such sites be managed as "discovery sites" with no on-site interpretation and no reconstruction or stabilization of the structure.

There are two exceptions to this policy. One is the Cape Spencer Lighthouse located inside park boundaries at Cape Spencer (outside the planning area). Built in 1924, the lighthouse is listed on the National Register of Historic Places, and is maintained by the U.S. Coast Guard (USCG). The other exception is the Glacier Bay Lodge complex. Completed in 1966 as part of a national initiative to build visitor facilities throughout the national park system, this award-winning building is potentially eligible for inclusion on the National Register of Historic Places. The Glacier Bay Lodge complex is the core of visitor facilities in Bartlett Cove, and is maintained under conditions of the Secretaries Standards for Historic Preservation by the Park Service and the parks concessioner. The general management plan for historic structures underwent section 106 compliance review in 1984, resulting in letters of concurrence of no effect from the state historic preservation officer and the Advisory Council on Historic Preservation to validate the determination that the park was using a proper management protocol.

For all parks, the Park Service maintains a List of Classified Structures (LCS), a comprehensive inventory of all historic and prehistoric structures in each park. Structures in this inventory may individually meet the criteria of the National Register of Historic Places or may be contributing elements of sites and districts that meet the register criteria. Other structures in the inventory may not be eligible for the national register (e.g., moved, reconstructed, and commemorative structures, and structures achieving significance within the last 50 years; NPS 1997a).

Thirteen structures are currently included on the Glacier Bay List of Classified Structures: six graves and seven architectural features (NPS 1999b). The six graves are located within the Dundas River Cemetery (XMF-015) and are listed as being in "poor" condition. The site of these graves is eligible for the national register "as the only known cemetery in Dundas Bay that illustrates the intermingling of the Tlingit, Russian Orthodox, and Anglo-American cultures" (NPS 1999b).

Three of the LCS architectural features (Dundas Bay Cannery [XMF-025] and Harbeson Cabins 1 and 2 [XMF-011 and XMF-010]) are rated in "fair" condition (e.g., are still standing; NPS 1999). The remaining four architectural features — the boiler and ramp at the Dundas Bay Cannery and the Ibach Cabin and Shed in Reid Inlet (XMF-032) — are on the LCS listing as being in "poor" and ruinous condition (NPS 1999b).

The Harbeson Cabin and Woodshed (Cabin 1 and 2 [XMF-011 and 010]) are eligible for the national register "as a physical remainder of early Anglo-American settlement and exploration of Dundas Bay in Glacier Bay National Park" (NPS 1999b). The Dundas Bay Cannery building, boiler, and ramp (constructed by Western Fisheries Co. of Portland in 1900 and operated until 1931) are eligible for the national register "as the only remaining physical representative of the three canneries that operated in what is now Glacier Bay National Park and Preserve" (NPS 1999b). The Ibach Cabin and Shed are eligible for the national register as the "physical representative of the events that opened the park to mining and for association with J.P. Ibach and Rex Beach" (NPS 1999b). Additional structures that are not included on the List of Classified Structures are discussed in the "Archeological Resources" subsection and can be found in table 3-10 and in figure 3-16.

Ethnographic Resources. Ethnographic resources are "basic expressions of human culture and the basis for continuity of cultural systems" that "encompass[es] both the tangible and the intangible" (NPS 1997a). Ethnographic resources consist of traditional arts and Native languages, religious beliefs, special places in the natural world, structures with historic associations, natural materials and subsistence activities, and traditional cultural properties (NPS 1997a). The following subsections provide ethnographic information such as Huna Tlingit social organization, territory, and sacred sites, and describe the 15 traditional cultural properties within the park that are the physical sites on the ground that anchor the ethnographic resource.

Social organization **—** The Huna Tlingit people occupy much of the northern portion of Tlingit territory, and constitute one of 19 tribes or Kwaans (although the Huna Tlingits prefer the term Kaawoo). Among the Tlingit, social organization revolves around the membership of every individual in one of two moieties (i.e., either of two basic units that make up a social group): Raven or Wolf (southern Tlingit territory) / Eagle (northern Tlingit territory). These moieties are matrilineal (i.e., tracing ancestral descent through the maternal line) and exogamous (i.e., marrying outside the family, clan, or other social unit). Each moiety comprises multiple clans, and each clan, in turn, comprises lineages or house groups. Five clans trace their origins to specific places within the park. The Raven moiety L'ukna.xadi Clan originates in Dry Bay at the mouth of the Alsek River. A descendant of the L'ukna.xadi clan, the Takdeintaan clan, originated on Cenotaph Island in Lituya Bay on the outer coast of the park. Three Eagle moiety clans trace their origins to Glacier Bay: the *Chookaneidi* clan to Berg Bay on the west shore of Glacier Bay, the *Wooshkeetaan* clan to the Point Gustavus area, and the *Kaagwaantaan* clan to the lower portion of Glacier Bay.

Territory **—** The park encompasses approximately two-thirds of the traditional territory of the Huna Kaawoo (or tribe). Glacier Bay, along with the outer coast of the park and Dundas Bay, is the epicenter for the development of Huna Tlingit culture. Tlingit clans and houses have ownership of specific territories that often coincided with preferred subsistence use areas (e.g., salmon streams, hunting areas, and berry patches) or trade routes, and each clan or house often managed resources in its territory (Schroeder and Kookesh 1990).

Huna Tlingit territory includes all of the waters of Glacier Bay, Icy Strait, Port Frederick, and Tenakee Inlet, and parts of Cross Sound and Chatham Strait. The land area includes the coastal areas between Cape Fairweather and Khaz Bay in the west, and Point Howard and Basket Bay in the east (Schroeder and Kookesh 1990; Goldschmidt and Haas 1998). Various publications recount the Huna Tlingit history in Glacier Bay (e.g., Dauenhauer and Dauenhauer 1987; Swanton 1909; Bohn 1964, as cited in Schoenberg 1999). For example, Huna Tlingit oral history tells of a primary village in Bartlett Cove that was evacuated because of glacial advance. According to Chookeneidi legend, the village consisted of five named houses — Kaawagaani Hit, Woosh Keek Hit, Eech Hit, Naanaa Hit, and Xinaa Hit of the Chookaneidi clan — and a row of Raven moiety houses, unnamed in Chookaneidi legend. After the glacier entered Bartlett Cove, these houses evolved into three distinct clans (Dauenhauer and Dauenhauer 1987). According to Huna Tlingit oral history, after the evacuation from Bartlett Cove, one Huna Tlingit group moved to Excursion Inlet, another group moved to the Ground Hog Bay area, and another group moved to Spasski (on the south shore of Icy Strait, on the north shore of Chichagof Island) and possibly other places near the entrance of Port Frederick (Schroeder 1995; Dauenhauer and Dauenhauer 1987). Many of the names for these clan houses are used for clan houses in present-day Hoonah (e.g., *Kaagwaantaan / Kaawagaani Hit* — "The House that Burned," *Wooshkeetaan / Woosh Kik Hit Taan* — "Half of a House," and *Chookaneidi* — "People of the Grass"; Schroeder 1995; Dauenhauer and Dauenhauer 1987). According to one clan legend, the origin of the clan name *Chookaneidi* came from the name of a grass (chookan) and *Chookan Heeni* ("Grassy River") at the head of Berg Bay, where women harvested subsistence foods (Schroeder 1995; Dauenhauer and Dauenhauer 1987).

Subsistence **—** Traditionally, the Tlingit relied on a broad range of terrestrial and marine resources for subsistence. Terrestrial mammals of importance included bear, deer, mountain goats / sheep, and birds (including eggs; DeLaguna 1990). Marine mammals of importance included the harbor seal, sea lion, sea otter, and occasionally porpoise. The Huna Tlingit were expert sealers, and often traded skins and oil to other Tlingit. Glacier Bay was an excellent sealing ground because seals often hauled up onto the ice flows to give birth (DeLaguna 1990). The Tlingit harvested five species of salmon — Chinook, sockeye, pink, coho, and chum — and these provided the bulk of the Tlingit diet. Other important species included halibut, herring (fish and eggs), eulachon (for fish and oil), crabs, cod, shrimp, rockfish, octopus, and squid. The intertidal zone also provided an abundance of foods, including a variety of seaweeds, three species of clams (a mainstay winter food), chitons, and limpets. Plant foods also constituted an important component of the Tlingit diet, and consisted of a variety of beach greens in spring months, and eight species of berries harvested throughout summer and early fall. In historic times, the inner bark of trees also was harvested for its sweet starchy cambium layer.

Each Tlingit tribal area had at least one principal winter village, typically located in a sheltered bay with a sandy beach for landing and launching canoes, and convenient access to subsistence and resource areas (e.g., salmon streams, clamming areas, berry patches, hunting areas, fresh water, and timber resources). During the summer, families scattered throughout the tribal region to their respective hunting and fishing camps. The Huna Tlingit's annual cycle involved:

- hunting for seal, fishing for halibut, and gathering eggs and plants in the spring.
- trading, harvesting berries, fishing, and hunting for seal in the summer.
- fishing, hunting, and trapping in the fall.
- returning to the village in the winter for a season of potlatches, trading expeditions, crafts, and repair of fishing gear (DeLaguna 1990).

Sacred sites **—** The Huna Tlingit consider many specific, discreet places within the park to be sacred sites. The physical geography of Glacier Bay is imbedded within the social fabric of Huna Tlingit culture, a social geography in which the interactions of living individuals are predetermined by the place their ancestors occupied in the ancient landscape. The Huna Tlingit clans, through the generations, became symbolically identified with the places they had come to own and occupy and with the events that had validated that ownership. The symbols and their meanings are conveyed through the concept of *at.o'ow*, which is an "owned or purchased thing" (Dauenhauer and Dauenhauer 1987). The "thing" may be land (e.g., a geographic feature such as a mountain, a landmark, or a historical site), a heavenly body, a spirit, a name, an artistic design, an image from oral literature, a story or song about an event in the life of an ancestor, or ancestors themselves. The "purchase" may be made with money or trade, as collateral on an unpaid debt, through personal action, or through human life (Dauenhauer and Dauenhauer 1987). For example, "the name of *Kaasteen*, the land of Glacier Bay, the story and the songs, and the visual image of the Woman in the Ice are the property or *at.o'ow* of the *Chookaneidi* clan," because these *at.o'ow* were "purchased with the life of an ancestor" (Dauenhauer and Dauenhauer 1987). The land of Glacier Bay is "sacred because it was purchased with the blood of the people" (Dauenhauer and Dauenhauer 1987).

The symbols (or crests), stories/legends, songs, places, and animals meld and become *at.o'ow*. Some legends extend to the mythical past and recount the activities of Raven at the time the world was created, and identify certain landforms within the park that are relics resulting from the creative act. Many legends recount clan connections to Glacier Bay at a time before the Little Ice Age. Certain clan legends recount supernatural and historical events that play prominently in establishing clan identity. Animals that played prominently in those events and the places where the events occurred have transformed into symbols that serve to this day as heraldic crests that identify Huna Tlingit clans with those events, animals, and places.

Many legends also recount the deeds of revered ancestors. It is often the sacrifice of these ancestors' lives (sometimes voluntarily) that validate the clan's claims to certain places and establish the social and spiritual link of the clan to the place. One story belonging to the *Chookaneidi* clan tells of a young woman ("Woman in the Ice") who broke a taboo, the result of which caused a glacier to advance upon the village in Bartlett Cove. The glacial advance caused the forced evacuation of the village. The young woman offered to stay behind and sacrifice her life to pay for the misfortune of her people, but her grandmother stayed instead. The sacrifice cemented the claim of the *Chookaneidi* clan to Glacier Bay (Dauenhauer and Dauenhauer 1987). Another story belonging to the *Wooshkeetaan* clan tells of a terrible inter-tribal war in which the chief of an opposing clan was killed. The chief from the *Wooshkeetaan* clan offered his life in payment for the opposing chief's death. The chief's nephew (and successor) offered to die instead. Both the chief and his nephew walked out onto the beach and were killed by the opposing clan. This sacrifice purchased for the *Wooshkeetaan* an inalienable right to this stretch of Glacier Bay landscape.

The Huna Tlingit are spiritually linked to the roots of the Glacier Bay ecosystem, embodied in the concept of *Haa Shuka*. The Huna Tlingit believe that the immortal souls of their ancestors continue to dwell in Glacier Bay. These ancestors include various species of fish and wildlife that are endemic to Glacier Bay, and that gave birth to the original human ancestors.

The Huna Tlingits believe that it is imperative that the ancestral homeland remains unpolluted and that the subsistence food base remains pure. This belief has its roots in a concept termed *Haa Shagoon*, which ties the ancestral souls to living and future generations of Huna Tlingits. For example, a child may be given the name of an ancestor, and the soul of that ancestor resides in that child. The child proceeds to learn, as he/she practices Tlingit lifeways, the social connections the ancestor occupied in the past. In addition, the child may be called upon to act out the roles of the ancestor in ritual or everyday settings. Thus, the social fabric of the ancient Glacier Bay landscape is kept alive in modern society and, if the culture remains vibrant, is projected in perpetuity into the future. For the chain to remain unbroken, however, current and future generations must know and understand the stories behind the ancestral names, and they must know the places to which the names and events are attached. Huna Tlingits believe that the best way for them to do this is to visit the sites and carry out meaningful activities that facilitate the transfer of traditional knowledge. Traditionally, much of this information sharing occurred throughout the course of the yearly subsistence cycle. Current legal restrictions on activities within the park have resulted in limitations placed on the Huna Tlingit traditional yearly subsistence cycle. While the Huna Tlingits are allowed access to the park, they participate only in those subsistence activities allowed by park regulations.

The Huna Tlingits believe Glacier Bay to be the cradle of their culture. It is the place where the animals, mountains, and ice took human form; the place that gave identity to their clans; and the place that gives order to their social relations, currently and into the distant future. Glacier Bay has sustained them nutritionally and spiritually for countless generations. The Huna Tlingits portray Glacier Bay to be their most important place and refer to it as their “Ice Box,” their “Garden of Eden,” and their “Holy Land.” Thus, the ethnographic resource is a complex suite of tangible and intangible entities, cultural beliefs, and natural features linked in a complex living web.

Traditional cultural properties — A traditional cultural property is an ethnographic resource that is eligible for inclusion on the National Register of Historic Places because of its association with cultural practices or beliefs of a living community that are: 1) rooted in that community’s history; and 2) important in maintaining the continuing cultural identity of the community (Parker and King 1998; NPS 2001d). A suite of harvest locales, village sites, and natural features, with their associated resources, legends, stories, songs, and art, help identify the ethnographic resource on the ground.

Some locations contain archeological resources (e.g., former village sites and camps), while others may be important resource gathering locales (e.g., berry patches or seabird colonies) that may lack physical indicators of cultural activity. Others may be grand geographic features (e.g., Mount Fairweather) that play prominently in clan legends and serve as anchors for group identity. Currently, formal documentation and assessment of traditional cultural properties within the park have not been completed; however, a Park Service preliminary assessment of the park has identified approximately 15 sites that may qualify as traditional cultural properties (see table 3-11 and figure 3-17).

TABLE 3-11: 15 PRELIMINARY HUNA TLINGIT TRADITIONAL CULTURAL PROPERTIES IN GLACIER BAY NATIONAL PARK AND PRESERVE

TCP ID #	TCP Name	Place-name ID #	NPS Location ID #	Tlingit Location Name	Translation	English Location Name
1	Bartlett Cove	56	GLBA-56A	Ghathéeni	Sockeye River Village	Bartlett River (and Lester Island Village)
		58	GLBA-58	L'awshaa Shakee Aan	Town on Top of the (Glacial) Sand Dunes	Bartlett Cove Area or Beardslee Islands
2	Pt. Gustavus	60	GLBA-60	S'é X'aayí Lutú	Clay Point	Point Gustavus
3	Pt. Carolus	2	GLBA-2	Yáay Shaak'ú	Whale's Little Head	Point Carolus
		3	GLBA-3	Yáay Shaak'ú Aan	Whale's Little Head Village	Point Carolus Village
		4	GLBA-4	L'awt'aak Héen	River Behind the [Glacial] Sand	Point Carolus
		5	GLBA-5	Wat'akhhéen	River Alongside the Face/Side	Carolus River
4	Berg Bay	10	GLBA-10	Xh'atadáa Noowú	Weasel(s) at the Corner(s) of the Mouth Fort	On Lars Islands
		12	GLBA-12	Chookanhéeni	Grassy Creek	Berg Bay River
5	South Marble Island	19	GLBA-19	Íxde Néixh' X'áat'i	South Marble Island	South Marble Island
6	Sealer's Island	39	GLBA-39	Aan Adéli	Village Watchman	Sealers Island
7	Tidewater Glacier	30	GLBA-30	Sít' Tlein	Big Glacier	Grand Pacific and Marjorie Glaciers
		31	GLBA-31	Sít'k'i T'ooch'	Little Black Glacier	Rendu Glacier
		33	GLBA-33	Sít' T'ooch'	Black Glacier	Carrol Glacier
		195	GLBA-195			Johns Hopkins Glacier
		196	GLBA-196			Lamplough Glacier
		197	GLBA-197			Reid Glacier
		200	GLBA-200			McBride Glacier
		201	GLBA-201			Riggs Glacier

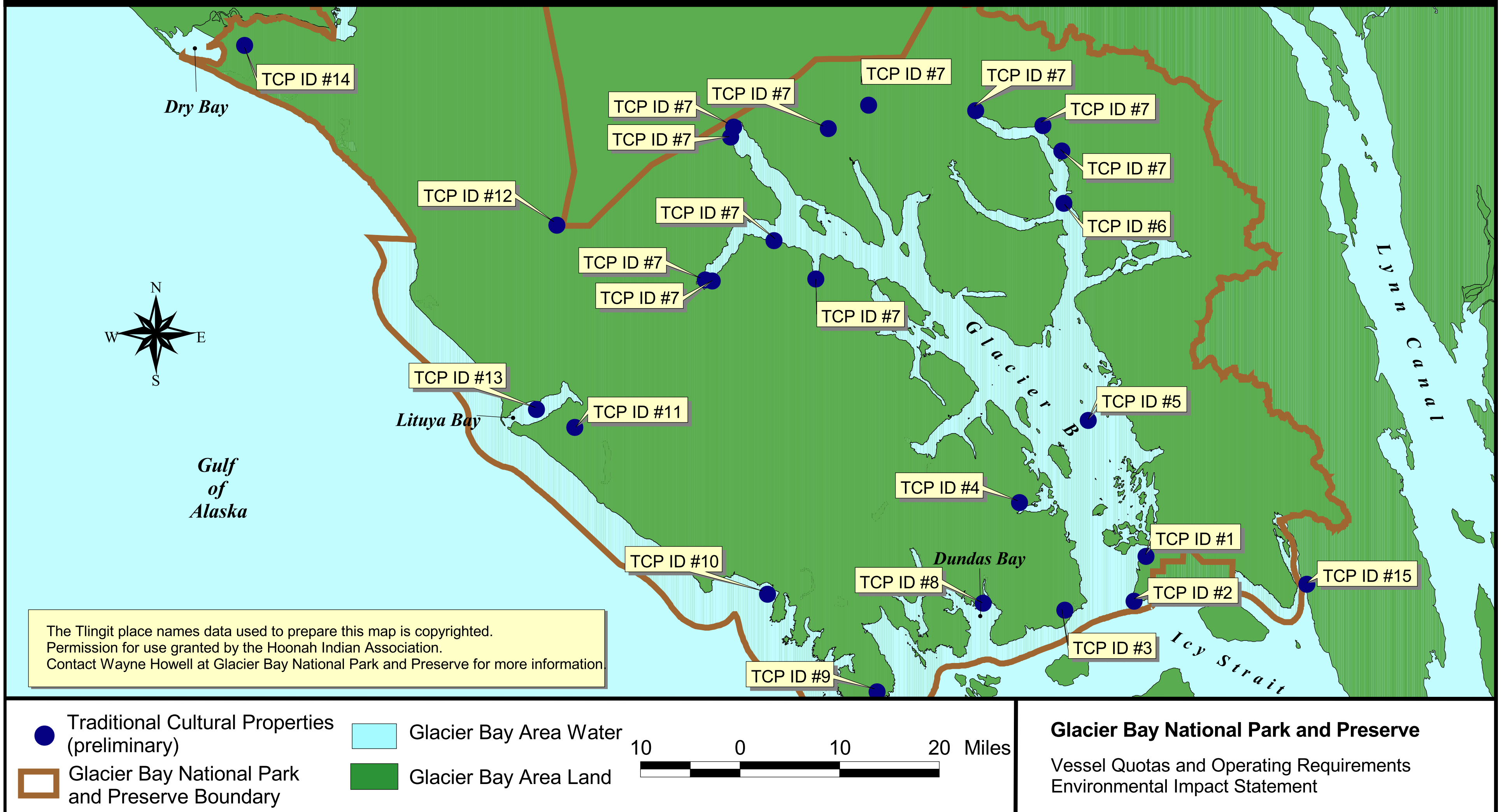
TABLE 3-11: 15 PRELIMINARY HUNA TLINGIT TRADITIONAL CULTURAL PROPERTIES IN GLACIER BAY NATIONAL PARK AND PRESERVE

8	Dundas River	94	GLBA-94	Xákwnoowú	Sandbar Fort	Mouth of Dundas River
		156	GLBA-156	L’éiw Noowú	Sand Fort	Dundas Bay Near Dundas River
		162	GLBA-162	Xunaa Kháawu Noowú	Hoonah People’s Fort	West Bank of Dundas River Near Mouth
		95	GLBA-95	L’istee	Fort name in old language	East bank of Dundas River below confluence with Seclusion River
9	Cape Spencer	114	GLBA-114	Nagukh.wa.aan (Ta.aan)	Town at the Face of [Nagukh]; Sleeping Village	Head of Dicks Arm
		116	GLBA-116	Nagukh.wadaa	Shoreline Around [Nagukh][Dicks Arm/Cape Spencer]	Cape Spencer to Polka Peninsula
10	Boussole Head	121	GLBA-121	Ghaanaxháa	?	Arch at Boussole Head (Astrolabe)
11	Bald Mt.	141	GLBA-141	Yéil Nées'kuxlitashaa	Raven Sea Urchin Echo Knife Mountain	Mt Crillion or La Perouse or Bald Mt
12	Mt. Fairweather	134	GLBA-134	Tsalxhaan	Ground Squirrel Land??	Mount Fairweather
13	Lituya Bay	125	GLBA-125	Ltu.áa	Lake Inside the Point	Lituya Bay
		127	GLBA-127	Kanaxhdakhéen	Flying Over	Centopath Island
14	Dry Bay	139	GLBA-139	Ghunaaxhoo	Among the Athabaskans	Dry Bay
		150	GLBA-150	Diyáayi	Looks Like a Whale	Land East of Dry Bay or Doame River
		155	GLBA-155	Yéil Áa Ludaawdlighoowu Yé	Place Where Raven Wiped His Beak	Alsek River Near Canadian Border?
15	Excursion Inlet	68	GLBA-68	Wéitadi Noow	Fort of the Young Woman in Seclusion (in Menarche)	Head of Excursion Inlet
		72	GLBA-72	Khuyeikh'	?	Excursion Inlet

Map of 15 Preliminary Huna Tlingit Traditional Cultural Properties in the Park

Figure 3-17

National Park Service
U.S. Department of the Interior



Glacier Bay National Park and Preserve

Vessel Quotas and Operating Requirements
Environmental Impact Statement

Prepared by: Ecology and Environment, Inc. for Stephen Braund and Associated, September 20, 2002

Cultural (or Ethnographic) Landscapes. The cultural landscape is an extension of the ethnographic resource. Cultural landscapes are a geographic area, including natural and cultural resources, associated with historic events, activities, or people. Landscapes are “intertwined patterns of things both natural and constructed,” and are a “reflection of human adaptation and use of natural resources which are often expressed in the way land is organized and divided, patterns of settlement, land use, systems of circulation, and the types of structures that are built” (NPS 1997a). At the broadest scale, the ethnographic resource encompasses entire landscapes. A landscape may be one of many component landscapes such as that of Dundas Bay or Bartlett Cove. In the case of Dundas Bay and Bartlett Cove, pre-Little Ice Age and post-contact oral and written histories can be linked to specific sites, places, and historical trends to provide a diachronic perspective of Tlingit culture in those places. A landscape also could be the entire landscape of the Glacier Bay region, which serves as a vast container of all that is Huna Tlingit culture.

The Glacier Bay cultural landscape is a compilation of all the landscape features and cultural and natural resources that provide meaning and significance to the Huna Tlingit people. The landscape features may be landforms that contain archeological resources marking the locations of former villages, or natural features (e.g., seabird colonies or mountains) that may lack evidence of cultural activity but comprise some of the most important cultural sites in the park. The ethnographic landscape also includes the plants and animals, terrestrial and marine, that inhabit the park and have sustained the Huna Tlingit people for countless generations. The Huna Tlingit recognize these plants and animals as direct ancestors to the human lineage of Glacier Bay. In the Glacier Bay ethnographic landscape, human activity has been an integral part of the ecosystem for generations.

The Glacier Bay ethnographic landscape is well defined by the Huna Tlingit place name map that contains approximately 200 traditional Huna Tlingit place names for the region. These place names depict legend sites, village sites, subsistence areas, landforms, water bodies, and historical events. The glue that holds the diverse elements of the ethnographic landscape together and gives it meaning is the information (e.g., stories, songs, legends, and art) that is shared and valued by successive generations of Huna Tlingit people. By incorporating this information in culturally appropriate ways within their culture, Huna Tlingits also manifest another vision to the Glacier Bay ethnographic landscape — the geography of Glacier Bay that is imbedded within the social fabric of Huna Tlingit culture.

The Park Service maintains a Cultural Landscapes Inventory (CLI) for all parks. The Cultural Landscapes Inventory is a “comprehensive inventory of all historically significant landscapes within the National Park System” that “identifies and documents each landscape’s location, physical development, significance, National Register of Historic Places eligibility, condition, integrity and current management" (NPS 1997a, 2001e). The Park Service has compiled Cultural Landscapes Inventories for Bartlett Cove and Dundas Bay (NPS 2001e, 2002d). A Cultural Landscapes Inventory has not been conducted for Glacier Bay.

Bartlett Cove is an area rich in Tlingit place names and oral history. It lies within the *Wooshkeetaan* clan territory of the Huna Tlingit. Huna Tlingit oral history tells of occupation of Bartlett Cove before the Little Ice Age, with a large village of many houses built atop a glacial moraine, as its name implies, L'awshaa Shakee Aan — Town on Top of the Sand Dunes. Sometime after the ice retreated from Glacier Bay in the early 1800s, Bartlett Cove was reoccupied, and by the 1880s, a second village, Gatheeni, had been established. A trading post, a fish saltery, and later a cannery, came to reside next to the village. Following the decline of the cannery operation after the turn of the 20th century and move of the village, several native allotments with fish camps maintained the Huna Tlingit presence in Bartlett Cove. In the 1940s, when anthropologists visited Hoonah in conjunction with a land claim study, Huna Tlingit people identified Bartlett Cove as the most important food-gathering locale in Glacier Bay (Goldschmidt and Haas 1998). With the establishment of the Park Service administrative and visitor service functions in Bartlett Cove beginning in the 1950s, the Native presence declined; however, the Huna Tlingit people rejuvenated their connections to Bartlett Cove in the late 1980s. In 1992, they conducted a demonstration that emphasized their claim and deep cultural connection to Bartlett Cove. The CLI study for Bartlett Cove states that the general landscape characteristics include natural systems and features, land use, spatial organization, cultural traditions (rooted in pre-Ice Age legends), a cemetery, and archeological sites. The Bartlett Cove ethnographic landscape may be eligible for listing on the National Register of Historic Places.

Dundas Bay contains the archeological remains of two Huna Tlingit villages with accompanying oral history and other cultural resources (e.g., cemetery, house pilings, smokehouse debris, and fragments of a dugout canoe). Stone cairns (believed to be Tlingit shrines) have been found near the summit of White Cap Mountain and atop Point Dundas. Dundas Bay is renowned for its traditional berry-picking areas (one Native name for the area translates as "Berry Land") where nagoonberries "appear in sufficient quantities to engender property rights" (Thornton n.d., as cited in NPS 2002d), and was known historically as a place for harvesting seals and salmon. *Xakwnoowu* (XMF-053), an important place name that appears in several legends, was described in Vancouver's account of the exploration of Icy Strait, and "is the place of important clan songs and stories." Another important site is the village of *L'istee* (XMF-013), which was the site of a potlatch (circa 1909) that validated *T'akdeintaan* clan ownership of the site (NPS 2002d). Non-Native cultural resources include the remains of several cabins (XMF-010, XMF-011, XMF-014, XMF-021, and XMF-022) and a cannery (XMF-025; see table 3-10 and figure 3-16). It was partly through interaction with the Dundas Bay cannery in Dundas Bay — first by learning to negotiate resource allocation, and later by learning to seine fish and do cannery work — that Huna Tlingits adapted to the 20th century. The period of significance for Dundas Bay is 800 years ago to the present. The Cultural Landscapes Inventory states that "the general landscape characteristics relevant to this inventory unit include natural systems and features, land use, spatial organization, buildings and structures, cultural traditions (including Huna Tlingit legends) and archaeological sites" (NPS 2002d). The Park Service states that the Dundas Bay ethnographic landscape is potentially eligible for listing on the national register (NPS 2002d).

3.4.2 Visitor Experience

3.4.2 Visitor Experience

One of the main purposes of all national parks is the enjoyment and understanding of park resources and values by the people of the United States. NPS policies for visitor use, including the policies of the park and preserve, promote visitor experiences that, on the whole, reflect the overall purposes and values of the park. The 1984 *General Management Plan*, which provides the overall direction for supporting park purposes and values, identifies the following management objectives specific to visitors:

- ensure patterns of use that enable visitors to enjoy and understand the natural features.
- provide recreational opportunities consistent with preservation of ongoing natural processes.
- balance forms of access and use to obtain a feeling of the ruggedness and wildness of this dynamic landscape and the solitude that early inhabitants found.
- witness the interrelated stories of geology, climate, glaciation, and biological communities of land and sea.
- appreciate the dynamic natural forces still at work.

This subsection describes park visitors and visitation numbers, followed by the different visitor experiences and opportunities available at the park.

Visitor Use and Experiences. Based on the 1999 *Bartlett Cove Visitor Study* (Littlejohn 2000), some of the most important reasons people visit the park are to:

- visit a national park.
- enjoy scenic beauty.
- view wildlife.
- view glaciers.
- visit Alaska.
- pursue recreational opportunities.
- experience wilderness.
- enjoy solitude/quiet.

Visitor experiences are a function of expectations and conditions encountered. Such expectations may vary by particular places visited within Glacier Bay. For example, backcountry visitors camping in Adams Inlet may have higher expectations for solitude than when camping in Glacier Bay. The backcountry visitor studies reviewed do not differentiate expectations by region. In addition, the park has not zoned wilderness for different standards of solitude, making specific regional analysis impossible. A person may leave the park dissatisfied because of inappropriate expectations or because conditions experienced did not allow for the realization of expected outcomes. These experiences can be influenced by:

- the quality of vessel and shore-side facilities and services utilized, including lodging, food/amenities, interpretive services, and trails.
- weather and visibility.
- vessel and aircraft traffic.
- the number, nature, and quality of human interactions.
- feeling of safety and security.

Visitors can be grouped by the way they travel and experience the park. For this environmental impact statement, five major visitor groups are defined: 1) cruise ship passengers; 2) tour vessel passengers; 3) charter vessel passengers; 4) private vessel visitors; and 5) backcountry visitors. Generalizations about visitors have been made based on the vessel class by which they are visiting the park. There is a broad spectrum of values, expectations, and opinions among visitors in each group. Simply because a visitor is on a cruise ship does not mean that he or she cannot view the park from a window or from the deck as a “wilderness” or a wild or pristine landscape; be awed by wildlife or a calving glacier; or that his or her experience cannot be diminished by the presence of other vessels, including other cruise ships, air pollution, or lack of wildlife sightings. Also, it cannot be assumed that because a visitor is on a charter vessel or private vessel that he or she will be disappointed by seeing another vessel or having to anchor near another one. In 2001, nearly 383,000 visitors traveled through Glacier Bay aboard cruise ships, tour vessels, charter vessels, or private vessels (NPS 2002e), and other modes. Motorized vessel passenger traffic peaked in 1999 at 358,000 (see table 3-12 and figures 3-18 through 3-20).

TABLE 3-12: GLACIER BAY VISITOR TRAFFIC, 1997-2001

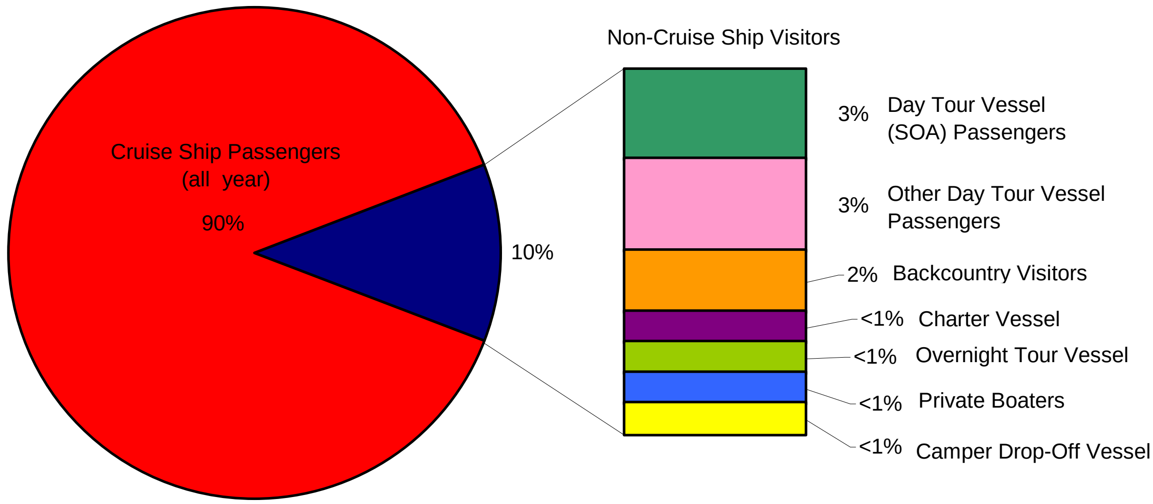
	2001	**2000**	**1999**	**1998**	**1997[b]**
Cruise Ship Passengers (June-Aug.)	217,611	227,779	228,654	215,366	198,528
Cruise Ship Passengers (all year)	336,582	342,462	356,220	339,406	304,586
Day Tour Vessel (SOA)[a]	8,994	9,572	10,905	11,249	11,473
Camper Drop-Off Vessel/Charters	708	667	169	867	992
Other Day Tour Vessels	9,820	11,996	12,022	13,639	8,954
Overnight Tour Vessels[b]	2,022	1,236	1,164	739	2,343
Private Boaters	na	1,236	1,343	2,279	2,050
Total Motorized Vessel Visitors	358,126	367,169	381,823	368,179	330,398
Backcountry Visitors	7,504	6,913	7,149	7,824	8,533
Total Glacier Bay Visitors[c]	**365,630**	**374,082**	**388,972**	**376,003**	**338,931**

Source: NPS 2002f.

TABLE 3-12: GLACIER BAY VISITOR TRAFFIC, 1997-2001

a. Day tour vessel data for 1999 include camper drop-off until late August.
b. The source document indicates some uncertainty as to the distribution of traffic between day and overnight tour vessels in 1997.
c. Does not include other visitors.
na = Not applicable.
SOA = *Spirit of Adventure.*

Figure 3-18: Percent of Annual Visitation by Visitor Category
(Based on Five- Year Average: 1997-2001)

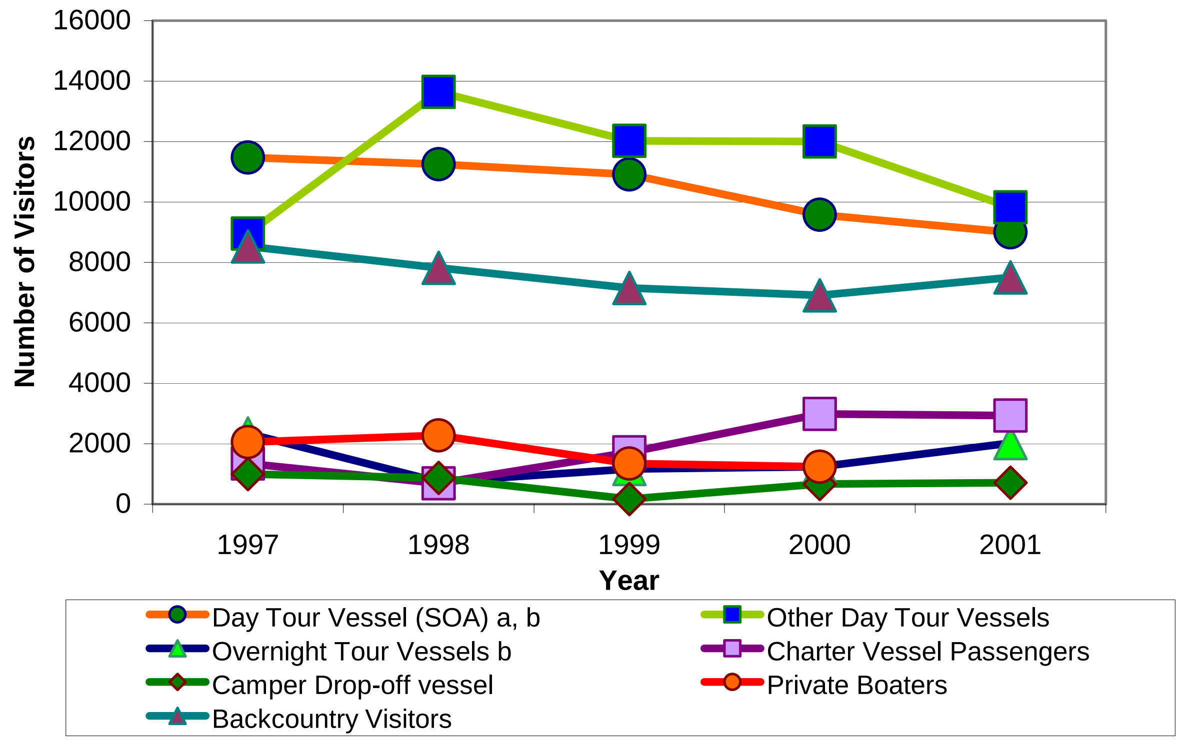


Five-Year Average Visitation to Glacier Bay: 370,656 People

SOA= *Spirit of Adventure*

Figure 3-19: Glacier Bay Visitor Traffic by Visitor Category, 1997-2001: Cruise Ship Visitors

Figure 3-20: Glacier Bay Visitor Traffic by Visitor Category, 1997-2001: Non-Cruise Ship Visitors



a. Day tour vessel data for 1999 includes camper drop-off until late August, SOA= *Spirit of Adventure*

b. The source document indicated some uncertainty as to the distribution of traffic between day and overnight tour vessels in 1997.

Cruise ship visitors — More than 90% of park visitors experience Glacier Bay aboard a cruise ship. These passengers typically travel on seven-day Inside Passage or cross-Gulf cruises or cruise/tours that may include stops in Ketchikan, Juneau, Skagway, Sitka, and/or Haines, as well as Seward. In 2001, 336,000 cruise ship passengers visited Glacier Bay (94% of total park visitation). A total of 219 cruise ships entered Glacier Bay, including 130 during June, July, and August. Cruise ships carried an average of 1,537 passengers into Glacier Bay each day (including a June/July/August average of 1,674).

Cruise ship visitors spend 8 to 9 hours in Glacier Bay, with their main destination being the West Arm and Margerie Glacier. Large cruise ships may have staggered entry times, but their presence in the Bay can overlap. Typically, a ship will enter the park between 7 and 8 A.M. and exit between 3 and 4 P.M. Another ship may enter the park at mid-day. A Park Service ranger naturalist, who provides an interpretive program, is brought onboard shortly after the ship enters the Bay. For cruise ship passengers, glacier viewing and wildlife sightings are a highpoint of their time in the park. Glacier Bay provides these passengers with the widely marketed “glacier day” on their Alaska cruise.

Cruise ships provide a means by which thousands of people can experience the park. They also provide the main mechanism for the Park Service to define and explain park resources to visitors. The variety of opportunities to experience the park that are available to people who visit the park aboard cruise ships is limited, however, because these visitors have little control over a visit that is a scheduled, planned experience as offered by the operators and NPS interpretive staff. Most cruise ship travelers do not set foot ashore in the park.

Tour vessel passengers — In 2001, just fewer than 21,000 visitors experienced Glacier Bay on a tour vessel. In 2000, there were 301 tour vessel entries, including 224 during June, July, and August, with an average of 76 passengers per vessel entry. A moderately small number of tour vessel visitors (10,000 in 2001) travel on four- to seven-day cruises on vessels with overnight accommodations.

About half of tour vessel passengers arrive to the park by either flying or ferrying to Gustavus (usually from Juneau), then boarding the park concession’s day tour vessel for an approximately 8-hour tour of the Bay. These passengers typically spend at least one night in the Gustavus area, either at the Glacier Bay Lodge or at one of the area’s bed and breakfast or lodging facilities. Recent demographic data regarding tour vessel visitors are not available; however, a 1989 survey provides some insight into these visitors’ experience at the park (Johnson 1990):

- Viewing glaciers is the single most important activity motivating tour vessel visitors to travel to Glacier Bay, followed by viewing wilderness scenery (Johnson 1990; Littlejohn 2000).

- Seeing and photographing glaciers was a highlight of the trip for most tour vessel visitors.

Tour vessels provide a slightly different visitor's experience than cruise ships, but in many ways the experience is similar, generally following a rather standardized schedule and routing; however, tour vessel routes can be more variable than those of cruise ships because tour vessels travel closer to shorelines and can spend time in inlets, in coves, and at islands not typically visited by cruise ships. The NPS ranger naturalists provide commentary throughout the day onboard all tour vessels so that visitors can learn about and understand park resources. The more intimate setting afforded by the tour vessels allows for greater opportunity for one-on-one interaction with the ranger naturalists. Many tour vessel visitors also stay at area lodges, where they have additional opportunities to interact with ranger naturalists stationed at the visitor's centers located at the lodges.

Charter vessel visitors — Charter vessels are available for hire on an unscheduled basis, although charter vessels that provide drop-off services are allowed to operate on a scheduled basis (NPS 1997b). Charter vessels offer a range of Glacier Bay experiences. Operators with charter permits include Elfin Cove and Pelican area sport fishing lodges that occasionally bring guests to Dundas Bay for sightseeing, sport fishing, or wildlife viewing. These visitors mainly go to Southeast Alaska to sport fish, with a side trip into Glacier Bay as a secondary motivator. Other charter operators provide day trip and overnight sightseeing opportunities in Glacier Bay.

Charter vessels provide opportunities for visitors who prefer smaller groups and less structure in their days. Also, because charters are typically smaller than cruise ships and tour vessels, visitors on charter vessels can enter and explore areas of shallow waters and many of the smaller coves. Charter vessels also provide opportunities for off-vessel experiences, including kayaking and shore visits.

Private vessel visitors — Private vessels range from yachts of 100 feet (30.5 meters) and more to smaller vessels carrying one to two people from the nearby communities of Gustavus, Bartlett Cove, Hoonah, Elfin Cove, or Juneau. Private vessel visitors may be in Glacier Bay for a variety of reasons, including glacier sightseeing, wildlife viewing, and sport fishing. The definition of private vessels does not include vessels used for commercial fishing.

In 2000, approximately 1,200 visitors arrived in Glacier Bay on a private vessel. Visitors aboard private vessels can experience solitude and quiet and are able to visit the most remote areas of the park.

Backcountry visitors — The term “backcountry visitors” refers to those individuals who seeka non-motorized outdoor recreational experience with wilderness qualities. Backcountry visitors include those visitors, mainly campers and kayakers, who use the drop-off service provided by tour and charter vessels to reach backcountry locations in Glacier Bay. Backcountry overnight trips in and around Glacier Bay have shown an overall upward trend since 1970 (NPS 1995a), although the last few years have shown a slight decrease from this trend (NPS 2001g). Since 1992, on average, 1,700 people per year have visited the backcountry (see table 3-13). Private groups tend to be small (an average of 2.5 people). Commercially guided groups average 10.8 people.

TABLE 3-13: CHARACTERISTICS OF GROUPS AND INDIVIDUALS TO THE BACKCOUNTRY IN GLACIER BAY NATIONAL PARK AND PRESERVE, MAY THROUGH SEPTEMBER 1997–2001

	Groups[a]	Individuals[a]	Nights[b]	Visitor-Use Nights[b]	Mean Trip Length (# nights)[b]	Mean Group Size[b]
Private groups	2,803	7,238	6,855	17,633	4.0	2.5
Commercial groups	122	1,316	479	5,067	4.6	10.8
Total	**2,925**	**8,554**	**7,334**	**22,700**		

Source: Kralovec 2002.

a. Data were derived from the Backcountry Permit database.
b. Data were derived from the Backcountry Visitor Survey database.

Many individuals plan their backcountry camping trips to experience a variety of recreational activities, such as whale watching and kayaking. Travel to Glacier Bay occurs at times when these activities are most desirable, mainly during June through August, with the highest use occurring in July. This time period coincides with the peak for cruise ship and other vessel traffic (Kralovec 2002).

Access to the Glacier Bay backcountry is mainly via commercial transportation, generally by tour vessel, charter vessel, or float plane. Commercially guided groups usually begin their trips in Bartlett Cove or by chartering a vessel or plane that transports them directly to the East or West Arm (Kralovec 2002). Those visitors not wishing to hire a commercial guide also can begin their trip from Bartlett Cove, where they can charter either a vessel or airplane to take them into the backcountry to a starting point or to one of the three or four designated day tour drop-off locations. Another option for visitors is to begin their trip by paddling directly from Bartlett Cove (these visitors usually limit their trip to the Beardslee Islands area.). Since 1997, the number of backcountry visitors starting their trip from Bartlett Cove has steadily increased.

More than 90% of backcountry visitors to the park camp on the shoreline in designated wilderness. Nearly all the marine shoreline that is flat enough can be or has been used as a campsite. Figure 3-21 shows the locations of campsites used during the period of 1997 to 2001. Shoreline wilderness camping is exposed to a variety of intrusions, mainly the sights and sounds of human activity, including the sight of motorized vessels, aircraft, and other groups camping in the backcountry. These types of intrusions can negatively affect the quality of a visitor's experience.

The backcountry wilderness experience — People often visit wild places because of a desire to escape the pressures and stresses of civilization; to learn about and appreciate nature; and to experience solitude, adventure, and wildness with the companionship of friends and family (Driver et al. 1987; Brown and Haas 1980). The National Park Service Act of 1916 (Organic Act, section 1), the Wilderness Act of 1964 (section 2c), and the Alaska National Interest Lands Conservation Act (section 101) call for providing recreational opportunities that emphasize viewing scenery or experiencing solitude, or that are primitive and unconfined. Management of wilderness provides "visitors with opportunities to experience solitude in a relatively unmodified natural environment with few management restrictions and facilities" (Lawson and Manning 2001).

The park is remote from the rest of the United States. Even by Alaska standards it is remote, with no roads leading to either Gustavus or Bartlett Cove (the starting point for nearly all visitors). This sense of remoteness is generally a leading factor for visitors wanting a truly wild experience. Although Glacier Bay is not accessible by road, numerous vessel routes exist for boats and flight paths for aircraft. The degree to which boats access Glacier Bay may limit the perception of remoteness by backcountry visitors.

Kayakers, hikers, and some boaters who camp on land are within sight, sound, and sometimes smell of motorized vessels, including vessels that travel outside wilderness. A study by Salvi and Johnson (1985) shows that the mean number of sightings of motorized watercraft, as reported by the respondents, totaled 9.8. This was before the increases in cruise ships and tour vessels authorized in the 1985 regulations. As additional motorized vessel use is permitted and as backcountry use increases or otherwise changes, research (Johnson 1990) has noted the possibility that some users' tolerance for seeing other people in the backcountry may be exceeded and that these users either may be displaced (not return to the area again) or may simply change their expectations regarding wilderness and solitude in Glacier Bay. Kralovec's report (2001) on backcountry visitor use showed more than 200 visitor complaints regarding motorized vessels and aircraft use in the backcountry. These complaints reflect intrusion into an experience where such use is not expected.


Backcountry
Use Locations
Figure 3-21
National Park Service
U.S. Department of the Interior
Tarr Inlet
Muir Inlet
Johns Hopkins
Inlet
Adams
Inlet
Hugh Miller Inlet
Scidmore Bay
Charpentier Inlet
Glacier Bay
Geikie Inlet
N
W
E
S
Beardslee
Islands
Backcountry Camp Sites and
Locations of Daily Kayak Drop-off / Pick-up
Dundas Bay
Kayak & Camper Drop-off
and Pick-up Locations
Camp Sites (1996-2001)
Park Boundary
Glacier Bay National Park and Preserve
Vessel Quotas and Operating Requirements
Environmental Impact Statement
5
0
5
10
Miles
Prepared by: Ecology and Environment, Inc., March 1, 2003

Glacier Bay's backcountry experiences are mainly water based. Only a few wildernesses within the National Wilderness Preservation System (NWPS) are so characterized, and many of those, such as the Boundary Waters Canoe Area Wilderness in Minnesota, are heavily used and regulated. The affected environment, therefore, exists within a social context that is growing in scarcity. Glacier Bay plays an important role in providing marine-oriented backcountry opportunities because it is relatively easier to access than other Alaskan marine wilderness areas.

A survey of park visitors was conducted during summer 1999, from July 23 to August 1 (Littlejohn 2000). A total of 666 questionnaires was distributed to visitors at Bartlett Cove; 545 respondents returned completed surveys, for an 82% response rate. The survey did not include visitors traveling to Glacier Bay on a cruise ship.

The survey asked respondents about their visit to Glacier Bay, including how they received information about the park, modes of transportation, participation in activities, reasons for visiting, length of stay, use of park services, satisfaction levels, interest in various educational subjects, and demographics. In addition, the survey asked backcountry visitors and vessel passengers how they were affected by the sightings of other park users, such as cruise ships, kayaks, and airplanes. Respondents also were asked about how their park experience was affected by other types of visitor-related effects, such as vessel stack emissions and aircraft noise.

Most survey respondents (84%) traveled into the Bay either by tour, charter, or private vessel. When asked about sightings of other visitor groups, most of these respondents said that they had seen at least three kayaking/camping groups per day, at least one cruise ship per day, and at least three other vessels per day. For most of these visitors, the sighting of other visitor groups had no detrimental effect. About one-fourth (24%) of the respondents said that seeing cruise ships detracted from their experience, while 11% said it enhanced their experience. Seeing airplanes detracted from the experience for 17% of respondents; seeing other vessels, 8%; and seeing kayakers/campers, 2%.

Nearly one-fourth (23%) of respondents said that they kayaked, hiked, or camped in the backcountry during their visit. When asked about daily sightings of other visitors, most backcountry visitors said that each day they had seen at least one other kayaking/camping group, at least one cruise ship, at least one other vessel, and at least one airplane.

3.4.3 Vessel Use and Safety

This subsection discusses vessel use and management in the park. Vessel safety under the current vessel quotas and operating requirements is discussed in subsection 4.4.3.

This subsection describes vessel use within Glacier Bay and Dundas Bay. Appendix E contains records related to the numbers of vessels using Glacier Bay based on vessel entry permits. This information includes a summary of the 2001 and 2002 Outer Waters Vessel Activity Surveys and presents vessel sightings from June to September of those years (NPS 2002j).

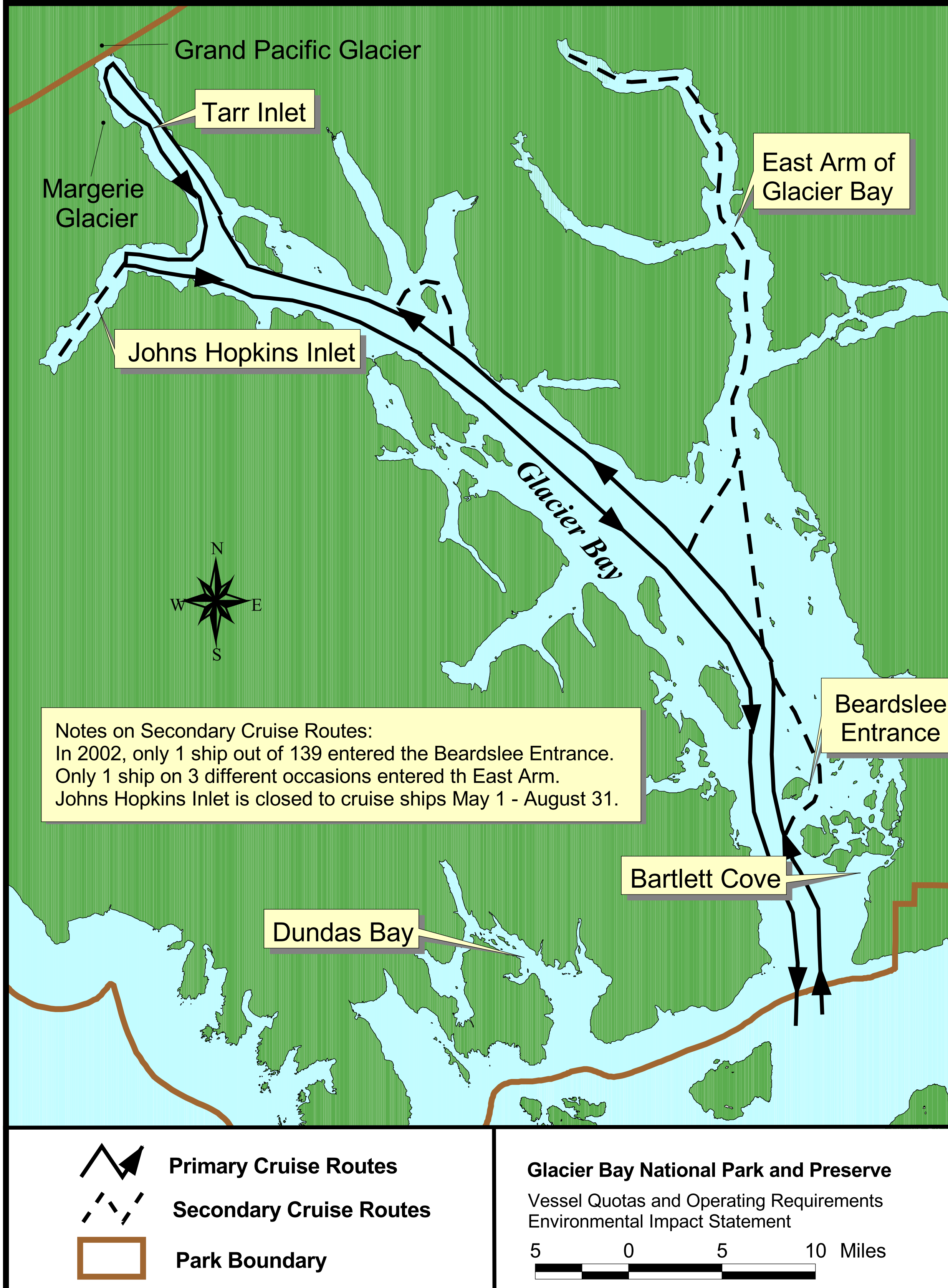
Cruise ships that enter Glacier Bay generally follow a predictable pattern. The first ship typically enters Glacier Bay at 6 or 7 A.M. A second ship may arrive at about the same time, but usually several hours later, at about 10 A.M. Upon entering Glacier Bay, each cruise ship slows to about 6 knots near the entrance of Bartlett Cove to allow two park rangers to board the vessel. These rangers deliver interpretive presentations to the passengers. Virtually every cruise ship makes the 55-mile (88.5-kilometer) voyage to Tarr Inlet to provide passengers a view of Margerie and Grand Pacific Glaciers. The ships then proceed south, departing Glacier Bay between 4 and 8 P.M. (Eley 2000). If the next destination is Seward, Yakutat, or Sitka, the ships turn west to transit Cross Sound; if the destination is Skagway, Juneau, or Ketchikan, they turn east once clear of the mouth of Glacier Bay. Figure 3-22 shows the typical cruise ship routes and major destinations.

Table 3-14 describes the typical itineraries followed by the early and mid-morning arriving cruise ships visiting Glacier Bay. This schedule has proven effective in providing opportunities for cruise ship visitors to enjoy, appreciate, and learn about the park.

Cruise Ship Routes in Glacier Bay

Figure 3-22

National Park Service
U.S. Department of the Interior



Prepared by: Ecology and Environment, Inc., February 27, 2003

TABLE 3-14: OPTIMAL TIMETABLES FOR CRUISE SHIP ENTRIES

Example of Optimal Itinerary for a 7 A.M. Arrival		Example of Optimal Itinerary for a 10 A.M. Arrival	
Time	**Activity**	**Time**	**Activity**
7 A.M.	Arrive Glacier Bay	10 A.M.	Arrive Glacier Bay
9 A.M.	Queen Inlet, begin commentary	10:30 A.M.	Interpretive presentation
10:30–11:30 A.M.	View Margerie and Grand Pacific Glaciers	11:15 A.M.	Second interpretive presentation, if needed
12:30–1:30 P.M.	View Lamplugh Glacier (Jaw Point / Johns Hopkins, if appropriate)	12 P.M.	Queen Inlet, begin commentary
2 P.M.	Reid Inlet	1:30–2:30 P.M.	View Margerie and Grand Pacific Glaciers
2 P.M.	Interpretive presentation	3:30–4:30 p.m.	View Lamplugh (Jaw Point / Johns Hopkins, if appropriate)
2:45 P.M.	Second interpretive presentation, if needed	5 P.M.	Reid Inlet
4 P.M.	Depart Glacier Bay	7 P.M.	Depart Glacier Bay

Notes:

Muir Inlet is not part of the optimal itinerary because the Park Service believes that the transit time needed for traveling to the East and West Arms of Glacier Bay could diminish the time spent at tidewater glaciers and thus diminish passenger enjoyment and understanding of the park.

Johns Hopkins Inlet is a not a preferred cruise ship destination because of seasonal area closures, high concentrations of harbor seals, and other factors that will often prevent going beyond, or even approaching, Jaw Point.

Other bays and inlets of the park (such as Dundas Bay and Lituya Bay) are not included because of potential conflicts between cruise ship activities and existing visitor uses.

Transit through **park marine waters outside headlands** — Icy Strait, Cross Sound, and the outer coast open waters (the park boundary extends 3 miles [4.8 kilometers] offshore) — is considered an incidental use of the park at this time. The Park Service encourages cruise ship operators to develop appropriate ship-board programs to further passenger knowledge and appreciation of these remote areas of the park.

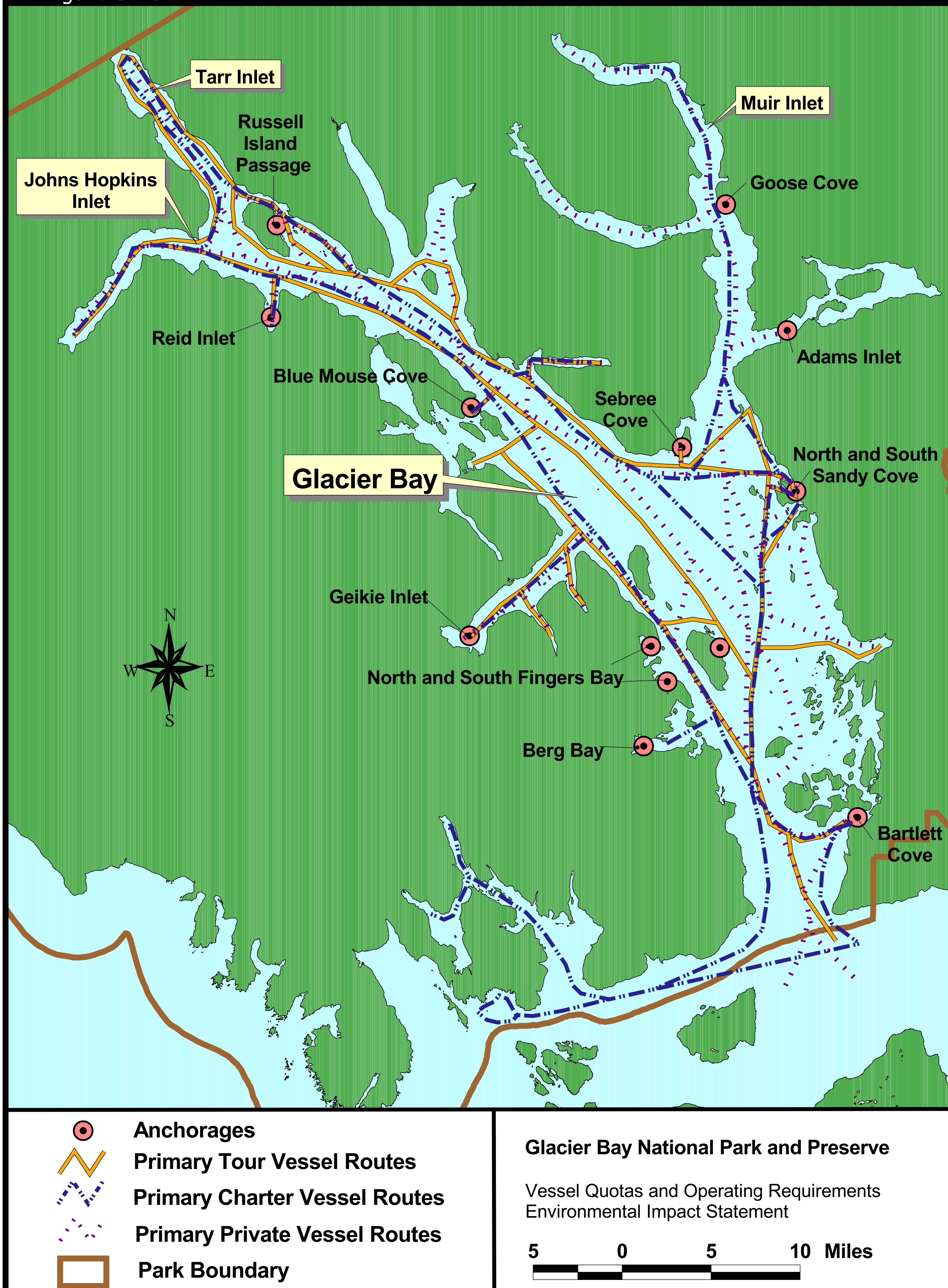
Tour, charter, and private vessels — Tour, charter, and private vessels are capable of entering remote inlets and harbors within Glacier Bay because of their smaller size and shallow draft compared to those of larger ships (see routes, major destinations, and anchorages illustrated in figure 3-23).

Tour vessel excursions are typically focused on sightseeing and attempt to provide passengers with an opportunity to see the tidewater glaciers, as well as other scenery and wildlife. These vessels often travel close to shore to provide passengers with a better view of bears, seals, eagles, and other wildlife, and can more freely maneuver about in smaller inlets and bays than those which larger ships can enter. Tour vessels that offer overnight excursions usually carry a USCG-licensed master (captain) and two to three licensed mates.

Tour, Charter, and Private Vessel Routes and Anchorages In Glacier Bay Proper

National Park Service
U.S. Department of the Interior

Figure 3-23



Prepared by: Ecology and Environment, Inc., February 27, 2003

Because an individual or group "hires" the vessel for the day, charter vessels often have a flexible schedule and route to accommodate the desires of the customer(s). An individual or group might hire a charter vessel to take them sightseeing or kayaking in a remote location, or to provide access to a remote shoreline for hiking or wildlife viewing. Some charter vessel customers simply wish to cruise to a remote anchorage to enjoy the scenery, the solitude, and a meal. According to Eley (2000), many small vessels anchor to provide kayaking directly from the vessel. Several are capable of "soft grounding" at the shoreline for deploying a bow gangway, thus allowing passengers to disembark directly to shore.

Private vessels are the least regulated and restricted class of vessels that operate in Glacier Bay. Within the limits of the park regulations, private vessels have total flexibility. Private vessels can visit any area of the park open to motorized vessels. Private vessels that are small can transit into smaller and more restricted inlets than other vessels. Like charter vessels, private vessels are used to take their occupants sightseeing, kayaking, hiking, wildlife watching, or just to anchor in a quiet cove.

Table 3-15 summarizes the number of entries into the park by private and charter vessels from 1998 to 2001.

TABLE 3-15: PRIVATE AND CHARTER VESSEL ENTRIES INTO GLACIER BAY NATIONAL PARK AND PRESERVE — 1998 TO 2001

	Private Vessels			Charter Vessels			
Year	Total Entries (Sum of General and Local Entries)	General Entries	Local Entries	June-to-August Entries	Glacier Bay	Other Marine Waters	Off-Season Entries
1998	**412**	348	64	**125**	67	58	18
1999	**418**	331	87	**191**	115	76	24
2000	**414**	356	58	**262**	173	89	38
2001	**385**	323	62	**273**	166	107	48

Administrative vessel traffic — Administrative vessels have unrestricted access to the waters of Glacier Bay to fulfill park maintenance responsibilities and to respond to emergencies. The number of administrative vessels transiting the park is not restricted to a daily or seasonal limit, to allow necessary flexibility in accomplishing these tasks. The effects of administrative activities, including those from motorized vessels, on park visitors and resources are mitigated by the requirement that all individuals engaged in these activities abide by all park regulations and guidelines. In addition, all requests for resource monitoring or research activities within the park go through a research permit process. Research permit applications are reviewed by park staff, who recommend that the superintendent either issue or deny a research permit, based on several factors. All applicable federal and state regulations are considered during this review. Research permits can be issued for the entire study or only a portion, and may include specific mitigation measures to protect park visitors and resources. If the review reveals that the resource monitoring or research activities would be detrimental to park visitors or resources, the permit is denied in full or modified to eliminate the detriment. In some cases, the need for the research is greater than the risk of the detriment to visitor experience or resources and the permit can be granted without modification.

Commercial fishing traffic — Commercial fishing is authorized within the non-wilderness marine waters of the park and preserve outside Glacier Bay, but currently is being phased out within the non-wilderness waters of Glacier Bay. The wilderness waters of Dundas Bay and Glacier Bay are closed to commercial fishing.

The three types of commercial fishing currently authorized in the non-wilderness waters of Glacier Bay are longline fishing for halibut, pot and ring fishing for tanner crab, and trolling for salmon. Fishing by lifetime-access permit holders will continue in Glacier Bay until all the current permit holders cease to fish. Vessel traffic associated with commercial fishing is not addressed directly in this environmental impact statement, but is considered in the assessment of cumulative effects.

Ferry — In 2002, a ferry service was offered from Juneau to Bartlett Cove four days per week. Public Law 105-83, section 127, provides for a daily ferry service:

> *For the sole purpose of accessing park or other authorized visitor services or facilities at, or originating from, the public dock area at Bartlett Cove, the National Park Service shall initiate a competitive process by which the National Park Service shall allow one entry per day for a passenger ferry into Bartlett Cove from Juneau: Provided, That any passenger ferry allowed entry pursuant to this Act shall be subject to speed, distance from coast lines, and other limitations imposed necessary to protect park resources: Provided further, That nothing in this Act shall be construed as constituting approval for entry into the waters of Glacier Bay National Park and Preserve beyond the immediate Bartlett Cove area as defined by a line extending northeastward from Point Carolus to the west to the southernmost point of Lester Island, absent required permits.*

The future schedule of the ferry service is subject to change.

Hoonah access — Visitation to Glacier Bay by members of the Hoonah Indian Association has been relatively low in relation to other local private boaters, despite the deep cultural connection that the Huna Tlingit people have to Glacier Bay. One explanation for this is derived from consultation between park staff and tribal members, and can be attributed to the current need to obtain permits to visit the Huna Tlingit ancestral homeland, a requirement disapproved by most Huna Tlingits and actually deemed insulting to many. This lack of visitation to the park by many Huna Tlingits, particularly the youth, has led to a decline in direct knowledge of Glacier Bay and its cultural traditions. In a joint effort between the Park Service and the Hoonah Indian Association to devise ways to retain a vital ethnographic resource, this permit requirement is being eliminated, and a procedure has been developed through an existing Memorandum of Agreement between the park and the Hoonah Indian Association. Access for members of the Hoonah Indian Association, may increase somewhat as a result.

3.4.4 Wilderness Resources

3.4.4 Wilderness Resources

This subsection describes the park's wilderness resources as a component of the human and natural environment and includes a brief definition of wilderness as a resource. It then identifies the locations of wilderness areas within the park, and discusses the status of wilderness within the park, including the relative contribution of the park's wilderness to the National Wilderness Preservation System.

Wilderness is unlike other components of the affected environment. Wilderness is a holistic concept, and the notion of it as a resource is different from that of individual attributes such as wildlife, water, and scenery. It does not represent a particular biophysical attribute, but rather a sense of naturalness that occurs within a pristine environment that is largely unaffected by human activity. Under the Alaska National Interest Lands Conservation Act, 2,658,186 acres of the park's total of 3,283,168 acres is congressionally designated as part of the National Wilderness Preservation System.

TABLE 3-16: DESIGNATIONS WITHIN GLACIER BAY NATIONAL PARK AND PRESERVE

Designation	Acres	Percentage of Total
Land		
Wilderness land	2,610,548	97.7%
Non-wilderness preserve land	54,811	2%
Non-wilderness land	8,504	0.3%
Total Land Acreage	**2,673,863**	**100%**
Water		
Non-wilderness waters	559,418	92%
Wilderness waters	47,638	8%
Total Water Acreage	**607,056**	**100%**

Source: NPS 2002g.

Note:

Non-wilderness preserve land includes a large contiguous area south and west of Dry Bay, incorporating most of the park. Non-wilderness park land is located mostly at and near Bartlett Cove.

The acreage totals in table 3-16 differ from those listed in section 701 of the Alaska National Interest Lands Conservation Act because of the use of more exact mapping techniques and isostatic rebound (see subsection 3.3.5). These wilderness resources include most of the land in the park and five marine wilderness waterways: the Beardslee Islands, Dundas Bay, the Hugh Miller / Scidmore complex, Adams Inlet, and Rendu Inlet (see figure 3-24). These marine wilderness waterways comprise 47,638 acres or about 8% of the total marine waters in the park (see table 3-16 and figure 3-24).

Much of the designated terrestrial wilderness in Glacier Bay and Dundas Bay consists of ice and rock outcroppings. Land cover near the coastal environment includes coniferous or hardwood forests at various stages of succession, depending on their proximity to the glaciers. Some old-growth forests occur in designated wilderness. While Glacier Bay and Dundas Bay contain a large amount of designated wilderness, backcountry visitation is largely restricted to the narrow belt of shoreline. The steep-topography coastal zone limits the area available for camping by backcountry visitors. Use is further concentrated, because visitors mainly are attracted to tidewater glacier areas and campsites along the shoreline. Administrative closures of certain beaches due to bear concerns or for wildlife protection have added to camper congestion on the remaining suitable beaches.

Park Wilderness in Relation to the Entire National Wilderness Preservation System. Currently, Alaska has 48 congressionally designated wilderness areas. With the passage of the Alaska National Interest Lands Conservation Act, eight additional areas were designated as wilderness under NPS management. Those eight wilderness areas comprise nearly 34 million acres (13.7×10^6 hectares), or 32% of the total wilderness acreage in all of the United States. In Alaska, the Glacier Bay wilderness represents nearly 6% of the total NPS wilderness and nearly 2.5% of the total acres of wilderness for all agencies that manage wilderness (Wilderness Information Network 2002).

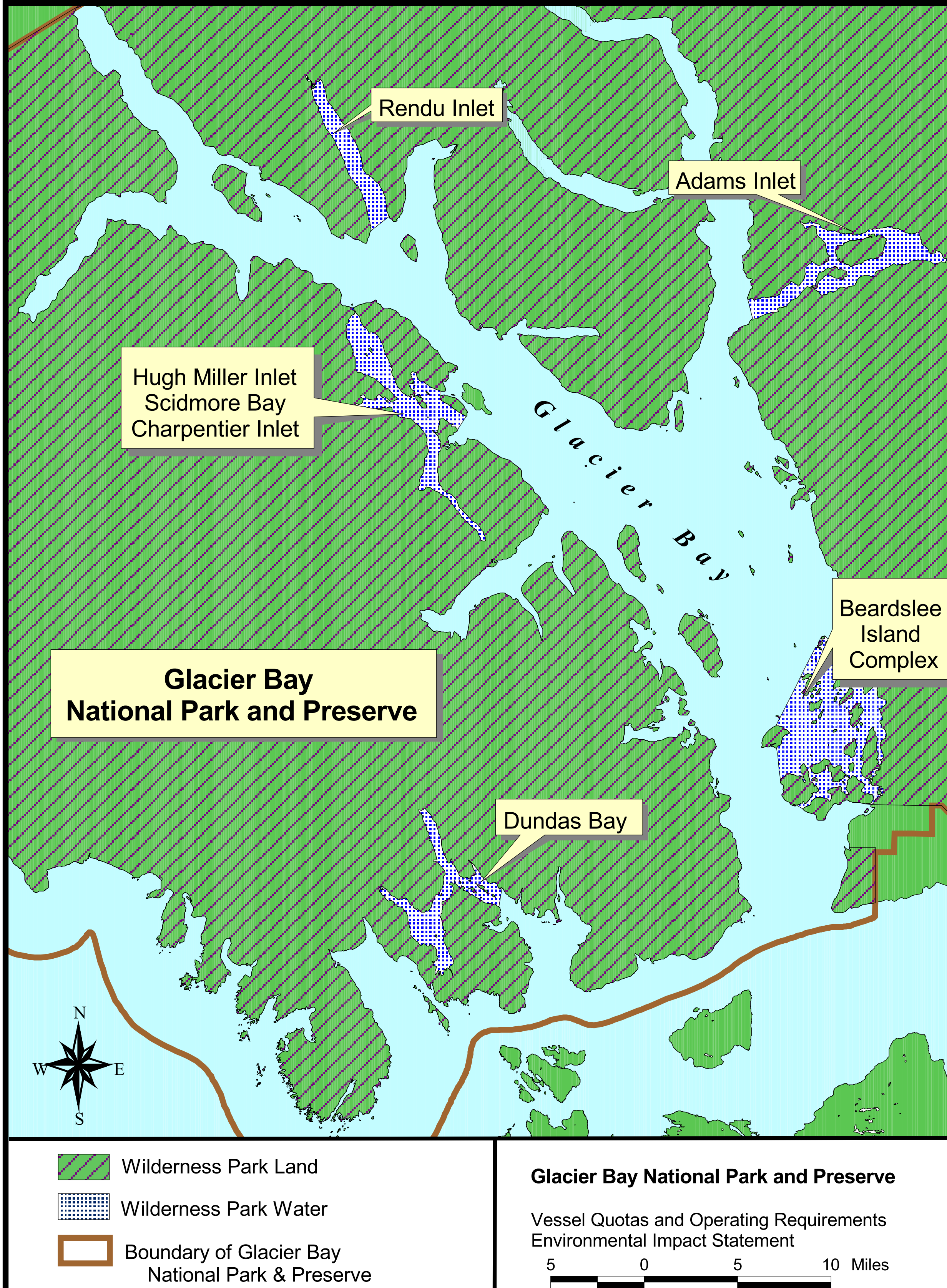
More important than its size, the Glacier Bay wilderness offers some of the most unique resources in all of the National Wilderness Preservation System. With its calving tidewater glaciers; temperate rainforest; plant diversity; and terrestrial and marine wildlife, including threatened and endangered species, the Glacier Bay wilderness is an unparalleled intact ecosystem.

Glacier Bay is one of the most pristine units in the National Wilderness Preservation System. A survey of backcountry visitors to Glacier Bay in 1984 (Salvi and Johnson 1985) showed that 68.8% of respondents did not see any evidence of litter and that 90.1% of respondents saw no cut branches or trees. During a reconnaissance backcountry sea kayak wilderness trip to the Hugh Miller / Scidmore area by one of the EIS team members in June 2001, very little evidence of human pollution or impact was detected along shorelines or within the water. The pristine qualities of wilderness, along with opportunities to experience solitude and other characteristics that attract backcountry visitors, are addressed in subsection 3.4.2, “Visitor Experience.”

WILDERNESS LAND AND WATER

Figure 3-24

National Park Service
U.S. Department of the Interior



Prepared by: Ecology and Environment, Inc., December 16, 2002

3.4.5 Local and Regional Socioeconomics

3.4.5 Local and Regional Socioeconomics

This subsection addresses the baseline socioeconomic environment of the communities neighboring Glacier Bay and Dundas Bay, and those communities affected by visitor traffic to Glacier Bay. Baseline data are presented for Gustavus, Elfin Cove, Hoonah, Pelican, Haines, Yakutat, Juneau, Skagway, and Sitka, Alaska. This subsection also provides baseline information regarding the role of the tourism industry in Southeast Alaska and the role that Glacier Bay plays in the industry.

Community baseline data addressed in this subsection include such factors as population, employment, and per capita and household income. The baseline analysis includes an assessment of economic connections or links between communities and Glacier Bay. These links include cruise ships that visit a community and Glacier Bay, local businesses with Glacier Bay permits, and geographic proximity to Glacier Bay.

There are two types of Glacier Bay business permits: concession contracts and incidental business permits (IBP). Concession contracts are awarded through a competitive process. Eight cruise ship companies have permits to enter Glacier Bay: Carnival Cruise Line; Celebrity Cruises, Inc.; Crystal Cruises Inc.; Holland America Line, Inc.; Princess Cruises, Inc.; World Explorer Cruises; Cruise West; and Norwegian Cruise Lines. Tour vessel operators with concession permits include Cruise West; Clipper Cruises; Glacier Bay Adventures; Glacier Bay Park Concessions, Inc. (a subsidiary of Juneau-based Goldbelt, Inc.); and Lindblad Expeditions.

In addition to cruise and tour vessel services, other concessions for Glacier Bay include 13 Glacier Bay charter vessels, one kayaking guide service, and one kayak rental concession. Glacier Bay Park Concessions, Inc., holds the lodging and food service concession contract for the government-owned Glacier Bay Lodge in Bartlett Cove. Lodging and hunting guide permits for Dry Bay, as well as several Alsek River rafting permits, also have been granted.

An incidental business permit authorizes services (NPS 2002h):

- for which no fixed commercial facilities are used or required within the park.
- for which the commercial activity originates outside the park.
- for which no money changes hands on park lands.
- for which no commercial solicitation occurs on park lands.
- that are appropriate in the park area.

Incidental business permits are issued for one-year terms. The types of services using these permits include charter vessel services in park waters outside Glacier Bay and Dundas Bay (which are open to concession permit holders only, May 16 through September 30), and kayaking in park waters outside Glacier Bay (open only to concession permit holders, June 1 through September 10). Backcountry guiding and air taxi operations are also authorized, with specific restrictions, with an incidental business permit. Approximately 40 incidental business permits are issued annually for Glacier Bay; however, there is no limit on the number of incidental business permits that can be issued.

Gustavus. Gustavus is a town of 429 residents located on the north shore of Icy Passage, at the entrance to Glacier Bay (Alaska Department of Labor and Workforce Development [ADLWD] 2000). The community is bordered on three sides by park and preserve land.

Local economy — Gustavus's economy (see table 3-17) is largely driven by the town's proximity to the park, which attracts large volumes of visitors to the area annually. The Park Service is by far the largest employer in the community. Glacier Bay Lodge, other area lodges, bed and breakfasts, and charter and tour companies provide additional local employment. Historically, fishing has been another important part of the economy. In 1997, 24 fishers fished 46 permits and earned $970,000. Because of Gustavus's reliance on the visitor and fishing industries, employment is largely seasonal. In 2001, 19 residents fished 29 permits, earning approximately $490,000 (Alaska Commercial Fisheries Entry Commission [ACFEC] 2002); however, participation and local earnings from fisheries have dropped substantially in recent years, due in part to the Glacier Bay commercial fishing closures and restrictions. The Gustavus Public School and the Park Service provide some year-round stability. Construction projects also have contributed to the local economy in recent years. Gustavus, with its large base of private land, has benefited significantly from real estate sales in recent years, and many summer homes help support local businesses and maintain a steady construction industry.

TABLE 3-17: ECONOMIC INDICATORS — GUSTAVUS, ALASKA

Population 2000	429
Population Change 1990–2000	+66.3%
Percent Alaska Native	4.2%
Percent Employed Workers	54.6%
Number Employed	190
Percent Unemployed	8.9%
Percent Not in Labor Force	36.5%
Median Household Income	$34,766
Per Capita Income	$21,089
Percent Employed in Visitor-Affected Businesses[a]	45.3%

Source: ADLWD 2000.

a. These businesses include retail trade, transportation/warehousing/utilities, and arts/entertainment/recreation/accommodation/food services.

Gustavus's economic links with the park and preserve — Glacier Bay represents the foundation of the Gustavus economy. Park management, park visitation, and commercial fishing accounted for most of the area's economic activity. Historically, commercial fishing in Glacier Bay has played an important role in the local economy. This has changed, however, with commercial fishing restrictions and closures in the Bay. For example, the Dungeness fishery was the most important fishery for the local economy five years ago; however, today, Dungeness fishing in the Bay is closed entirely, resulting in the loss of several hundred thousand dollars in annual gross income for local fishers and processors. The federal government bought out local Dungeness fisheries permit holders. Other fishers and processors are subject to the NPS compensation plan that is in the final stages of development and implementation. Those local fishers who qualify for the lifetime-access permits can continue to fish in parts of the park and preserve waters.

Visitor travel to Glacier Bay is a vital part of the Gustavus economy. As stated above, the Park Service, lodging facilities, and tour companies account for the bulk of local employment. Gustavus is served by daily jet service from Juneau in the summer, and commuter service year-round. In 2002, a ferry from Juneau arrived in Bartlett Cove four times weekly in the summer, and departed from Gustavus for the return trip. (In the past, this ferry ran daily trips between Juneau and Gustavus.) In a summer 2001 survey of visitors exiting Alaska at the Juneau Airport, 10% of respondents had spent at least one night in Gustavus or Glacier Bay (McDowell 2002a). Providing access to the park is Gustavus's major tourism asset. A Gustavus visitor information website bills Gustavus as the "Gateway to Glacier Bay National Park" and the "starting point to experiencing Glacier Bay" (Gustavus Internet Group 2002). As the website indicates, nearly all of Glacier Bay's non-cruise visitors must transit Gustavus at some point. While cruise ships themselves do not call on Gustavus, they do affect the local economy through payment of passenger fees to the park and preserve and through payment of the cost of the park's onboard interpretive program.

Although most of Gustavus's visitors are attracted to the area by the park, they usually spend at least some of their time in Gustavus. Only one lodging facility is located within the park, so many visitors stay in Gustavus's local inns and bed and breakfasts. Along with trips into the Bay aboard kayaks, charter vessels, and the day tour vessel *Spirit of Adventure*, visitors participate in many Gustavus-based activities, including kayaking, mountain biking, hiking, golfing, sport fishing, and wildlife viewing.

Gustavus-based businesses with concession permits to operate charter vessels in the park include Glacier Bay Country Inn, Grand Pacific Charters, Gustavus Marine Charters, and Sea Wolf Wilderness Adventures. Whisper Marine, True North Charters, Whale Bay Charters, and Cross Sound

Express have incidental business permits. Glacier Bay Sea Kayaks and Alaska Discovery have concession permits for kayaking, Glacier Bay Adventures has a concession permit for a tour vessel, and TLC Taxi has an incidental business permit for a taxi service. Air Excursions has an air taxi permit.

It should be noted that not all visitation to Gustavus is park related. Some regional residents (Juneau residents, in particular) use Gustavus as a weekend getaway destination, and some have summer homes in the area. Other visitors come to Gustavus for the sole purpose of sport fishing.

The Gustavus economy has never been sufficiently modeled to quantify the park's role in terms of local personal income; however, for the purposes of this study, it is assumed that about one-half of all local personal income is directly or indirectly linked to park visitation. This includes income related to visitors traveling to the area to see Glacier Bay on tour and charter vessels, as well as local income linked to passenger fees paid to the Park Service and spent locally.

Elfin Cove. Elfin Cove's population is seasonal, with just a handful of winter residents and up to approximately 70 summer residents. The community is located on the northern coast of Chichagof Island (ADLWD 2000) and lies less than 25 miles (40 kilometers) southeast of the entrance to Glacier Bay.

Local economy **—** Elfin Cove's economy (see table 3-18) revolves around the fishing industry. Twenty-seven year-round or seasonal residents hold commercial fishing permits, and 10 local lodges cater to sport-fishing visitors (Alaska Department of Community and Economic Development [ADCED] 2002). Nearly all employment is seasonal. Elfin Cove also serves as a vital service center for commercial and recreational vessels. The principal commercial fishery based in Elfin Cove is the salmon troll fishery. Elfin Cove also is the closest community to the principal trolling areas in the Inain Islands and Cross Sound, and has fuel; ice; and, in the past, a fish buyer. These reasons made Elfin Cove a hub for the commercial fishing industry. In addition to the 27 permit holders who list Elfin Cove as home, fishers from throughout the region have traditionally made Elfin Cove their port of call during the summer troll season. That may change now that a fish buyer is no longer located there.

TABLE 3-18: ECONOMIC INDICATORS — ELFIN COVE, ALASKA

Population 2000	32
Population Change 1990–2000	-43.9%
Percent Alaska Native	0%
Number Employed	10
Percent Unemployed	11.1%
Percent Not in Labor Force	51.9%
Median Household Income	$33,750
Per Capita Income	$15,089
Percent Employed in Visitor-Affected Businesses[a]	70.0%

Source: ADLWD 2000.

a. These businesses include retail trade, transportation/warehousing/utilities, and arts/entertainment/recreation/accommodation/food services.

Tourism. Elfin Cove's economy is heavily reliant on the sport-fishing industry, with 10 lodges. Occasionally, small cruise ships stop in Elfin Cove. In 2001, the *Yorktown Clipper* made 13 calls at Elfin Cove, with approximately 1,500 total passengers. The availability of fuel, groceries, a public dock, and a restaurant draws visitors aboard sport-fishing or tour vessels.

Elfin Cove's economic links with the park and preserve — Local economic links with Glacier Bay include commercial fishing and relatively limited visitor traffic. Elfin Cove's fishing lodges do not use access to Glacier Bay in marketing to clients; however, some include the park on sightseeing tours to Taylor and Dundas Bays. Two Elfin Cove businesses have concession permits to operate in the park as charter vessels. Six businesses have incidental business permits to operate as charter vessels. (Several of these businesses have additional incidental business permits that allow them to take clients hiking and kayaking.) For the purposes of this study, it is assumed that less than 10% of local personal income is directly or indirectly linked to park visitation aboard motorized vessels.

Hoonah. Hoonah is a predominantly Alaska Native community of 860 located on the northeast shore of Chichagof Island (ADLWD 2000). It is approximately 30 miles (48 kilometers) from the mouth of Glacier Bay.

Local Economy. Hoonah's economy (see table 3-19) is centered around commercial fishing, logging, and government. Commercial fishing provides much of the employment, with 117 residents holding permits (ADCED 2002). Two fish processing plants account for additional seafood-related employment. Commercial fishing restrictions in the park and preserve, and the associated compensation program, also will affect Hoonah's economy. Logging historically has been an important part of the economy, although timber activity in Hoonah (and throughout Southeast Alaska) has declined in recent years. USFS, municipal, and tribal government jobs help provide year-round stability to the economy. The Alaska Native Claims Settlement Act (ANCSA) village corporation, Huna Totem, also creates jobs for many local residents. Many residents depend on subsistence hunting and fishing as a food source.

TABLE 3-19: ECONOMIC INDICATORS — HOONAH, ALASKA

Population 2000	860
Population Change 1990–2000	+8.2%
Percent Alaska Native	60.6%
Number Employed	317
Percent Unemployed	12.5%
Percent Not in Labor Force	39.2%
Median Household Income	$39,028
Per Capita Income	$16,097
Percent Employed in Visitor-Affected Businesses[a]	24.2%

Source: ADLWD 2000.

a. These businesses include retail trade, transportation/warehousing/utilities, and arts/entertainment/recreation/accommodation/food services.

Tourism — Hoonah offers limited tourist attractions. A few businesses cater to sport-fishing visitors. One fishing lodge and a couple of bed and breakfasts provide some tourism-related employment. Several hunting guides also live in Hoonah. Although no cruise ships stop in Hoonah, one major cruise line has employed local residents to provide onboard presentations.

Hoonah's economic links with the park and preserve — Hoonah's economic links to the park have included commercial fishing (and related seafood processing) and a limited amount of visitor traffic. Of more importance to Hoonah residents are their long-standing cultural links to Glacier Bay and Dundas Bay. The village's original location in Glacier Bay was destroyed by a glacial advance. Hoonah residents historically have participated in subsistence activities in the Bay, including fishing, seal hunting, and gull egg harvesting.

Currently, a very small portion of local personal income is linked to Glacier Bay visitation; probably no more than 2% or 3%, based on study team estimates. The proposed Point Sofia development near Hoonah offers a potential future economic connection between Hoonah and the park. Huna Totem Corporation is in the conceptual phase of developing a visitor-oriented site that will attract cruise ships. This development could increase the demand for access to Glacier Bay, and could create additional economic links between Hoonah and the park, if the project is realized.

Pelican. Pelican is a small community of 163 residents located on Lisianki Inlet, on Chichagof Island (ADLWD 2000). Pelican lies about 50 air miles south of the park and preserve.

Local economy — Pelican's economic activity (see table 3-20) centers around fishing and seafood processing, because of the proximity to fishing grounds on the Pacific Gulf Coast. Forty-one residents hold commercial fishing permits (ADCED 2002). The largest local employer is Pelican Seafoods. Government and transportation jobs provide some employment, while tourism adds a small amount of economic activity.

TABLE 3-20: ECONOMIC INDICATORS — PELICAN, ALASKA

Population 2000	163
Population Change 1990–2000	-26.6%
Percent Alaska Native	21.5%
Number Employed	81
Percent Unemployed	5.5%
Percent Not in Labor Force	29.1%
Median Household Income	$48,750
Per Capita Income	$29,347
Percent Employed in Visitor-Affected Businesses[a]	12.3%

Source: ADLWD 2000.

a. These businesses include retail trade, transportation/warehousing/utilities, and arts/entertainment/recreation/accommodation/food services.

Tourism — Because of its remoteness, Pelican generally receives relatively little tourism-related traffic. An Alaska Marine Highway System ferry service visits Pelican just twice monthly in summer, and once monthly in winter. Regularly scheduled float plane service from Juneau has three arrivals daily in summer, and one arrival daily in the off-season. Most visitor activity is centered on several sport-fishing lodges and bed and breakfasts. Local lodging and charter businesses also advertise kayaking, hiking, wildlife viewing, and visiting local hot springs. Some kayakers use Pelican as a stop or jumping-off point for exploring Chichagof and Yakobi Islands. An annual music festival draws more than 100 visitors for one weekend in spring.

Pelican's economic links with the park and preserve — Although Pelican is geographically close to Glacier Bay, its economy currently is not closely linked to the park (commercial fishing and seafood processing have represented an economic link between Pelican and Glacier Bay). There is no direct, regular ferry service or air service between Pelican and Gustavus. Pelican's visitor website makes no mention of Glacier Bay as a nearby attraction, nor do the websites of several local visitor-oriented businesses (Pelican Convention and Visitors Bureau 2000). One local sport-fishing lodge has a concession permit to operate in the park, while another charter service has an incidental business permit. Currently, very little local personal income has a link to Glacier Bay visitation (probably no more than 2% or 3%, based on study team estimates).

Haines. Haines is a town of 2,392 residents located on the Chilkat Peninsula in northern Southeast Alaska (ADLWD 2000). Geographically, Haines is situated close to the park; the western border of the Haines Borough abuts the park's eastern border in the Chilkat Mountains.

Local economy — The Haines economy (see table 3-21) comprises mainly tourism, commercial fishing, construction, and government. Because of the seasonal nature of these industries (except government), a large portion of local employment is seasonal. The commercial fishing industry accounted for an estimated annual equivalent of about 90 jobs, or 10% of total employment, in 2000 (McDowell 2002b). The construction industry accounted for an average of 58 jobs in 2000, with peak employment at about 99 jobs, according to ADLWD data. Together, local, state, and federal government account for 190 year-round jobs, or 20% of local employment. Some government jobs result from Haines's status as a major trans-shipment point; it has an ice-free, deep-water port and dock, and year-round road access to Canada and Interior Alaska on the Haines and Alaska Highways.

TABLE 3-21: ECONOMIC INDICATORS — HAINES BOROUGH, ALASKA

Population 2000	2,392
Population Change 1990–2000	+13.0%
Percent Alaska Native	11.5%
Number Employed	992
Percent Unemployed	8.4%
Percent Not in Labor Force	38.4%
Median Household Income	$40,772
Per Capita Income	$22,090
Percent Employed in Visitor-Affected Businesses[a]	33.2%

Source: ADLWD 2000.

a. These businesses include retail trade, transportation/warehousing/utilities, and arts/entertainment/recreation/accommodation/food services.

Tourism — As several of Haines's industries, including fishing, timber, and mining, have declined over the last decade, its reliance on tourism has grown. In a 2002 study for the City of Haines, the employment attributed to the visitor industry in 2001 accounted for 26% of all wage and salary employment in Haines (20% being direct employment and 6% being indirect employment; McDowell 2002b). Visitor industry personal income accounted for 14% of all Haines employment-related personal income in 2001.

Approximately 200,000 visitors traveled to Haines in 2002. The bulk of these visitors were cruise passengers — 80,000 passengers off ships docked in Haines, and 40,000 off fast ferries from

Skagway. Between 50,000 and 60,000 visitors arrived by highway and ferry. In 2003, cruise passenger volume from ships docked in Haines is expected to drop to 21,500 (McDowell 2002b).

Haines's economic links with the park and preserve **—** Haines's economic links to Glacier Bay have included commercial fishing and visitor travel. Most of the direct, visitor-industry economic links between Haines and the park exist in Haines-based flightseeing tours that fly over the park. In addition, two local air carriers offer regularly scheduled service between Haines and Gustavus, and several other carriers will schedule flights as needed. There is no direct, regular ferry service between Haines and Gustavus. Most of Haines's independent visitors travel by highway or by the Alaska Marine Highway System, neither of which are connected to Gustavus. Some independent travelers visit both communities; 12% of visitors who spent at least one night in Haines also spent at least one night in Gustavus (McDowell 2002a).

Chilkat Guides, a company that runs rafting trips down the Alsek River, is the only local business with a concession permit for the park. Three other businesses — Alaska Mountain School, Earthcenter Adventures, and Mountain Flying Service — have incidental business permits.

An indirect economic connection between the park and Haines exists through the cruise industry. Of the 80,000 passengers off large cruise ships docked in Haines in 2002, 60% of them visited the park (McDowell 2002a). A significant portion of Skagway cruise passengers who travel by fast ferry to Haines also visit the park on their cruises, because Skagway sees 88% of all Alaska cruise traffic. Haines is also important in its role as an itinerary option for ships that do not have park permits. It shares this role with other southeast ports.

Approximately 5% of total personal income in Haines is directly or indirectly linked to Glacier Bay visitation, based on study team estimates. This includes income generated by cruise ship passengers who visit Haines (and spend money while in town) and Glacier Bay, as well as flightseeing and air taxi service to Gustavus. Haines recognizes its proximity to the park as a marketing asset. On the Haines Convention and Visitors Bureau website, the park and preserve is mentioned as being nearby and accessible by airplane (Haines Convention and Visitors Bureau 2002).

Yakutat. Yakutat is a community of 808 residents located at the mouth of Yakutat Bay on the Gulf of Alaska (ADLWD 2000). The Yakutat Borough shares its eastern border with the park and preserve.

Local economy **—** Yakutat's economy (see table 3-22) depends on commercial fishing, fish processing, and government. A cold storage plant has been the major private employer, and 162 residents hold commercial fishing permits (ADCED 2002). Of the 390 year-round jobs in 2000, 104

(27%) were government-related (ADLWD 2002). The service and retail sectors also constitute a large percentage of local employment (34%). Most residents depend on subsistence hunting and fishing as a food source.

TABLE 3-22: ECONOMIC INDICATORS — CITY AND BOROUGH OF YAKUTAT, ALASKA

Population 2000	808
Population Change 1990–2000	+14.6%
Percent Alaska Native	39.6%
Number Employed	440
Percent Unemployed	6.0%
Percent Not in Labor Force	22.2%
Median Household Income	$46,786
Per Capita Income	$22,579
Percent Employed in Visitor-Affected Businesses[a]	29.1%

Source: ADLWD 2000.

a. These businesses include retail trade, transportation/warehousing/utilities, and arts/entertainment/recreation/accommodation/food services.

Tourism — Tourism plays a moderate role in Yakutat's economy. Tourism activity is driven mainly by sport fishing. Several lodges are located in the area, offering world-class saltwater and freshwater fishing. Hunting also draws a few visitors every year. Yakutat also serves as a popular access point for guided and unguided rafting and kayak adventures. Alaska Discovery, for example, runs a trip that includes a night in Yakutat before and after a kayak trip in nearby Icy Bay. Climbers use Yakutat as a base for ascents of Mount St. Elias, Mount Fairweather, and Mount Logan. Other businesses catering to the visitor industry include a rental car agency, several restaurants, a kayak rental business, and a surf shop. According to 2000 U.S. Census data, nearly 30% of jobs are in visitor-affected businesses.

Yakutat's economic links with the park and preserve — Yakutat's economy has several links to the park, though very little, if any, is related to motorized vessel visitation. The town sees some visitor activity from river rafters who have descended down the Alsek and Tatshenshini Rivers, through the park into nearby Dry Bay. Climbers of Mount Fairweather, located in the park, use Yakutat as a base. Several local hunting guides take visitors into the park.

Three lodging facilities at Dry Bay have concession permits for lodging at Dry Bay Preserve: Johnny's East River Lodge, Northern Lights Haven, and Alsek River Lodge. Two hunting guides, Gary C. Gray and John H. Latham, have concession permits to hunt in Dry Bay Preserve. Gary C. Gray also has a concession permit for Alsek River rafting. The other Yakutat-based businesses operating in the park have incidental business permits. These include Brabazon Expeditions (sport fishing, guided hiking, sightseeing, and walking tours), See Alaska with Jim Keeline (sport fishing at Dry Bay), and Alsek Air Service.

Although cruise ships do not stop in Yakutat, they do pass by the community on their way to Hubbard Glacier; in 2001, 150 large cruise ships included the glacier on their itinerary (McDowell 2002c). Hubbard Glacier is affected by Glacier Bay cruise activity in that it is an alternative glacier-viewing spot. If a cruise itinerary does not include a Glacier Bay tour, the ship likely will stop at Hubbard Glacier instead. The local government has attempted to tax the cruise lines for entering Yakutat Bay; however, cruise lines are as yet declining to pay the tax. Two other enterprises in Yakutat service the cruise ships. A shuttle service boats pilots to and from cruise ships, and another enterprise provides interpretive guides for Hubbard Glacier.

Yakutat's visitor-oriented website does not mention the park and preserve, although its proximity is apparent on an online map of the area (Greater Yakutat Chamber of Commerce 2002).

Juneau. Juneau, the state capital, is a city of 30,711 people, located on the mainland of Southeast Alaska (ADLWD 2000). It lies about 50 air miles southeast of the park. Juneau is Southeast Alaska's largest city and is the service, supply, and transportation center for northern Southeast Alaska.

Local economy **—** Government is the mainstay of Juneau's economy (see table 3-23), with local, state, and federal employment constituting nearly 45% of all employment (7,000 jobs) in the community (ADLWD 2002). The seafood and mining industries, along with tourism (see below), also play important roles in the local economy. A total of 541 Juneau residents held commercial fishing permits in 2000, according to the Alaska Commercial Fisheries Entry Commission, and 412 Juneau residents purchased crew licenses in 2000 (ACFEC 2002). In 2001, seafood processor employment totaled an estimated 65 jobs. The mining industry employed an average of 291 workers in Juneau in 2000. The Greens Creek Mine, with about 265 employees, accounts for most of the mining employment in Juneau. Health care and social services are minor, but important, parts of the Juneau economy.

TABLE 3-23: ECONOMIC INDICATORS — CITY AND BOROUGH OF JUNEAU, ALASKA

Population 2000	30,711
Population Change 1990–2000	+14.8%
Percent Alaska Native	11.4%
Number Employed	16,537
Percent Unemployed	4.0%
Percent Not in Labor Force	24.5%
Median Household Income	$62,034
Per Capita Income	$26,719
Percent Employed in Visitor-Affected Businesses[a]	23.7%

Source: ADLWD 2000.

a. These businesses include retail trade, transportation/warehousing/utilities, and arts/entertainment/recreation/accommodation/food services.

Tourism. The visitor industry employs more Juneau residents than either seafood or mining. The most recent, comprehensive study of the economic effect of tourism on Juneau was prepared in 1996. That study found that, as of 1994, the visitor industry employed an annual average of 1,460 workers and generated $24 million in annual payroll (McDowell 1996a). This visitor industry employment included 630 jobs created as a result of cruise ship passenger spending and 830 jobs stemming from independent visitor spending (including convention visitors).

Since that study was completed, only the economic effect of the cruise industry has been re-examined. One study found that the cruise industry generated 748 jobs and $15.2 million in payroll in Juneau in 1999 (McDowell 2000a). In general, the independent market has been flat in Southeast Alaska over the last several years; however, some growth in Juneau's visitor industry has occurred. For example, employment in hotels increased by about 40 jobs between 1994 and 2000 (ADLWD 2002). Assuming modest growth in the independent market, in addition to the 118 new cruise-related jobs, current employment in Juneau's visitor industry can be estimated at about 1,650 jobs. Current payroll is estimated at approximately $30 million.

Visitors to Juneau arrive most often by cruise ship; 700,000 cruise passengers arrived in Juneau in 2002 (Juneau Convention and Visitors Bureau 2002). A recent study estimated annual non-cruise traffic (generally traveling by airplane or ferry) at 157,000 (Egret Communications / ARA Consulting 2002).

Juneau's economic links with the park and preserve — Approximately 5% of total personal income in Juneau is directly or indirectly linked to Glacier Bay visitation, based on study team estimates. The largest share of this is personal income generated by local spending by cruise ship passengers who also visit Glacier Bay. It also includes personal income generated by local businesses with links to Glacier Bay visitation, as described below.

As the southeast region's transportation hub, and with its location only 50 miles (80.5 kilometers) from Gustavus, Juneau has strong links with the park through its visitor industry. Every cruise ship that enters the Bay, large and small, includes Juneau on its itinerary. Of all cruise ships visiting Juneau in 2001, more than half (53%) visited Glacier Bay (McDowell 2002a).

Most independent visitors to the park must stop in Juneau, if only briefly. All jet flights and most commuter flights to Gustavus originate in Juneau. The ferry to Gustavus leaves from Juneau. Juneau is a logical spot for private boaters to stop on their way to or from the Bay. Exceptions are visitors flying in commuter aircraft from other southeast towns and some private vessel visitors. Also, there are some independent visitors who may only pass through the Juneau Airport on their way to and from the Bay. In a 2001 survey of visitors at the Juneau Airport who were exiting the state, 10% had spent at least one night in Gustavus or Glacier Bay and only a few of these visitors did not spend at least one night in Juneau (McDowell 2002a).

Several Juneau businesses have permits to operate in Glacier Bay. The largest of these is Goldbelt, Inc. Goldbelt, Inc., is an ANCSA corporation, owned by Alaska Natives, most of whom reside in Juneau. Goldbelt, Inc.'s, interests in Glacier Bay include:

- the Glacier Bay Ferry, a fast catamaran that runs between Juneau and Gustavus / Bartlett Cove four times per week.
- the *Spirit of Adventure*, a day cruise vessel that takes visitors into the Bay for glacier and wildlife viewing, with daily departures from Bartlett Cove.
- the Glacier Bay Lodge, the only overnight lodging operation in the park.
- Glacier Bay Cruises, a cruise line with three small cruise ships that tour the park and waters outside the park throughout the summer.

Another Juneau-based business with interests in Glacier Bay is Alaska Discovery, the main adventure tour operator in the park. In addition to operating a five-bedroom bed and breakfast in Gustavus, the business runs one-day sea kayaking tours out of Bartlett Cove and 24 multi-day kayaking trips in Glacier Bay each summer.

Several smaller-scale permit holders in the park are based in Juneau. These include Admiralty Tours, Seawind Charters, and Marine Adventure Sailing Tours.

Glacier Bay clearly has a role in attracting visitors to Juneau, although the extent is difficult to identify. On the Juneau Convention and Visitors Bureau website (www.traveljuneau.com), the park and preserve is highlighted frequently. It is mentioned on the “Welcome to Juneau” page in reference to glacier viewing, and again on the “All About Juneau” page as conveniently accessible from Juneau. On the “Nearby Areas” page, “Glacier Bay National Park & Gustavus” is the first area listed (followed by other communities such as Skagway, Haines, Yakutat, and Sitka). It is also in the “Ask the Locals” section, in which a two-day trip is recommended.

Skagway. Skagway is a community of 862 residents located on the northernmost end of Lynn Canal (ADLWD 2000). Skagway is 40 air miles from the park’s border in the Chilkat Mountains, and 150 miles by water from the mouth of the Bay.

Local economy — Skagway’s major industry is tourism. Retail, dining, lodging, and tour companies aimed at the visitor industry provide the bulk of Skagway’s jobs, leading to a highly seasonal employment situation. Unlike other southeast towns, Skagway has virtually no fishing industry; two residents fished three permits in 2001 (ACFEC 2002). Because of its access to the highway system, Skagway serves as a trans-shipment point for freight. State and local governments provide some year-round employment.

TABLE 3-24: ECONOMIC INDICATORS — CITY OF SKAGWAY, ALASKA

Population 2000	862
Population Change 1990–2000	+24.6%
Percent Alaska Native	3%
Number Employed	475
Percent Unemployed	11.1%
Percent Not in Labor Force	21.1%
Median Household Income	$49,375
Per Capita Income	$27,700
Percent Employed in Visitor-Affected Businesses[a]	53.9%

Source: ADLWD 2000.

a. These businesses include retail trade, transportation/warehousing/utilities, and arts/entertainment/recreation/accommodation/food services.

Tourism — The visitor industry plays an enormous role in Skagway’s economy (see table 3-24). In 2002, approximately 612,000 cruise passengers visited Skagway, according to the Skagway Convention and Visitors Bureau. They also estimate about 170,000 independent visitors (ADCED 2002). According to a 2000 study, the visitor industry injects approximately $60 million into the economy annually, and provides 450 jobs (Southeast Strategies and Dean Runyan Associates 2000). Skagway’s Gold Rush heritage (particularly its historic White Pass and Yukon Route railroad tours) is its major visitor asset. Skagway’s role as a northern terminus for the Alaska Marine Highway

System is a further draw for ferry and highway travelers. In addition, the Chilkoot Trail attracts a substantial number of hikers; the trail is part of the Klondike Gold Rush National Historic Park.

Skagway's economic links with the park and preserve — Skagway's strongest link to the park is with the cruise industry. Many cruise ships that stop in Skagway also visit the Bay. In addition, several local air carriers offer visitors flightseeing tours of the park. While daily air service between Skagway (through Haines) and Gustavus is offered, no regular ferry service runs between the two communities. Most of Skagway's independent visitors travel by highway and by the Alaska Marine Highway System, neither of which are connected to Gustavus. Skagway's visitor website does not mention Glacier Bay (Skagway Convention and Visitors Bureau 2000).

One Skagway-based business has a permit to operate in waters outside Glacier Bay. Packer Expeditions has an incidental business permit to provide kayak touring services. Based on study team estimates, about one-third of Skagway area personal income has an indirect link to Glacier Bay visitation, almost all related to spending by cruise ship passengers who also visit Glacier Bay.

Sitka. Sitka is a community of 8,835 residents located on the western side of Baranof Island on Sitka Sound (ADLWD 2000). It lies approximately 100 air miles southwest of Glacier Bay.

Local economy — Sitka's major industries are commercial fishing, seafood processing, tourism, government, and health care. Southeast Alaska Regional Health Corporation is the largest employer in the community, with 367 full-time-equivalent jobs in 2000 (McDowell 2002). The two largest seafood processors provided 241 jobs combined. Also in 2000, 583 Sitka resident permit holders fished 880 permits, generating about $23 million in ex-vessel value (the value of fish sold to processors). The federal government, notably the U.S. Coast Guard and U.S. Forest Service, which together accounted for 301 jobs in 2000, is also an important part of the economy (see table 3-25).

TABLE 3-25: ECONOMIC INDICATORS — CITY AND BOROUGH OF SITKA, ALASKA

Population 2000	8,835
Population Change 1990–2000	+2.9%
Percent Alaska Native	18.6%
Number Employed	4,352
Percent Unemployed	5.5%
Percent Not in Labor Force	26.4%
Median Household Income	$51,901
Per Capita Income	$23,622
Percent Employed in Visitor-Affected Businesses[a]	24.6%

TABLE 3-25: ECONOMIC INDICATORS — CITY AND BOROUGH OF SITKA, ALASKA

Source: ADLWD 2000.

a. These businesses include retail trade, transportation/warehousing/utilities, and arts/entertainment/recreation/accommodation/food services.

Tourism — The visitor industry is vital to Sitka's economy. In 2001, 206,000 cruise passengers visited Sitka, in addition to approximately 75,000 visitors who arrived by ferry and airplane (McDowell 2002d). Many of these non-cruise visitors come for Sitka's world-class sport fishing. Others are drawn by the area's kayaking opportunities, Russian heritage, and Native culture. Based on a 1996 study, Sitka's visitor industry generates approximately 500 annual jobs in the local economy, out of the total employment of 4,000 (McDowell 1996b, 2002d).

Sitka's economic links with the park and preserve — Sitka's economy has few links to the park. There is no direct, regular ferry service or air service between Sitka and Gustavus. Glacier Bay is too far away to be included in Sitka's flightseeing itineraries. In a 2001 survey of visitors exiting Alaska from Sitka's airport, only 3% of respondents had spent one or more nights in Gustavus or at the park (McDowell 2002a).

No Sitka-based businesses have permits to operate in the park. Sitka's visitor website makes no mention of Glacier Bay (Sitka Convention and Visitors Bureau 2000). An indirect link between Sitka and Glacier Bay exists in the cruise industry. In 2001, several large cruise ships included Sitka and Glacier Bay in their itineraries. Geographically, the route between Sitka and Glacier Bay is convenient for cruise ships. In addition, Sitka is an alternative destination for ships that do not have permits to enter the Bay and those that have extra time for a port call.

A small percentage (2% to 3%) of Sitka area personal income has an indirect link to Glacier Bay visitation, based on study team estimates, with almost all related to spending by cruise ship passengers who also visit Glacier Bay.

Southeast Alaska's Regional Visitor Industry. This subsection provides baseline information about the visitor industry (particularly the cruise industry) in Southeast Alaska and its effects on the regional economy. This information is critical to understanding the park's role in Southeast Alaska.

According to the Alaska Visitor Statistics Program, a statewide visitor survey project administered by the State of Alaska, approximately 1,202,000 out-of-state visitors came to Alaska in summer 2001, with 81% (or 974,000) visiting Southeast Alaska (Northern Economics 2002). Cruise Line Agency of Alaska (CLAA) data show that 691,000 of these visitors participated in a cruise, leaving approximately 280,000 non-cruise visitors to Southeast Alaska in summer 2001.

A 1999 statewide economic impacts study estimated that in 1998, visitors spent $949 million and the visitor industry created 20,300 jobs with $390 million in earnings (McDowell 1999). Including indirect effects, visitor-related spending totaled $2.6 billion, visitor-related employment totaled 30,700 jobs, and visitor-related earnings totaled $640 million. In Southeast Alaska, the visitor industry accounted for 4,400 jobs and $86 million in earnings.

The cruise industry in Southeast Alaska has maintained strong growth throughout the last decade, with passenger traffic increasing from 265,000 in 1992 to 719,000 in 2002 (CLAA 2002; see table 3-26). In the last five years alone, traffic has grown by 26%. A 2000 study estimated the economic effects of the cruise industry on Southeast Alaska for 1999. They included $193 million in purchases by cruise passengers, 1,990 average annual jobs, $40.2 million in payroll, and $7.8 million in total sales tax revenues.

TABLE 3-26: SOUTHEAST ALASKA CRUISE TRAFFIC, 1992–2003

Year	Number of Cruise Passengers
1992	265,000
1993	306,000
1994	379,000
1995	383,000
1996	464,000
1997	525,000
1998	569,000
1999	596,000
2000	640,000
2001	691,000
2002	719,000
2003 (projected)	813,000

Source: CLAA 2002.

Over the last 10 years, the cruise industry has played an increasingly important role in Southeast Alaska's economy. Cruise traffic, as stated above, has experienced strong and steady growth. In the meantime, according to data from the Alaska Department of Labor and Workforce Development, employment in Southeast Alaska's traditional basic industries has either stayed steady or declined over the past decade. These industries include seafood processing (0% growth), forest products (66% decline), state government (5% decline), and federal government (14% decline). Employment in these four industries, as a group, has declined by 23% since 1990, a loss of nearly 3,000 jobs. As a result, tourism — cruise travel, in particular — is playing an increasingly important role in the Southeast Alaska regional economy. Tourism is now the region's largest private sector industry in terms of employment.

While the events of September 11, 2001, and other factors have caused a slump in domestic and international travel, long-term projections show relatively quick recovery and long-term growth. The World Travel and Tourism Council (WTTC) expects 4.5% annual growth in travel and tourism between 2002 and 2012 (Weinstein 2002). Cruise ship capacity is expected to increase as well. Cruise passenger growth has increased annually at an average rate of about 7% since 1981. This growth rate is expected to continue over the next five years, according to the Cruise Lines International Association (CLIA 2002).

The Alaska cruise market is expected to experience its share of this growth. A study by Miami-based cruise industry consultant Bermello Ajamil & Partners predicts that the home port market from the combined ports of Seattle and Vancouver will grow from an estimated 1.2 million passengers to 2.2 million by 2010 (Vancouver Sun 2002). Alaska cruises now account for about two-thirds of the Vancouver/Seattle home ports.

The Park's Role in Southeast Alaska's Visitor Industry. Market research indicates that the opportunity to visit the park and other national parks in Alaska plays an important role in drawing visitors to the state. Research funded by the Alaska Travel Industry Association (ATIA) includes measures of prospective visitors' interest in visiting Glacier Bay. "Visiting Glacier Bay National Park" and "seeing the glaciers and fjords of Alaska" received the highest measures of interest (GMA Research Corporation 2001). Ninety-three percent of the prospective Alaska visitors surveyed expressed interest in visiting Glacier Bay. Part of the reason for the park's high level of recognition and interest among potential Alaska visitors is the cruise industry's national advertising campaigns, which often highlight the kinds of attractions found in the park. In fact, about one-third (32%) of Alaska's 1.2 million visitors total visited Glacier Bay in 2001, with most seeing the Bay from cruise ships (88% of the park's 383,000 visitors experienced Glacier Bay on a cruise ship in 2001). About half of Alaska's 700,000 cruise ship visitors visited Glacier Bay. Only 4% of the state's non-cruise visitors traveled to the Bay (McDowell 2002a).

While the kind of experience offered by Glacier Bay is in high demand among Alaska visitors, limitations on access to the Bay (regulatory and economic) apparently have not constrained growth in Alaska's visitor industry. For example, the number of June, July, and August cruise entries into Glacier Bay has been limited at 139 since 1996. During this time, cruise ship passenger traffic to Glacier Bay increased 28%, as a result of some shoulder-season growth and an increase in the passenger capacity of the ships visiting the Bay. Meanwhile, since 1996, the number of visitors traveling to or from Alaska on cruise ships has grown from 464,000 to 719,000, an increase of just more than 50%.

ENVIRONMENTAL CONSEQUENCES

GLACIER BAY
NATIONAL PARK AND PRESERVE, ALASKA

VESSEL QUOTAS AND OPERATING REQUIREMENTS • DRAFT ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 4. ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

This chapter evaluates the environmental consequences of the five alternatives presented in chapter 2. Each alternative specifies quotas (limits) and operating requirements for cruise ships, tour vessels, charter vessels, and private vessels in Glacier Bay and Dundas Bay. The potential effects associated with each alternative are analyzed and compared to the existing (baseline) conditions of each environmental resource topic identified in chapter 3.

Organization of the Effects Analysis. The effects analysis (sections 4.2 through 4.4) is organized by resource topic and includes subsections corresponding to the following:

- issues raised during scoping.
- the regulatory framework, if appropriate.
- the methodology and assumptions.
- the direct and indirect effects analysis for each alternative.
- the cumulative effects analysis for each alternative.
- the impairment analysis for each alternative.
- mitigation measures, if relevant, for each alternative.

Sections 4.5 through 4.7 discuss any unavoidable adverse effects that would result with the alternatives considered in this EIS, along with sustainability and long-term management. These topics must be addressed in any environmental impact statement.

4-2

4.1.1 Overview of Methodology and Threshold Criteria

In accordance with the National Environmental Policy Act and its implementing regulations, this environmental impact statement considers direct, indirect, and cumulative effects:

- **Direct effects** are those that result from the action and occur at the same time and place. Dispersion of air pollutants from a vessel stack into the atmosphere is an example of a direct effect.
- **Indirect effects** are those reasonably foreseeable effects that are caused by the action but that may occur later and farther from the location of the direct effect. For example, an indirect effect of reducing vessel traffic in Glacier and Dundas Bays may be an increase in demand for use of other areas.
- **Cumulative effects** are the incremental effect of the proposed action when added to the effects of past, other present, or reasonably foreseeable future actions. Cumulative effects can result from individually minor, but collectively significant, actions taking place over time.

Effects Thresholds. Thresholds provide an overall measurement of how the proposed action would influence the existing environment. The regulations issued by the Council on Environmental Quality to implement the National Environmental Policy Act define significance of effects in terms of context and intensity. Context refers to the geographic area of effect, which varies with the physical setting of the proposed action and with each element of the environment being analyzed. Intensity refers to the severity of the effect. Duration also must be considered in the assessment of effects and effects must be quantified as much as possible. For this environmental impact statement, effects thresholds are defined using four categories of significance:

- **Negligible** effects may or may not cause observable changes to natural conditions; regardless, they do not reduce the integrity of a resource.
- **Minor** effects cause observable and short-term changes to natural conditions, but they do not reduce the integrity of a resource.
- **Moderate** effects cause observable and short-term changes to natural conditions, and/or they reduce the integrity of a resource.
- **Major** effects cause observable and long-term changes to natural conditions, and they reduce the integrity of a resource.

Each resource topic discussion includes a threshold effects determination.

Methodology of the Impairment Evaluation. An impairment is an effect that "would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values" (NPS 2000b). An effect may constitute an impairment "to the extent that it affects a resource or value whose conservation is necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park; key to the natural or cultural integrity of the park or to opportunities for enjoyment of the park; identified as a goal in the park's General Management Plan (NPS 1984); or other relevant NPS planning documents" (NPS 2000b). To judge whether a resource is impaired "depends on the particular resources and values that would be affected; the severity, duration, and timing of the impact; the direct and indirect effects of the impact; and the cumulative effects of the impact in question and other impacts" (NPS 2000b). Ultimately, the impairment determination rests with the park superintendent, subject to the approval of the regional director. The impairment determination in this EIS are considered recommendations to the park superintendent, not absolute findings of impairment.

Mitigation Measures. This chapter also identifies and discusses mitigation measures. Mitigation measures are specific methods for avoiding, minimizing, rectifying, reducing, or compensating for an alternative's adverse effect(s). For each resource and alternative, a mitigation measures subsection identifies reasonable measures that could alleviate any adverse environmental effects. It discusses any adverse effects of the mitigation measures and their appropriateness. Although mitigation measures are identified, the Park Service will select the specific mitigation measures to be taken when a decision regarding a preferred alternative is made.

In addition, there also are in-place mitigation measures associated with each of the alternatives. These in-place mitigation measures include existing regulations, primarily associated with vessel operating requirements. These regulations will remain in effect regardless of the alternative selected as a result of this EIS. In addition, a number of the operating requirements proposed for change in alternatives 4 and 5 may also serve to mitigate adverse environmental effects. An evaluation of the effect of these actions is included in the analysis of alternatives.

Conclusions. Following the effects analysis and mitigation measures, a conclusion section integrates these evaluations. Each analysis of the effects of an alternative on a resource finishes with an overall summary regarding whether the effects are negligible, minor, moderate, or major.

Sustainability and Long-Term Management. The analysis of sustainability and long-term management (section 4.7) focuses on the following three concepts:

- the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity (NEPA section 102[c][iv]).
- any irreversible or irretrievable commitments of resources that would be involved if an alternative were implemented (NEPA section 102[c][v]).
- any adverse impacts that could not be avoided if an action were implemented (NEPA section 101[c][ii]).

4.1.2 Major Assumptions for the Effects Analysis

4.1.2 Major Assumptions for the Effects Analysis

The effects analysis is built upon several assumptions regarding the existing situation in Glacier Bay and Dundas Bay, as well as conditions that may be expected to occur in the future. Most of these assumptions are resource-specific and are discussed under the effects methodology description for each resource area; however, other assumptions apply to many or all topics. These assumptions are summarized below.

Visitor Use and Demand. This analysis assumes that the demand to experience Glacier and Dundas Bays will continue to increase in concert with growth in population (Alaska and the United States as a whole) and the Alaska tourism industry. Alternatives 1, 2, and 3 would regulate the number of charter and private vessel entries from June through August. To establish a basis for comparison among alternatives for vessel activity during the off-season, average daily vessel-use statistics were generated for May and September (see table 4-1).

TABLE 4-1: ASSUMPTION OF USE LEVELS IN MAY AND SEPTEMBER, GLACIER BAY AND DUNDAS BAY, UNDER ALTERNATIVES 1, 2, AND 3

	Glacier Bay	**Dundas Bay**
Vessel Class	**Daily Vessel Use** ***Number of Vessels Present Each Day***	**Daily Vessel Use** ***Number of Vessels Present Each Day***
Cruise ship	Up to 2	0
Tour vessel	Up to 3	Up to 2, average 0.5
Charter vessel	No limit	Up to 8, average 3
Private vessel	No limit	Up to 8, average 4

For each alternative, it is further assumed that vessel entries to the park would eventually reach maximum allowable levels in the peak period spanning May through September. Currently, cruise ship entries often reach maximum levels in the off season, May and September, and during the peak period, June through August. Actual use, however, may be at lower levels, because the park experiences no-shows and demand sometimes has been lower than established quotas. Entries into the park during other times of the year are generally expected to reflect lower demand, and therefore be at levels less than the maximum entry limits. Cruise ships are assumed to be absent from park waters from November through March.

Effects of Vessels. For the purposes of analysis, it is also assumed that all vessels within each vessel class produce the same types and intensities of environmental effects. This assumption is based on the similar use patterns within each vessel category, as well as the general size of each vessel category.

Size is accounted for in alternatives 4 and 5, in which vessel speed restrictions are defined according to vessel size rather than vessel category. In addition, effects related to vessel presence in the park are assumed to be direct proportional to the number of vessels. In other words, twice as many vessels of any particular category would be assumed to cause twice the level of effects, in terms of intensity.

4.1.3 Assumptions for the Cumulative Effects Analysis

4.1.3 Assumptions for the Cumulative Effects Analysis

Projects and actions assumed to contribute to cumulative effects in this analysis are listed below. These projects and actions are likely to affect several or all resources evaluated in this environmental impact statement:

- the park and preserve's backcountry management plan and environmental impact statement.
- commercial fishing.
- the USFS *Draft Supplemental Environmental Impact Statement (May 2002) for the Tongass Land Management Plan Revision — Roadless Area Evaluation for Wilderness Recommendations.*
- commercial and private vessels in waters outside Glacier Bay and Dundas Bay.
- increases in tourism and the population of Southeast Alaska.
- natural phenomena.
- non-motorized vessel use in Glacier Bay and Dundas Bay.
- flightseeing.
- new vessel propulsion technology.
- NPS administrative actions / patrols.

The following subsections describe these projects and actions.

The Park and Preserve Backcountry Management Plan and Environmental Impact Statement. The park backcountry management planning process is under way, and an environmental impact statement will be developed to present alternatives for managing the park's wilderness and backcountry. The environmental impact statement will address visitor use of wilderness and non-wilderness waters and land, especially shorelines. It likely will consider use via non-motorized vessels (mainly kayaks), as well as some aspects of recreational boating, camper vessel drop-offs, and off-vessel activities. The planning process and environmental impact statement will result in a record of decision that will direct the course of the park's backcountry management.

This plan will potentially contribute to cumulative effects on visitor experience; cultural resources; and natural resources, including marine birds. The plan will address visitor use and distribution, which will have implications related to locations where visitors can be dropped off by vessels and where kayakers can travel. Depending on where visitors can land, they may disturb bird colonies or damage cultural resources.

Commercial Fishing. Commercial fishing vessels are not included in the proposed action and alternatives presented in this environmental impact statement; however, the effects of commercial fishing must be considered as part of the cumulative effects analysis. The wilderness waters of Glacier Bay and Dundas Bay are closed to commercial fishing. Commercial fishing currently is authorized within the park and preserve's non-wilderness marine waters located outside Glacier Bay (including Icy Strait, Cross Sound, and along the Bay's outer coast), but is being phased out within the non-wilderness waters of Glacier Bay.

The Omnibus Consolidated and Emergency Supplemental Appropriations Act for Fiscal Year 1999 closed portions of the park and preserve to commercial fishing. It also mandated that other portions close after the lifetime of qualified fishers. Some portions of the park were left open to commercial fishing (USGS 2002e).

Currently, three main types of commercial fishing are authorized in the non-wilderness waters of Glacier Bay: longline fishing for halibut, pot and ring fishing for Tanner crab, and trolling for salmon. Fishing by lifetime-access permit holders will continue in Glacier Bay until all the current permit holders cease to fish.

The halibut fishery is managed on a limited-entry, quota-share basis. The fishing season typically runs from March 15 to October 15. Individual fishers are assigned Individual Fishing Quotas (IFQ), which apportion their share of the total annual commercial harvest. Halibut fishing was closed in Glacier Bay in November 1999, except for certain "grandfathered" fishers who are permitted to continue fishing non-wilderness portions of the Bay during their lifetime (NPS 1999d). Participation in the halibut fishery in 2001 (the most recent year for which data are available) was approximately 37 vessels in Glacier Bay (area 184) and 93 vessels in Dundas Bay and Icy Strait from Elfin Cove to the area north of Point Augusta (area 182; International Pacific Halibut Commission (IPHC), Kong, electronic mail, February 25, 2003).

Under federal law, the commercial Dungeness crab fishery was completely closed in Glacier Bay as of September 30, 1999. Currently, no Dungeness crab fishery operates in Glacier Bay (NPS 1999). In 2002, eight permit holders fished for Tanner crab in Glacier Bay (statistical area 114-70), and none in Dundas Bay. The Tanner crab fishery lasted six days from February 15 to 21, 2002 (ADFG, Rumble, electronic mail, February 27, 2003).

Commercial salmon trolling was closed in Glacier Bay in June 1999, except for certain "grandfathered" fishers who are permitted to continue fishing non-wilderness portions of the bay during their lifetime (NPS 1999d). During 2002, participation in the salmon troll fishery was as follows:

- Winter (October 11, 2001–April 14, 2002): Five hand-trollers and fewer than three power-trollers in the main portion of the Bay, and fewer than three hand-trollers in the West Arm.
- Spring (April 15–June 30, 2002): No participation.
- Summer (July 1–September 30, 2002): Fewer than three hand-trollers and four power-trollers in Dundas Bay (ADFG, Johnson, electronic mail, February 25, 2003).

The USFS *Draft Supplemental Environmental Impact Statement (May 2002) for the Tongass Land Management Plan Revision — Roadless Area Evaluation for Wilderness Recommendations*. The Tongass National Forest abuts the park in several locations. The preferred alternative in the Tongass draft supplemental environmental impact statement is the no-action alternative (which is the existing 1997 Tongass forest plan revision). The U.S. Forest Service’s reason for selecting no action as the preferred alternative is that the 1997 revision was the result of a significant collaborative effort to seek a balance for protecting and managing the Tongass National Forest. The areas directly adjacent to the park are designated as “Mostly Natural Setting” and are further categorized in the plan / preferred alternative as one of the following:

- **Land Use Designation II Wilderness**. Areas that are congressionally designated as roadless and that permit fish and wildlife improvements and primitive recreation facilities.
- **Semi-Remote Recreation**. Areas where recreation and tourism are in natural-appearing settings and where moderate to high opportunities for solitude and self-reliance are provided.
- **Remote Recreation**. Areas for recreation in remote natural settings outside wilderness, where opportunities for solitude and self-reliance are high.

Areas for “Intense Development,” including timber harvest and mineral exploration, are not located adjacent to the park; however, recreational activities in the Tongass National Forest adjacent to the park could contribute to cumulative effects on park resources.

Commercial and Private Vessels in Waters outside Glacier Bay and Dundas Bay. Commercial and private vessels traversing Icy Strait and the outer coast could contribute contaminants to Glacier Bay and Dundas Bay through accidental discharge of petroleum, sewage, graywater, ballast water, and marine debris.

Increases in Tourism and the Population of Southeast Alaska. Increases in tourism and the population of Southeast Alaska will continue to increase demand to visit the park, and to increase vessel and other recreational activities in this part of the state. It is assumed that, over time, vessel quotas (limits) would be reached as demand increases. Development of a new visitor's center in Glacier Bay and a private cruise ship port in Hoonah, as well as population growth throughout Southeast Alaska, could result in increasing demand to visit Glacier Bay by cruise ship, tour vessel, charter vessel, or private vessel

Natural Phenomena. Many forces acting on the marine environment (e.g., global climate change, sea otter recolonization of portions of Glacier Bay, or disease or parasite epidemics) may be responsible for increases or decreases in the population and distribution of marine species.

Non-Motorized Vessel Use in Glacier Bay and Dundas Bay. Visitors often use kayaks and canoes to access many areas of the park where motorized vessels are prohibited. Although these modes of travel do not cause the same types of disturbances as motorized vessels, they can create disturbances that may contribute to effects.

Flightseeing. Aircraft overflights, regulated by the Federal Aviation Administration (FAA), create noise and can be seen.

New Vessel Propulsion Technology. Vessel propulsion changes may be incorporated into newer vessels that transit the marine waters of Southeast Alaska, including those that enter Glacier Bay and Dundas Bay. Such changes could include use of jets in small passenger vessels and ferries, vessels that are faster than those currently in use, and incorporation of "stealth" technology that would reduce underwater and above-water noise. Justification for speed limits to protect whales may become outdated in light of new technologies. For example, jet-driven vessels are less maneuverable at low speeds, and variable pitch propellers create different sounds and frequencies at different pitches under water.

NPS Administrative Actions / Patrols. The Park Service regularly operates 12 vessels regularly out of Bartlett Cove and in concentrated whale-use areas. NPS vessels include one naturalist transfer vessel (*M/V Serac*) that transports naturalists to and from cruise ships as the ships enter and exit Glacier Bay. Typically, two round trips are made for every cruise ship entry (one drop-off and one pickup); therefore, the number of hours of generated noise is linked directly to cruise ship entries. The Park Service also regularly operates four patrol vessels, five resource management vessels, and two fisheries research vessels throughout the park. Park patrol vessels often are used in the lower Bay and in Bartlett Cove. All vessels are based at Bartlett Cove and therefore transit concentrated whale-use areas to reach other locations in the park. The Park Service also employs a small freight vessel and an inflatable vessel for outer coast patrols (NPS 1995).

4.2 PHYSICAL ENVIRONMENT

4.2.1 Soundscape

This section provides an overall evaluation of effects of human-made noise, mainly from cruise ship and tour, charter, and private vessel traffic in Glacier and Dundas Bays, on the natural soundscape. As described in subsection 3.2.2, the natural soundscape in the park comprises the surface soundscape and the underwater soundscape. For the underwater soundscape, the biological effects of human noise on marine mammals and fish are the main concerns. The biological (terrestrial wildlife and marine birds) and human (principally visitor experience) environments of the surface soundscape are affected by human-made noise. Because these two soundscapes are affected differently, each is discussed separately for each alternative. The focus of each of these discussions is on the overall effects of human noise on the natural soundscape, rather than on species-specific effects.

Issues of Concern Raised during Scoping. The main issues raised by the public related to human-made sound are as follows:

- The sight and noise of vessel traffic alters marine mammal behavior; therefore, any increase in the number of vessels would further disrupt marine mammal behavior.
- Changing levels of underwater noise could alter fish behavior, including feeding, resting, traveling, distribution, and communication.
- Vessel noise could intrude on visitor solitude in Glacier Bay.

Regulatory Framework. "Director's Order 47, Sound Preservation and Noise Management" defines appropriate and inappropriate noise (NPS 2001c). The overall policy goal of NPS units, as identified in this order, is to protect, maintain, or restore the natural soundscape resource. It does state, however, that some sound-producing activities may be appropriate if they are included in the park's purposes as defined by its enabling legislation (see subsection 1.3.4). In the Omnibus Parks and Public Lands Management Act of 1996 (Public Law 104-333), Congress emphasized park values and resources when it limited the authority of the Park Service to set operating conditions related to noise in the park and preserve. Specifically, this act states that:

> *No operating conditions or limitations relating to noise abatement shall be imposed unless the secretary determines, based on the weight of the evidence from all available studies including verifiable scientific information from the investigations provided for in this subsection, that such limitations or conditions are necessary to protect park values and resources.*

Methodology and Assumptions. The basis for determining effects included section 1.4 of NPS policies (NPS 2001b) and Director's Order 47 (NPS 2001c). The first step in the effects analysis of the natural soundscape involved identifying the sources of human-made sounds that could occur in

Glacier Bay and Dundas Bay (see subsection 3.2.2). The main source of human-made noise that would result from implementation of any of the alternatives is the operation of cruise ships, tour vessels, charter vessels, and private vessels. Vessel noise, as used in this EIS, refers to all sounds generated from cruise ships and tour, charter, and private vessels, and includes the engine and propeller noise, voices, public address systems, bow wave noise, and wakes breaking onshore. Other human-made sounds considered include noises made by off-vessel uses, such as kayak drop-offs from tour vessels. This evaluation does not consider the soundscape in the developed areas of Bartlett Cove. It is understood that Bartlett Cove has ambient sounds that are the result of human activities; however, these sounds are associated with activities considered to be essential to the park's purpose and management (e.g., the visitor's center, the Bartlett Cove dock, the campground, and park administration). Therefore, these ambient sounds are viewed as appropriate under Director's Order 47 (NPS 2001c).

The second step in the effects analysis was to identify the sound levels and the consequences that could be expected and, consistent with NPS policies, those that could be accepted by the park superintendent within the context of park purposes and values, including the enjoyment of park resources by people and protection of wildlife.

Surface soundscape **—** No studies of the natural surface soundscape have been conducted in the park; therefore, the surface sound threshold effects criteria were established qualitatively based on the following factors:

- frequency (how often human-made sounds would be generated).
- magnitude (how loud they would be).
- duration (how long they would last).

Key to this qualitative evaluation were vessel type, number of vessels, speed of vessels, and location of vessels relative to potential listeners, with sound frequency, magnitude, and duration assumed to be directly proportional to the number of vessels present by vessel category. The evaluation also considered visitor opinions related to sound at the park (Littlejohn 2000) and interviews of park staff and others having first-hand experience with vessel noise at the park. Table 4-2 lists the surface sound threshold criteria considered for determining the severity of predicted effects of each alternative.

Underwater soundscape **—** The effects of the underwater soundscape are based on the findings of several studies (Wenz 1982; Unick 1983; Miles and Malone 1983; NSWC 2002).

TABLE 4-2: THRESHOLD CRITERIA FOR EFFECTS ANALYSIS OF THE SOUNDSCAPE

Negligible	Human-made sounds would be in the background and not dominate the soundscape. Background soundscape is generally the result of wind agitation on the water surface. Obviously, the background level depends on wind speed. Human-made sounds could be heard (perceived) by terrestrial and aquatic organisms, but would not interfere with natural functioning or processes. Sounds occurring in developed areas would be the result of normal, allowable activities. (Note: The acceptability of human-made sounds is generally greater in developed areas and generally less in undeveloped areas.) Human-made sounds could be heard (perceived) by visitors, but would not interfere with visitor enjoyment or understanding of park resources and values.
Minor	Human-made sound would cause regular short-term changes (i.e., in the scale of hours) in the behavior of individual animals at locations near the sound's source, but would not cause long-term changes in behavior (i.e., in the scale of days or weeks) at the population level or cause animals to avoid habitats important to breeding, feeding, or shelter. Human-made sounds could be heard by visitors, but would not interfere with (and would actually support) the overall visitor enjoyment and understanding of park resources and values. Visitors are annoyed by human-made sound, but not to the point that their overall enjoyment of park resources and values would be lost.
Moderate	Human-made sounds would cause animals near the sound source to leave an area, have difficulty in foraging or resting, or be more vulnerable to predation, but the overall effect would be limited to short-term changes in behavior, distribution, or abundance. Human-made sounds could be heard regularly over a broad area, such as an inlet or passage, yet natural processes would continue to function and be enjoyed by visitors.
Major	Human-made sounds would interfere with natural processes, resulting in a long-term change in organisms' behavior or distribution, or in reduction in abundance. Human-made sounds would interfere with natural processes, such that visitor enjoyment of park resources would decline, visitors would regularly comment or complain about the noise, or there would be few places within the park that visitors would consider quiet. Human-made sounds would daily violate NPS regulations, as stated in 36 CFR 2.12, Director's Order 47, and NPS policies (NPS 2001), including unacceptable levels, as determined by the park's superintendent. In remote, backcountry areas, human-made sounds regularly would be generated and would be unreasonable to users of those areas, considering the nature and purpose of the sound-generating activity's location, time of day, purpose for which the area was established, impact on park users, and other factors that would govern the conduct of a reasonably prudent person under the circumstances. Human-made sounds would interfere with scientific research to the point at which such research would not be possible.

Alternative 1 (No Action) — Effects on the Surface Soundscape. Under current management conditions, human-made sound is generated where cruise ships, tour vessels, charter vessels, private vessels, or people are present. Sound carries over the waters of Glacier and Dundas Bays and to the adjacent shorelines (with the exception of non-motorized waters and adjacent shorelines sufficiently distant from motorized waters). Vessel noise also is reflected back in enclosed inlets and near steep, tall rock walls and cliffs. Popular stops along the route to upper Glacier Bay are the locations where intrusions of human-made sounds would be expected to occur most frequently (see figure 3-22, which depicts the main vessel routes). These areas include (excluding Bartlett Cove):

- Beardslee Entrance.
- Whidbey Passage.
- Flapjack Island.
- South Marble Island.
- Point Gustavus.
- Tarr, Johns Hopkins, and Reid Inlets.

Assuming the maximum number of vessel entries allowed under alternative 1, and that all these vessels travel up and down Glacier Bay in a single day (an unlikely occurrence), up to 67 vessel passes would cross an imaginary line extending from the east to west shores of the Bay. As shown in figure 3-22, however, cruise ships travel mostly through the center of Glacier Bay, so shoreline areas are at least 1 mile away. Also, because sound dissipates directly as a function of spatial distance, cruise ship noise fades into the background in shoreline areas. On the water near the cruise ships, the sounds can be heard more clearly. Cruise ships can make a minor excursion through Tarr Inlet, Johns Hopkins Inlet, and Reid Inlet, and near South Marble Island, exposing these water bodies to human-made noise up to four times per day (two vessels in and out) from June through August, roughly five days per week.

Tour and charter vessels, as shown in figure 3-22, travel much closer to shorelines. With a combined daily quota of nine, up to 18 events could expose shorelines to human-made noise from tour and charter vessels; however, expected exposure frequencies would be half that, because vessels tend to tour different areas on return trips versus trips up the Bay.

Under existing conditions, cruise ships do not visit Dundas Bay; however, it is a popular charter vessel destination. Although no vessel quotas currently are established for Dundas Bay, it is expected that charter vessel use of Dundas Bay, over time, will increase by two to three times. Assuming that future charter entries will reach five per day during June through August, and one per day for May and September, a maximum of 15 charter vessels in a peak season, the frequency of charter vessel noise could be up to 30 exposures.

The magnitude of vessel-caused sound depends on the distance of the vessel from potential listeners, the type of vessel generating the sound, and the activity of the vessel. As stated previously, cruise ships mainly travel up the center of Glacier Bay and do not frequent Dundas Bay. In addition, cruise ships are designed to operate at sound levels that do not detract from passengers' experiences. Still, cruise ships create noise from engines, propellers, and related mechanical operations. The loudest sound from a cruise ship is its public address system. The same holds true for tour vessels. Tour vessels, as well as charter vessels, that drop off kayakers would generate additional noises at specific locations.

The duration of exposures to the sound of a passing vessel in the Bays is currently in the range of 5 to 20 minutes. A passing vessel creates a relatively steady droning engine sound, increasing with approach and decreasing with departure. In Glacier and Dundas Bays, vessels, including cruise ships, travel at relatively slow speeds and generate similarly low sound outputs. At close distances, vessel bow wakes can be heard for up to several minutes.

As described in this chapter's introduction, this section evaluates the effect of human-made sounds on the biological and human environments. The following subsections describe the effects occurring under the current regulations, and those that would continue to occur should the Park Service select alternative 1 (no action).

Direct and indirect effects on the surface soundscape for the biological environment — alternative 1 — Noise and the presence of vessels would cause some animals (especially those in the water or along the shoreline) to flush or otherwise leave areas near the vessels, as described in the marine bird and marine mammals subsections. More detailed descriptions of the magnitude and duration of these effects are included in those subsections. Vessel noise and presence likely cause wolves, bears, wolverines, and other animals sensitive to disturbance to move away from shoreline areas when vessels are near.

As described in subsection 4.3.3, marine birds are sensitive to vessel noise, but the overall sight and physical presence of an approaching vessel create the most disturbance. Even with regular disturbance, overall effects are expected to be minor, with no reduction in population levels. Noise may contribute to other disturbances related to molting waterfowl, harlequin ducks, feeding murrelets, and tufted puffins, as well as sea otters and harbor seals, as described in more detail in subsection 4.3.3.

Within concentration areas and anchorages, noise could be sufficient to cause wildlife to avoid the shorelines (see primary anchorages depicted in figure 3-22). Wildlife may alter behavior in response to noise in these areas by traveling when most people are asleep and not frequenting anchorages. Human-made sound would cause regular short-term changes (i.e., in the scale of hours) in the behavior of individual animals at locations near the source of those sounds, but would not cause long-term changes in behavior (i.e., in the scale of days or weeks) at the population level or cause animals to avoid habitats important to breeding, feeding, or shelter. Effects of surface sound on the biological environment under alternative 1, therefore, would be considered minor.

Direct and indirect effects on the surface soundscape for the human environment — alternative 1 — Because most people experience the Bay by traveling in motorized vessels, motor noise from each visitor's vessel is expected to mask sound from other vessels. In addition, vessel passengers are often inside the cabin, or, if on deck, are exposed to wind that also masks sounds. Overall, sound levels at popular destinations, such as Tarr and Johns Hopkins Inlets, detract from some visitor's enjoyment of these areas. The cruise ships' and tour vessels' public address systems may be heard in several locations. In addition, tour and charter vessels dropping off groups for kayaking or shore-based activities would introduce concentrated areas of human-made sound, most of which would be voices.

Visitors on the shoreline and users of non-motorized vessels (e.g., kayaks and sailboats) are most vulnerable to vessel sounds. Even visitors in non-motorized waters, which are intended to provide opportunities to enjoy public resources in the absence of vessel noise, may be subject to vessel sounds, especially if the visitors are near motorized waters. Sensitivity depends highly on the individual. Some people might enjoy seeing motorized vessels pass or accept it as part of a maritime park experience. Others may be angered and annoyed by the sight and sounds of a vessel. Still, overall, these human-made sounds are considered acceptable within the context of park purposes and values.

Cruise ships and tour vessels use public address systems to inform visitors about park resources. With approximately 2,500 people aboard a modern cruise ship, the public address system is an effective way for the Park Service to provide interpretation of the park's resources. The public address system is not continuous, and, within the tidewater glacier areas, narrations are relatively short and most time is left for passengers to enjoy the glaciers in relative silence. Most cruise ship and tour vessel passengers accept and enjoy the address system, so the primary concern is for those in other vessels or on shore. The effects on these people would be considered moderate, because some short-term loss of enjoyment may occur. Specifically, in the 1999 Bartlett Cove visitor survey (Littlejohn 2000), when visitors were asked what they least liked about their visit to the park, 2% mentioned airplane and/or boat noise.

Cumulative effects on the surface soundscape — alternative 1 — Other than vessels, the most notable sound source within Glacier Bay and, to a lesser degree, Dundas Bay, is aircraft. Aircraft landing in the park are infrequent, averaging fewer than one per day in Glacier Bay and fewer than two per day at Bartlett Cove. Aircraft sounds, combined with those of administrative vessels, fishing vessels, cruise ships, tour vessels, charter vessels, and private vessels, would have a moderate effect on the natural soundscape within specific locations and times; however, these multiple sources of human-made sound would occur over a relatively short period of time (i.e., less than an hour).

Impairment analysis for the surface soundscape — alternative 1 — Under alternative 1, effects on the soundscape would be moderate, and an impairment of the park's natural soundscape would not be expected. Glacier Bay and Dundas Bay provide plenty of opportunities to experience natural soundscapes, provided that recreational users plan reasonably to avoid heavy vessel traffic areas. Wildlife communities currently are not impaired by existing levels of sound.

Potential mitigation measures for the surface soundscape — alternative 1 — The park could conduct sound inventories of popular stops and destinations and establish soundscape preservation objectives for these areas, as described in Director's Order 47 (NPS 2001c). Subsequent monitoring and modifications could serve to protect natural soundscapes in these areas, within the context of park values and resources.

Conclusion, surface soundscape — alternative 1 — Overall effects on soundscape would be consistent with park values and resources, and would be minor, with the exception of moderate effects on backcountry users (because they are the most likely to be sensitive to sounds and to be exposed to vessel sounds). Vessel sounds could contribute to disturbance of tufted puffins, harlequin ducks, feeding murrelets, and molting waterfowl (see subsection 4.3.3, "Marine Birds and Raptors"), as well as sea otters and harbor seals, resulting in moderate effects.

Alternative 1 (No Action) — Effects on the Underwater Soundscape.

Direct and indirect effects on the underwater soundscape — alternative 1 — As documented in the *Underwater Noise Interim Report* (NSWC 2002), vessel noise is pervasive under the waters of Glacier Bay. While no studies have been conducted in Dundas Bay, vessel noise also is expected to be a regular element of the underwater soundscape there.

Under the existing vessel-use levels, vessel noise levels would be expected to be similar to the results found in the *Underwater Noise Interim Report* (NSWC 2002). The report indicates that the average vessel noise level registered 94 decibels, while natural sources of noise — wind and rainfall — are 83 and 89 decibels, respectively. The only marine animal noise level reported was for humpback whales; however, an average noise level was not calculated. The report concluded only that humpback whale noises were recorded less frequently than vessel noises. Vessel noises were identified in 60% of readings taken during June, July, and August; in 40% of readings in May and September; and in 10% of readings in October through April.

The magnitude of effect of vessel-caused sound on underwater soundscape depends on vessel size and the distance of the affected environment from the vessel. Cruise ships create the most sound disturbance, but are much less common in the public's waters than medium and small vessels. Based on the *Underwater Noise Interim Report* (NSWC 2002), all vessel sizes create underwater noise at a level that is greater than the average noise level of wind and rainfall.

The direction of the vessel disturbances is short-lived as the sound dissipates through the water. The duration will vary depending on the type of vessel, the speed of the vessel, and natural factors such as tidal flow and weather conditions.

The underwater biological environment will be directly affected by vessel-caused sound. Vessel noise interferes with animal communication. The natural noise from wind and rainfall is lessened by vessel noise, thereby altering the underwater soundscape.

Cumulative effects on the underwater soundscape — alternative 1 — Noise from administrative traffic, including NPS vessels and research vessels, would be additive to the noise created by cruise ships and tour, charter, and private vessels, but the main source of human-made noise in the waters of Glacier and Dundas Bays is park visitors.

Noise within the world's oceans has been a growing concern throughout the scientific and environmental communities. Commercial vessel traffic, offshore oil exploration, and military sonar systems add to the potential problems associated with underwater noise. Vessel traffic in Glacier and Dundas Bay adds to this noise level.

Impairment analysis for the underwater soundscape — alternative 1 — The level of vessel noise, while relatively high and pervasive, would not result in an impairment of the underwater soundscape, because wildlife and fish populations would remain sound and the overall integrity and functioning of the underwater environment would be maintained.

Potential mitigation measures for the underwater soundscape — alternative 1 — The Park Service requires underwater sound measurements of cruise ships as part of the concessions permitting process, and relative quietness is a factor considered when selecting which cruise lines are provided access to the park. Other than that, no specific measures to reduce underwater noise are proposed. Application of additional studies on underwater vessel noise and its effects on marine mammals and fish could provide new targets for changing vessel noise generation to reduce effects.

Conclusion, underwater soundscape — Alternative 1 — Vessel sound would remain common within the underwater environments of Glacier and Dundas Bays. This sound would cause regular short-term changes (i.e., within the range of hours) in the behavior of individual fish and marine mammals; however, this sound is not expected to result in unhealthy population levels.

Alternative 2 — Effects on the Surface Soundscape. Overall effects on the surface soundscape would be similar to those identified under alternative 1, although overall sound generated would be slightly lower because of reduced vessel entries. Sound will carry over the waters of Glacier and Dundas Bays and to the adjacent shorelines (with the exception of non-motorized waters and adjacent shorelines sufficiently distant from motorized waters). Vessel noise also is reflected back in enclosed inlets and near steep, tall rock walls and cliffs. Popular stops along the route to the upper Bay will be the locations where intrusions of human-made sounds would be expected to occur most frequently. Peak season frequency of charter vessel noise would be the same in Dundas Bay, with up to 30 exposures.

Direct and indirect effects on the surface soundscape for the biological environment — alternative 2 — As with alternative 1, the sounds of vessels along the shoreline are not expected to be sufficiently loud or frequent to affect wildlife, insects, or other animals. Overall effects are expected to be minor, with regular disturbance, but with no reduction in population levels. Noise may contribute to other disturbances related to molting waterfowl, harlequin ducks, feeding murrelets, and tufted puffins (see subsection 4.3.3), as well as sea otters and harbor seals. Within concentration areas and anchorages, noise could be sufficient to cause wildlife to avoid the shorelines (see primary anchorages depicted in figure 3-22).

Direct and indirect effects on the surface soundscape for the human environment — alternative 2 — For the same reasons described under alternative 1, motorized vessel users would not be affected by vessel-generated sounds, except at destination points, such as Tarr and Johns Hopkins Inlets. The public address systems may be heard in several locations. In addition, tour and charter vessels dropping off groups for kayaking or shore-based activities would introduce concentrated areas of human-made sound, most of which would be voices. As described under alternative 1, visitors on the shoreline are most vulnerable to vessel sounds.

Overall, these human-made sounds are considered acceptable within the context of park purposes and values; therefore, under alternative 2, the overall effect on soundscape from a visitor experience standpoint would be considered minor. Because backcountry visitors have a lower tolerance for vessel and other human-made noise, the effect on soundscape in backcountry areas near where vessels often travel would be considered moderate.

Cumulative effects on the surface soundscape — alternative 2 — The cumulative effects would be the same as those under alternative 1. The most notable source of sound, other than vessels, within Glacier Bay and, to a lesser degree, Dundas Bay, is aircraft. Aircraft sounds, combined with those of administrative vessels, fishing vessels, cruise ships, tour vessels, charter vessels, and private vessels, would create a moderate effect on the natural soundscape at specific locations and times; however, these effects would occur over a relatively short time period (i.e., less than an hour).

Impairment analysis for the surface Soundscape — alternative 2 — Effects on soundscape would be moderate and therefore would not be considered an impairment of the park's natural soundscape.

Potential mitigation measures for the surface soundscape — alternative 2 — As for alternative 1, the park could conduct sound inventories of popular stops and destinations and establish soundscape preservation objectives for these areas, as described in Director's Order 47 (NPS 2001c). Subsequent monitoring and modifications would serve to protect natural soundscapes in these areas, within the context of park values and resources.

Conclusion, surface soundscape — alternative 2 — Overall effects on soundscapes would be essentially the same as those under alternative 1, with a negligible decline in overall vessel use and associated noise generation. The effects would be consistent with park values and resources, and overall effects would be minor, with the exception of moderate effects on backcountry users who are the most likely to be sensitive to sounds and are the most exposed to vessel sounds. Vessel sounds could contribute to disturbance of tufted puffins, harlequin ducks, feeding murrelets, and molting waterfowl, resulting in moderate effects (see subsection 4.3.3, "Marine Birds and Raptors"), as well as sea otters and harbor seals.

Alternative 2 — Effects on the Underwater Soundscape.

Direct and indirect effects on the underwater soundscape — alternative 2 — Alternative 2 calls for the lowest number of seasonal-use days for private vessels between June and August. In addition, cruise ship traffic would be reduced by 23%; however, the overall effects would remain within levels similar to those described for alternative 1. As described in the marine mammals and marine fishes subsections (4.3.2 and 4.3.4, respectively), effects would be minor, with localized reductions in populations, but without large-scale effects.

Cumulative effects on the underwater soundscape — alternative 2 — As with all the alternatives, administrative traffic and float planes would add to the underwater sounds created by cruise ships and tour, charter, and private vessels. Even considered collectively, this level of sound would not be expected to reduce overall functioning of the marine environments in Glacier and Dundas Bays.

Impairment analysis for the underwater soundscape — alternative 2 — Because effects would be minor, the underwater soundscape would not be impaired.

Potential mitigation measures for the underwater soundscape — alternative 2 — None are proposed. Application of additional studies of vessel noise, as well as application of new technologies, could serve to reduce vessel noise; however, because of the high transmission level of noise under water, vessel noise is expected to remain common throughout Glacier and Dundas Bays.

Conclusion, underwater soundscape — alternative 2 — Vessel noise would remain common in Glacier and Dundas Bays, even with the reduction of cruise ships. Effects would remain within the minor category, with some localized reductions in populations of marine mammals and fishes, but without large-scale changes to functioning of the marine ecosystem.

Alternative 3 — Effects on the Surface Soundscape. Overall effects on soundscape under alternative 3 would be identical to those defined for alternative 1, except for an increase in cruise-ship-related sounds. Under this alternative, frequency of cruise-ship-related sounds would increase up to two times per day every day in the popular destination inlets of Glacier Bay's West Arm.

Direct and indirect effects on the surface soundscape for the biological environment — alternative 3 — As with alternative 1, the sound of vessels along the shoreline would not be sufficiently loud or frequent to affect wildlife, insects, or other animals. Overall effects would be minor, with regular disturbance, but with no reduction in population levels. Noise could contribute to other disturbances related to molting waterfowl, harlequin ducks, feeding murrelets, and tufted puffins (see subsection 4.3.3), as well as sea otters and harbor seals. Within concentration areas and anchorages, noise could be sufficient to cause wildlife to avoid the shorelines (see primary anchorages depicted in figure 3-22).

Direct and indirect effects on the surface soundscape for the human environment — alternative 3 — For the same reasons defined for alternative 1, motorized vessel users would not be affected by vessel-generated sounds, except at destination points, such as Tarr and Johns Hopkins Inlets. The frequency of intrusions by cruise-ship-generated noise into the natural soundscape would increase to twice per day, every day, with public address systems heard in several locations. In addition, tour and charter vessels dropping off groups for kayaking or shore-based activities would introduce concentrated areas of human-made sound, mostly voices. As described under alternative 1, visitors on the shoreline are most vulnerable to vessel sounds.

Potentially, some visitors might consider the interruptions within the popular inlets of the West Arm unacceptable, because there would be no relief from the presence of cruise ships. Overall, the associated human-made sounds are considered acceptable within the context of park purposes and values; therefore, the overall effect on soundscape from a visitor experience standpoint would be moderate. Because backcountry visitors would have lower tolerance for vessel and other human-made noise, the effect on soundscape in backcountry areas near where vessels often travel also would be considered moderate.

Cumulative effects on the surface soundscape — alternative 3 — The cumulative effects under alternative 3 would be the same as those under alternative 1. The most notable additional source of sound within Glacier Bay and, to a lesser degree, Dundas Bay, is the sound of aircraft. Cumulatively, aircraft noise, combined with the sounds of administrative vessels, fishing vessels, cruise ships, tour vessels, charter vessels, and private vessels, would have a moderate effect on the natural soundscape at specific locations and times; however, any effects would be for a relatively short time period (i.e., less than an hour).

Impairment analysis for the surface soundscape — alternative 3 — Effects on soundscape would be moderate and therefore not considered an impairment of the park's natural soundscape.

Potential mitigation measures for the surface soundscape — alternative 3 — As suggested for alternative 1, the park could conduct sound inventories of popular stops and destinations and establish soundscape preservation objectives for these areas, as described in Director's Order 47 (NPS 2001c). Subsequent monitoring and modifications would serve to protect natural soundscapes in these areas, within the context of park values and resources.

Conclusion, surface soundscape — alternative 3 — Overall effects on soundscapes would be essentially the same as those described for alternative 1, with an increase in frequency of cruise-ship-related sounds. The effects would be consistent with park values and resources, and overall effects would be minor, with the exception of moderate effects at the popular inlets in Glacier Bay's West Arm and on backcountry users. Because cruise ships do not enter the West Arm, no more than 50,000 or 15% of the park's visitors would visit the West Arm annually. Vessel sounds could contribute to disturbance of harlequin ducks, feeding murrelets, and molting waterfowl, resulting in moderate effects, as well as sea otters and harbor seals.

Alternative 3 — Effects on the Underwater Soundscape.
Direct and indirect effects on the underwater soundscape — alternative 3 — Alternative 3 would allow the greatest number of cruise ships while maintaining existing use-day levels for the other vessel classes between June and August; however, the overall effects would remain within levels similar to those described for alternative 1. Effects would be minor, with localized reductions in populations.

Cumulative effects on the underwater soundscape — alternative 3 — As with all the alternatives, administrative traffic and float planes would add to the underwater sounds created by cruise ships and tour, charter, and private vessels. Even considered collectively, this level of sound would not be expected to reduce overall functioning of the marine environments in Glacier and Dundas Bays.

Impairment analysis for the underwater soundscape — alternative 3 — Because effects would be minor, the underwater soundscape would not be impaired.

Potential mitigation measures for the underwater soundscape — alternative 3 — None are proposed. Application of additional studies of vessel noise, as well as application of new technologies, could serve to reduce vessel noise. Because of the high transmission level of noise under water, however, vessel noise is expected to remain common throughout Glacier and Dundas Bays.

Conclusion, underwater soundscape — alternative 3 — Vessel noise would remain common in Glacier and Dundas Bays and would increase in Glacier Bay because of the increased number of cruise ships. Effects would remain within the minor category, with some localized reductions in populations of marine mammals and fishes, but without large-scale changes to functioning of the marine ecosystem.

Alternative 4 — Effects on the Surface Soundscape. Overall effects on the surface soundscape would be reduced under alternative 4, as reduced vessel numbers would, in turn, reduce the overall noise generated; however, the frequency of sound intrusions from tour and charter vessels would increase because of the change in daily vessel quotas. Cruise-ship-related noise under alternative 4 would be at the lowest level compared to the other alternatives. In addition, the soundscape of Dundas

Bay would be considerably improved with charter vessels limited to three per day. Tour vessels would be prohibited from entering Dundas Bay and the West Arm; charter vessels would continue to travel in the West Arm. Also under this alternative, the Beardslee Entrance would be closed to cruise ships, thereby eliminating cruise ship noise (particularly public address systems) from the Beardslee Island area.

Direct and indirect effects on the surface soundscape for the biological environment — alternative 4 — As with alternative 1, the sound of vessels along the shoreline is not expected to be sufficiently loud or frequent to affect wildlife, insects, or other animals.

Direct and indirect effects on the surface soundscape for the human environment — alternative 4 — For the same reasons defined under alternative 1, motorized vessel users would not be affected by vessel-generated sounds, except at destination points, such as Tarr and Johns Hopkins Inlets. As described under alternative 1, visitors on the shoreline are the most vulnerable to vessel sounds. Overall, human-made sounds generated under this alternative would be considered acceptable within the context of park purposes and values; therefore, the overall effect on soundscape from a visitor experience standpoint would be considered minor. Because backcountry visitors typically have lower tolerance for vessel and other human-made noise, the effect on soundscape in backcountry areas near where vessels often travel would be considered moderate.

Cumulative effects on the surface soundscape — alternative 4 — The cumulative effects of alternative 4 would be the same as those of alternative 1. The most notable additional source of sound within Glacier Bay and, to a lesser degree, Dundas Bay, is aircraft. Aircraft sound, combined with the sounds of administrative vessels, fishing vessels, cruise ships, tour vessels, charter vessels, and private vessels, would have a moderate effect on the natural soundscape at specific locations and times, but would occur for a relatively short time period (i.e., less than an hour).

Impairment analysis for the surface soundscape — alternative 4 — Effects on soundscape under alternative 4 would be moderate and therefore not considered an impairment of the natural soundscape of the park.

Potential mitigation measures for the surface soundscape — alternative 4 — As with alternative 1, the park could conduct sound inventories of popular stops and destinations and establish soundscape preservation objectives for these areas, as described in Director’s Order 47 (NPS 2001c). Subsequent monitoring and modifications would serve to protect natural soundscapes in these areas, within the context of park values and resources.

Conclusion, surface soundscape — alternative 4 — Overall effects on soundscape would be similar to those of alternative 1, except that natural soundscapes at the popular inlets of the West Arm would be improved by reduced cruise ship traffic. Natural soundscapes of the East Arm also would improve because of the absence of tour vessels. Soundscape conditions in Dundas Bay would greatly improve because of the restriction in charter vessel use and the closing of the Bay to tour vessels.

Alternative 4 — Effects on the Underwater Soundscape.

Direct and indirect effects on the underwater soundscape — alternative 4 — Alternative 4 has the lowest number of seasonal-use days for cruise ships between June and August. In addition, vessels greater than 262 feet (80 meters) would be required to maintain a speed of 13 knots in Glacier Bay year-round. This would reduce intensity of sound output, but increase duration. The overall effects, however, would remain within levels similar to those described for alternative 1. Effects would be minor, with localized reductions in populations. Reduction of vessel traffic in Dundas Bay would reduce sound levels in this area, but underwater vessel sound is expected to remain common.

Cumulative effects on the underwater soundscape — alternative 4 — As with all alternatives, administrative traffic and float planes would add to the underwater sounds created by cruise ships and tour, charter, and private vessels. Even considered collectively, this level of sound would not be expected to reduce overall functioning of the marine environments in Glacier and Dundas Bays.

Impairment analysis for the underwater soundscape — alternative 4 — Because effects would be minor, the underwater soundscape would not be impaired.

Potential mitigation measures for the underwater soundscape — alternative 4 — None are proposed. Application of additional studies of vessel noise, as well as application of new technologies, could serve to reduce vessel noise. Because of the high transmission level of noise under water, however, vessel noise is expected to remain common throughout Glacier and Dundas Bays.

Conclusion, underwater soundscape — alternative 4 — Vessel noise would remain common in Glacier and Dundas Bays, even with the reduction of cruise ships. Effects would remain within the minor category, with some localized reductions in populations of marine mammals and fishes, but without large-scale changes to functioning of the marine ecosystem.

Alternative 5 — Effects on the Surface Soundscape. Overall effects on the natural soundscape under alternative 5 would be similar to those defined under alternative 1, with essentially the same level of vessel noise generated under the same vessel quotas.

Tour vessels would be prohibited from entering the wilderness waters of Dundas Bay, contributing to an improvement in the Bay's natural soundscape. In addition, charter vessels would be limited to an average of three entries per day in Dundas Bay, although on peak-use days, the natural soundscape could be disrupted by human-made sound in several locations because only an average limit would be set. This would be considered a minor effect, because charter vessel operators tend to avoid concentration areas and would soon avoid situations found to detract from their guests' experience. Also under alternative 5, the Beardslee Entrance would be closed to cruise ships, thereby eliminating cruise ship noise (particularly public address systems) from the Beardslee Island area.

Direct and indirect effects on the surface soundscape for the biological environment — alternative 5 — As with alternative 1, the sound of vessels along the shoreline would not be expected to be sufficiently loud or frequent to affect wildlife, insects, or other animals. Overall effects would be minor, with regular disturbance, but no reduction in population levels would be experienced. Noise may contribute to other disturbances related to molting waterfowl, harlequin ducks, feeding murrelets, and tufted puffins (see subsection 4.3.3), as well as sea otters and harbor seals. Within concentration areas and anchorages, noise could be sufficient to cause wildlife to avoid the shorelines.

Direct and indirect effects on the surface soundscape for the human environment — alternative 5 — For the same reasons defined under alternative 1, motorized vessel users would not be affected by vessel-generated sounds, except at destination points, such as Tarr and Johns Hopkins Inlets. Public address systems may be heard in several locations. Human-made sound, mainly voices, would be introduced by tour and charter vessels dropping off groups for kayaking or shore-based activities. Because vessel speed limits would be based on "over the ground" speed instead of "over the water" speed (see chapter 2) under alternative 5, vessels traveling against the current would, in theory, travel faster and create more noise. This is "in theory" because, in practice, most private vessels already base their speed on ground speed rather than on water speed. This change would increase the noise caused by cruise ships and tour and charter vessels, but not at a level to shift overall conclusions regarding effects on the natural soundscape. As described under alternative 1, visitors on the shoreline are the most vulnerable to vessel sounds.

Overall, these human-made sounds would be considered acceptable within the context of park purposes and values; therefore, the overall effect on soundscape from a visitor experience standpoint would be considered minor. Backcountry visitors typically have lower tolerance for vessel and other human-made noise; therefore, the effect on soundscape in backcountry areas near where vessels often travel would be considered moderate.

Cumulative effects on the surface soundscape — Alternative 5 — The cumulative effects of alternative 5 would be the same as those effects described for alternative 1. Other than water vessels, aircraft represent the most notable additional sound source within Glacier Bay and, to a lesser degree, Dundas Bay. Aircraft sound, combined with sounds of administrative vessels, fishing vessels, cruise ships, tour vessels, charter vessels, and private vessels, would have a moderate effect on the natural soundscape at specific locations and times, but would occur for a relatively short time period (i.e., less than an hour).

Impairment analysis for the surface soundscape — Alternative 5 — Effects on soundscape would be moderate and therefore would not be considered an impairment of the natural soundscape of the park.

Potential mitigation measures for the surface soundscape — Alternative 5 — As with alternative 1, the park could conduct sound inventories of popular stops and destinations and establish soundscape preservation objectives for these areas, as described in Director's Order 47 (NPS 2001c). Subsequent monitoring and modifications would serve to protect natural soundscapes in these areas, within the context of park values and resources.

Conclusion, surface soundscape — alternative 5 — Overall effects on natural soundscape would be essentially the same as those under alternative 1, with a negligible decline in overall vessel use and associated noise generation. The effects would be consistent with park values and resources, and overall effects would be minor, with the exception of moderate effects on backcountry users, who are more sensitive to and more exposed to vessel sounds. Vessel sounds could contribute to disturbance of tufted puffins, harlequin ducks, feeding murrelets, and molting waterfowl, resulting in moderate effects, as well as sea otters and harbor seals.

Alternative 5 — Effects on the Underwater Soundscape.

Direct and indirect effects on the underwater soundscape — Alternative 5 — Vessel levels would be the same as those in the existing conditions (alternative 1). Operating requirements would reduce some noise levels. Speed restrictions for cruise ships (or any vessel greater than 262 feet [80 meters]) would reduce some noise levels but increase exposure time; however, the overall effects would remain within levels similar to those described for alternative 1. Effects would be minor, with localized reductions in populations. Reduction of vessel traffic in Dundas Bay would reduce sound levels in this area, but underwater vessel sound is expected to remain common.

Cumulative effects on the underwater soundscape — alternative 5 — As with all the alternatives, administrative traffic and float planes would add to the underwater sounds created by cruise ships and tour, charter, and private vessels. Even considered collectively, this level of sound would not be expected to reduce overall functioning of the marine environments in Glacier and Dundas Bays.

Impairment analysis for the underwater soundscape — alternative 5 — Because effects would be minor, the underwater soundscape would not be impaired.

Potential mitigation measures for the underwater soundscape — alternative 5 — None are proposed. Application of additional studies of vessel noise, as well as application of new technologies, could serve to reduce vessel noise. Because of the high transmission level of noise under water, however, vessel noise is expected to remain common throughout Glacier and Dundas Bays.

Conclusion, underwater soundscape — alternative 5 — Vessel noise would remain common in Glacier and Dundas Bays, even with the reduction of cruise ships. Effects would remain within the minor category, with some localized reductions in populations of marine mammals and fishes, but without large-scale changes to functioning of the marine ecosystem.

Soundscape Summary. Under all alternatives, vessel noise would continue to be common on the surface and under water. All the alternatives would result in two main effects on the surface soundscape. First, vessel noise (along with sight) would annoy some visitors seeking non-motorized experiences within the backcountry and throughout Glacier and Dundas Bays. Second, sounds from cruise ships, tour vessels, and other vessels in concentration areas (particularly near the tidewater glaciers) would annoy some visitors and detract from their experience. This effect is considered moderate.

Under all the alternatives, vessel noise would cause some wildlife to avoid the shoreline or, for mammals, to shift use to night, when animals are less wary and when vessel traffic is lighter. Overall effects of noise on threatened and endangered species (including the humpback whale), marine mammals, and marine fishes are described in their respective subsections. This subsection provides a general summary and synthesis of those conclusions.

As documented in the *Underwater Noise Interim Report* (NSWC 2002), vessel noise is pervasive under the waters of Glacier Bay. While no studies have been conducted in Dundas Bay, vessel noise is expected to be a regular element of the underwater soundscape there as well.

The amount of noise and the effects on soundscape are directly related to the number of vessels. While the numbers of vessels change among alternatives, under all the alternatives, marine mammal and fish populations would continue to remain healthy.

4.2.2 Air Quality

Vessel operations result in emissions of criteria air pollutants (as defined by EPA regulations), including particulate matter, carbon monoxide, sulfur dioxide, nitrogen dioxide, and hydrocarbons from combustion of fuel in vessel engines. Carbon dioxide is not considered a criteria pollutant, but is a global-warming gas emitted from vessel engines. Lead and other toxic constituents found in vessel fuels are emitted in trace amounts.

Vessel emissions may cause visibility reductions immediately after the exhaust exits the vessel, which is often seen as a plume of exhaust. The intensity of this plume is measured by its opacity; i.e., the amount of light that could pass through it. As the emissions move away from the vessel, they disperse and mix with ambient air. Under certain weather conditions, the plume may not dissipate or haze may form, resulting in a visibility reduction.

This subsection evaluates the potential effects on air quality within the park that would be caused by the implementation of the proposed alternatives.

Issues of Concern Raised during Scoping. The issues concerning air quality that were identified during the scoping process are as follows:

- Increases in vessel quotas could increase the particulate and pollutant load entering the air column and have a detrimental effect on air quality by increasing, thus changing, air quality, visibility, and the presence of haze.
- Increases in vessel quotas could increase the stack emissions and could result in detrimental effects to human health and the environment.

Regulatory Framework. The regulations that address air quality, emissions, and visibility fall under the federal Clean Air Act (CAA). Additional requirements are provided by NPS management policies and guidance.

Air quality **—** The Clean Air Act of 1970, 42 United States Code (USC) 7401 et seq., amended in 1977 and 1990, is the main federal statute governing air pollution. The Clean Air Act designates six pollutants as criteria pollutants based upon the effect of these pollutants on human health and the environment:

- respirable particulate matter smaller than 10 micrometers in diameter.
- carbon monoxide.
- sulfur dioxide.
- nitrogen dioxide.

- lead.
- ozone.

The National Ambient Air Quality Standards are regulatory levels that were established for these pollutants to protect public health and welfare. State and local air quality control agencies must have a state implementation plan that prescribes measures to maintain attainment or eliminate or reduce the severity and number of violations of National Ambient Air Quality Standards, and to achieve expeditious attainment of these standards. The Alaska Department of Environmental Conservation has been delegated with this responsibility.

Areas where ambient air concentrations of a pollutant are below the ambient air quality standard limits are classified as being "in attainment" for the pollutant. The park is considered to be in attainment for all criteria pollutants; however, no ambient air quality monitoring for the National Ambient Air Quality Standards criteria air pollutants has been conducted in the park.

The Clean Air Act establishes areas that are subject to Prevention of Significant Deterioration (PSD) regulations. PSD regulations limit emissions in areas where air quality is in attainment with the National Ambient Air Quality Standards. In 1977, Congress designated all international parks, national wilderness areas, and national memorial parks in excess of 5,000 acres, and all national parks in excess of 6,000 acres, as Class I areas under this legislation; Class I affords the greatest degree of protection. Areas not covered by a Class I protection level were designated as Class II. Class II areas are still protected from significant deterioration in existing air quality, but the emissions thresholds determining requirements for detailed analysis of effects are higher for Class II areas than for Class I areas. In Class I areas where good visibility and scenic vistas are a goal, visibility is monitored and tracked to document baseline conditions and to assess potential effects. This is not required by the Clean Air Act in Class II areas, and has not been done in Glacier Bay.

Currently, the park and preserve remains a Class II area. In 1980, it was re-designated from a national monument to a national park and preserve; the 1977 congressional designation of Class I areas did not apply to national monuments. On June 25, 1980, (45 *Federal Register* 43002) the federal land manager recommended that the park and preserve be re-designated as a Class I area, establishing Air Quality Related Values (AQRVs) for the park. In his presentation to Congress, Secretary of the Interior Cecil D. Andrus reported:

> "*The following air quality related values are important attributes of the area of Glacier Bay National Park and Preserve:*
>
> - *Glacial Activity: Particulate air pollutants landing on glacial ice would affect the rate of glacial melt, which, in turn, would alter the sequence of natural events in Glacier Bay Monument.*

- *Visibility: The area is a unique scenic area with long viewing distances; reduction of visual range would alter scenic qualities.*

- *Flora: Lichens, important early colonizers of areas bared by glaciers, are demonstrably sensitive to air pollutants. Other flora of the area may not grow where they are subjected to appreciable air pollutants; these have not yet been identified. Alteration of species composition of communities would alter the natural succession patterns; the opportunity for scientific study would then be lost.*

- *Fauna: Changes in glacial behavior and in the lichen populations would result in changes in terrestrial faunal community. Changes in water quality would effect the aquatic faunal community*."

Under the NPS management policies, the Park Service will "seek to perpetuate the best possible air quality in parks to (1) preserve natural resources and systems; (2) preserve cultural resources; and (3) sustain visitor enjoyment, human health, and scenic vistas" (subsection 4.7.1.). The NPS management policies state that the Park Service will assume an aggressive role in promoting and pursuing measures to protect Air Quality Related Values from the adverse effects of air pollution. The *m*anagement policies apply equally to all NPS-managed areas, regardless of CAA designation. Therefore, the Park Service will protect resources at Class I and Class II units. NPS management policies provide additional protection from that afforded by the Clean Air Act's National Ambient Air Quality Standards alone, because specific park Air Quality Related Values can be adversely affected at levels below the National Ambient Air Quality Standards. Another piece of legislation that is important to the mitigation of air quality concerns in the park is the Omnibus Parks and Public Lands Management Act of 1996. Congress passed this law in 1996, prohibiting the Park Service from imposing air, water, and oil pollution measures that are more stringent than what has been established by the authorized agencies, while allowing some flexibility for voluntary mitigation (Public Law 104-333, Omnibus Parks and Public Lands Management Act of 1996, section 703: Glacier Bay NP [cruise-ship-related provisions]).

Visibility — Visibility was identified as an Air Quality Related Value for the park and preserve, although no visibility standards specific to the park have been established. The only element of visibility currently measured and regulated in the park is opacity. Nitrogen oxides, sulfur oxides, hydrocarbons, and particulate matter emitted from the vessels can result in visible emissions. Opacity is a quantification of the visibility reduction resulting from these emissions (a visible white water vapor plume is not considered an opacity increase). Typically, a trained observer measures opacity at the emission point. Opacity also is measured by equipment mounted in the vessel exhaust stack. Alaska has opacity standards for marine vessels (18 Alaska Administrative Code [AAC] 50.70). The Alaska Department of Environmental Conservation's visible emissions monitoring and compliance program is responsible for enforcement of federal and state opacity standards. The NPS vessel management plan established additional federal opacity standards specific to the park (36 CFR 13.65[b][4]). These standards are as follows:

> *Visible emissions from a marine vessel, excluding condensed water vapor, may not result in a reduction of visibility through the exhaust effluent of greater than 20% for a period or periods aggregating more than:*
>
> 1) *three minutes in any one hour while underway, at berth, or at anchor; or*
>
> 2) *six minutes in any one hour during initial start up of diesel driven vessels; or*
>
> 3) *12 minutes in one hour while anchoring, berthing, getting underway or maneuvering in Bartlett Cove.*

In 1997, the park and preserve developed a marine vessel emissions program (Young 1999). This program is used to observe, report, and enforce the opacity requirements of the NPS vessel management plan as described in 36 CFR 13.65(b)(4). The Omnibus Act of 1996 prevents the park from enforcing 2) and 3) above, but because the limit of 20% opacity for 3 minutes is a state regulation listed in 18 AAC 50.70, 1) is enforced within the park. Park rangers are certified as visible emissions (opacity) evaluators using the EPA Method 9 opacity procedure to monitor stack emissions. The Park Service attempts to read opacity of smoke plumes from each cruise ship entering the park a minimum of two times during each operating season. When the opacity regulations are exceeded, the reader documents the observation and notifies the vessel operator, district ranger, and concessions management specialist.

The Park Service addresses opacity compliance through administrative or criminal procedures. Should a violation of record be determined, written notification is given to the vessel operator. One violation of record results in the recommendation to the superintendent that the operator's annual evaluation be rated as "marginal." A second violation of record by the same ship within three years of the first results in the recommendation to the superintendent that the ship involved not be allowed to re-enter the park. Each violation is subject to review by the park superintendent, and may result in immediate revocation of the concessions permit, thereby prohibiting the offending ship from operating in the park. Third-party complaints are investigated by emission readers and followed up with notification to the district ranger, the concessions management specialist, and possibly the Alaska Department of Environmental Conservation. All air quality complaints are documented, in writing if possible, on a standard visitor comment form and/or an NPS case incident form. The vessel operator is informed of the complaint, and the Park Service attempts to observe the ship on its next scheduled entry into Glacier Bay. In compliance with concession permit conditions, all cruise ships that enter the park are equipped with opacity monitors. Opacity measurement records are submitted as a condition of the vessel's concessions permit, and while these data are not used specifically for violation enforcement, they are considered when the park evaluates new and renewed applications for entry permits.

Methodology and Assumptions. To evaluate air quality within the park — total emissions and visibility reduction — were analyzed. Total emissions from vessels were estimated to evaluate the amount of pollutants that would enter the air above Glacier Bay and to determine whether this amount would affect human health or the park's plant and animal life. The visual effect caused by these emissions was also evaluated to assess the potential for visible plumes and uniform haze.

In the process of developing methodology for the effects evaluation and threshold criteria, the air quality standards shown in table 4-3 were reviewed and evaluated.

TABLE 4-3: EMISSIONS AND AIR QUALITY CRITERIA REVIEWED FOR POTENTIAL APPLICABILITY

Criteria Description	Applicability
NPS and State of Alaska Marine Vessel Visible Emission Standards	Can be used.
Prevention of Significant Deterioration Stationary Source Permit Thresholds	Can be used, but limited. Estimates of potential change in annual emissions due to each alternative can be compared to stationary source permit thresholds to evaluate potential air quality degradation, although these are not applicable to mobile sources.
NPS draft *Guidance on Assessing Impacts and Impairment to Natural Resources* (NRPC 2002)	Can be used. NPS guidance is based upon CAA thresholds and NAAQS standards, as well as the Organic Act and NPS management policies related to the protection of NPS lands. Total emission thresholds are similar to PSD thresholds established by the Clean Air Act.
National and Alaska Ambient Air Quality Standards	Cannot be used. Ambient air quality standards are applicable, but data are non-existent for Glacier Bay– The closest data are from Juneau, Alaska. There are insufficient meteorological data and no applicable dispersion model to accurately conduct modeling in the park and preserve to determine the ambient effect for comparison to standards.
National Emission Standards for Hazardous Air Pollutants (NESHAPS)	Cannot be used. NESHAPS standards have not been promulgated for commercial marine engines.
EPA Vessel Emission Standards	Cannot be used. New vessel emission standards recently published should result in improvements in ship emissions. However, these standards are established only for new equipment, and quantification of any emission reductions would be speculative.
Visibility Standards	Can be used. Visibility monitoring is not performed at Glacier Bay; therefore, a background value cannot be established.
Air Quality Related Values (AQRV)	During the review to Congress in 1980 regarding the park, the federal land manager established Glacial Activity, Visibility, Flora, and Fauna as Air Quality Related Values for the park.

Most of the air quality standards in table 4-3 were considered inappropriate for this analysis. The NPS draft *Guidance on Assessing Impacts and Impairment to Natural Resources* (NRPC 2002) provides direction to evaluate total emissions and Air Quality Related Values in accordance with the Clean Air Act and NPS management policies. The human health criteria, based upon CAA definitions, PSD standards, and NAAQS, provide an appropriate measure for total emissions effect evaluation. In the evaluation of Air Quality Related Values, the guidance provides specific threshold criteria related to ambient ozone levels, deposition levels, and estimated visibility and nitrogen oxide (NO_X) and SO_2 ambient air levels. These thresholds cannot be used in this evaluation because of the lack of data. The guidance does provide additional threshold descriptions to evaluate visibility effects based upon observed conditions, and these thresholds are applicable and can be used to assess effects in this evaluation.

To quantitatively assess projected total annual emissions due to implementation of each alternative, the available data, consisting of vessel classifications, operations, and use-day quotas, were analyzed using *EPA420-R-00-002, Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data* (EPA 2000). In addition to evaluating total emissions, the change in emissions was quantitatively determined by comparing projected air quality and emissions data for each alternative to the no-action alternative. Dundas Bay is not included in the quantitative assessment because operational data for vessel use of this area do not provide specific information necessary to develop emission estimates, although it is assumed that the effect of vessel emissions to Dundas Bay would be less than the effect to Glacier Bay because cruise ships do not use Dundas Bay. Given the topography and size of Dundas Bay, the inversion conditions that are observed in Glacier Bay would not be replicated in Dundas Bay. Dundas Bay is smaller and receives less vessel traffic than Glacier Bay, so it is assumed that there would be fewer emissions in Dundas Bay.

Projections of future air pollutant emission levels were derived based on proposed changes in vessel activity for each alternative. The method of calculating emissions and the assumptions used are described in appendix D. Daily and annual use-day quotas were used to determine the number of in-season use days for all vessels and off-season use days for cruise ships and tour vessels. Baseline numbers from 2001 were used to estimate off-season use days for private and charter vessels. NPS staff and vessel operator observations were used to determine average time at each speed classification (time-in-mode). Speed restrictions of 13 knots under alternatives 4 and 5 would require that cruise ships and tour vessels spend additional time in the Bay, so total time spent by cruise ships entering and leaving the Bay at a slow cruise was doubled based on the assumption that these vessels usually travel between 24 and 26 knots. Daily emissions were calculated assuming that vessel use of Glacier Bay is at the maximum daily quota. The total provides a worst-case evaluation of daily emissions in the park on a given day and under these conditions. Annual emissions include all emissions emitted during the calendar year.

The threshold criteria (see table 4-4) developed for the air quality analysis are based on NPS guidance (NRPC 2002) for human health thresholds and qualitative visibility Air Quality Related Values. Projections of expected visibility conditions were based upon existing opacity data.

TABLE 4-4: THRESHOLD CRITERIA FOR THE AIR QUALITY EFFECTS ANALYSIS

Effect	Human Health and Environment Threshold Criteria				Visibility AQRV Criteria
	For Proposed Action, Total Emissions		Current Air Quality		
Negligible	<50 TPY (each pollutant)	**AND**	<60% of the National Ambient Air Quality Standards	**OR**	No perceptible visibility effects likely (no visible smoke or plume); no smell of exhaust.
Minor	>50 and <100 TPY (any pollutant)	**AND**	<80% of the National Ambient Air Quality Standards	**OR**	Perceptible visibility effects occur, but are of very short duration (less than one day) and not visible to most people.
Moderate	>100 TPY (any pollutant)	**AND**	>80% of the National Ambient Air Quality Standards	**OR**	Perceptible visibility effects occur but will be limited in duration, extent, and magnitude.
Major	>250 TPY (any pollutant)	**AND**	>80% of the National Ambient Air Quality Standards	**OR**	Visibility effects from project-specific or cumulative emissions are of long duration, can be frequently observed, or are visible over a broad area.

Source: (NRPC 2002).TPY = Tons per year.

Alternative 1 (No Action) — Effects on Air Quality. The analysis of the no-action alternative's effects on air quality is presented as effects of total emissions and the potential for visibility reductions.

Direct and indirect effects on air quality — alternative 1.

<u>Air Emissions Totals.</u> Table 4-5 presents the estimated daily and annual emissions in Glacier Bay for alternative 1. This table shows that estimated annual emissions for alternative 1 would be higher than those for the existing conditions because under existing conditions, maximum daily vessel quotas have not been met (see Table 3-1). Emissions calculated for alternative 1 were based on maximum allowable use-day quotas; in contrast, the estimated emissions for existing conditions, presented in chapter 3, were calculated using actual entry and use-day data from 2001. In 2001, the total use days were lower than the existing quotas. While there are no regulatory limits for daily emission totals, these numbers provide information related to the potential for visibility problems on busy seasonal days.

TABLE 4-5: ALTERNATIVE 1 (NO ACTION) DAILY AND ANNUAL VESSEL EMISSIONS (MAXIMUM ALLOWABLE ENTRIES)

Daily Emissions (pounds per day)	**Daily Vessel Quota**	**PM**	**NO_X**	**SO_2**	**CO**	**HC**
Cruise Ships	2	136.01	4,393.30	486.65	511.46	57.50
Tour Vessels	3	23.00	925.84	103.14	98.33	9.38
Charter Vessels	6	7.42	297.51	33.00	35.42	3.70
Private Vessels	25	70.53	2,836.98	315.80	307.51	29.93
Total		236.97	8,453.63	938.59	952.71	100.52

Annual Emissions (tons per calendar year)	**Annual Use Days**	**PM**	**NO_X**	**SO_2**	**CO**	**HC**
Cruise Ships	261	8.87	286.66	31.75	33.37	3.75
Tour Vessels	612	1.76	70.83	7.89	7.52	0.72
Charter Vessels	607	0.38	15.05	1.67	1.79	0.19
Private Vessels	2,388	3.37	135.49	15.08	14.69	1.43
Total		14.38	508.03	56.40	57.37	6.09
Net Change from Baseline		2.66	95.63	10.62	10.77	1.13

Note:
Annual-use days include proposed seasonal-use day quotas for all vessels and May and September use-day quotas for cruise ships and tour vessels. Ferry service is included in tour vessel totals. Projected off-season use days for charter and private vessels are based upon existing numbers (see chapter 3).

PM = particulate matter.
CO = carbon monoxide.
SO_2 =sulfur dioxide.
NO_x = nitrogen oxides.
HC = hydrocarbons.

Because climate and seasonal quotas prevent the maximum number of vessel entries from occurring every day of the year, a separate estimate of entries was evaluated to determine annual emissions. The annual emission totals provide information to evaluate the potential long-term effect of the pollutants in the park. While these are evaluated as annual emissions, operations occur only from May to September. Estimated total emissions of nitrogen oxides from all vessels in Glacier Bay under this alternative would exceed 250 tons per year, but the estimated emissions of all other criteria pollutants would be below the 100-tons-per-year threshold criteria. While a quantitative estimate of emissions is not possible for Dundas Bay, it is assumed that the effect of vessel emissions to Dundas Bay would be less than the effect to Glacier Bay. Although there would be no cruise ships and reduced times for other vessels in the Bay, it is likely that emissions of nitrogen oxides in Dundas Bay would still be more than 100 tons per year. Other than vessel emissions, only small local emission sources, such as park vehicles, building heating systems, electrical generators, and campfires, exist in the park. The effects of these sources are discussed in the cumulative effects subsection.

Because of the lack of available air quality data, to determine whether emissions in the park would result in air quality that exceeds state or federal air quality standards, a comparison was made with air quality in Juneau, Alaska, an urbanized area that receives more cruise ships than the park. The Alaska Department of Environmental Conservation conducted air quality monitoring in Juneau in May and July 2001 and August to September 2001. Maximum readings of ambient air concentrations of nitrogen dioxide, sulfur dioxide, and particulate matter less than 10 microns are between 10% and 40% of the National Ambient Air Quality Standards(ADEC 2001a). Although Juneau has different topography and meteorological conditions than the park, it is unlikely that the park, with its fewer sources of emissions, would have ambient air quality that is greater than 80% of the National Ambient Air Quality Standards. Monitoring in the park would provide confirmation of this hypothesis. Therefore, using human health threshold criteria, total emissions would result in a moderate effect to the park under alternative 1.

<u>Visibility Reductions.</u> Daily emission totals, visible opacity, and weather conditions are factors that contribute to a reduction in visibility. Under periods of temperature inversions or days with low winds, visible emissions do not dissipate quickly, resulting in long visible plumes from ship stacks that obscure views. The visible emissions from one or several vessels could cause the development of haze throughout Glacier Bay. Visible emissions in Dundas Bay are likely to cause a minor effect because of the reduced traffic, lack of cruise ships, and less potential for temperature inversions that would trap the emissions.

As voluntary conditions of concession permits, many cruise ships have agreed to the use of opacity monitors and the submission of opacity data. Figure 4-1 provides an example of a portion of an opacity monitoring chart that was provided to the Park Service for review. The spikes in opacity are a result of engine startup, and this is a typical and usually unavoidable cause of a visible plume. Not all visible emissions from vessel stacks violate opacity standards, but all visible emissions have the potential to affect visibility in the park. The opacity levels recorded in Figure 4-1 do not constitute a violation of opacity, but it is likely that these emissions were visible to most people. The duration, extent, and magnitude of these visible emissions would have depended greatly on the weather conditions when the plume was generated.

Visible plumes that violate opacity limits are likely to affect visibility in the park, and strict enforcement of the existing opacity limits would reduce this potential effect. Emissions from vessels other than cruise ships are not typically monitored for opacity violations, but they can also produce plumes and contribute to haze. Given the large potential for daily NO_x emissions that would be a result of the daily vessel quotas, there is the potential for haze to develop during temperature

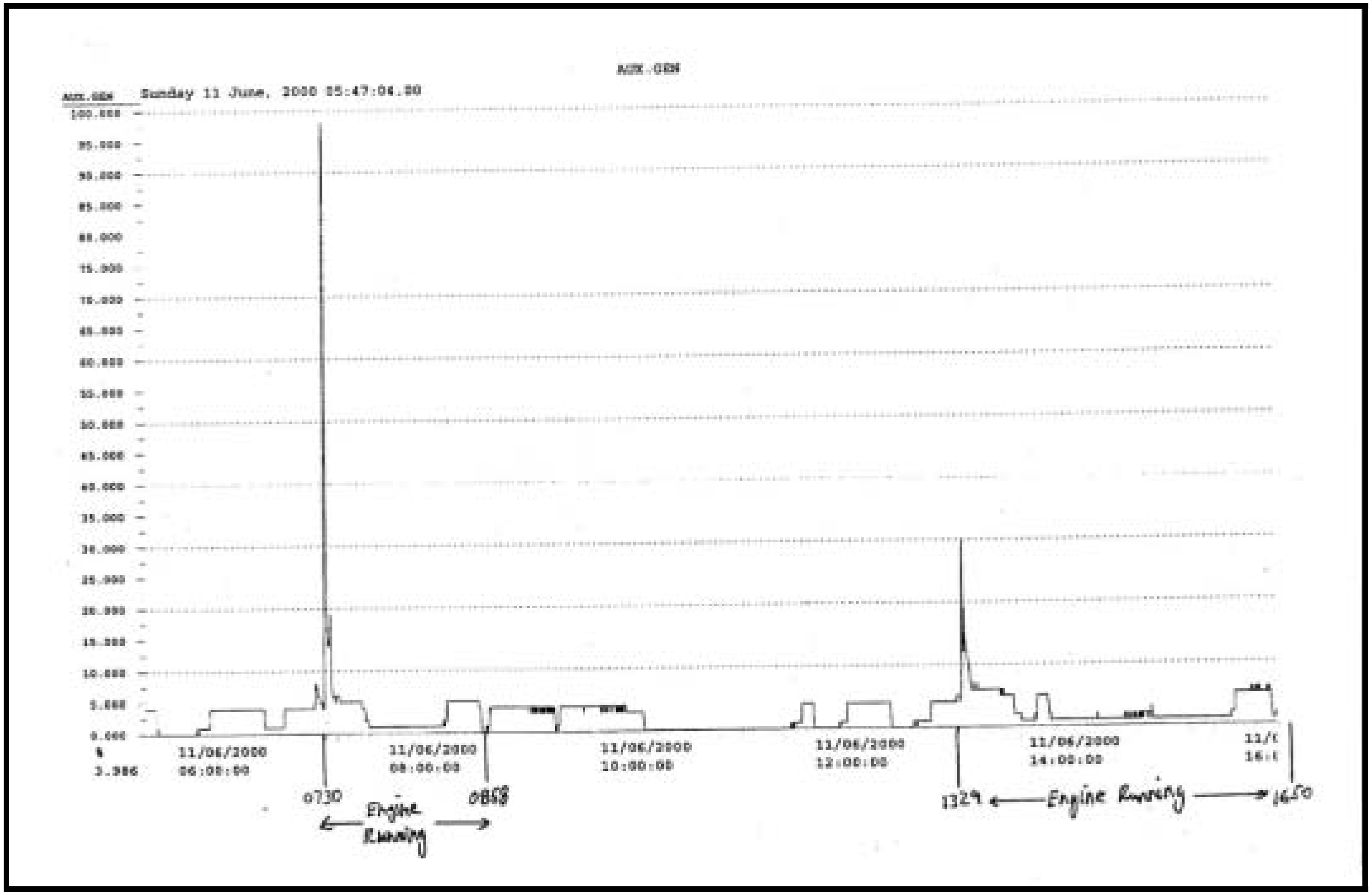


Figure 4-1 Cruise Ship Auxiliary Generator Opacity Monitor Readings in Glacier Bay, June 11, 2000
This figure shows an example of the monitoring readings taken when engines are started up and then running within the bay. The visibility reduction associated with the start up plumes would be dependant upon the weather conditions at the time of the emission, but most likely were visible to most people.

Source: NPS 2001 Cruise Ship Report of February 12, 2001. Gustavus, AK: National Park Service, Glacier Bay National Park and Preserve, Concession Office.

inversions. While there is potential for haze to occur, the duration and frequency of these conditions has not been documented.

Park rangers certified to evaluate emissions enforce the state opacity limits. As of February 19, 2003, 86 certified opacity observations have been conducted since 1997, resulting in five observed violations (Young 2002). Twenty-eight opacity measurements were conducted in 1999, resulting in five observed violations and two violations of record (Young 2002). Three exceedances were caused by an unavoidable need to maneuver the ship for safety reasons; therefore, the ship was not cited. Limited resources resulted in only three readings in 2000, no readings in 2001, and 13 readings in 2002. There were no opacity violations recorded in 2002. However, of the 13 observations conducted, 11 did result in observable emissions that were recorded to be between 5% and 30% during the observation period of 20 minutes, which would be visible to most people (see table 4-6). Under the threshold criteria established to protect the Air Quality Related Values of visibility, the emissions would, at a minimum, result in a moderate effect on the park. Further documentation of visibility conditions within the park would provide data necessary to determine the duration, extent, and magnitude of the visibility reduction and uniform haze.

TABLE 4-6
GLACIER BAY NATIONAL PARK AND PRESERVE AIR QUALITY PROGRAM 2002
VISIBLE EMISSION OBSERVATION PROGRAM SUMMARY

FROM 07/06/02 TO 09/11/02

VESSEL	DATE	OPACITY (%-20 minutes)
1.Dawn Princess	07/06/02	0–15%
	07/20/02	0–20%
2.Ocean Princess	09/02/02	5–15%
3.Star Princess	07/15/02	10–20%
4.Sun Princess	07/27/02	0–10%
	09/07/02	5–15%
5.Ryndam	07/29/02	10–15%
6.Statendam	09/10/02	0–5%
7.Veendam	09/03/02	5–30%
8.Volendam	07/19/02	5–20%
9.Zaandam	09/11/02	5–15%
10.Crystal Harmony	08/04/02	10–25%
11.Universe Explorer	07/14/02	0%

Source: NPS 2003.

<u>*Cumulative effects*</u> *on air quality — alternative 1 —* Other than vessel emissions, only small local emission sources, such as park vehicles, building heating systems, electrical generators, and campfires, exist in the park. Medium- and long-range emissions that are transported from outside the park boundaries also can affect air quality in the park. The effect of these emission sources are negligible compared to motorized vessel emissions and would continue unchanged under all alternatives; therefore, they would continue to have a negligible additional effect on the park's air quality.

Impairment analysis for air quality — alternative 1 — NPS draft guidance (NRPC 2002) provides the following determinants for assessing impairment of air resources:

- Where air quality concentrations are projected to adversely affect visitor or employee health, they are more likely to be considered impairment.
- Where human-made emissions in a park are likely to affect visibility conditions such that they affect visitor enjoyment or detract from the view of scenic vistas (in parks where good visibility is a goal), they are more likely to be considered impairment.
- Where human-made emissions in a park are likely to create significant effects to resources and values that are specifically mentioned in enabling legislation, key to natural or cultural integrity or opportunities for enjoyment of the park, or identified in the park general management plan or other planning document, they are more likely to be considered impairment.
- Where projected resource effects are above air quality "concern thresholds" for visibility, or nitrate or sulfate deposition, they are more likely to be considered impairment.
- Where human-made emissions are likely to create unnatural and visible smoke, haze, or plume (in parks where good visibility is a goal), they are more likely to be considered impairment.
- Where existing air quality adversely affects visibility, flora, fauna, soil, or water, small increases in park emissions that would exacerbate these stresses on resources would be more likely to be considered impairment.
- Where very clean air quality conditions exist for the "best visibility days" in a park, a small addition in emissions (in parks where good visibility is a goal) may be more likely to result in visibility impairment.

Under existing conditions, it is unlikely that air emissions would adversely affect visitor or employee health or create a physical effect to park resources. Visible emissions from vessels are present and create an unnatural and visible smoke or plume. These emissions within the park detract from the scenic quality of the park for visitors, although the visibility reductions are not permanent and could disperse with changes in weather conditions or changes to vessel operations. The duration of the visible plumes would also vary, depending upon the weather conditions. In 2002, while 11 of the 13 emission observations noted the presence of visible emissions, two observations noted no visible emissions, and there were no opacity violations, so the magnitude of the visible plume emissions in

2002 complied with acceptable standards. Through concession permitting conditions, violators would not be allowed to continue to operate in the park, providing an important incentive for the cruise ships to control opacity episodes. Given the available data, it is unlikely that impairment is currently occurring, and strict reinforcement of concession permit conditions would help to ensure that impairment would not occur. Further study of ambient air quality and visibility should be conducted to verify this conclusion.

Monitoring recommendations for air quality — alternative 1 — To enable researchers to quantitatively evaluate the actual effects of vessel emissions on the park's air quality, detailed meteorological data and ambient air quality and deposition readings for ozone, nitrogen oxides, sulfur dioxide, and particulates should be collected within the park during the summer season. In addition, visibility condition observations should be conducted to assess the effect on visibility and presence of haze under different meteorological conditions. Visibility data can be collected using a network of cameras at strategic locations, which should be operated during the summer season. Meteorological data collected at the same time in the park would provide information regarding the frequency of inversions and could be compared to daily photographs to determine effect of emissions under such conditions. These baseline data would provide information to determine the specific level of emissions in Glacier Bay. This information is necessary to quantitatively evaluate visibility and ambient air quality in the park.

Potential mitigation measures for air quality — alternative 1 — Currently, the park superintendent is limited in the regulatory restrictions that can be required of cruise ships by the Omnibus Parks and Public Lands Management Act of 1996. However, the act does state that "when competitively awarding permits to enter Glacier Bay, the Secretary may take into account the relative impact particular permittees will have on park values and resources" (Public Law 104-333). Concession conditions can be used to reduce visible and total emissions in the park. Cruise ship operators who currently hold concession permits to operate in the park have committed to voluntary conditions to reduce emissions and opacity, including the installation of opacity monitors and alarms to inform ship operators of potential opacity violations, reduced engine use in the Bay, not using incinerators in the Bay, and improved operating parameters. Competition for the few available concession permits would continue to provide opportunities for improvement, because permit applications would require renewal in 2004. Potential mitigation could include the use of cleaner fuels, onboard emission control systems, and early compliance with new EPA vessel emission standards. Because such mitigation would be voluntary, the overall effectiveness of mitigation beyond regulatory requirements would depend on the initiatives and policies of the cruise lines.

To enforce opacity requirements, park rangers who are certified as a visible emissions (opacity) evaluator using the EPA Method 9 opacity procedure must continue to monitor stack emissions. Continued enforcement of existing opacity limits is important to reducing visibility problems in the park. The Park Service's marine vessel emissions program (Young 1999) provides adequate structure and direction to enforce opacity violations, provided it is followed as written and that appropriate funding is available to do so.

Conclusion, air quality — alternative 1 — Total annual emissions of nitrogen oxides are projected to be 508.03 tons per year, which are higher than existing emission totals based upon 2001 operational data. However, it is unlikely that ambient air quality is greater than 80% of the National Ambient Air Quality Standards for any criteria pollutants. Based on daily estimated emissions data and data regarding visible plume observations, existing daily vessel use quotas would continue to reduce visibility to a magnitude that is below opacity standards and for a duration and extent that vary and depend upon weather conditions. The emissions would cause a moderate effect on park air quality. Visible emissions in the form of plumes from cruise ship stacks would occur for periods that would vary with weather conditions. The magnitude of these plumes should remain under opacity violation thresholds; therefore, the effects to visibility are considered moderate. The magnitude and duration of visible plumes are not likely to result in impairment under this alternative. Further study should be conducted to evaluate actual ambient air quality if this alternative is chosen.

Alternative 2 — Effects on Air Quality.

Direct and Indirect Effects on Air Quality — Alternative 2 — Under Alternative 2, seasonal entries and daily vessel quotas would return to 1985 levels. Table 4-7 presents the estimated worst-case daily and annual emissions in Glacier Bay under alternative 2. Because of the reduction in seasonal-use days for cruise ships, charter vessels, and private vessels, projected total annual emissions would be lower than those under alternative 1, although they would be higher than existing conditions. Because of the seasonal quotas, there would be some days in which only one or no cruise ships would be in the Bay, resulting in fewer daily emissions than the maximum projected daily emissions. Concerns for visibility effect would remain the same and would likely continue to result in a moderate effect to the park. Although the effect of this change would result in fewer emissions and potential changes in visibility than those in alternative 1, there still could be an increase in effects compared to existing conditions because maximum daily vessel quotas are not currently attained.

TABLE 4-7: ALTERNATIVE 2 DAILY AND ANNUAL VESSEL EMISSIONS

Daily Emissions (pounds per day)	Daily Vessel Quota	PM	NO_X	SO_2	CO	HC
Cruise Ships	2	136.01	4,393.30	486.65	511.46	57.50
Tour Vessels	3	23.00	925.84	103.14	98.33	9.38
Charter Vessels	6	7.42	297.51	33.00	35.42	3.70
Private Vessels	25	70.53	2,836.98	315.80	307.51	29.93
Total		236.97	8,453.63	938.59	952.71	100.52
Annual Emissions (tons per calendar year)	**Annual Use Days**	**PM**	**NO_X**	**SO_2**	**CO**	**HC**
Cruise Ships	229	7.79	251.52	27.86	29.28	3.29
Tour Vessels	612	1.76	70.83	7.89	7.52	0.72
Charter Vessels	566	0.35	14.03	1.56	1.67	0.17
Private Vessels	2,131	3.01	120.91	13.46	13.11	1.28
Total		12.90	457.29	50.77	51.58	5.46
Net Change from the No-Action Alternative (1)		-1.48	-50.74	-5.63	-5.79	-0.63
Net Change from Baseline		1.18	44.89	4.99	4.97	0.50

Note:
Annual-use days include proposed seasonal-use-day quotas for all vessels and May and September use-day quotas for cruise ships and tour vessels. Ferry service is included in tour vessel totals. Projected off-season use days for charter and private vessels are based upon existing numbers (see chapter 3).

PM = particulate matter.
CO = carbon monoxide.
SO_2 = sulfur dioxide.
NO_x = nitrogen oxides.
HC = hydrocarbons.

Total annual emissions of nitrogen oxides in Glacier Bay are projected to be 457.29 tons per year, which are lower than Alternative 1 projected emission totals but higher than existing emission totals based upon 2001 operational data. Emissions in Dundas Bay are assumed to be less than those in Glacier Bay, but more than 100 tons per year as in Alternative 1. However, it is unlikely that ambient air quality is greater than 80% of the National Ambient Air Quality Standards for any criteria pollutants. Based on daily estimated emissions data and data regarding visible plume observations, proposed daily vessel use quotas would continue to reduce visibility at a magnitude that is below opacity standards and at a duration and extent that would vary and depend upon weather conditions. The emissions would cause a moderate effect on park air quality, although this would be less of an effect than that under Alternative 1. Visible emissions in the form of plumes from cruise ship stacks would occur for periods that would vary with weather conditions. The magnitude of these plumes is likely to remain under opacity violation thresholds. The potential for visible plumes would be reduced compared to Alternative 1, and the effect on visibility would be moderate.

Cumulative effect on air quality — alternative 2 — The only significant change to emissions within the park is attributed to the vessels assessed in this evaluation; therefore, cumulative effects would be similar to those of alternative 1 and would continue to have a negligible additional effect on the park's air quality.

Impairment analysis for air quality — alternative 2 — Based on daily estimated emissions data and data regarding visible plume observations, existing daily vessel quotas would continue to reduce visibility at a magnitude that is below opacity standards and for a duration and extent that depend upon weather conditions. This effect would be less than that under Alternative 1, although it could be more than existing conditions. The duration and magnitude of visible plumes are not likely to result in impairment. Strict enforcement of concession permit conditions would help to ensure that impairment would not occur.

Potential mitigation measures for air quality — alternative 2 — Proposed monitoring and mitigation mentioned under alternative 1 would also be applicable to this alternative.

Conclusion, qir quality — alternative 2 — The direct and indirect effects of implementation of alternative 2 on air quality would be moderate. The frequency, magnitude, and duration of visible plumes are not likely to result in impairment under this alternative. Further study should be conducted if this alternative is chosen to evaluate actual ambient air quality.

Alternative 3 — Effects on Air Quality.

Direct and indirect effects on air quality — alternative 3 — Under Alternative 3, cruise ship daily vessel quotas would be increased to the maximum number allowed under the vessel management plan. Table 4-8 presents the estimated daily and annual emissions in Glacier Bay under alternative 3. Implementation of alternative 3 would result in an increase in annual emissions compared to alternative 1 and existing conditions. With 184 allowable seasonal-use days for cruise ships during the summer season, this would result in two entries per day every day of the summer season, representing the worst-case daily emission potential. Increased traffic would be likely to result in an increase in visibility observations, and because opacity violations are often the result of maneuvering for safety reasons, the increase in traffic loads in the Bay could result in more opacity violations. Alternative 3 would likely result in a moderate effect on air quality, resulting from the increase in total emissions that would cause more potential for visible emissions, uniform haze, and opacity violations. The effect would be greater than that under alternative 1.

TABLE 4-8: ALTERNATIVE 3 DAILY AND ANNUAL VESSEL EMISSIONS

Daily Emissions (pounds per day)						
	Daily Use Quota	**PM**	**NO_X**	**SO_2**	**CO**	**HC**
Cruise Ships	2	136.01	4,393.30	486.65	511.46	57.50
Tour Vessels	3	23.00	925.84	103.14	98.33	9.38
Charter Vessels	6	7.42	297.51	33.00	35.42	3.70
Private Vessels	25	70.53	2,836.98	315.80	307.51	29.93
Total		236.97	8,453.63	938.59	952.71	100.52
Annual Emissions (tons per calendar year)						
	Annual Use Days	**PM**	**NO_X**	**SO_2**	**CO**	**HC**
Cruise Ships	306	10.41	336.09	37.23	39.13	4.40
Tour Vessels	612	1.76	70.83	7.89	7.52	0.72
Charter Vessels	607	0.38	15.05	1.67	1.79	0.19
Private Vessels	2,388	3.37	135.49	15.08	14.69	1.43
Total		15.91	557.46	61.87	63.13	6.73
Net Change from the No-Action Alternative (1)		1.53	49.42	5.47	5.75	0.65
Net Change from Baseline		4.19	145.06	16.09	16.52	1.78

Note:

Annual-use days include proposed seasonal-use day quotas for all vessels and May and September use-day quotas for cruise ships and tour vessels. Ferry service is included in tour vessel totals. Projected off-season use days for charter and private vessels are based upon existing numbers (see chapter 3).

PM = particulate matter.

CO = carbon monoxide.

SO_2 = sulfur dioxide.

NO_x = nitrogen oxides.

HC = hydrocarbons.

Total annual emissions of nitrogen oxides are projected to be 557.46 tons per year, which are higher than projected emissions under Alternative 1 and existing emission totals based upon 2001 operational data. Emissions in Dundas Bay are assumed to be less than those in Glacier Bay, but more than 100 tons per year as in Alternative 1. However, it is unlikely that ambient air quality would exceed 80% of the National Ambient Air Quality Criteria for any criteria pollutants. Based on daily estimated emissions data, visible plume observations, and vessel-use day quotas, under this alternative, visibility would be reduced. However, the level of reduction would be above opacity standards. The duration and areal extent of the visibility reduction would vary with weather conditions. The emissions would cause a moderate effect on park air quality. Visible emissions in the form of plumes from cruise ship stacks would occur for periods that would vary with weather conditions. The magnitude of these plumes would be likely to remain under opacity violation thresholds. The potential for visible plumes is increased compared to Alternative 1, but the effect to visibility would remain as moderate.

Cumulative effect on air quality — alternative 3 — The only significant change to emissions within the park is attributed to the vessels assessed in this evaluation; therefore, cumulative effects would be similar to those of alternative 1 and would continue to have negligible additional effect on the park's air quality.

Impairment analysis for air quality — alternative 3 — The implementation of alternative 3 would result in an increase in annual emissions compared to alternative 1 and existing conditions. Visible emissions in the form of plumes from cruise ship stacks would occur more frequently compared to alternative 1. Under inversion conditions, these plumes can occur for long periods and are more likely to result in uniform haze. The magnitude of these plumes is more likely to breech opacity violation thresholds. To prevent the increase in opacity violations, the park would need to strictly enforce the concession permit conditions and opacity limit. With strict permit enforcement, impairment would not occur.

Potential mitigation measures for air quality — alternative 3 — Proposed monitoring and mitigation mentioned under alternative 1 would also be applicable to this alternative. Strict enforcement of opacity regulations and concession conditions would provide the best method for preventing opacity violations.

Conclusion, air quality — alternative 3 — The direct and indirect effects of implementation of alternative 3 on air resources would be moderate. Strict enforcement of opacity limits would be required to prevent an increase in the magnitude of visibility reductions. The magnitude and duration of visible plumes are not likely to result in impairment under this alternative. Further study should be conducted if this alternative is chosen to evaluate actual ambient air quality.

Alternative 4 — Effects on Air Quality.

Direct and indirect effects on air quality — alternative 4 — Under alternative 4, vessel operations would be limited to the pre-1985 allowable number of entries, and additional speed limitations would be enforced on cruise ships. Quotas on cruise ships, tour vessels, and charter vessels would decrease, and quotas on private vessels would increase. While the speed limits proposed under this alternative would require that the cruise ships remain in the Bay longer, the speed reductions would result in a decrease in annual emissions compared to alternative 1 and the existing conditions. Maximum daily emissions also would decrease as a result of the speed limitations. Because of the seasonal quotas, there would be some days in which only one or no cruise ships would be in the Bay, resulting in fewer daily emissions than the maximum projected daily emissions. Table 4-9 presents the estimated daily and annual emissions in Glacier Bay under alternative 4. Decreases in traffic and speeds are also likely to result in a reduction in visible emissions because total daily emissions are down and the potential for opacity observations is also reduced.

TABLE 4-9: ALTERNATIVE 4 DAILY AND ANNUAL VESSEL EMISSIONS

Daily Emissions (pounds per day)						
	Daily Vessel Quota	**PM**	**NO_X**	**SO_2**	**CO**	**HC**
Cruise Ships	2	147.28	1,432.00	142.21	521.04	95.57
Tour Vessels	2	17.25	694.38	77.36	73.74	7.04
Charter Vessels	5	6.18	247.92	27.50	29.51	3.09
Private Vessels	22	62.07	2,496.55	277.90	270.60	26.34
Total		232.78	4,870.85	524.96	894.90	132.03
Annual Emissions (tons per calendar year)						
	Annual	**PM**	**NO_X**	**SO_2**	**CO**	**HC**
Cruise Ships	153	5.63	54.77	5.44	19.93	3.66
Tour Vessels	459	1.32	53.12	5.92	5.64	0.54
Charter Vessels	515	0.32	12.77	1.42	1.52	0.16
Private Vessels	2,441	3.44	138.50	15.42	15.01	1.46
Total		10.71	259.16	28.19	42.10	5.81
Net Change from No-Action Alternative (1)		-3.66	-248.87	-28.21	-15.27	-0.27
Net Change from Baseline		-1.00	-153.24	-17.59	-4.50	0.86

Note:

Annual-use days include proposed seasonal-use day quotas for all vessels and May and September use-day quotas for cruise ships and tour vessels. Ferry service is included in tour vessel totals. Projected off-season use days for charter and private vessels are based upon existing numbers (see chapter 3).

PM = particulate matter.

CO = carbon monoxide.

SO_2 =sulfur dioxide.

NO_x = nitrogen oxides.

HC = hydrocarbons.

Total annual emissions of nitrogen oxides are projected to be 259.16 tons per year, which are lower than those of alternative 1 and existing emission totals based upon 2001 operational data. Emissions in Dundas Bay are assumed to be less than those in Glacier Bay, but more than 100 tons per year as in alternative 1. Based on these estimated emissions data, it is unlikely that ambient air quality in the park would exceed 80% of the National Ambient Air Quality Standards for any criteria pollutants. Based on daily estimated emissions data and data regarding visible plume observations, implementation of the proposed daily vessel quotas in this alternative would likely result in an improvement in visibility. The emissions could cause a moderate effect on park air quality, although this would be less of an effect than that under alternative 1 and would be an improvement compared to existing conditions. Visible emissions in the form of plumes from cruise ship stacks would occur for periods that would vary with weather conditions. The magnitude of these plumes is expected to remain under opacity violation thresholds. Despite the reduction of the potential for visible plumes compared to alternative 1, the effects to visibility are considered to be moderate.

Cumulative effects on air quality — alternative 4 — The only significant change to emissions within the park is attributed to the vessels assessed in this evaluation; therefore, cumulative effects would be similar to those of alternative 1 and would continue to have a negligible additional effect on the park's air quality.

Impairment analysis for air quality — alternative 4 — Based on daily estimated emissions data and data regarding visible plume observations, reduced daily vessel quotas and reduced speed would result in less potential for visibility reductions compared to alternative 1. The duration and magnitude of visible plumes are not likely to result in impairment, and visibility conditions would likely improve as a result of the implementation of this alternative.

Potential mitigation measures for air quality — alternative 4 — Proposed monitoring and mitigation mentioned under alternative 1 would also be applicable to this alternative.

Conclusion, air quality — alternative 4 — The direct and indirect effects of implementation of this alternative on air resources would be moderate and less than those of alternative 1. Strict enforcement of opacity limits would limit the potential for visibility reductions. The magnitude and duration of visible plumes are not likely to result in impairment under this alternative.. Further study of visibility effects should be conducted if this alternative is selected.

Alternative 5 — Effects on Air Quality.

Direct and indirect effects on air quality — alternative 5 — Under alternative 5, cruise ship operations would be limited to the current number of entries allowed under the vessel management plan, and additional speed limitations would be enforced on cruise ships. Compared to alternative 1, cruise ship entries would be reduced annually, tour and charter entries would remain the same, and private vessel entries would increase. Operation limitations on tour vessels, charter vessels, and private vessels would be similar. While the speed limits proposed under this alternative would require that cruise ships remain in the Bay longer, the speed reductions would result in a decrease in annual emissions compared to alternative 1. Maximum daily emissions also would decrease as a result of the speed limitations. Because of the seasonal quotas, there would be some days in which only one or no cruise ships would be in the Bay, resulting in fewer daily emissions than the projected maximum daily emissions. Table 4-10 presents the estimated worst-case daily and annual emissions in Glacier Bay under alternative 5. Decreased traffic and speeds are also likely to result in a reduction in visible emissions because total daily emissions are down and the potential for opacity observations is also reduced. While total emissions of nitrogen oxides are likely to result in continuation of a moderate effect due to total emissions and some continued potential for visible emissions, this effect would be reduced compared to alternative 1 and existing conditions.

TABLE 4-10: ALTERNATIVE 5 DAILY AND ANNUAL VESSEL EMISSIONS

Daily Emissions (pounds per day)						
	Daily Vessel Quota	**PM**	**NO_X**	**SO_2**	**CO**	**HC**
Cruise Ships	2	147.28	1,432.00	142.21	521.04	95.57
Tour Vessels	3	23.00	925.84	103.14	98.33	9.38
Charter Vessels	6	7.42	297.51	33.00	35.42	3.70
Private Vessels	25	70.53	2,836.98	315.80	307.51	29.93
Total		248.23	5,492.33	594.15	962.28	138.58
Annual Emissions (tons per calendar year)						
	Annual	**PM**	**NO_X**	**SO_2**	**CO**	**HC**
Cruise Ships	231	8.51	82.70	8.21	30.09	5.52
Tour Vessels	551	1.58	63.77	7.10	6.77	0.65
Charter Vessels	607	0.38	15.05	1.67	1.79	0.19
Private Vessels	2,717	3.83	154.16	17.16	16.71	1.63
Total		14.30	315.68	34.15	55.36	7.98
Net Change from No-Action Alternative (1)		-0.08	-192.36	-22.25	-2.01	1.89
Net Change from Baseline		2.58	-96.73	-11.63	8.76	3.02

Note:

Annual-use days include proposed seasonal-use day quotas for all vessels and May and September use-day quotas for cruise ships and tour vessels. Ferry service is included in tour vessel totals. Projected off-season use days for charter and private vessels are based upon existing numbers (see chapter 3).

PM = particulate matter.
CO = carbon monoxide.
SO_2 = sulfur dioxide.
NO_x = nitrogen oxides.
HC = hydrocarbons.

Total annual emissions of nitrogen oxides are projected to be 315.36 tons per year, which are lower than alternative 1 and existing emission totals based upon 2001 operational data. Emissions in Dundas Bay are assumed to be less than those in Glacier Bay, but more than 100 tons per year, as in alternative 1. Based on the estimated emissions data, it is unlikely that ambient air quality in the park would exceed 80% of the National Ambient Air Quality Standards for any criteria pollutants. Based on daily estimated emissions data and visible plume observations, the proposed daily vessel quotas under this alternative would likely result is an improvement in visibility. The emissions could cause a moderate effect on park air quality, although this would be less of an effect than that under alternative 1 and would be an improvement compared to existing conditions. Visible emissions in the form of plumes from cruise ship stacks would occur for periods that would vary with weather conditions. The magnitude of these plumes is expected to remain under opacity violation thresholds. Potential for visible plumes is reduced compared to alternative 1 and represents moderate effects.

Cumulative effects on air quality — alternative 5 — The only significant change to emissions within the park is attributed to the vessels assessed in this evaluation; therefore, cumulative effects would be similar to those of alternative 1 and would continue to have a negligible additional effect to the park's air quality.

Impairment analysis for air quality — alternative 5 — Based on daily estimated emissions data and data regarding visible plume observations, speed restrictions and quotas would result in less potential for visibility reductions compared to alternative 1. The duration and magnitude of visible plumes would not result in impairment, and visibility conditions would likely improve as a result of the implementation of this alternative.

Potential mitigation measures for air quality — alternative 5 — Proposed monitoring and mitigation mentioned under alternative 1 would also be applicable to this alternative.

Conclusion, air quality — alternative 5 — The direct and indirect effects of implementation of this alternative on air resources would be moderate and less than those of alternative 1. Strict enforcement of opacity limits would limit the potential for visibility reductions. The magnitude and duration of visible plumes are not likely to result in impairment under this alternative.. Further study of visibility impacts should be conducted if this alternative is selected.

Summary, Air Quality. The emissions of nitrogen oxides in Glacier Bay under all the alternatives would be above the 250-tons-per-year threshold; however, based on the size of the area and on the limited number of other significant emission sources, and using Juneau's air quality for comparison, it is unlikely that these emissions would result in ambient air concentrations that are greater than 80% of the National Ambient Air Quality Standards. NO_X emissions in Dundas Bay also are likely to be more than 100 tons per year. Therefore, there would be a moderate effect on air quality in Glacier Bay and Dundas Bay under all the alternatives. Based on estimated emissions data for Glacier Bay and data regarding visible emission observations, proposed speed restrictions and quota changes under alternatives 4 and 5 would reduce projected annual emission totals and are likely to improve visibility, although increases to private vessel quotas under these alternatives would offset some of this improvement. Alternative 3 would produce the highest annual emissions, potentially increasing the frequency and magnitude of visible plumes and uniform haze, although not likely to result in impairment of park resources. The extent and magnitude of visibility reductions have not been documented. Collection of meteorological, ambient air quality, and visibility resource data would provide more specific analyses of the effects of vessel emissions in the park. Competition for concession permits should be encouraged to continue to drive voluntary mitigation measures, because enforcement of mitigation beyond established regulatory requirements is not allowed. Because of this, daily vessel quota reductions and speed limitations provide the only mitigation that can be enforced in the park to control total emissions. Continued maintenance of the park's marine vessel emissions program (Young 1999) to enforce opacity regulations would provide protection of the park's visibility resources.

4.2.3 Water Quality

4.2.3 Water Quality

This subsection evaluates the sources and history of water pollution in Glacier Bay and Dundas Bay; regulatory framework; and the probable effects on water quality from implementing the alternatives. The regulatory framework is described first, followed by the direct, indirect, and cumulative effects on water quality from implementing each alternative. The potential for the alternatives to impair water resources also is discussed, as well as mitigation measures, if required. Conclusions are summarized at the end of the analysis for each alternative.

Issues of Concern Raised during Scoping. The issues concerning water quality that were raised during public scoping are as follows:

- Increases in vessel quotas increase the potential for unauthorized releases of marine debris, petroleum, graywater, blackwater, oil, ballast, photographic chemicals, dry cleaning solutions, and cleaning solvents. The unauthorized release of marine debris and other contaminants may degrade water quality, affect the ecosystem, and imperil park visitors.
- Increasing the vessel quota increases the potential of small and catastrophic oil spills. Current technology is inadequate to clean up oil spills in ice-filled waters.
- Vessels other than large cruise ships may not have the capacity to hold and treat waste. Possible increases in these types of vessels could result in increased discharges of waste, resulting in degradation of the marine environment.
- The park’s zero discharge policy for cruise ships means that they are dumping their sanitary waste outside the park.

Regulatory Framework. The relevant federal, state, local, and international laws and regulations pertaining to water quality in Glacier Bay and Dundas Bay are identified below. Specific regulatory requirements and thresholds are summarized in table 4-11; this is not an exhaustive list.

Federal laws and regulations —

- Clean Water Act, section 32 and regulations, and section 311 and regulations; 33 CFR 159; 40 CFR 140; 33 CFR 151.
- Oil Pollution Act (OPA) of 1990 — 33 USC 2701 et seq.
- Resource Recovery and Conservation Act (RCRA).
- Act to Prevent Pollution from Ships (see International Convention for the Prevention of Pollution from Ships [MARPOL], under international laws).

State laws and regulations —

- State of Alaska’s Water Quality Standards (18 AAC 70).

- State of Alaska's Commercial Passenger Vessel Environmental Compliance Program (CPVEC; Alaska Statute 46.03; 18 AAC 69).

All of the regulations are pertinent to the analysis of the alternatives, but the State of Alaska's Commercial Passenger Vessel Environmental Compliance Program needs additional explanation to understand how it is applied. The Alaska Department of Environmental Conservation's CPVEC law regulates the discharges of the contaminants associated with graywater and blackwater, but has different provisions for vessels according to their size. The department regulates only those vessels that can accommodate 50 or more passengers in lower berths (overnight accommodations). It further distinguishes between small commercial passenger vessels (50 to 249 passengers) and large vessels (250 or more passengers). All small and large commercial passenger vessels must comply with the standards (see table 4-11), but not all of them are able to comply immediately. Those that cannot comply are operating under interim protective measures. All large commercial passenger vessels that discharge graywater or blackwater must be in compliance with the standards by 2003. Small commercial passenger vessels must come into compliance by 2004 (ADEC 2002b); therefore, large and small commercial passenger vessels may be discharging certain contaminants above standards.

Local policies and regulations — No local governmental water quality laws apply to the park; however, the Park Service prohibits discharge of blackwater at Bartlett Cove (see appendix B). Additionally, as part of the permitting process for obtaining entry to the park, cruise ship operators must submit a pollution minimization plan that documents how each operator implements the industry's best management practices (BMPs) to minimize pollution emissions to air and water and to prevent fuel spills. The park's goal of minimizing pollution, coupled with the competitive environment for winning entry permits, typically results in cruise ship operators submitting a pollution minimization plan that incorporates a zero discharge policy, specifically recognizing the effects to water quality from discharge of graywater, sanitation devices, incinerator ash, and oil/water separator effluent. Currently, all cruise ships with entry permits for the peak season, June 1 to August 31, have incorporated such a policy in their pollution minimization plans. In addition, three operators currently have entry permits during the off-peak season, each of whom also have committed to a zero discharge policy in their pollution minimization plans. All of the operators define zero discharge as no discharge of graywater or blackwater (NPS, Nemeth, electronic mail, October 21, 2002).

International laws and regulations — Cruise ships that are flagged under countries that are members of the International Convention for the Prevention of Pollution from Ships must comply with MARPOL requirements. MARPOL 73/78 is the international treaty regulating the disposal of wastes generated by normal operation of vessels. MARPOL 73/78 is implemented in the United States by the Act to Prevent Pollution from Ships, under the lead of the United States. Particularly relevant to this analysis are MARPOL annexes I, IV, and V, which are described in more detail in table 4-11.

TABLE 4-11: MAJOR REGULATORY REQUIREMENTS AND THRESHOLDS FOR GLACIER BAY WATERS AND MARINE VESSEL WASTES

Waste	Law or Reg.	Requirements and Thresholds	Responsible Agency
Blackwater (Sewage)	U.S. Clean Water Act	Discharges of untreated sewage or sewage with a fecal coliform bacterial count greater than 200 colonies per 100 milliliters, or total suspended solids exceeding 150 milligrams per 100 milliliters are not allowed within 3 nautical miles of the shoreline. Requires a certified operable Marine Sanitation Device (MSD) on every vessel (U.S. and foreign) with an installed toilet.	U.S. Environmental Protection Agency; U.S. Coast Guard
	36 CFR 2.14	Polluting or contaminating park area waters or water courses with sanitation and refuse is prohibited.	Park Service
	Alaska Statute 46.03.460–46.03.490	Discharge limit set for blackwater (treated sewage) of 200 fecal coliform colonies per 100 milliliters and 150 milligrams per liter of suspended solids. Discharge limited to at least 1 mile from shore and 6 knots vessel speed, unless more stringent effluent levels are demonstrated.	Alaska Department of Environmental Conservation
	NPS 2002 Compendium	No discharge of blackwater in Bartlett Cove waters.	Park Service
	NPS Entry Permit	Zero discharge agreement established with cruise ship operators through competitive bid process for entry permits. Not NPS policy.	Self-regulated
	International Convention for the Prevention of Pollution from Ships Annex IV	The discharge of sewage into the sea is prohibited, except when: the ship is discharging ground-up and disinfected sewage using a system approved by the administration at a distance of more than 4 nautical miles from the nearest land, or sewage that is not comminuted or disinfected at a distance of more than 12 nautical miles from the nearest land; or the ship has in operation an approved sewage treatment plant which has been certified by the administration. The effluent shall not produce visible floating solids in, nor cause the discoloration of, the surrounding water.	U.S. Coast Guard
Graywater	U.S. Clean Water Act	No restrictions on discharging graywater.	U.S. Coast Guard, U.S. Environmental Protection Agency
	36 CFR 2.14	Polluting or contaminating park area waters or water courses is prohibited.	Park Service
	Alaska Statute 46.03.460–46.03.490	Discharge limit set for graywater of 200 fecal coliform colonies per 100 milliliters and 150 milligrams per liter of suspended solids. Discharge limited to at least 1 mile from shore and 6 knots vessel speed.	Alaska Department of Environmental Conservation
	NPS Entry Permit	Zero discharge agreement established with cruise ship operators through competitive bid process for entry permits. Not NPS policy.	Self-regulated
Solid Wastes, Marine Debris	36 CFR 2.14	Polluting or contaminating park area waters or water courses is prohibited.	Park Service
	International Convention for the Prevention of Pollution from Ships 73/78, Annex V	Dumping floatable dunnage, lining, and packing material is prohibited within 25 miles of shore. Dumping other un-ground garbage is prohibited within 12 miles. Incinerator ash is typically considered non-hazardous, and may be disposed of at sea in accordance with International Convention for the Prevention of Pollution from Ships annex V. Ash identified as being hazardous must be disposed of ashore in accordance with Resource Conservation and Recovery Act.	U.S. Coast Guard

TABLE 4-11: MAJOR REGULATORY REQUIREMENTS AND THRESHOLDS FOR GLACIER BAY WATERS AND MARINE VESSEL WASTES

Waste	Law or Reg.	Requirements and Thresholds	Responsible Agency
Toxic Wastes	Resource Conservation and Recovery Act (RCRA)	Dry cleaning solvent (perchlorethylene [PERC]); batteries including lead acid, lithium, and nickel cadmium; some print shop waste; and photo processing waste containing silver in excess of 5 parts per million are classified as hazardous waste under the Resource Conservation and Recovery Act and must be handled accordingly.	U.S. Environmental Protection Agency
	18 AAC 70.20	Antidegradation policy: Existing water uses and the level of water quality necessary to protect existing uses must be maintained and protected.	Alaska Department of Environmental Conservation
	NPS Entry Permit	Zero discharge agreement established with cruise ship operators through competitive bid process for entry permits. Not NPS policy.	Self-regulated
Oil	U.S. Oil Pollution Act of 1990	No visible sheen or oil content greater than 15 parts per million within 12 miles. Oily waste must be retained onboard and discharged at an appropriate reception facility.	U.S. Coast Guard
	18 AAC 70.020	There may be no concentration of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration.	Alaska Department of Environmental Conservation
	International Convention for the Prevention of Pollution from Ships 73/78, Annex I	All vessels of any type more than 400 gross tons traveling over international waters are required to have an approved Shipboard Oil Pollution Emergency Plan (SOPEP). Vessel must be equipped as far as practicable and reasonable with installations to ensure the storage of oil residues onboard and their discharge to reception facilities, or into the sea providing the ship is more than 12 nautical miles from the nearest land, the oil content of the effluent is less than 100 parts per million, and the ship has in operation an oil discharge monitoring and control system, oil-water separating equipment, and oil filtering system or other installation.	U.S. Coast Guard

Methodology and Assumptions. To evaluate the water quality effects of implementing the alternatives, the Park Service reviewed existing literature to define a baseline for Glacier Bay and Dundas Bay. Records of fuel spills and vessel discharges in the park were reviewed to establish a history of incidents resulting in discharges. The potential effects were determined by comparing them with the regulatory standards summarized in table 4-11.

To establish a qualitative understanding of petroleum discharges in Glacier Bay and Dundas Bay, reports and studies developed for the Park Service were reviewed. Specifically, the *Spill Prevention, Countermeasures and Control (SPCC) Plan* (Baker 2000a); the *Needs Assessment for a Major Fuel Oil Spill* (Eley 2000); and related NPS documents provide the basis for establishing the historical trends of petroleum discharges to the Bay and the safety measures in place to respond to a petroleum spill. This evaluation assumes that these data are representative of current conditions, and these data were extrapolated to determine the potential effects of each alternative.

To provide a qualitative understanding of vessel wastewater discharges, data compiled by the Alaska Department of Environmental Conservation under the Commercial Passenger Vessel Environmental Compliance Program were reviewed. The Park Service used these data to estimate discharges that could occur as a result of the implementation of each alternative because no blackwater discharge data are available for the park. It is reasonable to assume that these data would be representative of all passenger vessels that operate within the park. Assumptions were made about the potential effects of increased vessel traffic using the existing data for historical vessel traffic, fuel spill history from vessels at the Bartlett Cove Fuel Transfer and Storage Facility, and documented vessel discharges in the Bay. It was assumed that discharges, including spills in the future, would be similar to the historical patterns and levels if the number of vessels entering Glacier Bay remained the same. It also was assumed that any increase in the number or frequency of vessels entering the Bay would incrementally increase the potential for accidental petroleum spills, as well as the quantities of petroleum storage and transfers required at the Bartlett Cove facility. Increased vessel traffic also would increase the potential for vessel discharges into the Glacier Bay ecosystem.

Effects to water quality were evaluated by extrapolating ADEC data and historical trends for fuel spills and discharges and comparing the projections to federal and state regulations (see table 4-11). The alternatives' effects on water quality are evaluated within the context of the marine waters of Glacier Bay. The duration of effects was judged based on the regulatory timeframe for each parameter. The threshold criteria presented in table 4-12 are used to describe the intensity of effects on water quality and are based on the state and federal regulations summarized in table 4-11.

TABLE 4-12: THRESHOLD CRITERIA FOR EFFECTS ANALYSIS ON WATER QUALITY

Negligible	No detectable or measurable changes to water quality or exceedances of water quality standards would occur.
Minor	Any degradation of water quality would be temporary (less than 48 hours) and limited to the immediate area of the discharge or, in the case of marine debris, to low volumes.
Moderate	Any degradation of water quality would be short-term (less than one month) and localized.
Major	Water quality would be degraded by an ongoing exceedance of water quality standards or a spill or upset that degrades water quality in the long term.

The potential water quality effects are further categorized as either routine (from normal or daily operations and activities) or upset (from distinctive, unlikely, severe incidents). To eliminate repetition, much of the discussion is found only under alternative 1 (no action). The discussions of water quality effects for alternatives 2, 3, 4, and 5 were developed using alternative 1 as a baseline.

Alternative 1 (No Action) — Effects on Water Quality. Under alternative 1, entry quotas and operating requirements would not change. For this analysis, it has been assumed that current effects to water quality would continue; therefore, this section describes the sources of pollutants and other parameters that currently affect, or in the recent past have affected, water quality in the park.

Direct and indirect effects on water quality — Alternative 1. Four parameters related to vessel traffic that currently affect water quality in the park are — petroleum from an oil or fuel release, wastewater and other contaminants, marine debris, and re-suspension of sediments.

<u>Petroleum from a Fuel or Oil Release</u>. The effects of a fuel or oil release can be highly variable, depending on the type, quantity, and location of the spill. In general, exposure to the most toxic substances decreases with time and is usually limited to the initial spill area. "In some areas, habitats and populations can recover quickly. Unfortunately, in other environments, recovery from persistent or stranded oil may take years. Some organisms may be seriously injured or killed very soon after contact with the oil in a spill, however, non-lethal toxic effects are more subtle and often longer lasting" (EPA 2002c). Appendix F, table 1, describes the properties and effects of gasoline and diesel, including environmental toxicity, as well as effectiveness of mechanical recovery and shoreline countermeasures. Additional information regarding spill prevention scenarios and response countermeasures can be found in the park's spill prevention control and countermeasure plan (Baker 2000a; Ely 2000).

The existing level of motorized vessel use in the park has resulted in discharges of petroleum products. Petroleum can enter marine waters by the following mechanisms:

- leaks, spills, or deliberate discharge of bilge or ballast water containing petroleum products.
- leaks from the use of two-stroke engines.
- leaks or spills at the Bartlett Cove vessel fueling facility.
- spills involving the Park Service fueling barge in Blue Mouse Cove.
- accidental releases of petroleum as a result of a vessel grounding or collision.

The following subsection describes the potential sources of petroleum products that could be released into the marine waters of the park.

BILGE AND BALLAST WATER: Residual oil, lubricants, and possibly fuel may accumulate in the bilge (i.e., lowest part within the interior hull) of vessels. Cruise ships can generate 1,300 to 37,000 gallons of oily bilge water per day (Herz and Davis 2002). On most cruise ships, oily bilge water is pumped through an oil/water separator. Separated water is either discharged into marine waters or offloaded to a treatment facility while the ship is in port. Smaller vessels typically hold their bilge water until it can be pumped out at port.

Although law prohibits the release of oily bilge water, an accidental release may occur. Between 1994 and 2001, three discharges of bilge water resulting in a visible sheen were documented in Glacier Bay by a charter vessel in 1995, and tour vessels in 1999 and 2001 (see appendix E). Additional undocumented events resulting in release of fuel also may have occurred.

A bilge water release from a small vessel would be limited to the immediate area of discharge. Because discharge volumes from a single smaller vessel would contain relatively small amounts of petroleum, this would have little or no long-term effect on ambient water quality. In an accidental or inadvertent release of bilge water from a cruise ship, the total amount of oily waste entering the park would be larger, but the discharge also would be dispersed over a larger area while the vessel travels; therefore, the potential effects to water quality likely would be minimized. The potential effects would be greater if there were an inadvertent release by a cruise ship while stopped in ice-filled water. The risk is addressed in the subsection regarding collisions and grounding.

Some vessels accommodate changes in weight and trim by taking on or discharging ballast water held in ballast tank. In general, cruise ships discharge ballast water only when they are taking on fuel (in Seattle or Vancouver for the Alaska season). The Park Service informally learned from Holland America Line that intake of ballast “would rarely be necessary in Glacier Bay” (NPS, Nemeth, electronic mail, September 16–18, 2002). The fuel barges do not take on or discharge ballast water

(Petro Marine, Robertson, pers. com., January 6, 2003); therefore, any release of ballast water would be unintentional.

TWO-STROKE ENGINES: Another mechanism for oil to reach the Bay is through the release of fuel or oil from two-stroke engines. According to the Park Service, most outboard engines used in the Bay, both by the public and by the Park Service, are two-cycle engines. These are typically found on smaller vessels. The park is actively changing engines on government vessels to four-stroke as the older engines are retired. While a formal survey has not been conducted, the Park Service estimates that roughly two-thirds to three-fourths of outboards on private vessels are two-cycle (Young 2002).

Two-stroke engines release up to 20% to 30% of the gas/oil mixture unburned directly into the water (EPA 2002d). The American Watercraft Association believes that this is neither significant nor dangerous since because of the raw fuel eventually evaporates into the atmosphere. Other studies indicate that two-stroke engine emissions cause the most damage to the aquatic environment within the first 24 hours of discharge and that without dilution the contaminated water could remain toxic for weeks (Bluewater Network 2001).

With advancing technology, newer two-cycle engines will pollute less and will meet the upcoming EPA regulations scheduled for implementation in 2006. They will use direct and high-pressure fuel injection technologies to overcome the waste oil problems inherent in older two-cycle engines (Young 2002). Research found, however, that while these new direct-injected two-stroke engines are cleaner than older models, on average they polluted more than four-stroke engines (Bluewater Network 2001).

The boats using two-stroke engines can travel to remote areas in the park, thereby introducing pollutants in areas not visited by larger vessels. Furthermore, the tidal flushing in some remote areas may be restricted and the flushing cycles longer than in the main channel. It could take several tide cycles to exchange the water in a smaller restricted fjord than it does in mid-channel. The pollutants left by a small vessel in these areas could affect more water simply because they are present longer (NPS, Banks, pers. com., 2002).

Direct adverse effects, if any, would be limited to the area of use. Small vessels do not concentrate in any one area, and because of the strong currents in Glacier Bay, their sheens would dissipate and disperse rapidly (Young 2002), excluding some remote areas outside the main channel. Because single-discharge volumes would contain relatively small amounts of petroleum, little or no long-term degradation of ambient water quality would be expected.

BARTLETT COVE PETROLEUM TRANSFER AND STORAGE FACILITY: The marine transfer facility at Bartlett Cove is operational year-round, but is not available to the public from October to April. Primary demand for fuel is during the visitor-use season period (May through September). The Bartlett Cove facility provides fuel for vessels up to 150 feet (46 meters) in length. Cruise ships cannot fuel at the facility because of their size.

The Bartlett Cove facility stores and dispenses gasoline and diesel fuel. The capacity of the storage facility is approximately 15,000 gallons of gasoline and 100,000 gallons of diesel (five 20,000-gallon tanks). The double-walled tanks are filled only to 90% of their capacity; therefore, the total wet capacity of gasoline is 13,500 gallons and the total wet capacity of diesel is 90,000 gallons, for a total wet capacity of 103,500 gallons (Baker 2000b). Two 3,000-gallon overflow tanks (one for each fuel) are in place to prevent the fuel from escaping in an accidental overflow. The third overfill protection system for the bulk fuel storage tanks is two 3000-gallon overflow tanks located within the tank farm, one diesel and one gasoline. Should any bulk fuel storage tank be overfilled during the filling process, the fuel will flow into the vent/overflow piping and into the overflow tank. At normal filling rates, this allows approximately 5 minutes for the operating personnel to shut valves and stop the filling process.

Commercially operated barges transfer fuel to the facility approximately every three weeks in the summer and every other month in the winter. The capacity of each of the two petroleum barges is up to 1,500,000 gallons of fuel (Eley 2000). The barges typically deliver 50,000 to 100,000 gallons of gasoline or diesel to Bartlett Cove per month during the May-to-September tourism season (Eley 2000).

All fuel transfer operations (loading and unloading) at the Bartlett Cove Petroleum Transfer and Storage Facility meet the requirements of the U.S. Coast Guard according to the facility's spill prevention control and countermeasures plan. Because most spills are caused by human error, preventive measures, including strict control of access to the dispensing pumps, are adhered to (Baker 2000a).

Potential fueling-facility-associated petroleum spills could occur from three separate areas of operation:

- leaks from the underground storage tanks (USTs) or pipelines at the tank farm.
- spills from product transfers from the marine barge to the Bartlett Cove tank farm.
- spills during dispensing of fuel on dock or onshore.

Previous investigations of soils and hydrogeology at the Bartlett Cove tank farm suggest that fuel leaks from underground tanks and piping do not reach Bartlett Cove because of the flat hydraulic gradient and the ability of soils to absorb petroleum compounds; however, spill incidents during fuel dispensing can lead to direct discharges of fuel into marine waters.

Appendix F, table 2, identifies the response equipment that is currently available should a spill occur at Bartlett Cove and Blue Mouse Cove. Appendix F, table 3, outlines the probable spill scenarios for the Bartlett Cove facility. The most likely discharge occurs during dispensing of fuel to the vessels. The most probable spill is 1 pint of gasoline or diesel fuel waterborne in any single incident; however, if over-pumping occurs, a spill of approximately 150 gallons may occur (Baker 2000a).

Spills of petroleum products into Bartlett Cove have been documented since 1978 (Baker 2000a); these spills have ranged in quantity from several ounces up to 20 gallons. The largest recorded spill volume at the Bartlett Cove facility was a 100-gallon spill caused by the failure of an injector system on one of the facility generators; however, this spill occurred in an upland area. Most of the spills that have occurred at the Bartlett Cove facility have been related to the refueling of vessels. Based on the recorded spill history of this facility, an average of four to five spill incidents involving small quantities (less than 5 gallons) of fuel occur per year (Baker 2000a).

According to the Bartlett Cove Fuel Transfer and Storage Facility oil SPCC plan for the park and preserve (Baker 2000a), the largest potential spill at the facility is 3,000 gallons of diesel. The estimated worst-case scenario spill identified in the Bartlett Cove SPCC plan would have the potential for severe and immediate adverse effects to resources requiring a high level of water quality. Under alternative 1, however, the probability of effects to water quality as a result of this type of spill would remain roughly the same as present conditions, which is negligible. In the unlikely event of this spill scenario, effects likely would be localized and short-term, and change in water quality could be minimized by an effective spill response.

BLUE MOUSE COVE FUEL BARGE: The fuel barge *Petrel* serves as a fueling station for NPS vessels, including the Up-Bay patrol and research vessels (Young 2002). In addition to being a fuel supply for daily park operations, the barge also serves as an emergency fuel supply in the upper reaches of the Bay in the event of a large incident such as a vessel grounding or fuel spill, which involves intensive emergency vessel traffic. The barge has steel double-walled construction and measures 38 by 14 feet, with a steel watertight storage structure mounted on top, storing fuel spill and other supplies. The Park Service tows the barge up to Blue Mouse Cove, where it is anchored from May through September. Then it is returned to Bartlett Cove for the winter (see figure 3-22). The barge has two tanks; the large tank has a capacity of 5,000 gallons and typically stores gasoline, and the smaller tank is 500 gallons and stores diesel (NPS 1995c). The barge carries spill prevention and response equipment. The worst-case scenario spill of 5,500 gallons of fuel, therefore, would have the potential for severe and immediate adverse effects to resources requiring a high level of water quality, but the probability of such a spill is small.

A large spill, although unlikely, could occur when the barge is en route to Blue Mouse Cove or upon return to Bartlett Cove. Historically spills at the Blue Mouse Cove fuel barge facility have been small and infrequent. Only one recorded incident occurred at the Blue Mouse Cove fuel barge; in 2000, 1 to 2 gallons of diesel overflowed and spilled into the water. The effects of these small spills would be limited to the immediate area of discharge and short term. Additionally, while it could not be fully avoided, changes to water quality would be minimized by implementing pollution prevention measures, such as rapid deployment of spill containment equipment.

ACCIDENTAL RELEASE DUE TO GROUNDING OR COLLISION: Historical data indicate that the likelihood of a spill due to collision or grounding is low; and, in the event that a spill occurs, the response capability is high (Eley 2000). A needs assessment (Eley 2000) used for planning for a major fuel spill in Glacier Bay concluded that:

- powered groundings, the most likely accident, are most likely to occur when vessels intentionally deviate from established tracklines; if the ship remains relatively stable after a powered grounding, extensive bottom damage will not usually result in a serious fuel spill, even if fuel tanks are involved.
- loss of propulsion could cause drift grounding if anchoring or restoration of power does not occur.
- an accident involving an excursion vessel or small passenger vessel could occur anywhere in the park.
- the probability of a fuel spill as a result of a collision with ice is low.
- the average most probable fuel spills are from fishing vessels.

The largest spills would result from a collision or grounding of the tank barges; the two barges carry up to 1,500,000 gallons of fuel each. Cruise ship tanks may carry more than 400,000 gallons, and tour vessels may have up to approximately 12,000 gallons.

The park has a pre-approved agreement with the regional fuel spill response organization, Southeast Alaska Petroleum Resource Organization (SEAPRO). Southeast Alaska Petroleum Resource Organization is Southeast Alaska’s response action contractor and oil spill removal organization. Southeast Alaska Petroleum Resource Organization has two fuel spill response barges at Bartlett Cove and additional response equipment at Gustavus that are available to members to respond to spills in Glacier Bay, although they are not solely dedicated to the park. The SEAPRO barges also would respond to fuel spill incidents even if the vessel was not a contracted member. The fuel tank barge operators in Southeast Alaska are members of Southeast Alaska Petroleum Resource Organization. The fuel tank barges carry spill response equipment that can be deployed immediately.

Cruise ship companies maintain and implement a Shipboard Oil Pollution Emergency Plan in accordance with the International Convention for the Prevention of Pollution from Ships (applicable to vessels of 400 gross tons or more). The Shipboard Oil Pollution Emergency Plan is unique to each ship and must be approved by the ship's flag state. It includes procedures for reporting fuel spill incidents and taking immediate action to mitigate the spill and coordinate cleanup actions (Holland America Line [HAL] 1997). According to a representative pollution minimization plan of Holland America Line, spill cleanup equipment maintained onboard their ships consists of enough sorbent boom to cover one side of the ship, and sorbent pads. With this equipment, it is possible to contain a small spill or discharge (HAL 1997).

Despite the provisions to cleanup spills, the park has conditions that could severely hinder spill response capabilities. These include adverse weather conditions, extreme tidal ranges, and ice-filled waters. Many vessels visit the ice-filled waters near the glaciers at Johns Hopkins Inlet, Tarr Inlet, and Reid Inlet. Waters in many of the upper inlets, including Rendu, Skidmore/Charpentier, Wachusett, Adams, and Geikie, can be choked with pan ice during winter (November to May; NPS, Soiseth, pers. com., 2002). A fuel spill in ice-filled waters presents challenges different from a spill in other areas in the park. If a spill enters ice-filled waters, SEAPRO barges cannot respond. They are suitable only for incidental contact with ice (SEAPRO, Pritchard, pers. com., October 9, 2002). In general, no spill response technology currently is available to adequately clean fuel spills in slush or ice. In addition, spill response equipment, other than onboard equipment, is located at Bartlett Cove and could require several hours to mobilize to headwater areas of the Bay. Circumstances including distance to the spill, weather, and conditions of the icy water may result in delayed response to a spill in ice-filled waters. According to NPS personnel, no spills are known to have occurred in ice-filled waters (NPS, Nemeth, pers. com., unknown date). Furthermore, the probability of a fuel spill as a result of a collision with ice is low (Eley 2000); however, a tour vessel struck an iceberg and suffered hull damage in 1996 (see appendix E).

<u>Summary of Effects of Petroleum Releases</u>. Effects of petroleum releases are highly dependent on the type, size, and location of the spill, as well as on the effectiveness of spill response activities.

Under alternative 1, changes to water quality and the occurrences of discharges of bilge or ballast water, petroleum releases from two-stroke engines, a petroleum spill at the fuel dispensing facilities, or from a collision would remain approximately the same as present conditions.

Changes to water quality due to discharges of bilge water, releases from two-stroke engines, and small petroleum spills due to normal operations would be highly localized or limited to the immediate area of discharge, and would be temporary, because much of the spilled fuel would dissipate or evaporate quickly; therefore, the effects to water quality from these types of releases under alternative 1 would be considered minor.

For a larger release (e.g., a worst-case discharge at either the Bartlett Cove or Blue Mouse Cove fueling station), direct adverse effects would be more extensive than with small spills. Likewise, under circumstances where petroleum was discharged while a vessel was stationary, not allowing for quick dissipation, effects of the petroleum could be more significant than if the discharge occurred while the vessel was under way. While resulting petroleum spills cannot be fully avoided, their effects to water quality in Glacier Bay proper and Dundas Bay may be minimized with spill response technology. The fueling facility takes numerous precautions to avoid this scenario, and in the event of an actual spill, spill response capability is high. Because these types of spills may be short-term and could result in a threat to health of wildlife and/or their habitat, the effects to water quality from these occurrences under alternative 1 would be considered moderate.

In the unlikely event of a catastrophic spill, especially under circumstances in which an effective response is not possible, such as in ice-filled waters, direct adverse effects to resources requiring a high level of water quality may be severe and long-term, and may include direct mortality or threat to health of wildlife and/or their habitat. According to the U.S. Coast Guard, a major marine fuel spill is any spill more than 100,000 gallons (EPA, Carr, electronic mail, February 24, 2003). Activities such as pre-planning, strategic staging of spill response barges, and spill response training may lessen the effects; however, these events may occur for a variety of reasons, foreseeable or not, and as such, no proper mitigation exists. The effects from catastrophic spills and from petroleum discharge in ice-filled waters where spill response is hindered would constitute a major effect on water quality. A more in-depth discussion of spill potential is addressed in subsection 4.4.3, “Vessel Use and Safety.”

Overall, the implementation of alternative 1 would likely result in minor effects to water quality as a result of petroleum releases because under normal operating circumstances, the current effects are minor and the risk of an upset would remain the same (see subsection 4.4.3, “Vessel Use and Safety”).

<u>Wastewater and Other Vessel Discharges</u>. Ships generate several types of waste produced by passengers and ship operations. These wastes include graywater, blackwater, hazardous waste, and solid waste.

GRAYWATER AND BLACKWATER: Graywater contains non-sewage waste from showers, baths, sinks, and laundries. Treatment of graywater is not required before discharge from a vessel. It can contain such components as food waste; oil and grease; detergents; and, on some vessels, medical or dental wastes. Blackwater is water contaminated with human waste collected from shipboard toilets (sewage). The Alaska Department of Environmental Conservation estimates that a large cruise ship generates 5 gallons of treated blackwater per person per day and 50 gallons of graywater per person per day (ADEC 2002b).

Discharge of blackwater, or sewage, can result in eutrophication, which can lead to the growth of some algae and other microscopic organisms that capture oxygen. Disease and toxins can adversely affect exposed plants, animals, and humans. While some substances will evaporate or dissolve quickly, others may persist for many years. Although some organisms may be seriously injured or killed immediately after exposure, others may suffer from non-lethal effects. In some areas, habitats and populations can recover quickly, while others require years to recover. Graywater normally does not contain sewage, but may contain harmful wastes.

The Alaska Science Advisory Panel evaluated contaminants in cruise ship discharges, focusing on metals and total suspended solids effluent data. Their study concluded that effects of contaminants in sediments that could be associated directly with cruise ships were unlikely (ADEC 2002b).

Cruise ships hold their wastewater for a limited period of time, such as during their tour of Glacier Bay, while smaller vessels, including most tour vessels and charter and private vessels, generally cannot, and must discharge their treated waste continuously. Given the large number of passengers aboard, an accidental discharge of untreated wastewater from a large cruise ship would constitute the worst-case discharge scenario; however, all cruise ships must legally treat their blackwater before it is released. There has been only one documented release of wastewater in the park; in 1999, a cruise ship discharged graywater outside Bartlett Cove.

As part of the permitting process for obtaining entry to the park, cruise ship operators submit a pollution minimization plan that documents how each operator implements the industry’s best management practices to minimize pollution emissions to air and water and to prevent fuel spills. The plan is submitted with their application for an entry permit. The park’s goal of minimizing pollution, coupled with the competitive environment for winning entry permits, typically results in cruise ship operators submitting a pollution minimization plan that incorporates a zero discharge policy. Currently, all cruise ships with entry permits for the peak season, June 1 to August 31, have incorporated such a policy in their pollution minimization plans. In addition, three operators have entry permits during the off-peak season, all of whom have also committed to a zero discharge policy in their pollution minimization plans. In each pollution minimization plan, each operator defines zero discharge as no discharge of graywater or blackwater (NPS, Nemeth, electronic mail, October 21, 2002). Cruise ships operators also may include in their pollution minimization plan a provision to turn off incinerators while the ship is in park. According to the Park Service, if operators discharge fuel or wastewater, the park can penalize them either criminally or through the concession program, depending on the severity of the spill or discharge, the appropriateness of the operator's response, and/or cooperation with the park and other agencies (NPS, Seraphin, electronic mail, January 6, 2003).

With advances in technology, vessels will either install advanced wastewater treatment systems whose discharges comply with CPVEC requirements or they will not be allowed to operate in the park. In addition, those vessels that are continuously discharging generate smaller volumes of waste and the waste is dispersed over large areas; therefore, the potential effects to water quality are likely to be minimized.

For large cruise ships, which can easily hold their wastewater while traveling in Glacier Bay, the likelihood of a release of wastewater to the Bay is low. In the case of smaller cruise ships and tour vessels that cannot hold their waste, wastewater is treated and discharged continuously. While the effects of a discharge of graywater or blackwater can vary, a 2002 report by the ADEC Science Advisory Panel estimates that wastewater effluent in open waters is diluted by a factor of 1:50,000 (one part effluent to 50,000 parts sea water, for a large cruise ship traveling at 6 knots and discharging wastewater at 200 cubic meters per hour) within less than 15 minutes. At these dilution levels, the only contaminant likely to be measured above ambient levels in the sea water would be fecal coliforms (ADEC 2002b). Some smaller ratio of dilution is anticipated for smaller vessels, such as tour vessels and small cruise ships, or vessels moving at slower speeds, because this dilution factor is determined by the size and speed of the vessel, and the rate of discharge. The Advisory Panel suggest that, while the loading of contaminants from smaller vessels is relatively small, stationary discharge of wastewater and discharge in areas of low net marine water outflow should be avoided because of slowed mixing and dispersion (ADEC 2002b). Private vessels may not be able to treat their wastewater before it is diluted. Because of the small volumes involved and the dilution factor, the effects would not be significant.

Changes in water quality due to wastewater discharge would be limited to the immediate area of the discharge, and effects would be short-term because the effluent would be diluted and dispersed rapidly; therefore, under alternative 1, a discharge of wastewater would be considered a minor effect.

HAZARDOUS WASTE: Hazardous wastes may be generated while a ship is within park waters from processes such as photo development, dry cleaning, printing, and reverse osmosis or distillation for drinking water. Additionally, common items regularly onboard many vessels may qualify as hazardous waste, including pharmaceuticals, cleaning solutions, fluorescent lights, and batteries. A typical cruise ship with 3,000 passengers and crew will generate approximately 15 gallons of photographic processing chemicals, 1.5 gallons of dry cleaning and other chemicals, and 1.5 gallons of paint waste per day (Herz and Davis 2002).

Hazardous wastes, if not handled properly, can enter the wastewater stream on vessels by flushing them down drains, or tossing cans or other items into normal trash areas. Then, a discharge of wastewater or solid waste would allow the hazardous materials to enter marine waters. The potential for a discharge of hazardous waste, therefore, can be equated to the potential for a release of wastewater or solid waste, although each discharge of such waste would not necessarily contain hazardous materials.

The changes to water quality from these types of discharge are limited to the immediate area of the discharge, and depending on the type or quantity of the hazardous material, the extent of degradation can be highly variable. While some substances will evaporate or dissolve quickly, others may persist for many years. Although some organisms may be seriously injured or killed immediately after exposure, others may suffer from non-lethal effects. In some areas, habitats and populations can recover quickly, while others require years to recover (EPA 2002c).

The likelihood of a discharge of significant amounts of hazardous wastes is low, and the hazardous material would be diluted upon entrance to the marine waters; therefore, under alternative 1, a discharge of hazardous wastes is considered a minor effect.

SOLID WASTE: Solid waste generated onboard vessels includes food waste, bottles, plastic containers, cardboard, and paper. Each day, an average cruise passenger will generate 2 pounds of dry trash and dispose of two bottles and two cans (International Council of Cruise Lines [ICCL] 2002). On large vessels, up to 85% of a ship's solid waste is incinerated; the remainder is retained onboard and disposed of at port. Incinerator ash is typically considered non-hazardous, and may be disposed of at sea in accordance with International Convention for the Prevention of Pollution from Ships annex V. Ash identified as being hazardous must be disposed of ashore in accordance with the Resource Conservation and Recovery Act. Because of the smaller number of passengers onboard tour, charter, and private vessels, these passengers generate less trash than cruise ships passengers. Cruise ships and tour vessels operating under concession permits are required to haul their solid wastes and trash out of the park. Solid waste from private vessels and the Park Service is transferred to the park landfill near

Bartlett Cove (NPS 1995a). As part of their concession permit, cruise ships take their incinerators off line while in park waters. It is unlikely that solid waste would be discharged to the marine environment under alternative 1. The changes to water quality would be negligible.

<u>Marine Debris</u>. Marine debris (also known as flotsam) occasionally is seen in park waters and accumulates on park shorelines. The main source of the debris is from vessels outside the park and not regulated by the Park Service. Marine debris includes commercial fishing gear, building materials, and other industrial items. Sacks of trash, coffee cups, balloons, and other items from cruise ships and other vessels are occasionally found in park waters and on shorelines, though the volume of debris from cruise ships is less than the volume from other sources from outside the park (NPS 1995a).

Studies of marine debris volumes in the park are limited (Polasky 1992, in NPS 1995). Marine debris has been found on the protected waters and shores of Glacier Bay and the park's exposed outer coast. Within Glacier Bay, most debris is concentrated on beaches of the lower Bay, south of Willoughby Island. Marine debris accumulates to a much greater degree on windward beaches of the exposed outer coast between Cape Spencer and Dry Bay. Within the semi-protected area of Icy Strait/Cross Sound, marine debris accumulates on beaches at levels intermediate to those of Glacier Bay and the outer coast.

Cruise ships and tour vessels operating under concession permits are required to haul their solid wastes and trash out of the park. Solid waste from Glacier Bay Lodge, private vessels, and the Park Service is transferred to a local landfill.

While at sea, marine mammals, fish, and seabirds can become entangled with or ingest marine debris. On shore, debris degrades the natural beauty of beaches and poses a threat to wildlife and health hazards to humans. Bears regularly eat debris. Marine debris such as plastic can persist in the marine environment and along the shoreline for many years. Currents also can carry it far from the point of discharge.

Because most of the marine debris in the park is discharged from vessels not covered in this document (including vessels traveling outside the Bay and fishing vessels), and the volumes discharged by vessels covered in this EIS would be low under alternative 1, the effect of the volume of marine debris in the Bay on water quality would be minor. Although vessels covered in this EIS may discharge some debris in violation of the Act to Prevent Pollution from Ships, the Park Service currently implements efforts to minimize these discharges. For example, each concession agrees to operate in accordance with the guidelines in a pollution minimization plan that is contained in each concession permit.

Re-Suspension of Sediments. Re-suspension of sediments can increase turbidity and degrade water quality by reducing light penetration, discoloring the ocean surface or interfering with filter-feeding benthic organisms sensitive to increased turbidity. The effects of sediment re-suspension depend on vessel velocity, current velocity, sediment size, and the vertical stability of water columns.

Satellite images of the mid-water channel waters of Glacier Bay in the wake of a tour vessel show re-suspended sediments. Sediment re-suspension by cruise ships has been observed in the upper Bay, where cruise ships have re-suspended glacial sediments from denser stratified waters below the surface to near surface in periglacial areas.

The deepest vessel listed in the NPS Vessel Database for the park and preserve (Nemeth 2002) has a draft (depth) of 33 feet (10.1 meters). Vessels in Glacier Bay can create internal waves of less than 40 feet (12 meters). A vessel affects only the volume of water it displaces when moving through the water. Hooge and Hooge (2002) state that stratification occurs in the summer. They found that the first layer of stratification occurs at approximately 10 meters (33 feet), but other research has shown that stratification can occur in the first 1 to 2 meters (3.3 to 6.6 feet). Most vessels in Glacier Bay have only drafts deep enough to affect the shallowest stratified layers. A vessel may cause localized mixing of the upper stratified layers along its trackline, but the effects are localized, short-term, and approximately the same width as the beam of the vessel and trail behind the track. The water tends toward recovering to the original stratified state. Waters near the glaciers are likely to be stratified, with an upper layer containing glacial silt within a freshwater lens. When a vessel travels through this lens, the upper lens mixes with the lower, more saline layer; however, the mixing is limited to the volume of water displaced by the vessel and the disturbance of the stratification is temporary.

Internal waves generated by vessels traveling through waters less than 40 feet deep (approximately 12 to 13 meters) cause the re-suspension of sediments. In general, areas with depths less than 40 feet are near the shore; therefore, sediments are re-suspended as vessels travel close to shore. The re-suspension, however, is not likely to be greater than the re-suspension that occurs because of natural wave action. As with vessels traveling near the glaciers, the volume of water displaced by the vessel defines the area affected and the effect is likely to be temporary in calm waters. In already turbid waters, such as beaches with wave action and near the glaciers in the upper arms, the re-suspension of sediments due to the approach of vessels may have no noticeable change in turbidity.

The effects to water quality in Glacier Bay or Dundas Bay would be limited to the immediate area and temporary. Water quality would return to normal parameters, and therefore would be considered a minor effect under alternative 1.

Summary of Direct and Indirect Effects on Water Quality — Alternative 1. The potential changes to water quality from small discharges of fuel oil from bilge water, two-stroke engines, fuel transfer operations, or a discharge of other contaminants, would result in temporary, localized changes to water quality. Additionally, the re-suspension of sediments and marine debris would be localized and short-term. These changes, resulting from routine operations, would degrade water quality for less than one month. Larger spills at the Bartlett Cove or Blue Mouse Cove fueling facilities also would be expected to alter water quality to levels above allowable state and federal water quality standards for less than one month, and would have a moderate effect. Other than an unlikely catastrophic event, such as a total loss of all fuel aboard a large cruise ship or fuel barge, the implementation of this alternative would have an overall minor effect on water quality. The overall direct and indirect effects would be minor because changes in water quality would be short-term and localized, except in the unlikely event of a catastrophic spill.

Cumulative Effect on Water Quality – Alternative 1. Other actions or activities that could contribute to the changes to water quality in Glacier Bay and Dundas Bay include other vessels used in the park that are not managed under this plan, vessels operated outside Glacier Bay and Dundas Bay, increases in population and tourism in Southeast Alaska, and logging in the Tongass National Forest. Research vessels (NPS and non-NPS), commercial fishing vessels, other administrative use (NPS traffic), and float planes potentially contribute pollution through discharges of fuel, wastewater, and other contaminants. The potential changes in water quality from commercial fishing vessels within Glacier Bay would decrease over time as commercial fishing ceases in the park.

The effects from these actions, combined with those resulting from implementation of alternative 1, would be minor. Increases in tourism and the human population of Southeast Alaska could result in increased vessel and other recreational activities. Because alternative 1 would regulate vessels within the park, the effects would be the same, but commercial and private vessels operating outside Glacier Bay and Dundas Bay could accidentally discharge petroleum, blackwater, graywater, or ballast water, and marine debris could migrate into Dundas Bay and Glacier Bay. The effects of small or “normal” spills would be minor, given the volumes of water in the surrounding area; however, if a catastrophic spill occurs immediately adjacent to the entrance of either Bay, then the effects due to contaminant migration could be major. Runoff from areas logged near the park could contribute sediment and increase turbidity; however, according to the USFS Tongass management plan, no areas immediately adjacent to the park are scheduled for logging, so this effect would be minor.

Impairment Analysis for Water Quality – Alternative 1. Of all of the vessel discharges that would occur under alternative 1, only a catastrophic fuel spill as a result of a grounding or collision, or a spill in ice-filled water, would result in a long-term major water quality effect. Based on historical data, the likelihood of catastrophic spills is low (Eley 2000) and effects can be minimized in open water with an effective spill response. The park maintains a supply of spill response equipment at Bartlett Cove and Blue Mouse Cove. Table 2 of appendix F identifies the location, quantity, and deployment time for this equipment. In addition, the Alaska Department of Environmental Conservation has adopted a USCG proposal that provides fuel spill response expectations for the tank vessel and cruise ship industry. The expectations include response guidelines for the two, six, 12, and 24-hour timeframes. Appendix B of the *Needs Assessment for a Major Fuel Oil Spill* (Eley 2000) details the proposal. In the case of a spill that enters ice-filled waters, however, no technology exists to contain or remediate the spill. Because there is a very low probability of a spill in ice-filled waters, the risk of such a spill causing an impairment of park water resources is low. In conclusion, with the exception of a large-scale catastrophic spill or spill in ice-filled waters, the level of impacts anticipated from alternative 1 would not impair water quality.

Potential Mitigation Measures for Water Quality – Alternative 1.
Mitigation measures that could be used to protect water quality include:

- educating ship captains about the causes of collisions and groundings that could result in spills, including knowledge of local conditions and hazards such as strong currents, submerged rocks, floating ice, and vessel traffic patterns.
- educating permit holders about waste minimization and proper disposal of waste to reduce the discharge of marine debris.
- requiring each cruise ship pollution minimization plan to include a section regarding solid waste minimization and proper disposal of waste.
- working with state and federal water quality regulators to enhance enforcement of water quality regulations.
- removing marine debris periodically, as needed.
- establishing a water quality monitoring program to establish a database of water quality parameters.
- incorporating into the concession contracts of those tour vessels that are allowed to discharge treated wastewater continuously a provision that, whenever feasible, those operators will avoid stationary discharge of wastewater, as well as discharge in areas where the movement or flux of water is limited.
- upgrading spill response equipment and training for NPS, USCG, and vessel operations.
- requiring the Park Service to convert to four-stroke engines by 2006.
- employing the mitigation measures in subsection 4.3.6, such as establishment of a 500-foot no-wake zone with a speed limit of 3 knots within 500 feet of the shoreline to reduce additional sediment re-suspension in the nearshore habitat.

Conclusion, Water Quality – Alternative 1. The overall direct and indirect effects to water quality would be minor because changes in water quality would be short-term and localized. The cumulative effect would be minor. Moreover, implementation of alternative 1 would not likely result in impairment of water quality resources in the park, with the exception of a large-scale catastrophic oil spill; therefore, the overall effect of this alternative on water quality would be minor.

Alternative 2 – Effects on Water Quality. With the implementation of alternative 2, fewer cruise ships would enter Glacier Bay and Dundas Bay each year and the level of entries by tour vessels would remain the same. The number of seasonal-use days for charter and private vessels would decrease.

Direct and Indirect Effects on Water Quality – Alternative 2. This section discusses the potential effects from three main pollutant sources that may be discharged from vessels: petroleum from a fuel release; wastewater and other contaminants, and marine debris; and the potential effects of re-suspension of sediments.

<u>Petroleum from a Fuel or Oil Release</u>. As discussed in the evaluation of alternative 1, petroleum products can be released by vessels into the Bay through discharge of oily bilge water, use of two-stroke engines, at the fuel transfer facilities, or by collision or grounding. Also as discussed in alternative 1, contamination from a bilge water release would be limited to the immediate area of discharge and any accidental discharge would be dispersed over a larger area; therefore, the potential effects to water quality likely would be minimized. Under alternative 2, the occurrences and effects on water quality of discharges of bilge water may be incrementally lower because of the reduction of seasonal-use days and entries for all vessels in Glacier Bay; however, the potential alterations to water quality would remain the same, and are considered minor under alternative 2.

The operation of two-stroke engines in Glacier Bay or Dundas Bay can result in a small sheen of oil forming on the water where the engine is being run. Alternative 2 would reduce the seasonal entries and use days for private vessels; therefore, fewer smaller vessels that typically use the two-stroke engines would be in the Bay. The effects of their use under this alternative would be considered minor because the potential for discharge would still exist.

Potential water quality changes as a result of fueling at the Bartlett Cove and Blue Mouse Cove facilities would be less than those of alternative 1 because of the decrease in the number of seasonal entries and seasonal-use days for charter and private vessels. The potential for a spill also would be reduced for the same reason. A small, localized spill at these facilities would be minor, but a spill under upset conditions could be more widespread, may be more difficult to fully contain, and would result in a larger area having degraded water quality for a longer period of time. Such a spill would be considered a moderate effect.

The risk of a vessel grounding or a collision under this alternative and a resulting fuel spill would be incrementally lower than under alternative 1. Although there is not a direct correlation between the number of vessels and the likelihood of a grounding or collision, it is expected that the overall reduction in cruise ships and charter and private vessel seasonal entries and seasonal-use days under this alternative would reduce the probability of groundings and collisions. The effects of large catastrophic petroleum spills, however, would remain the same, and constitute a major effect on water quality.

Overall, under normal operations, the anticipated effects from petroleum releases through the implementation of alternative 2 would be minor given that the risk of a major upset would be low.

<u>Wastewater and Other Contaminants</u>. Similar to alternative 1, the likelihood of a release of wastewater from a large cruise ship is low and water quality changes due to discharge of graywater or blackwater would be limited to the immediate discharge area. Implementation of alternative 2 would allow fewer seasonal-use days and entries for all vessel categories, except tour vessels, which could incrementally reduce the potential for a discharge of wastewater. In the case of smaller vessels that discharge continuously, wastewater would be diluted and dispersed; therefore, as with alternative 1, the discharge of wastewater is considered a minor potential effect under alternative 2.

The potential for discharge of solid waste and ballast water may be incrementally lessened by the reduction in cruise ships entering the Bay in alternative 2; however, the effects would be similar to those of alternative 1 and would constitute a minor effect on water quality.

<u>Marine Debris</u>. Marine debris already is present in Glacier Bay and would be expected to be present with implementation of alternative 2. Most of the marine debris in the park is discharged from vessels not covered in this EIS, and the volumes discharged by vessels covered in this document would be low under alternative 2; therefore, the changes to water quality from the volume of marine debris in Glacier Bay under alternative 2 would be minor, and potentially lower than those of alternative 1.

<u>Re-Suspension of Sediments</u>. Similar to alternative 1, vessels potentially would re-suspend sediments in the nearshore area during minus tides and near glaciers where there are freshwater lens. This would be considered a minor effect because it would be local and short-term.

Summary of Direct and Indirect Effects on Water Quality – Alternative 2. Implementation of alternative 2 compared to the implementation of alternative 1 could result in incrementally fewer changes to water quality because of the reduction of seasonal entries and seasonal-use days for all vessel categories except tour vessels entering Glacier Bay; however, the overall consequences would be similar. Alternative 2 would result in minor effects as a result of small discharges of fuel oil from bilge water, two-stroke engines, fuel transfer operations, or a discharge of other contaminants that would be localized and only temporarily change water quality. Additionally, the re-suspension of sediments and marine debris also would result in short-term localized changes to water quality. These tend to result from routine operations and activities, and the effects would be short-term and limited to the immediate area of discharge. Upsets at the Bartlett Cove or Blue Mouse Cove fueling stations or a release from a stationary vessel could result in moderate effects to water quality (i.e., a short-term change in water quality), because of the potential volumes of fuels that could be discharged. A large-scale catastrophic spill would result in major effects to water quality (i.e, a long-term reduction in water quality). Either scenario could be minimized with spill response technology.

The overall effect of implementation of alternative 2 would have minor effects on water quality. These effects would be fewer than those from the implementation of alternative 1 because of the decrease in seasonal-use days and because entries for most vessel classes would reduce the risk of upsets. The occasional release of petroleum through normal operations, however, would not cease, so small discharges that would result in temporary changes to water quality would still be anticipated.

Cumulative Effects on Water Quality – Alternative 2. The cumulative effects of external actions (e.g., other vessels used in the park that are not managed under this plan, vessels operated outside Glacier Bay and Dundas Bay, increases in population and tourism in Southeast Alaska, and logging in the Tongass National Forest) in conjunction with alternative 2 could be less than those of alternative 1 because of the proposed decrease in vessel traffic and quotas. The decline in commercial fishing vessel traffic in Glacier Bay over time will also reduce the potential for water quality changes. The effects of the external actions are not expected to change the water quality of the park significantly; therefore, the cumulative impact of this alternative would be minor.

Impairment Analysis for Water Quality – Alternative 2. Similar to alternative 1, only a catastrophic fuel spill resulting from a collision or grounding on open waters or a spill in ice-filled water would result in a long-term major water quality effect. The possibility of a catastrophic spill occurring would be low and reduced compared to alternative 1 because of the reduction in daily vessel quotas. The effects, in open water, could be minimized. The risk of a spill would be less than that in alternative 1 because fewer vessels would be entering Glacier Bay; therefore, the potential for an effect to result in impairment of park water resources is low.

Potential Mitigation Measures for Water Quality – Alternative 2. Because of the sensitivity of this resource, mitigation measures that could be used to maintain high water quality would be the same as those described in alternative 1.

Conclusion, Water Quality – Alternative 2. The direct and indirect effects of alternative 2 would be minor because they would be short-term and localized, with the exception of a large-scale catastrophic fuel spill, which would have major effects. The cumulative effect of this alternative would be minor. Moreover, implementation of this alternative would not result in impairment of water quality resources in the park; therefore, the overall effect of the implementation of this alternative would be minor.

Alternative 3 – Effects on Water Quality. Alternative 3 would continue the current vessel management activities and operating restrictions, but would allow future increases in cruise ship traffic up to the quotas authorized in the 1996 vessel management plan. Alternative 3 is similar to alternative 1, except seasonal entry quotas for cruise ships would increase in time from the current total of 139 to a total of 184.

Direct and Indirect Effects on Water Quality – Alternative 3. This section discusses the potential changes to water quality from four parameters: petroleum from an oil or fuel release, wastewater and other contaminants, marine debris, and re-suspension of sediments.

<u>Petroleum from a Fuel or Oil Release</u>. Discharges from the use of two-stroke engines, small bilge releases, and spills at the fueling facilities would remain identical as those under alternative 1, because there would be no change in the number of smaller vessels under this alternative. These effects are considered minor, because they would be temporary and limited to the immediate area of the discharge.

For a worst-case discharge at either the Bartlett Cove or Blue Mouse Cove fueling station, or a release from a stationary vessel, direct adverse effects would be more extensive than those of small spills. If petroleum were discharged while a vessel is stationary, effects of the petroleum may be more significant. The fueling facility takes precautions to avoid spills, and when a spill occurs, the spill response capability is high. These types of spills are anticipated to be short-term and could result in a threat to the health of wildlife and/or their habitat. The effects would be much the same as those under alternative 1, but there would be a slightly higher probability that a spill may occur under this alternative if seasonal-use days and entries were increased to 184.

Although a direct correlation would be difficult to make, the increases in the total number of cruise ships with seasonal entry permits under this alternative could incrementally increase the likelihood for a major spill over the long term. While the total number of cruise ships allowed in the park in a year would be greater under this alternative than in current conditions, the number of cruise ships in the Bay at any one time would be the same as the current conditions; therefore, like alternative 1, the potential for a collision, a grounding, or other en-route accidents resulting in a large spill would be low but slightly higher than that of alternative 1 (see subsection 4.4.3, "Vessel Use and Safety"). Any large catastrophic spill resulting from an accident would be considered a major effect.

Overall, the implementation of alternative 3 would result in minor effects to water quality as a result of petroleum releases under normal operating circumstances. The effects would be similar to those of alternative 1; however, the risk of an upset would remain low, but slightly higher than that in alternative 1 (see subsection 4.4.3, "Vessel Use and Safety").

Wastewater and Other Contaminants. It is assumed that under this alternative, there would be a proportional increase in potential discharges due to the increased number of vessel entries over current conditions. Because graywater or blackwater discharges are diluted within less than 15 minutes and would be limited to the area immediately surrounding the discharge, and the potential for a large cruise ship discharging wastewater is low, the changes to water quality due to the discharge of wastewater would be the same as those under alternative 1 and would be considered minor. In addition, under the pollution minimization plan included in the concession permit, cruise ships should take reasonable measures to address discharges in park waters.

The potential for discharge of solid waste and ballast water may be incrementally greater because of the increase in the number of cruise ships entering the Bay over the summer season; however, the changes to water quality would be similar to those of alternative 1 and would constitute a minor effect on water quality under alternative 3.

Marine Debris. Marine debris already is present in Glacier Bay and would be expected to be present with implementation of alternative 3. Most of the marine debris in the park is discharged from vessels not covered in this EIS, and the volume discharged from vessels covered in this document is low. The increased number of vessels under alternative 3 would likely result in an increase in marine debris incrementally greater than that under alternatives 1 and 2. However, the volume would remain low; therefore, the effect of the volume of marine debris on the Bay's water quality in alternative 3 would be minor.

Re-Suspension of Sediments. Under alternative 3, vessels would re-suspend sediments in the nearshore area during minus tides and near glaciers where there are freshwater lenses. As under alternative 1, this is considered to be a minor change to water quality because the daily vessel limit would remain the same and the effects would be local and short-term.

Summary of Direct and Indirect Effects on Water Quality – Alternative 3. Alternative 3 would result in minor changes to water quality as a result of small discharges of fuel oil from bilge water, two-stroke engines, fuel transfer operations or a discharge of other contaminants, re-suspension of sediments, and marine debris. Moderate effects may occur as a result of larger spills at the Bartlett Cove and Blue Mouse Cove fueling facilities, or a release from a stationary vessel, and water quality could be altered to levels that violate Alaska and federal water quality standards. Major effects are unlikely, but could occur as a result of a worst-case scenario spill due to collision or grounding, or a severe spill in ice. In the unlikely event of a catastrophic spill, such as a total loss of all fuel aboard a large cruise ship or fuel barge, there would be a major effect on water quality; however, under normal operations, the implementation of this alternative would have minor direct and indirect effects on water quality.

Cumulative Effects on Water Quality – Alternative 3. The cumulative effects of alternative 3 and other external actions (e.g., other vessels used in the park not managed under this plan, vessels operated outside Glacier Bay and Dundas Bay, increases in population and tourism in Southeast Alaska, and logging in the Tongass National Forest) would be similar, but not identical to those of alternative 1. Over time, with the cessation of commercial fishing in Glacier Bay, there would be a decrease in potential effects on water quality from releases from the vessels. The cumulative effects could be slightly greater than those of alternative 1 because of the proposed increase in vessel entries; however, the effects of the external actions, with the exception of a large-scale catastrophic spill, would not significantly change the water quality of the park, and the cumulative effect on water quality under this alternative would be minor.

Impairment Analysis for Water Quality – Alternative 3. Similar to alternative 1, only a catastrophic fuel spill resulting from a collision or grounding on open waters or a spill in ice-filled water would result in a long-term major water quality effect. The possibility of a catastrophic spill is low, and the effects in open water under good conditions can be minimized. Although additional cruise ships would be allowed in the park under alternative 3, the risk of a major spill is similar to, but incrementally greater than, that of alternative 1 because a larger number of vessels would be in Glacier Bay seasonally; therefore, the potential for an effect to result in impairment of park water resources is low.

Potential Mitigation Measures for Water Quality – Alternative 3. Because of the sensitivity of this resource, mitigation measures to maintain high water quality are the same as those described in alternative 1.

Conclusion, Water Quality – Alternative 3. Implementation of alternative 3 may result in incrementally greater effects on water quality compared to alternative 1 because of the increased number of cruise ships entering Glacier Bay. The overall direct and indirect effects of the implementation of this alternative would be minor because changes to water quality as a result of normal operations would be short-term and localized; however, a catastrophic large-scale fuel spill could result in major effects. The contribution of cumulative effects from other activities would be negligible. Moreover, implementation of this alternative would not result in impairment of water quality resources in the park. The overall effect of the implementation of this alternative would be minor.

Alternative 4 – Effects on Water Quality. Under alternative 4, the number of cruise ships entering Glacier Bay would be limited to 92 during the regular season. The number of cruise ships allowed in the months of May and September would be decreased to 61. The daily quotas for other vessel classifications would be slightly reduced. There would be a reduction in the number of seasonal-use days for cruise ships, tour vessels, and charter vessels; however, there would be a slight increase in the number of seasonal-use days for private vessels. Seasonal entries would be discontinued. Cruise ships and tour vessels would be restricted from Dundas Bay, Beardslee Entrance, and the East Arm (tour vessels would be allowed in the entrance waters of the East Arm).

Direct and Indirect Effects on Water Quality – Alternative 4. This subsection discusses the potential changes to water quality due to: petroleum from an oil or fuel release, wastewater and other contaminants, marine debris, and re-suspension of sediments.

<u>Petroleum from a Fuel or Oil Release</u>. The reduced number of cruise ship seasonal-use days under alternative 4 could result in a lower level of risk for the inadvertent discharge of bilge water. Additionally, restricting tour vessels from entering Dundas Bay would avoid the risk of a discharge of oily waste in Dundas Bay. Because cruise ships do not use the Bartlett Cove marine transfer facility or the Blue Mouse Cove fuel barge, the existing level of use of these facilities would not change; the potential for small petroleum releases during normal operations would decrease slightly from existing conditions because of the reductions in daily vessel quotas for tour, charter, and private vessels. The slight increase in private vessel seasonal-use days would not be expected to change the potential for a release. These releases could result in short-term, localized changes to water quality; however, an upset at these facilities would still result in moderate effects on water quality.

The risk of a vessel grounding or collision and a resulting fuel spill under this alternative would be incrementally lower than that under alternative 1 because of the overall reduction in vessels in the park at any given time; however, the potential effects of a large petroleum discharge would remain the same and represent a major effect on water quality. Under this alternative, the restrictions on tour vessels in Dundas Bay and tour vessels and cruise ships in the East Arm of Glacier Bay would reduce the likelihood of fuel spill effects in those areas. In addition, under this alternative, the formally defined cruise ship routes (typically in mid-channel) would better separate the various users, and provide an increased margin of safety for the avoidance of nearshore collisions. The reduced ship speed to 13 knots under this alternative may also reduce the potential for accidents in tight conditions.

Under normal operations, the effects from petroleum releases through implementation of this alternative would be minor.

<u>Wastewater and Other Contaminants</u>. Under this alternative, the potential for a large cruise ship to release wastewater is low and would be lower than that under alternative 1 because fewer large cruise ships would enter the park. As with the other alternatives, the changes to water quality from a release would be limited in size and duration. The changes to water quality from smaller vessels that discharge continuously would be similar to those of alternative 1 — short-term and localized.

The potential for discharge of solid waste and ballast water would be incrementally smaller than that in alternative 1 because of the reduction in cruise ships entering Glacier Bay; however, the changes to water quality would be similar to those in alternative 1 and would constitute a minor effect on water quality under alternative 4, because they would be short-term and localized.

<u>Marine Debris</u>. Marine debris, most of which is discharged from vessels not covered in this document, is present in Glacier Bay and would be expected to be present with implementation of alternative 4. The volume of debris from vessels covered in this document would be low under alternative 4; therefore, similar to alternative 1, the effect of marine debris in the Bay on water quality would be minor.

<u>Re-Suspension of Sediments</u>. Under alternative 4, vessels would re-suspend sediments in the nearshore area during minus tides and near glaciers when there are freshwater lenses. This would be considered a minor effect because it would be local and short-term. Under alternative 4, cruise ships would be required to remain in mid-channel waters. This restriction would reduce nearshore re-suspension of sediments over current conditions. Additionally, there would be a reduction of any

potential re-suspension of sediments in Dundas Bay, Beardslee Entrance, and parts of the East Arm because cruise ships and tour vessels would be restricted from these areas.

<u>Summary of Direct and Indirect Effects on Water Quality – Alternative 4</u>. Water quality could be degraded under alternative 4 because of small discharges of fuel oil from bilge water, two-stroke engines, fuel transfer operations, or a discharge of other contaminants, but changes would be temporary and localized. Additionally, the re-suspension of sediments and the discharge of marine debris would occur. Moderate effects may occur as a result of larger spills at the Bartlett Cove and Blue Mouse Cove fueling facilities. An unlikely catastrophic event, such as a total loss of all fuel aboard a large cruise ship or fuel barge, or a severe spill in ice-filled waters, would result in major effects on the water quality. The implementation of this alternative under normal operations, overall, would have minor direct and indirect effects on water quality.

Cumulative Effect on Water Quality – Alternative 4. As with alternative 1, the cumulative effects of other activities (e.g., other vessels used in the park that are not managed under this plan, vessels operated outside Glacier Bay and Dundas Bay, increases in population and tourism in Southeast Alaska, and logging in the Tongass National Forest) in conjunction with the effects of alternative 4 could contribute to changes in water quality in the park, but the effects would be slightly less than those resulting from alternative 1 because of the proposed decrease in vessel traffic and quotas. The decrease in commercial fishing in Glacier Bay also will decrease the potential changes to water quality. Overall, the cumulative effect of this alternative would be minor.

Impairment Analysis for Water Quality – Alternative 4. As discussed in the analysis for the previous alternatives, because of the low overall risk of an accident that would result in a fuel spill and the spill response capacity in Glacier and Dundas Bays, alternative 4 would not result in an impairment of park water resources. Only a catastrophic fuel spill resulting from a collision or grounding on open waters or a spill in ice-filled water would result in a long-term major water quality effect. The likelihood of this type of spill occurring is low, and the effects, under good conditions, can be minimized with spill response technology.

Potential Mitigation Measures for Water Quality – Alternative 4. Because of the sensitivity of this resource, mitigation measures to maintain high water quality are the same as those described in alternative 1.

Conclusion, Water Quality – Alternative 4. The potential effects of the implementation of alternative 4 could result in incrementally fewer effects to water quality than alternative 1 because of the reduction of cruise ships and other vessel classes (seasonal basis) entering Glacier Bay. Routine effects as a result of operations of smaller vessels would remain, but be incrementally reduced. The overall direct and indirect effects would be minor because of normal operations, because changes to water quality would be temporary and localized, with the exception of a catastrophic spill. The cumulative effect of this alternative would be minor. Moreover, implementation of this alternative would not result in impairment of water quality resources in the park. The overall effect of this alternative on water quality would be minor.

Alternative 5 – Effects on Water Quality. Under alternative 5, the number of cruise ships entering the park would be the same as that in alternative 1 from June to August, but the entries would be fewer in May and September. Cruise ships would be restricted from Dundas Bay, Beardslee Entrance, and Adams Inlet under this alternative. Tour vessels would be restricted from wilderness waters of Dundas Bay and would be limited by daily vessel quota and seasonal-use days. The number of private vessel seasonal-use days would increase from alternative 1 to 5.

Direct and Indirect Effects on Water Quality – Alternative 5. This subsection discusses the potential damage to water quality due to petroleum from an oil or fuel release, wastewater and other contaminants, marine debris, and re-suspension of sediments.

<u>Petroleum from an Oil or Fuel Release.</u> Petroleum products can be released by vessels into the Bay through discharge of oily bilge water, use of two-stroke engines, spills at the Bartlett Cove or Blue Mouse Cove fuel facilities, or collision or grounding. All changes to water quality would be anticipated to be the same as those in alternative 1 because the number of cruise ship entries would remain the same, and the number of two-stroke private vessel entries would increase. The changes to water quality from oily bilge water and the use of two-stroke engines under alternative 5 would be minor. The number of small spills at the Bartlett Cove and Blue Mouse Cove facilities would be the same as those under alternative 1 and would have the same temporary and highly localized effects, in which state and federal water quality standards could be exceeded. therefore, these spills would constitute a minor effect on water quality. A worst-case-scenario spill at these facilities would be short-term and localized, and would constitute a moderate effect on water quality.

The risk of a vessel grounding or collision under this alternative and a resulting fuel spill would be equivalent to that of alternative 1. Changes in water quality due to a severe petroleum discharge as a result of collisions, groundings, and other en-route accidents would remain the same, and therefore would constitute a major effect on water quality. Under this alternative, the restrictions on tour vessels in Dundas Bay and cruise ships in Adams Inlet would reduce the likelihood of a fuel spill in those areas. In addition, under this alternative, the formally defined cruise ship routes (typically in mid-channel) would better separate the various users, and provide an increased margin of safety for the avoidance of near-shore collisions. Cruise ship speeds would be reduced to 13 knots, which would likely reduce the potential for catastrophic spills by providing more time for course corrections.

<u>Wastewater and Other Contaminants</u>. Implementation of alternative 5 would allow the same number of cruise ships into Glacier Bay as alternative 1, but an increase in the number of private vessel seasonal-use days. There would be a small change in the likelihood of discharge of wastewater, or the changes to water quality due to such discharge, as compared with alternative 1; therefore, as with alternative 1, the discharge of wastewater would be considered a minor effect under alternative 5. Under alternative 5, the potential for discharge of solid waste and ballast water would be the same as that under alternative 1, and would constitute a minor effect on water quality under alternative 5.

<u>Marine Debris</u>. Most of the marine debris in the park is discharged from vessels not covered in this document. The volume of marine debris currently present in Glacier Bay would be expected to be present with implementation of alternative 5; therefore, the effect of marine debris on water quality under alternative 5 would be minor.

<u>Re-Suspension of Sediments</u>. Under alternative 5, vessels would re-suspend sediments in the nearshore area and near glaciers with freshwater lenses. This would be considered a minor effect because it would be local and short-term.

<u>Summary of Direct and Indirect Effects on Water Quality – Alternative 5</u>. Under alternative 5, minor changes to water quality could result from small discharges of fuel oil from bilge water, two-stroke engines, fuel transfer operations, or a discharge of other contaminants. Additionally, the re-suspension of sediments and marine debris also could cause temporary changes to water quality. Worst-case-scenario spills at the Bartlett Cove and Blue Mouse Cove fueling facilities could alter water quality such that contaminant levels would exceed state and federal water quality standards. Major effects also could occur from worst-case-scenario spills as a result of grounding or collision, especially in ice-filled waters; however, the likelihood of this type of spill is low. This alternative would slightly reduce the likelihood of a spill through closure of Adams Inlet to cruise ships, closure of all wilderness waters to tour vessels, and reduction of the cruise ship speed limit to 13 knots. Other than an unlikely catastrophic event, such as a total loss of all fuel aboard a large cruise ship or fuel barge, the implementation of this alternative, overall, would have a minor effect on water quality.

Cumulative Effects on Water Quality – Alternative 5. The cumulative effects from the implementation of alternative 5 with the other activities affecting the park (e.g., other vessels used in the park that are not managed under this plan, vessels operated outside Glacier Bay and Dundas Bay, commercial fishing vessels operating in Glacier Bay, increases in population and tourism in Southeast Alaska, and logging in the Tongass National Forest) would result in effects similar to those of alternative 1. The cumulative effects of the other actions, with the exception of a large-scale catastrophic spill, would not contribute significantly to changes in water quality in the park, and the effect would be minor.

Impairment Analysis for Water Quality – Alternative 5. Similar to alternative 1, only a catastrophic fuel spill resulting from a collision or grounding on open waters or a spill in ice-filled water would result in a long-term major water quality effect. The possibility of a catastrophic spill occurring is low, and the effects, in open water, can be minimized. The risk of a spill is less than that in alternative 1 with the addition of vessel speed limits; therefore, the potential for an effect to result in impairment of park marine water resources is low.

Potential Mitigation Measures for Water Quality – Alternative 5. Mitigation measures to maintain high water quality are the same as those described in alternative 1.

Conclusion, Water Quality – Alternative 5. The potential effects of the implementation of alternative 5 would result in similar effects as that under alternative 1, because the same number of cruise ships vessels would be allowed in Glacier Bay over the course of the season, but there would be an increase in the number of private vessel seasonal-use days. The overall direct and indirect effects of this alternative on water quality under normal operations would be minor; only temporary, localized changes to water quality would be anticipated, with the exception of a catastrophic fuel spill. The cumulative effects of this alternative would also be minor. Moreover, with the exception of a large-scale catastrophic spill, implementation of this alternative would not result in impairment of water quality resources in the park. Overall, the effect of implementing this alternative would be minor.

Summary, Water Quality. All of the alternatives would result in minor effects on water quality, with the exception of a catastrophic spill of oil or fuel by a cruise ship or fuel barge. The only potential major effect on water quality would be due to a large oil or fuel spill. While this event is unlikely, and a direct correlation is difficult to determine, the addition or reduction in vessels entering the Bay may incrementally increase or decrease, respectively, the likelihood of the event over the long term. When considered in a cumulative context, the contribution of each of the alternatives to a cumulative water quality effect is minor. Finally, none of the alternatives would directly result in an impairment of park water resources.

4.3.1 THREATENED AND ENDANGERED SPECIES

4.3 BIOLOGICAL ENVIRONMENT

4.3.1 Threatened and Endangered Species

Two species present within the park are listed as threatened or endangered under the Endangered Species Act of 1973 (ESA). The central North Pacific stock of humpback whales (*Megaptera novaeangliae)* is listed as endangered and is a seasonal resident of Glacier Bay and Dundas Bay. The threatened eastern stock of Steller sea lions uses a haul-out (south Marble Island) in Glacier Bay and one rookery (Graves Rocks) along the outer coast of the park. Individuals from the endangered western stock of Steller sea lions also use south Marble Island (Raum-Suryan and Pitcher 2000; Raum-Suryan 2001), but they represent only a small fraction of the total Steller sea lion population in Glacier Bay.

Issues of Concern Raised during Scoping. Specific concerns expressed by the public regarding threatened and endangered species in Glacier Bay include the following:

- The sight and noise of vessel traffic alter humpback whale and Steller sea lion behavior; therefore, any increase in the number of vessels would further disrupt their behavior.
- Vessels travelling at high speeds could cause whale fatalities due to collisions.
- Increases in vessel traffic could result in increased vessel collisions, and whale or sea lion mortality or injury could result from such collisions.
- Increases in vessel traffic will increase marine debris, contamination and the risk of a large oil spill, which could harm whales and sea lions.
- Whales at Bartlett Cove may be harmed because of the high level of vessel traffic there.

Regulatory Framework. The 1996 decision included several protection measures for both the humpback whale and Steller sea lion, building upon others that had been established through biological opinions issues by the NOAA Fisheries under ESA consultations.

Park regulations prohibit vessels from pursuing or approaching within ¼ mile of a humpback whale in all Glacier Bay National Park waters (36 CFR 13.65(b)(3)(i)). The Glacier Bay regulations are more strict than the 100-yard minimum approach distance dictated by the NOAA Fisheries that prohibit approach within 100 yards of humpback whales in Alaska (50 CFR 224.103).

Several regulations are in also in place to protect Steller sea lion haul-out areas. Park regulations prohibit vessels from approaching within 100 yards of the Steller sea lion haul out at South Marble Island (36 CFR 13.65(b)). NOAA Fisheries guidelines for viewing marine mammals in the wild recommend that people “remain at least 100 yards from whales, dolphins, porpoises, and from seals and sea lions that are on land, rock, or ice.” A copy of the marine mammal viewing guidelines is available at http://www.fakr.noaa.gov/protectedresources/mmviewingguide.html (NOAA Fisheries

2002). While the NOAA Fisheries guidelines are only suggestions, NOAA Fisheries considers that, in most cases, following these guidelines will avoid taking marine mammals, including harassment (*Federal Register,* Volume 67, Number 20, 30 January 2002).

Also common to all alternatives are vessel course and speed restrictions in "whale waters." Whale waters restrictions are implemented by the Park Superintendent to protect humpback whale aggregations in Glacier Bay (36 CFR 13.65(b)(3)(iv)(A)). The locations of designated whale waters are re-evaluated in various alternatives (see Table 2-13) to simplify Park regulations and maximize their effectiveness, but the use of temporary whale waters to protect humpback whales is common to all alternatives. The Superintendent can also implement "temporary whale waters" course and speed restrictions anywhere in Glacier Bay where warranted by the presence of whales. Specific criteria are applied to help determine the need for vessel restrictions. Typically, mid-channel course restrictions and a 10 knot speed limit are implemented when more than one humpback whale is seen consistently in an area over 3 or more days, or when the whales begin to concentrate in mid-channel or in areas of heavy vessel traffic (e.g., Bartlett Cove or South Marble Island). The purpose of vessel speed and course restrictions is to minimize whale disturbance and lower the risk of whale/vessel collision.

Threatened and endangered species are protected under the Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972. The Endangered Species Act provides for the listing of endangered and threatened species of plants and animals, as well as the designation of critical habitat for those species. The act prohibits the "taking" of any endangered species by any person or vessel subject to the jurisdiction of the United States, including federal agencies and any actions authorized by a federal agency, without an incidental take authorization. The definition of "taking" includes injury and harassment. The Endangered Species Act also requires federal agencies to exercise their authority, through consultation with the NOAA Fisheries, not to take any action that may jeopardize the species' continued existence.

The National Park Service has initiated consultation with the NOAA Fisheries under Section 7 of the Endangered Species Act. This consultation is to address potential effects on the humpback whale and Steller sea lion. This draft environmental impact statement serves as a biological assessment, as defined under Section 7 of the Endangered Species Act.

No defined or proposed critical habitat for threatened or endangered species is present in the planning area.

Humpback whales and Steller sea lion are also protected under the Marine Mammal Protection Act (see section 4.3.2, Marine Mammals).

Methodology and Assumptions. Based on the requirements of the Endangered Species Act and the Marine Mammal Protection Act, this environmental impact statement focuses on the two effect categories: harassment and harm.

Table 4-13 defines the thresholds use to describe the overall level of effects determined through the analysis.

TABLE 4-13: THRESHOLD CRITERIA FOR THE EFFECTS ANALYSIS ON THREATENED HUMPBACK WHALES AND ENDANGERED STELLER SEA LIONS IN GLACIER BAY AND DUNDAS BAY

Negligible	The behavior, hearing, abundance, or distribution of one or more Steller sea lions or humpback whales would change because of vessel activity for less than one day. These temporary changes would have little or no effect on individual survival or reproduction.
Minor	The behavior, hearing, abundance, or distribution of one or more Steller sea lions or humpback whales would change because of vessel activity for more than one day but less than the remainder of the 92-day vessel season. The changes would not reduce individual survival or reproduction.
Moderate	The behavior, hearing, abundance, or distribution of one or more Steller sea lions or humpback whales would change because of vessel activity for a period longer than the 92 day vessel season, but less than one year. Mortality or injury to a very small number of individuals could occur as a result of ship collisions or individuals could experience sublethal effects that lead to reductions in long-term survival or reproduction. Population-level distribution, abundance, survival, or reproduction in Glacier Bay, Dundas Bay and Southeast Alaska would remain unchanged.
Major	The behavior, hearing, abundance, distribution or mortality of Steller sea lions or humpback whales would permanently change because of vessel activity, resulting in reduced individual survival or reproduction sufficient to change population-level distribution and abundance in Glacier Bay, Dundas Bay and Southeast Alaska, jeopardizing the stock's continued existence.

Methods to evaluate effect — Based on scientific literature, professional judgment, and published NOAA Fisheries opinions regarding marine mammal sound exposure, received levels in excess of 130 decibels were estimated to be sufficient to have the potential to change the behavior of whales (e.g., cause them to avoid the area, dive, or interfere with their feeding or communication). Because seals and sea lions are generally less sensitive to underwater noise than whales, dolphins, and porpoises (Ketten 1998), any evaluation of effects based on analyses for humpback whales will provide a conservative evaluation of the effects on Steller sea lions. The analysis compares alternatives by estimating the amount of potential whale and sea lion habitat that could be ensonified to 130 decibels or more over a given period of time.

Noise levels from motorized vessel traffic were estimated using a Zones of Influence model developed by Richardson et al. (1995) and described in Appendix C. Sound propagation was estimated using a transmission loss model developed by Malme et al. (1983). The transmission loss model was updated using current vessel sound signatures (Kipple 2002) and adapted to include three major bottom topography and substrate features present in the planning area (Malme et al. 1983). Source levels of underwater noise were calculated using the noise signatures of cruise ships, tour vessels and charter vessels. Cruise vessel noise signatures were recorded at a speed of 10 knots

(Kipple 2002). One reading of a cruise ship traveling at 19 knots was used to estimate faster moving cruise ships. This reading may not be representative of all cruise ships traveling outside of whale waters. Vessel noise is unique for each vessel (the sound generated from a particular vessel is called the "sound signature"). Some cruise ships actually become quieter as they speed up from certain speeds, due to the vessel rising in the water or some other factors. In addition, the movement of sound through the water is complex, especially within the complex underwater topography of Glacier Bay. Still, this reading was included in this assessment to provide a general estimate of noise generated from cruise ships at speeds near which they travel outside of whale waters. Therefore, estimates based on this reading are general approximations, based on the best available information. Tour, charter, and private vessels noise signatures recorded in the 1980s (Malme et al. 1983) were used because no new recordings have been made. "Ensonification," in this document, means an area that is exposed to noise above the 130 decibels.

Alternative 1 (No Action) – Effects on Threatened and Endangered Species.

Estimation of ensonified area — alternative 1 — Vessel noise is prevalent under water throughout much of Glacier Bay and Dundas Bay. Based on recent results from the underwater sound study being conducted at Glacier Bay, peak vessel noises average 94 decibels, or about 11 decibels louder than the average wind noise level (NSWC 2002). The percentage of samples (one taken every hour) in which vessel noise was detected ranged from nearly 70% in August to 7% in December. The average daily detection rate was 32%.

When traveling at relatively high speeds (greater than 10 knots), cruise ships "ensonify" areas much greater than any other vessel type that visits Glacier and Dundas Bays (in this EIS, to ensonify means to expose an area to noise greater than 130 decibels). Based on calculations use the vessel signatures recorded by Kipple (2002), cruise ships traveling at 10 knots projected noise at or above 130 decibels for about 500 meters (LGL 2003). Only one measurement of a vessel traveling faster was included in the evaluation. That vessel, however, was estimated to project noise at or above 130 decibels for up to 5,000 meters, or approximately 3 miles. While this zone is only a rough estimation, it does show that cruise ships can be considerably louder when traveling at relatively high speeds. This is the area in which humpback whales and Steller sea lion could alter their behavior in response to the sound generated by the cruise ship. Behavioral changes could range from leaving the area to no change at all. While some humpback whales and Steller sea lions may avoid the "ensonified" area, others may remain.

Because of the relatively great distance at which cruise ships generate noise above 130 decibels, and because cruise ships travel up the entire length of Glacier Bay to Tarr Inlet, it is assumed that most of Glacier Bay's waters are exposed temporarily to sound levels greater than 130 decibels every time a cruise ship visits the Bay. However, at any one time, the amount of area affected is much smaller. The six-mile diameter ensonification zone represents about 6% of the total area of Glacier Bay. At any one time, no more than two cruise ships would be traveling at relatively high speeds. At such times, the total area of Glacier Bay affected at one time would be roughly 12%. This situation represents the most area that would be affected by noise at any one time.

In whale waters, when whales are present and speed limits are set at 10 knots (which occurs each year when whales begin to concentrate), cruise ship noise is dramatically less (see the discussion above on noise related to cruise ship speed). Also, in whale waters, cruise ships (and all other vessels) are required to remain at least one mile from shore. Because of this, nearshore areas, where most whale (and other marine mammal sightings occur), would not be subject to noise levels greater than 130 decibels as frequently as other areas. Based on the Glacier Bay Underwater Noise Interim Report (NSWC 2002), an area just south of Bartlett Cove and approximately 1 mile off shore, peak vessel noise levels exceeded 120 decibels only about 1% of the time. In addition, the study found that noise levels dropped considerably when vessel speed limits in whale waters were set at 10 knots, rather than at 20. Based on this analysis, it appears that the operating restrictions established under Alternative 1 are effective in reducing noise levels where humpback whales are most common.

Other vessel types produce relatively small amounts of noise and, considered collectively under alternative 1, would "ensonify" less than one-tenth of one-percent of the total area of Glacier Bay. Table 4-14 shows the area ensonified for each vessel type (with two speeds presented for cruise ships).

TABLE 4-14: ESTIMATES OF ENSONIFIED AREA EMITTED BY EACH VESSEL CLASS

Vessel Class	130 decibel zone radius (ft)	130 decibel (mile^2)	Glacier Bay area
Cruise ship (10 knots)	1804 (0.34 mi)	0.36	.0719%
N. Wind 19 knots	16404 (3.1 mi)	30	5.9432%
Tour	459	0.02	0.0047%
Charter	459	0.02	0.0047%
Private	75	0.0007	0.0001%
Source: LGL 2003.			

Based on the current understanding of vessel noise exposure, current vessel quotas and operating requirements do not cause hearing loss or "harm" in humpback whale or Steller sea lion. While noise intensity (loudness) from cruise ships are potentially loud enough to cause temporary or permanent hearing loss, the duration of exposure would be too short to cause damage. For example, a cruise ship at 10 knots would exposed any stationary object to sound levels of 130 decibels or greater for no more than approximately 4 minutes. For a ship traveling 19 knots, the maximum time a stationary object would be exposed to 130 decibels or more is approximately 17 minutes. These time periods are shorter than the 20- to 22-minute exposures that caused temporary hearing loss (temporary threshold shift) in a harbor seal, elephant seal, and California sea lion (Kastak et al. 1999).

In conclusion, it is expected that cruise ship noise would disturb humpback whales and Steller sea lions on a regular basis, but that the duration and intensity of effect would not be sufficient to harm or otherwise cause these species to leave Glacier Bay. The maximum duration that any one point would be exposed to sound levels over 130 decibels is in the range of less than 3.5% of the time from June through August. The cruise ship limits that would be in effect have been in effect for several years, and humpback whale numbers in the area have increased during that time.

Changes in behavior of threatened and endangered species due to the sight and noise of motorized vessel traffic — alternative 1 — The sight and sounds of motorized vessels are known to disturb both humpback whales and Steller sea lions. Under the current vessel quotas and operating requirements, both species are regularly exposed to vessel traffic. The specific reaction of an individual on any particular encounter cannot be predicted, since the reaction depends on many factors, including the specific sensitivity of the individual animal, the speed and course of the vessel, the specific vessel type, and an unknown number of other factors.

Still, it can be assumed that the presence of vessels in Glacier and Dundas Bays startles, frightens, and/or annoys individual animals and, in some cases, causes them to flee, dive, make sounds (or stop making sounds) or, for Steller sea lions, occasionally causes them to leave a haul out area. Such reactions have been regularly observed in the park and elsewhere. Animals may also react in less detectable ways, such as changing breathing or heart rates or changing swimming patterns. Behavioral changes may be due to fear, annoyance, or interference in feeding or resting. The effect of such changes in behavior is a reduced benefit from whatever activity the animal was undertaking at the time of the encounter, as well as the energy expended due to the reaction. If an animal is feeding, then the effect is a loss of energy acquired. If the animal is resting, then the effect is a loss of rest and, potentially, the need to rest later rather than feeding. The effect can include exposure to hazards such as another vessel, predators, or other animals that might be territorial or otherwise antagonistic. Long-term exposure can potentially increase stress, which, as has been shown in humans, can contribute to heal problems. Long-term exposure may also cause individuals to become accustomed to the sight and sounds of vessels and consider them as just another element of their environment.

The ultimate effect is reduced energy intake and increased energy expenditure, and increased risks of harm. Such loss of energy and increased risks can reduce the health of the individual and, when considered with many other factors, might contribute to reduced reproduction and survival.

Under alternative 1, individual Steller sea lions would be regularly disturbed by vessel traffic. No studies of the behavioral responses of Steller sea lions in water to motorized vessel traffic are available, but it is generally reported that most seals and sea lions in water investigate vessels and some noise sources (Richardson et al. 1995). In a study of Steller sea lions at a non-breeding haul out in Glacier Bay, the activity rate of sea lions at the haul out increased as vessels approached within 180 meters (Mathews 1997). Vessels that maintained a slow, steady course and kept the engines on seemed to disturb sea lions less than vessels with erratic course or speed. This supports the intuitive conclusion that private vessels, which are more maneuverable and whose operators may be less aware of protection rules, might actually disturb Steller sea lions more than larger vessels, Steller sea lion responses to motorized vessel traffic while hauled out on land have been examined in a few other locations with short-term responses of increased vocal behavior followed by entrance into the water when a vessel approached within 100 to 200 meters.

Humpback whales that use Glacier and Dundas Bays would also be regularly disturbed by vessel traffic. The scientific literature related to behavioral reactions of humpback whales to noise reports a wide range of responses and is inconclusive. Studies typically report a few case studies observed during the course of a larger study and represent extreme behavioral responses for a few individuals with a limited statistical link directly to a given factor such as noise or vessel proximity (Baker and Herman 1989, Bauer 1995). Moreover, the conclusions reached by different researchers are contradictory, indicating that the responses of humpback whales to vessels are variable and not completely understood (Frankel and Clark 1998).

In their feeding areas, humpback whale distribution is closely correlated with forage fish and euphausiid density and distribution (Krieger and Wing 1986; Krieger 1988). Humpback whales persistence in areas of high prey density, despite vessel traffic or industrial noise (e.g. Todd et al. 1996), illustrate that whales will tolerate disturbance if a nearby prey resource is sufficiently attractive. However, a lack of response to vessel traffic or other types of underwater noise may be detrimental in some cases, and may expose whales to the risk of vessel collision and injury. For example, Todd et al. (1996) reported that humpback whales in Trinity Bay, Newfoundland showed no overt behavioral reaction to dredging and underwater explosions in terms of their residency, movements, or general respiratory behavior. However, two dead whales found in the area showed evidence of inner ear damage consistent with exposure to extreme sound levels. The inner ear damage may have contributed to an observed increase in the rate of whale entanglement in fish traps (Todd et al. 1996). Building on the work of Todd et al. (1996), Borggaard et al. (1999) found that humpback whales remained in an area of high prey availability despite exposure to loud construction activity, including underwater explosions, dredging, and vessel traffic during a four-year period of offshore construction.

Factors such as habituation, sensitization, individual variability, and a whale's initial activity likely explain some of the observed variability in response to vessel traffic. The complicated acoustic pathways associated with vessel noise may also mislead whales as to locations of ships or the rate at which they are approaching (Terhune and Verboom 1999) Whale responsiveness to vessels can play an important role in their ability to avoid vessel collisions (Laist et al. 2001; Terhune and Verboom 1999).

Given the close relationship between prey density and distribution of marine mammals, some individuals may not leave an area — ensonified or not — when prey are present. Shifts in distribution may range from hours to days, but seem unlikely to exceed a day. Annual humpback whale population counts have increased and remained high since 1996 under the level of vessel traffic proposed in alternative 1 (see figure 4-2). Thus, noise associated with vessel traffic is likely to have minor effects on the distribution of Steller sea lions and humpback whales within Glacier Bay or Dundas Bay and negligible effects on the Southeast Alaska feeding herd or the central North Pacific stock of humpback whales or the eastern stock of Steller sea lions.

While humpback whales or Steller sea lions could be regularly disturbed by vessel traffic and noise, the overall effect to the behavior and the ability of individuals to breed, feed, and seek shelter would be negligible to minor.

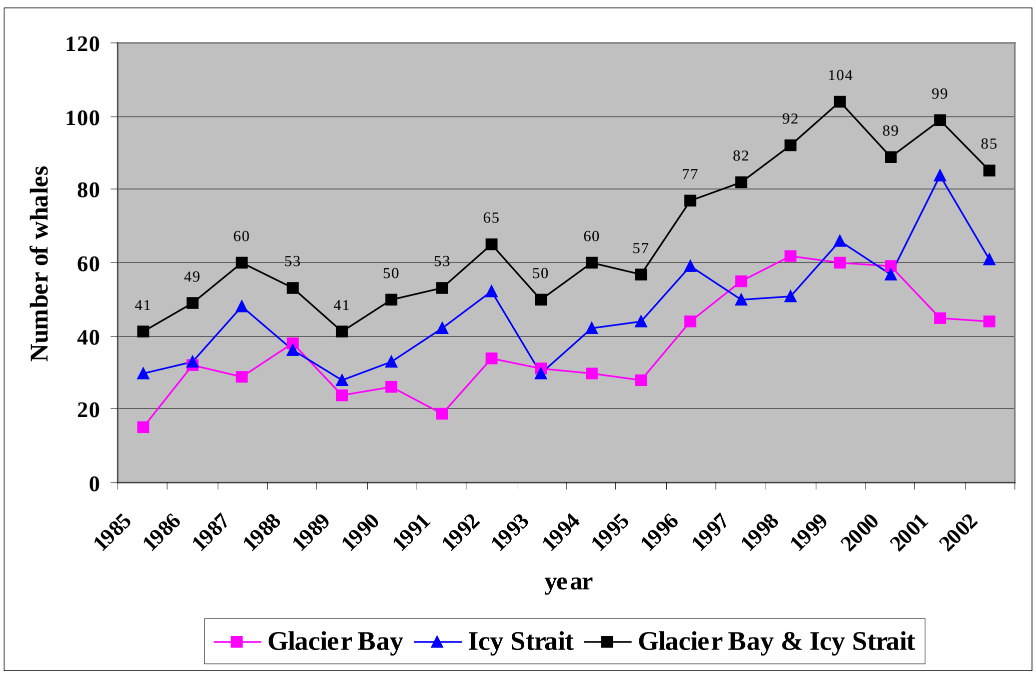


FIGURE 4-2: ANNUAL HUMPBACK WHALE POPULATION COUNTS

Effects of vessel noise on communication and hearing – alternative 1 — Vessel noise is expected to interfere with humpback whale and Steller sea lion hearing and communication at a level sufficient to be considered "harassment." Individuals of both species would be occasionally exposed to noise levels sufficient to temporarily reduce their ability to feed, breed, or seek shelter. Both species would continue using Glacier and Dundas Bays. Vessel noise would not be sufficient to constitute “harm,” meaning that individuals are not expected to experience hearing loss. The analysis behind both of these conclusions is presented in the following paragraphs.

During scoping, the issue was raised that sound might mask hearing of humpback whales or Steller sea lion. Sound is very important to marine mammals, thus, a reduction in hearing sensitivity would reduce the ability of humpback whales or Steller sea lions to communicate or hear important sounds of predators or prey. As described in chapter 3 and appendix C, marine mammals have highly evolved hearing capabilities (for review, see Richardson et al. 1995); however, such highly evolved hearing also includes the ability to hear important sounds, even within a noisy environment. Marine mammals have been found to discriminate important sounds at levels equal to background noise (e.g., Malme et al. 1983). To reduce masking of sounds, marine mammals can shift the frequency band of their communications to use a less “noisy” spectrum, alter the number or rate of calls, or increase the source levels of calls.

In some cases, vessel noise is broadband in nature, and “less noisy” bands may not be available. Additionally, some communications may be frequency-dependent and shifting the dominant bands of such vocalizations may not be possible (Baker 1985). Such situations are assumed to occasionally occur in Glacier Bay and Dundas Bay and communications would be masked at times. Because the duration of noise exposure to vessels is typically short-term, interruptions in communication are expected to occur during brief, isolated events.

Vessel noise in Dundas and Glacier Bays is not sufficient to cause hearing loss in either species. Permanent or temporary hearing loss is a possibility if humpback whales or Steller sea lions were exposed to very loud sounds for a sufficiently long period to induce such loss. This hearing loss can take the form of temporary threshold shift (TTS) or permanent threshold shift (PTS; see appendix C for definitions and details of these terms). A recent acoustic modeling study examined killer whale exposure to noise generated by whale-watching activities in the Strait of Juan de Fuca (Erbe 2002). Erbe (2002) estimated the various zones of noise exposure and speculated that killer whales could experience permanent reductions in hearing ability as a result of prolonged noise exposure (8 hours per day, 5 days per week, for 50 years) from whale-watching vessel traffic at source levels of 145 to 169 decibels.

Humpback whales are known to tolerate loud noises when prey is sufficiently present. So individuals might stay in an area, even if the noise is so loud that they are losing their hearing abilities. Todd et al. (1996) and Borggaard et al. (1999) showed that despite exposure to underwater explosions where received sound levels at 1 nautical mile (1.9 kilometers) from the source ranged from 123 to 153 decibels, feeding humpback whales remained in an area of high prey density. The researchers later detected that whales in the area suffered a higher-than-normal rate of entanglement in fishing nets, an occurrence that may have resulted from a reduced ability for the whales to detect net produced acoustic cues. Additionally, two dead whales found in the area showed evidence of inner ear damage consistent with exposure to extreme sound levels (Todd et al. 1996).

Based on the current understanding of vessel noise exposure, however, implementation of alternative 1 would not result in hearing loss or “harm,” as defined under the Endangered Species Act. While noise intensity (loudness) would be sufficiently high, the duration of exposure would be too short to cause damage. For example, if a whale or sea lion remained stationary and submerged below a passing cruise ship at 10 knots, it would be exposed to sound levels of 130 decibels or greater for approximately 4 minutes. For a ship traveling 19 knots, the ensonified area would be larger (since the vessel is louder), but the ship would be traveling past the area faster. Nevertheless, a submerged sea lion or whale below a passing cruise ship traveling at 19 knots would be exposed to 130 decibels or more for approximately 17 minutes. These time periods are shorter than the 20- to 22-minute exposures that caused temporary hearing loss (temporary threshold shift) in a harbor seal, elephant seal, and California sea lion (Kastak et al. 1999).

Effects of vessel collisions — alternative 1 — A cruise ship or tour vessel collision with a whale is more likely to result in the death of the whale than is a collision with a charter or private vessel. However, the likelihood of a cruise ship colliding with a humpback whale is reduced by the fact that cruise ships spend the majority of their time in offshore areas (Fig 3-24), while approximately 90% of humpback whale sightings occur within 1 mile of shore (Fig 3-X; Gabriele et al. 1999). In the Lower Bay whale waters, all vessels must remain at least 1 mile from shore, so the risk of collision is reduced.

Since 1996, at least four whales (humpbacks, gray whales, and unidentified whales) have been killed by vessel collisions in Southeast Alaska, while more have been struck, but have not been confirmed as killed (NOAA Fisheries Stranding Network database query January 2003). In July 2001, an adult female humpback whale was found floating dead in park waters at the mouth of Glacier Bay. The whale was identified as whale #68, an individual first photographed in Glacier Bay in 1975. A detailed necropsy revealed that the whale had sustained “multiple compound fractures of the skull” that would have been immediately fatal to the animal (Gulland 2001). The nature of the injuries was consistent with a strike by a large ship. Although this was the first documented mortality of a ship-struck whale in Glacier Bay National Park, park records document two other non-fatal whale-vessel collisions since 1985. Several humpback whales in the Southeast Alaska photographic catalog have propeller scars or other injuries that clearly indicate collisions with vessels (C. Gabriele, pers. com., J. Straley, pers. com.), although there is no way to determine where the whales were when they were struck. Two male humpbacks in the Glacier Bay area obtained wounds on their dorsal fins in 2001 and 2002 that are believed to originate from collisions with small vessels (see photographs in Doherty and Gabriele 2002).

Vessel size and speed are important variables in whale-vessel collisions. Russell and Knowlton (2001) suggested that when vessel speeds exceed about 13 knots, the ability of right whales to avoid collisions is reduced. Collisions between a whale and a ship greater than 80 meters in length (which in Glacier Bay would be cruise ships) are likely to result in the death of the whale (Laist et al. 2001).

While collisions with smaller vessels are less likely to kill a whale, the effects cannot be discounted. Under the current regulations and operating requirements, smaller vessels are many times more numerous and travel more close to shore, which is where humpback whales tend to be. Also, operators of private vessels are more likely to operate their vessels in ways that pose a greater risk of collision, due to being less familiar with regulations. Several humpback whales in Glacier Bay have been observed with scars assumed to be from collisions with vessels, and many of these collisions are likely to be from vessels other than cruise ships. While alternative 1 includes many measures to reduce the risk of collisions, such collisions cannot be completed prevented.

All motorized vessels would be restricted to a 20-knot speed (measured through the water) for transits through Lower Bay whale waters in Glacier Bay in June through August under alternative 1. The risk of whale fatality in the event of a collision with a large ship is higher at this speed than at speeds less than 14 knots (Laist et al. 2001). When whales aggregate in whale waters, the vessel speed limit would decrease to 10 knots, reducing both the risk of collision and the risk or mortality if a collision occurred. Outside of the lower Bay, vessels may operate at any speed; therefore, the potential for fatal collisions between ships and whales remains. However, Park regulations authorize the superintendent to implement whale waters vessel course and speed restrictions to protect whale aggregations anywhere in Glacier Bay.

Overall, the probability of humpback whale-vessel collision in Glacier Bay is unknown, but is assumed to be less than the annual rate of ship strikes (0.8 strikes per year) for the Central North Pacific stock for the period 1995 to 1999 (Angliss et al. 2001). Vessel collision is possible with any level of vessel traffic but increases with increased traffic. Many protective operating requirements are in place in the current regulations, including speed restrictions in designated whale waters, mid-channel course requirements for all vessel classes while in designated whale waters, and approach and avoidance protocols. Collisions between vessels and humpback whales are expected to be rare yet inevitable.

Steller sea lions are found at most water depths, but tend to be sighted farther offshore than other marine mammals (Gabriele and Lewis 2000), and therefore, are more likely to encounter larger vessels. Given their maneuverability, however, a collision between vessels and Steller sea lions seems unlikely. The lack of published evidence or stranding records of Steller sea lions being struck by vessels indicates that the potential for collisions due to vessel traffic in alternative 1 is low.

Other effects from motorized vessel movement — alternative 1 — The potential for a major fuel spill under this alternative is negligible (see section 4.4.3, "Vessel Traffic and Safety.")

Vessel wakes effects on Steller sea lions and humpback whales would be negligible. Steller sea lions regularly use nearshore habitats around rookeries and haul-outs encountering heavy surf action, waves, and wakes while moving to and from shore. At most rookeries and haul-outs within their range, they regularly encounter wave action in excess of that resulting from vessel wakes. Likewise, humpback whales are used to wave action and would not be adversely affected.

Humpback whales and Steller sea lions also might become entangled in marine debris dropped from vessels. Entanglement of juvenile Steller sea lions in marine debris was linked to the decline of the Western stock (Merrick 1987). However, few records exist of entangled sea lions or humpback whales in Glacier Bay. In addition, based on direct observations at the park shorelines, marine debris is relatively low within Glacier Bay and Dundas Bay. Some garbage inevitably gets into the water from vessels traffic, either deliberately or accidentally, including Styrofoam cups, paper, and plastic bags. Other debris comes in from outside waters, as evidenced by the fact that more garbage is found along the shorelines of the lower Bay and in the upper Bay. The overall level of marine debris is considered small and does not pose a major threat any wildlife in the park, including humpback whales and Steller sea lions.

The type of debris found is generally not the type in which marine mammals become entangled. Most entanglement comes from fishing gear (especially nets), while recreational vessel debris contains small waste items such as food wrappers, containers, bottles, and cans.

Cumulative effects on threatened and endangered species — alternative 1 — The humpback whales that visit South East Alaska are exposed to harassment and harm due to many factors other than those being considered in this EIS (cruise ship and tour, charter, and private vessels).

Administrative vessels (NPS vessels, research vessels, and other vessels not requiring individual permits) increase the level of noise and potential for collision. For 2000, 2001 and 2002, an average of seven (range 5.7 to 7.8 vessels/day) administrative vessels entered Glacier Bay each day during the 92-day vessel season. Based on courses provided by the Park Service and an estimated source level similar to private vessels, it is estimated that each administrative vessel ensonifies 4 square kilometers of Glacier Bay at 130 decibels or more during each day, which results in an additional 28 square kilometers (2%) of Glacier Bay ensonified at or above 130 decibels. Administrative vessels also increase the risk of collision and other effects related to vessel traffic.

Some administrative traffic benefits humpback whales and Steller sea lions. Enforcement patrols, which are also part of administrative traffic, serve to enforce the many regulations in place to protect humpback whales and Steller sea lions. Likewise, whale research vessels, which in some ways may disturb humpback whales, also provide the critical information needed to protect whales, including designation of temporary whale waters and much needed information regarding the effects of vessel traffic on these species.

Aircraft may cause some disturbance to whales. In 2001, NPS whale monitoring staff witnessed an incident in which two floatplanes circled low over three humpback whales, although these incidents occurred outside of park waters and did not appear to affect the whales' behavior (Doherty and Gabriele 2002). Humpback whales also experience vessel noise and harassment outside of park waters, and, since regulations are less stringent and, in some cases, enforcement less rigorous, the level of harassment and potential for harm may be greater in the outside waters (especially Icy Strait) than within the park.

Because humpback whales are migratory, they encounter many other obstacles outside of Glacier and Dundas Bays, which are primarily wintering areas. Most of the whales travel to Hawaii to breed, while a few travel to Mexico. Along the way they encounter a wide range of vessel traffic, including oil tankers, cargo ships, and large fleets of commercial fishing vessels. Once on their breeding grounds, they are again met with whale watching and other vessels (Green 1990).

Pollution, overfishing, and other factors have reduced some prey species, and persistent organic pollutants (POPs), such as the pesticide DDT, and polychlorinated biphenyls (PCBs) can contaminate prey and, in turn, accumulate in humpback whales.

Entanglement, particularly in fishing nets, has become a growing problem throughout the range of humpback whale, including Southeast Alaska.

Finally, scientists and environmental groups have long raised concerns about the amount of noise created by shipping, military activities (including sonar), oil and gas exploration, and other sources.

All of these factors result in population level changes in the humpback whale stock that frequents Southeast Alaska, including Glacier and Dundas Bays and Icy Strait. Even with these impacts, population is increasing, but probably at a lower rate and with a lower potential peak than if these effects were not occurring.

While all of these activities could directly or indirectly affect the central North Pacific stock of humpback whales, this population has been growing since commercial whaling ended. Angliss et al. (2001) reports the annual human-caused mortality rate would have to exceed 7.4 humpback whales per year for the central North Pacific stock to experience a population decline. The current, minimum estimate for human-caused mortality from direct fishery interactions, vessel collisions, and entanglement in marine debris is 4.3 whales per year.

The eastern stock of Steller sea lions has increased in recent years, and may be at the highest levels in recent history, warranting reevaluation of the species threatened status (Kruse et al. 2001); therefore, cumulative effects of human-caused activities are considered negligible. Additionally, natural phenomena such as global climate change and long-term fluctuations in the North Pacific water temperature (El Niño or La Niña events) may affect marine mammals in Glacier Bay through a redistribution of prey, changes in ocean currents, or the loss of terrestrial habitat (for Steller sea lions) if sea level rises, but a consideration of the cumulative effects of such natural phenomena is speculative and is not addressed further.

Impairment analysis for threatened and endangered species — alternative 1 — Two purposes of implementing legislation for the park pertain to the continued presence of marine mammals within the park:

- Maintain sound populations of, and habitat for, wildlife species of inestimable value to citizens.
- The park "in large part … [is] intended to be [a] large sanctuary where fish and wildlife may roam free, developing their social structure and evolving over long periods of time as nearly as possible without the changes that extensive human activities would cause."

Any effects to threatened or endangered marine mammals that could be interpreted as resulting in overall population declines for either local populations or regional populations would impair park resources and values. Alternative 1 would not result in population declines for either humpback whales or Steller sea lions; therefore, neither of these park resources would be impaired.

Endangered Species Act conclusions – alternative 1 — Based on the analysis just presented, alternative 1 would likely adversely affect both humpback whales and Steller sea lions. For both species the effects would include harassment from the sight and sounds of vessel traffic. For humpback whales, the effect would include harm from vessel collisions.

Potential mitigation measures for threatened and endangered species — alternative 1 — Reducing vessel speeds have been shown to decrease noise produced within Glacier Bay and the surrounding waters. In addition, vessels traveling at reduced speeds are less likely to collide with a humpback whale, and if a collision were to occur, the probability of mortality is lower for ships traveling at reduced speeds. The primary mitigation measure to reduce the effects of vessel activity on threatened and endangered marine mammals, therefore, is to reduce overall vessel speeds in park waters. Mathews (2000) proposes educational efforts to help visitors avoid approaching sea lions at South Marble Island, and consideration of increasing the 100-yard approach distance, to reduce sea lion disturbance.

Conclusion, threatened and endangered species — alternative 1 — Disturbance to humpback whales and Steller sea lions from the alternative 1 could result in negligible to minor effects. Any displacement of whales and sea lions from Glacier Bay or Dundas Bay would be short-term. Collisions with vessels are expected to be rare due to whale and sea lion distribution, vessel traffic patterns, and Park regulations, yet over the long term collisions are inevitable. Temporary or permanent threshold shifts are unlikely in humpback whales or Steller sea lions inhabiting Glacier or Dundas Bay, due to source levels, duration of exposure and existing Park regulations, resulting in negligible to minor effects. Humpback whale and Steller sea lion populations in Glacier Bay National Park have been exposed to the level of vessel traffic proposed in alternative 1 since 1996 with no evidence of population decline. The central North Pacific stock of humpback whales and the eastern stock of Steller sea lions have increased, in recent years despite increasing human activities throughout the North Pacific Ocean, including the humpback whale wintering habitat surrounding the Hawaiian Islands. It is possible that populations would have increased at a faster rate without the effects of vessel traffic.

Alternative 2 — Effects on Threatened and Endangered Species.

Direct and indirect effects on threatened and endangered species – alternative 2 —

<u>Estimation of Ensonified Area — Alternative 2.</u> The maximum effect of alternative 2 at any given time would be the same as outlined for alternative 1, with area of about 12% of Glacier Bay being ensonified at any one time. However, under alternative 2, fewer cruise ships would enter Glacier Bay than is currently allowed. A total of 107 cruise ship visits would be allowed, creating the possibility of 214 seventeen-minute passings (two per cruise ship visit) where sound would be greater than 130 decibels at any given point. This represents a maximum duration of approximately 2.7% of the time any one point would be disturbed by cruise ship noise from June through September.

It is expected that cruise ship noise would disturb humpback whales and Steller sea lions on a regular basis, but that the duration and intensity of effect would not be sufficient to harm or otherwise cause these species to leave Glacier Bay.

<u>Behavioral Effects of Exposure to Motorized Vessels on Threatened and Endangered Species — Alternative 2.</u> As defined under alternative 1, noise from motorized vessels would have some effects on humpback whale and Steller sea lion behavior near vessels, especially those animals found within the area ensonified at approximately 130 decibels; however, any behavioral changes would likely be within normal behavioral ranges and not result in physical harm or death. The smaller projected seasonal ensonified zone may result in fewer disturbances than would occur under alternative 1; therefore, behavioral effects are expected to range from negligible to minor, as all reported behavioral changes are anticipated to last for less than one day.

<u>Effects of Noise and Vessel Traffic on Distribution of Threatened and Endangered Species — Alternative 2.</u> Reducing vessel numbers from the current level would reduce potential changes in the distribution of humpback whales and Steller sea lions in Glacier Bay or Dundas Bay. Still, the overall effects would remain similar. Studies of humpback whale distribution have shown whale locations in the feeding season are more closely linked to prey density and distribution than other factors suspected to influence distribution. Consequently, it is likely that humpback whales and Steller sea lions would feed where their prey are adequately concentrated regardless of exposure to noise and vessel traffic. As a result, noise and vessel traffic in Glacier and Dundas Bays would likely impose minor effects on the distribution of Steller sea lions and humpback whales and negligible effects on the Southeast Alaska feeding herd of the central North Pacific stock of humpback whales or the Eastern stock of Steller sea lions.

<u>Effects of Vessel Noise on Communication and Hearing – Alternative 2.</u> As discussed for alternative 1, noise from vessels can mask communication between individuals. It is anticipated that vessel noise exposure would persist at any single location only as long as the passing vessel was audible to the humpback whale or Steller sea lion. It is expected that cruise ship sound would persist for approximately one to two hours (Malme et al. 1983), and the peak level when communication could be masked only lasts for a matter of minutes. Because effects on communication would be intermittent and temporary, overall effects would be minor.

As with alternative 1, and the details described about the mobile nature of vessels and marine mammals makes the probability of temporary or permanent threshold shift low enough that expected effects to threatened and endangered species would be negligible to minor.

<u>Effects of Vessel Collisions — Alternative 2.</u> Current speed restrictions of 10 knots (measured relative to water speed) in whale waters where whales aggregate and up to 20 knots in whale waters without whale aggregation would apply to alternative 2. The unlimited speed limit in other waters of Glacier Bay poses an increased risk of collisions between ships and whales. As indicated for alternative 1, about 90% of whale sightings occur in the nearshore area, well removed from the mid-channel where most cruise ships and larger tour and charter vessels travel; however, should a collision occur between a humpback whale and a vessel, the effects would be moderate to major. With the seasonal reduction in cruise ship entries for alternative 2 relative to alternative 1, the probability of collisions would be lower than for alternative 1.

The maneuverability and speed of Steller sea lions make the probability of vessel strikes unlikely; therefore, effects from vessel collisions would be negligible.

<u>Other Effects from Motorized Vessels — Alternative 2.</u> As with alternative 1, any effects from wakes would likely be negligible for humpback whales or Steller sea lions.

*Cumulative effects on threatened and endangered species — alternative 2 — A*ctivities and natural phenomena discussed in alternative 1 also would affect threatened and endangered species under alternative 2. Overall effects may be incrementally less because of the small decrease in seasonal use, and the corresponding reduction in the seasonally ensonified area; however, it is unlikely that these differences would be detectable. Effects from activities outside Glacier Bay or Dundas Bay, combined with effects from activities within Glacier Bay or Dundas Bay, range from negligible to major; however, cumulatively the probability of major and moderate effects are low enough that the cumulative effects of implementing alternative 2 would be minor to the Central North Pacific stock of humpback whales and Eastern stock of Steller sea lions.

Impairment analysis for threatened and endangered species — alternative 2 — Alternative 2 would not result in population declines for either humpback whales or Steller sea lions; therefore, neither park resource would be impaired.

Endangered Species Act conclusions — Based on the analysis just presented, alternative 1 would likely adversely affect both humpback whales and Steller sea lions. For both species the effects would include harassment from the sight and sounds of vessel traffic. For humpback whales, the effect would include harm from vessel collisions.

Potential mitigation measures for threatened and endangered species — alternative 2 — Mitigation recommended in alternative 1, including speed limits for all waters of Glacier and Dundas Bay, continued collection of vessel acoustic signatures, noise exposure data, vessel courses and simultaneous marine mammal observations, would reduce the effects of alternative 2.

Conclusion, threatened and endangered species — alternative 2 — effects from disturbance to marine mammals from alternative 2 would be considered minor. The displacement of humpback whales and Steller sea lions from Glacier Bay or Dundas Bay would likely be short-term and would have a minor to moderate effect. Moderate to major effects would result from a collision between a vessel and a marine mammal, as would harm due to permanent threshold shift, should it be induced, but the low likelihood of these events makes expected effects negligible. Population increases for both the Central North Pacific stock of humpback whales and the Eastern stock of Steller sea lions, concurrent with increased exposure to noise, fishing operations, vessel traffic, and pollution during the past decade or more, suggest that the overall effects of vessel traffic under alternative 2 would be minor.

Based on calculations use the vessel signatures recorded by Kipple (2002), cruise ships traveling at 10 knots projected noise at or above 130 decibels for about 0.6 miles. This is an area over 80 times smaller than estimated for a vessel signature recorded at 19 knots (LGL 2003).

Alternative 3 — Effects on Threatened and Endangered Species.

Direct and indirect effects on threatened and endangered species — alternative 3 — All alternatives have a maximum daily use of two cruise ships per day. During such days, a maximum area of about 12% of Glacier Bay would be ensonified at any one time. However, under alternative 3, additional ships would are assumed to be allowed into Glacier Bay than are currently allowed. A total of 184 cruise ship visits would be allowed, creating the possibility of 184, seventeen minute passings (2 per cruise ship visit) where sound would be greater than 130 decibels at any given point. This represents a maximum duration of approximately 4.6 percent of the time any one point would be disturbed by cruise ship noise from June through September.

This amount is not expected to be sufficient to cause major effects on humpback whales or Steller sea lions due to noise, but it could cause fewer whales to use certain areas of Glacier Bay. Because of uncertainties related to potential effects of additional cruise ships, this effect is considered moderate.

<u>Behavioral Effects of Exposure to Motorized Vessel Noise — Alternative 3.</u> For alternative 3, noise from motorized vessels would be expected to have some effects on humpback whale or Steller sea lion behavior near vessels, especially those within the 130 decibels zone. As with alternatives 1 and 2, however, behavioral changes would likely be within normal behavioral ranges and not result in physical harm or death. The larger projected seasonally ensonified area may result in more

disturbances than would occur under alternative 1. Effects from behavioral disturbance would be expected to range from negligible to minor, depending on the temporal persistence of the change.

Effects of Noise and Vessel Traffic on Distribution — Alternative 3. As with alternatives 1 and 2, the distribution of endangered and threatened species present in Glacier and Dundas Bays may be affected by vessel noise and traffic under alternative 3; however, persistent changes in distribution are not believed to result from vessel traffic. The increase in the number of vessels present during the season may result in larger or more persistent shifts in distribution that those in alternatives 1 and 2; however, it is unlikely that those effects would be detectable with current monitoring efforts. A shift in distribution for some humpback whales or Steller sea lions within Glacier Bay would likely have negligible to minor effects for the populations within Glacier Bay, but negligible effects for the Southeast Alaska stock of humpbacks and Eastern stock of Steller sea lions.

Effects of Vessel Noise on Communication and Hearing — Alternative 3. As with alternatives 1 and 2, noise from vessels could mask communication between individuals. The seasonal increase in the number of vessels present under alternative 3 may result in more frequent or persistent masking events than those in alternatives 1 and 2; however, any effects would still be expected to be negligible because of the natural ability of humpback whales and Steller sea lions to reduce or avoid masking of important communication.

As with alternatives 1 and 2, the mobile nature of the sound sources and the mobile nature of marine mammals would make a temporary or permanent reduction in hearing sensitivity unlikely. The seasonal increase in vessel traffic in alternative 3 likely would not result in increased probability of temporary or permanent threshold shift.

Effects of Vessel Collisions — Alternative 3. The current speed restrictions of 10 knots (measured relative to water speed) in whale waters when whales are aggregated and up to 20 knots when no aggregation exists apply to alternative 3. The lack of a speed restriction in the remainder of Glacier Bay motorized waters would elevate the potential for collisions between ships and whales. The maneuverability and speed of Steller sea lions make the probability of collision low enough that effects would likely be negligible. Humpback whales; however, may experience moderate to major effects from vessel collision, but the annual rate of collisions with humpback whales in Glacier Bay is lower than the annual rate of ship strikes (0.8 whales per year) for the entire central North Pacific stock (Angliss et al. 2001).

Other Effects from Motorized Vessels — Alternative 3. As with alternatives 1 and 2, any effects from wakes would be expected to be negligible to humpback whales or Steller sea lions.

Cumulative effects on threatened and endangered species — alternative 3. Humpback whales and Steller sea lions in Glacier Bay and Dundas Bay would be affected by the same external activities and natural processes identified in alternatives 1 and 2. The overall effects may be incrementally higher under alternative 3 because of the increase in seasonal vessel traffic; however, it is unlikely that any differences in the populations would be detectable under current monitoring practices. The incremental increase in effects from vessel traffic under alternative 3 are expected to be minor and not result in cumulative effects rising to the point where population declines would result or persist beyond natural variability.

Impairment analysis for threatened and endangered species — alternative 3 — any effects on threatened and endangered species that could be interpreted as a decline in either population would be considered to impair park resources and values. Moderate or major effects could occur in the event of physical harm or death due to permanent threshold shift or vessel collision. Alternative 3 would not result in population declines for either humpback whales or Steller sea lions; therefore, neither stock would be impaired.

Endangered Species act conclusions — Based on the analysis just presented, alternative 1 would likely adversely affect both humpback whales and Steller sea lions. For both species the effects would include harassment from the sight and sounds of vessel traffic. For humpback whales, the effect would include harm from vessel collisions.

Potential mitigation measures for threatened and endangered species — alternative 3 — Mitigation measures recommended in alternative 1 and 2 also are recommended under alternative 3. These mitigation measures include speed limits in all motorized waters of Glacier Bay. In order to develop adaptive and effective mitigation measures it is critical to collect more vessel acoustic signatures, noise exposure data, accurate vessel routes, and simultaneous marine mammal observations during regular vessel activities to identify areas of sensitivity and overlap.

Conclusion, threatened and endangered species — alternative 3 — Effects from disturbance to threatened and endangered species from alternative 3 would be expected to range from negligible to minor. The displacement of humpback whales or Steller sea lions from Glacier Bay or Dundas Bay would likely be short-term and would have negligible to minor effects. A collision between a vessel and a humpback whale or Steller sea lion would have moderate to major effects, as would harm due to a reduction in hearing sensitivity. The expected effects on the populations of threatened or endangered marine mammals would be negligible due to low likelihood of harm or death. Population increases for both the central North Pacific stock of humpback whales and the eastern stock of Steller sea lions, concurrent with increased exposure to noise, fishing operations, vessel traffic, and pollution during the past decade or more, suggest that the overall effects of vessel traffic under alternative 3 would be minor.

Alternative 4 — Effects on Threatened and Endangered Species.

Direct and indirect effects on threatened and endangered species — alternative 4 —

Behavioral Effects of Exposure to Motorized Vessel Noise – Alternative 4. It is expected that noise from motorized vessels will have some effects on humpback whale and Steller sea lion behavior near vessels, especially those within the 130 decibels ensonified zone. Due to operational adjustments that would be in effect for alternative 4, it is likely that tour, private, and charter vessel could leave and re-enter Glacier Bay. It is unknown how often or how long vessels may leave Glacier Bay during their “use day.” It is assumed that most vessels would use their time in Glacier Bay, as access there is the limiting factor, but not access to Icy Strait or other locations outside Glacier and Dundas Bay; therefore, while a decrease in the ensonified zone is possible due to vessels leaving and re-entering Glacier Bay, it would result in negligible changes to the total areas ensonified. As in alternatives 1 through 3, behavioral changes would likely be within normal behavioral ranges, and would not result in physical harm or death. Thus, behavioral effects due to vessel noise could range from negligible to minor and would be somewhat less than those for alternatives 1 through 3 by some unknown degree.

Effects of Noise and Vessel Traffic on Distribution – Alternative 4. The distribution of threatened and endangered species in Glacier Bay or Dundas Bay may be affected by vessel traffic under alternative 4. As discussed for the previous alternatives, most evidence indicates that changes in distribution during the feeding season, rather than the presence or absence of vessel traffic, result in changes in the distribution and abundance of important prey. A shift in distribution for some humpback whales or Steller sea lions within Glacier Bay or Dundas Bay would likely have negligible to minor effects to the Glacier Bay populations, but negligible effects to Southeast Alaska stocks as their distribution is highly variable among days and seasons. Under alternative 4, the East Arm of Glacier Bay (Muir Inlet and connected waters) would be closed to tour vessel and cruise ship traffic. If vessel traffic and noise influenced the distribution of humpback whales and Steller sea lions, the East Arm would then provide a refuge where humpback whales and Steller sea lions could be seen more regularly. A change in distribution for humpback whales or Steller sea lions to the East Arm would suggest minor to moderate effects on distribution from vessel traffic, but overall would suggest that humpback whales and Steller sea lions could find areas to avoid noise exposure. Currently, all vessel classes have equal access to Glacier Bay, but under alternative 4 a lack of cruise ship and tour vessel traffic in the East Arm may change charter and private vessel use of the East Arm; therefore, threatened and endangered species seeking refuge from cruise and tour vessels in the East Arm may be subjected to higher levels of charter and private vessel traffic that may result in similar exposure to vessel noise.

Such changes in distribution may result in negligible to moderate effects as these vessels have lower noise signatures than cruise ships.

Effects of Vessel Noise on Communication and Hearing – Alternative 4. As with alternatives 1 through 3, noise from vessels has the potential to mask communication between individuals, due to increases in the overall background sound level or due to temporary noise exposure as a vessel passes nearby. Due to the mobile nature of marine mammals and their ability to vary the duration, frequency, and intensity of most calls (see appendix C), effects would be expected to be negligible to minor.

The potential for temporary and permanent threshold shift exists under alternative 4, as it does under alternatives 1 through 3. The mobile nature of humpback whales and Steller sea lions, combined with the mobile sound sources, continue to make the probability of temporary and permanent threshold shift small; however, effects to marine mammal hearing still would be expected to be negligible to minor.

Effects of Vessel Collisions – Alternative 4. Vessel speed regulations under alternative 4 would change in two ways from those under alternatives 1 through 3. First, speed restrictions would be in place from May 1 to September 30, rather than May 15 to August 31 as in alternatives 1 through 3. Second, speed restrictions would be based on vessel length. Outside whale waters, vessels less than 80 meters (262 feet) would be restricted to 20 knots, while vessels of 80 meters (262 feet) and greater would be restricted to 13 knots. When whale waters are designated, all vessels within whale waters would be restricted to 10 knots. All vessel speeds would still be measured through the water.

Laist et al. (2001) reported that vessel collisions and the severity of large vessel collisions with whales were reduced when vessels operated at speeds less than 13 knots. The reduction in vessel speeds mandated for alternative 4 would reduce the potential for collisions and the severity of collisions between larger vessels and humpback whales; however, since any collision would result in the death of the whale, a collision would have moderate to major effects. The reduced probability and severity of large vessel collisions with whales due to reductions in speed may reduce overall effects of vessel collisions to moderate. Steller sea lions are unlikely to be struck by vessels because they are more maneuverable than humpback whales; therefore, effects to Steller sea lions would be negligible.

Other Effects from Motorized Vessels – Alternative 4. As with alternatives 1 through 3, any effects from wakes likely would be negligible for humpback whales or Steller sea lions.

Cumulative Effects on Threatened and Endangered Species – Alternative 4. Activities and natural phenomena discussed in alternative 1 also would affect threatened and endangered species under alternative 4. The incremental change in effects due to vessel traffic and operational procedures under alternative 4 likely would be minor. If speed restrictions in Glacier Bay result in the reduction in overall noise exposure, vessel collisions, and severity of collisions, as predicted, the precedent for speed restrictions may become a valuable mitigation tool to reduce cumulative effects due to human activities in areas used by threatened and endangered marine mammals.

Impairment Analysis for Threatened and Endangered Species – Alternative 4. Any effects to threatened or endangered marine mammals that could be interpreted as resulting in overall population declines for either local populations or regional populations would impair park resources and values. Alternative 4 would not result in population declines for either humpback whales or Steller sea lions; therefore, neither park resource would be impaired.

Endangered Species Act Conclusions

Based on the analysis just presented, alternative 1 would likely adversely affect both humpback whales and Steller sea lions. For both species the effects would include harassment from the sight and sounds of vessel traffic. For humpback whales, the effect would include harm from vessel collisions.

Potential Mitigation Measures for Threatened and Endangered Species – Alternative 4. Vessel speed restrictions are thought to be a major mitigating factor for effects on endangered and threatened marine mammals using Glacier and Dundas Bays. Alternative 4 would provide mitigation for the effects of vessel traffic, but without well-designed monitoring to evaluate the effectiveness of speed restrictions, the appropriate use of speed limits could not be applied to other sensitive areas that may warrant protection. The closure of the East Arm to cruise and tour vessels could also provide mitigation for the effects of different vessel classes (if any exist) on humpback whales and Steller sea lions. Without well-designed studies to evaluate the effectiveness of such potential mitigating measures, the value of a “refuge” in the East Arm cannot be fully understood. Mitigation measures for alternatives 1 through 3 also apply to alternative 4, but would be less powerful than those integrated mitigation studies suggested above.

Conclusion, Threatened and Endangered Species – Alternative 4. The reduction in seasonal use days for all vessel classes would result in a smaller overall ensonified zone than that of alternative 1. If a few vessels leave and re-enter Glacier Bay or Dundas Bay, then the seasonally adjusted average ensonified zone would be the smallest for all the alternatives.

Disturbance to threatened and endangered species from alternative 4 could range from negligible to minor effects. Humpback whales or Steller sea lions may shift in distribution from the West Arm to the East Arm to reduce exposure to cruise ship and tour vessel traffic noise. Such a change in distribution likely would result in minor effects to the threatened and endangered species populations of Glacier Bay or Dundas Bay; however, they may then be subjected to higher levels of charter vessel and private vessel traffic. The overall effect of alternative 4 on humpback whales and Steller sea lions would be minor, and relative to alternatives 1 through 3, would significantly reduce effects due to reduced vessel speeds and a reduction in vessel use of the East Arm. With appropriate studies of effectiveness of these potential mitigation measures, the positive value of alternative 4 could provide significant insight to the understanding of these complex resource conflicts for other regions and sensitive species.

Alternative 5 – Effects on Threatened and Endangered Species.

Direct and Indirect Effects on Threatened and Endangered Species – Alternative 5.

<u>Estimation of Ensonified Area – Alternative 5</u>. Like alternative 4, alternative 5 would place a speed restriction on cruise ships throughout Glacier Bay. This would greatly reduce the area exposed to vessel noise greater than 130 decibels. No measurements of vessel speeds of 13 knots are available, but it is assumed that a much smaller area would be affected, with most shoreline areas likely being sufficiently far to have dramatically reduced time at which they are exposed to vessel noise greater than 130 decibels.

Also under Alternative 5, temporary speed limits in areas where whales are observed would be increased from 10 knots to 13 knots. This would create more noise in whale waters, since, at least in some cruise ships, underwater sound generation increases dramatically with speed increases. The exact effect of this cannot be determined since no sound signatures are available for cruise ships traveling at 13 knots. Therefore, the overall effect is considered to be moderate.

<u>Behavioral Effects of Exposure to Motorized Vessel Noise – Alternative 5</u>. It is expected that under alternative 5, noise from motorized vessels would have some effects on the behavior of humpback whales and Steller sea lions when near vessels, especially those swimming within the 130 decibels ensonified zone. As in alternatives 1 through 4, such behavioral changes likely would be within normal behavioral ranges and not result in physical harm or death; however, because of the potential for more total vessel entries to encounter humpback whales or Steller sea lions, there is potential for more disturbance. Thus, behavioral effects could range from negligible to minor.

<u>Effects of Noise and Vessel Traffic on Distribution – Alternative 5</u>. The distribution of threatened and endangered species in Glacier Bay or Dundas Bay may be affected by vessel traffic under alternative 5. The East Arm of Glacier Bay (Muir Inlet and connected waters) would be closed to cruise ship traffic under this alternative. The East Arm may then provide a refuge from cruise ship noise for humpback whales or Steller sea lions. Due to low cruise ship traffic in the East Arm this change in operating procedures would not be expected to result in any significant seasonal difference in noise

exposure or vessel traffic. Most changes in the distribution of humpback whales during the feeding season are related to changes in prey distribution and abundance; therefore, effects on the distribution of humpback whales or Steller sea lions would be expected to be negligible to minor with implementation of alternative 5.

<u>Effects of Vessel Noise on Communication and Hearing – Alternative 5</u>. As with alternatives 1 through 4, noise from vessels has the potential to mask communication between individuals (see appendix C). The increase in private vessels and the ensonified zone would result in more masking, but the incremental increase would be expected to be small relative to times when sound levels would be within the normal background range. Considering the mobile nature of marine mammals, their ability to change the frequency, duration, or source levels of most calls, and the temporary exposure to sounds as vessels pass, effects on communication likely would be negligible to minor.

The potential for temporary and permanent threshold shift exists under alternative 5, as it does under alternatives 1 through 4 (see appendix C). The mobile nature of humpback whales and Steller sea lions and the mobile sound sources continue to make the probability of temporary and permanent threshold shift remote. The increase in private vessels would result in higher overall noise exposure and somewhat increase the potential for temporary and permanent threshold shift. The alternation of relatively quiet periods between the louder periods when vessels pass reduces the possibility of temporary and permanent threshold shift. Effects to humpback whale or Steller sea lion hearing likely would be minor.

<u>Effects of Vessel Collisions – Alternative 5</u>. Vessel speed regulations under alternative 5 would change in the same ways as they would under alternative 4. Speed restrictions would be in place from May 1 through September 30, rather than May 15 through August 31, and would be based on vessel length. Outside whale waters, vessels less than 80 meters would be restricted to 20 knots, while vessels of 80 meters and longer would be restricted to 13 knots or less; however, under alternative 5, vessel speed for tour, charter, and private vessels would be measured "over ground" rather than "through the water." Most tour, charter, and private vessels rely on GPS devices that measure speed over ground, independent of water speed. This type of "over ground" measurement using GPS equipment does not account for the effects of water currents on vessel speed because speed is a measure of distance traveled per unit of time. Vessel speed as measured with transducers is based on the rate of movement through water and may be either elevated or decreased compared to speed measured "over ground," depending on the direction of water movement relative to vessel movement. Cruise ships are generally equipped with transducers and would continue to measure speed "through the water."

Laist et al. (2001) reported that vessel collisions and the severity of large vessel collisions with whales were reduced when vessels operated at speeds less than 13 knots. By measuring vessel speed over ground vessels would operate at speeds in excess of the speed limit when they are traveling against the current. The currents in Glacier Bay are most influenced by the tides. During slack tide and incoming tides this error would not result in vessels going above the speed limit by measuring their speed over ground; however, during the outgoing tide vessels would exceed the speed limit based on the speed of the current. The outgoing tide occurs approximately 40% of the time each day. Effects due to collisions with vessels would be expected to be moderate to major. The speed limit for alternative 5 represents a mitigation measure that would reduce effects relative to alternatives 1 through 3. A reduction in the severity of effects due to vessel collisions (as a result of reduction in speed below 13 knots) may reduce the effects of vessel collisions with humpback whales to moderate approximately 60% of the time. Steller sea lions would be unlikely to be struck by vessels because they are more maneuverable than humpback whales; therefore, effects to Steller sea lions would be negligible.

<u>Other Effects from Motorized Vessels – Alternative 5</u>. As in alternatives 1 through 4, any effects from wakes likely would be negligible for humpback whales and Steller sea lions.

Cumulative Effects on Threatened and Endangered Species – Alternative 5. Activities and natural phenomena discussed in the previous alternatives also would affect threatened and endangered species under alternative 5. The incremental effects of alternative 5 to the current cumulative effects to humpback whales and Steller sea lions would be expected to be minor.

Impairment Analysis for Threatened and Endangered Species – Alternative 5. Any effects to threatened or endangered marine mammals that could be interpreted as resulting in overall population declines for either local populations or regional populations would impair park resources and values. Alternative 5 would not result in population declines for either humpback whales or Steller sea lions; therefore, neither park resource would be impaired.

Potential Mitigation Measures for Threatened and Endangered Species – Alternative 5. Mitigation recommended in alternative 4 applies to alternative 5.

Conclusion, Threatened and Endangered Species – Alternative 5. The estimated area ensonified at 130 db re 1 μPa or greater is highest for alternative 5. If effects are directly related to the area exposed to noise, then alternative 5 has the greatest potential for effects.

The effects due to behavioral disturbance of threatened and endangered species from alternative 5 could range from negligible to minor. Changes in distribution are likely related to changes in prey distribution and abundance. Populations of endangered humpback whales and threatened Steller sea lions have increased in recent years. These increases have occurred simultaneously with increases in vessel traffic, vessel speed, ocean noise, ocean pollution, fishing, and whale watching. No areas in Glacier Bay or Southeast Alaska have been abandoned by either humpback whales or Steller sea lions; therefore, the overall effects of vessel traffic under alternative 5 are expected to be minor.

Summary, Threatened and Endangered Species. During the past 30 years, vessel operations have increased in Glacier Bay proper. It would be expected that if vessel traffic were having major effects at the population level, that population levels would decrease with this traffic increase. The central North Pacific stock of humpback whales and the eastern stock of Steller sea lions have increased, however, during the same time that vessel traffic has increased. In addition, human activities have increased throughout the North Pacific Ocean and in the humpback whale wintering habitat surrounding the Hawaiian Islands. It is possible that populations would have increased more without vessel traffic. Still, it can be concluded that, cumulatively, these activities have not had more than a minor effect on either stock of humpback whales or Steller sea lions. Minor effects would be expected to continue under alternative 1 (no action).

All alternatives would cause individual whales and sea lions to move away from passing vessels in Glacier Bay or Dundas Bay; however, because whale distribution has been shown to be more a factor of prey abundance than avoidance of vessels, overall effects are expected to be at the individual level and, therefore, minor to moderate. Collisions with ships would be rare, but cannot be ruled out under any of the alternatives. Killing a humpback whale would be considered a major effect, even though the effect would still be at the individual level and would not counter the general increasing trend in humpback whale populations. Current levels of noise exposure are not sufficient to cause hearing damage in marine mammals. The amount of available underwater habitat where vessel noise is expected to be sufficiently loud to disturb whales in Glacier Bay would be 28% under alternatives 1 and 5, 24% under alternative 2, 31% under alternative 3, and 20% under alternative 4.

4.3.2 MARINE MAMMALS

4.3.2 Marine Mammals

This section evaluates the consequences of implementing the various vessel management alternatives on marine mammals. Species evaluated in this section are all those known to occur or with the potential to occur in Glacier or Dundas Bay. They are:

- minke whale.
- harbor porpoise.
- Dall's porpoise.
- killer whale.
- harbor seal.
- sea otter.

Issues of Concern Raised during Scoping. Specific public concerns regarding marine mammals include the following:

- The sight and noise of vessel traffic alter marine mammal behavior; therefore, any increase in the number of vessels would further disrupt their behavior.
- Increases in vessel traffic could result in increased marine mammal/vessel collisions.
- Vessel traffic may be contributing to the harbor seal populations declines noted in Johns Hopkins inlet.

Potential effects on marine mammals in Glacier Bay proper and Dundas Bay from motorized vessels include the following:

- behavior may change.
- distribution in the park may change.
- communication may be disrupted.
- permanent or temporary hearing impairment may occur.
- collisions may occur.
- ingestion of pollutants or debris may occur.

Regulatory Framework. Marine mammals are protected under the Marine Mammal Protection Act (16 USC 1361). This law prohibits any person or vessel subject to the jurisdiction of the United States, with limited exceptions, from "taking" marine mammals in the United States or the high seas without authorization. Taking, as defined in the Marine Mammal Protection Act, is "to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect or kill any marine mammal" (16 USC 1362). The 1994 amendments to the Marine Mammal Protection Act distinguish two types of takings or harassment:

- **Level A harassment** means "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild."
- **Level B harassment** means "any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild."

In other words, Level A harassment involves injury and Level B harassment includes direct or indirect disturbance. Much debate among scientists and regulators has centered on how substantial a change in behavior must be before an activity is deemed to have taken an animal by Level B harassment. In response to the Marine Mammal Commission's recommendation that biological significance was not appropriate to incorporate into the statutory definition of 'take,' the NOAA Fisheries recently stated that:

> *". . . a simple change in a marine mammal's actions does not always rise to the level of disruption of its behavioral patterns. … If the only reaction to the [human] activity on the part of the marine mammal is within the normal repertoire of actions that are required to carry out that behavioral pattern, NOAA Fisheries considers [the human] activity not to have caused a disruption of the behavioral pattern, provided the animal's reaction is not otherwise significant enough to be considered disruptive due to length or severity. Therefore, for example, a short-term change in breathing rates or a somewhat shortened or lengthened dive sequence that are within the animal's normal range and that do not have any biological significance (i.e., do not disrupt the animal's overall behavioral pattern of breathing under the circumstances), do not rise to a level requiring a small take authorization."* (NOAA Fisheries 2001)

Moreover, the same NOAA Fisheries opinion states that:

> *". . . neither simply hearing a noise (and not having a reaction) nor having a minor startle reaction such as looking toward the sound source (but no other behavioral response) to the noise… rise to a level to be considered a disruption of a behavioral pattern and therefore constitute harassment"* (NOAA Fisheries 2001)

Based on the above guidance from the NOAA Fisheries and the published findings of the National Research Council (2000), the following analyses assume that simple exposure to sound does not constitute Level B harassment. Furthermore, brief disturbances that do not disrupt the behavioral patterns of marine mammals in a biologically significant manner also do not constitute Level B harassment. For example, a marine mammal that exhibited a startle response by diving in response to the approach of a vessel but resumed undisturbed behavior within a short period is not considered to have been taken by harassment. However, long-term and frequent disturbances can become biologically significant.

Methodology and Assumptions. Effects on marine mammals were evaluated based on a review of the literature, consultations with National Park Service biologists, and records and reports related to marine mammals in Glacier and Dundas Bays. Noise exposure from motorized vessel traffic was evaluated as described previously for threatened and endangered marine mammals (subsection 4.3.1).

Table 4-15 summarizes the significance criteria used to evaluate effects of the alternatives on marine mammals. Criteria were developed based on extensive consultation with Glacier Bay National Park and Preserve biologists, professional judgment, and published literature on marine mammals.

TABLE 4-15: THRESHOLD CRITERIA FOR THE EFFECTS ANALYSIS ON MARINE MAMMALS

Negligible	An individual or group of marine mammals in Glacier Bay proper or Dundas Bay would notice a human-caused stimulus, such as a passing vessel, but the disturbance would not change short-term behavior and would not be biologically significant. There would be no harm to an individual or group of individuals. The duration would last only as long as the stimulus was perceptible to the individual or group.
Minor	An individual or group of marine mammals in Glacier Bay proper or Dundas Bay would notice a human-caused stimulus and would be disturbed, resulting in a short-term change in behavior (i.e., “Level B” harassment). The individual/group would resume undisturbed behavior within one day of exposure to the stimulus with no biologically significant effects. No individual or group of individuals would be harmed or injured.
Moderate	An individual or group of marine mammals in Glacier Bay proper or Dundas Bay would notice a human-caused stimulus and would be disturbed, resulting in a long-term change in behavior (i.e. “Level B” harassment, or “Level A” harassment). Individuals may be occasionally injured or killed, but at levels that do not affect overall population size. The individual/group would be affected for more than one day with the potential for biologically significant effects. Population numbers in Glacier and Dundas Bays may be less than if the action were not taken, but not to the point that populations become unstable or well below historic numbers.
Major	A majority of individuals of one or more species within Glacier Bay and Dundas is exposed to “Level A” harassment by a human-caused stimulus or action that results in physical injury or mortality. “Level B” harassment would be so frequent as to reduce populations below levels or shift use away from important habitat areas (e.g. breeding or feeding concentration areas). The injury or mortality would have biologically significant effects on populations within Glacier and Dundas Bays (or beyond) .

Alternative 1 (No Action) – Effects on Marine Mammals.

Direct and Indirect Effects on Marine Mammals – Alternative 1.

<u>Estimation of Ensonified Area — Alternative 1</u>. Vessel noise is prevalent underwater throughout much of the Glacier and Dundas Bays. Based on recent results from the underwater sound study being conducted at Glacier Bay, peak vessel noises average 94 decibels, or about 11 decibels louder than the average wind noise level (Kipple 2002). The percentage of samples (one taken every hour) in which vessel noise was detected ranged from nearly 70 percent in August to 7 percent in December. The average daily detection rate was 32 percent.

When traveling at relatively high speeds (greater than 10 knots), cruise ships "ensonify" areas much greater than any other vessel type that visits Glacier and Dundas Bays (in this EIS, to ensonify means to create noise greater than 130 decibels). Based on calculations using vessel signatures recorded by Kipple (2002), cruise ships traveling at 10 knots projected noise at or above 130 decibels for up to 500 meters (LGL 2003). Only one measurement of a vessel traveling faster was included in the evaluation. That vessel, however, was estimated to project noise at or above 130 decibels for up to 5,000 meters, or approximately 3 miles. While this zone is only a rough estimation, it does show that cruise ships can be considerably louder when traveling at a relatively high speed.

Because of the relatively great distance at which cruise ships generate noise above 130 decibels, and because cruise ships travel the entire length of Glacier Bay to Tarr Inlet, most of Glacier Bay's waters are exposed temporarily to sound levels greater than 130 decibels every time a cruise ship visits the Bay. However, at any one time, no more than two cruise ships would be traveling at relatively high speeds. At such times, the total area of Glacier Bay that would be "ensonified" is 12%, approximately.

In whale waters, when whales are present and speed limits are set at 10 knots (which occurs each year when whales begin to concentrate), cruise ship noise is dramatically less (see the discussion of cruise ship noise above). Also, in whale waters, cruise ships (and all other vessels) are required to remain at least 1 mile from shore (unless approaching shore, when they must take a course perpendicular to the shoreline). Because of this, nearshore areas, where most marine mammal sightings occur, would be relatively quiet.

Other vessel types produce relatively small amounts of noise and, considered collectively under alternative 1, would "ensonify" less than one-tenth of one-percent of the total area of Glacier Bay. Table 4-16 shows the area ensonified for each vessel type (with two speeds presented for cruise ships).

TABLE 4-16: AREA ENSONIFIED BY EACH VESSEL TYPE

Vessel Class	130 decibel zone radius (m)	130 decibel (km^2)	GLBA area
Cruise	1804 (0.34 mi)	0.36	.0719%
N. Wind 19 knots	16404 (3.1 mi)	30	5.9432%
Tour	459	0.02	0.0047%
Charter	459	0.02	0.0047%
Private	75	0.0007	0.0001%
Source: LGL 2003.			

Based on the current understanding of vessel noise exposure, current vessel quotas and operating requirements do not cause hearing loss or "harm" in marine mammals. While noise intensity (loudness) from cruise ships are potentially high enough to cause temporary or permanent hearing loss, the duration of exposure would be too short to cause damage. For example, for a ship traveling 19 knots, a stationary object would be exposed to 130 decibels or more for approximately 17 minutes. For a ship traveling at 10 knots, a stationary object would be exposed to sound levels of 130 decibels or more for approximately 4 minutes. These time periods are shorter than the 20- to 22-minute exposures that caused temporary hearing loss (temporary threshold shift) in a harbor seal, elephant seal, and California sea lion (Kastak et al. 1999).

In conclusion, it is expected that vessel noise would disturb marine mammals on a regular basis, but that the duration and intensity of effect would not be sufficient to harm or otherwise cause these species to leave Glacier Bay. The maximum duration that any one point would be exposed to sound levels over 130 decibels is in the range of less than 3.5% of the time from June through August. The cruise ship limits for alternative 1 that would be in effect have been in effect for several years, and humpback whale numbers in the area have increased during that time.

<u>Behavioral Effects of Exposure to Motorized Vessel Noise on Marine Mammals — Alternative 1**.**</u> All alternatives require that within designated whale waters, vessels must travel at least one mile from shore. The majority of marine mammal use occurs near shore. Cruise ships generally travel mid-channel up Glacier Bay and near shoreline areas only when approaching the tidewater glaciers. When near the glaciers, cruise ships generally slow down to 8 knots or less, which creates much lower sound levels. Still, outside of whale waters, cruise ships travel at a relatively high rate of speed (up to 26 knots). At these speeds, the ensonified area extends three miles in either direction, so that, where the channel is less that 6 miles wide, the ensonified zone is essentially shoreline to shoreline.

Under alternative 1, vessel speed limits are set in designated and temporary whale waters only. In general, vessel noise progressively increases as vessel speed increases. For example, modeling indicated that, at 10 knots, the average cruise ship generated a 500 meter radius at which sound levels were 130 decibels or greater. The one ship, where noise data is available for speeds greater than 10 knots (19 knots in Kipple 2002), generated a radius of 5,000 meters – an area 83 times larger (based on the ensonification model). Because under alternative 1 speed limits apply only to whale waters, vessel noise would be much louder outside of whale waters.

EFFECTS OF NOISE AND VESSEL TRAFFIC ON DISTRIBUTION OF MARINE MAMMALS — ALTERNATIVE 1. The distribution of marine mammals in Glacier Bay or Dundas Bay may be affected by vessel traffic. Reactions of individual marine mammals to sound can be highly variable. Some individuals may not leave an area with vessel traffic, while others may shift distribution for times ranging from hours to days. A shift in distribution for some marine mammals within Glacier Bay or Dundas Bay would be likely to have minor effects to the populations within Glacier Bay or Dundas Bay, but negligible effects on the stocks that inhabit Southeast Alaska. It is likely that any marine mammals displaced from Glacier Bay would move elsewhere and resume normal activities.

EFFECTS OF VESSEL NOISE ON COMMUNICATION AND HEARING — ALTERNATIVE 1. As described in section 4.3.1, the effects of vessel noise on marine mammals hearing and their ability to communicate are directly linked. Sounds from vessels have the potential to mask communications between individuals; however, marine mammals have evolved ways of reducing the effects of ambient noise on communications. They may shift the frequency band of their communications to use a less "noisy" spectrum, or alter the number, source level, or rate of calls. These changes are expected to occur as a result of both anthropogenic noise and natural sources of ambient noise (e.g., waves breaking, wind noise, etc.). If such shifts in communication do not fall outside normal ranges used by the animals, then the effects would be negligible; however, if the masking noise is broadband in nature, and in excess of species attainable source levels, there may not be less "noisy" bands in the useful spectra for marine mammals. Additionally, some sounds may be frequency dependent, and shifting the dominant bands of some calls may not be possible. Under such conditions the critical calls may be masked. If the masked calls are important for social or other purposes (e.g., echolocation to find food), then individuals may suffer minor effects. It is possible, therefore, that vessel noise would have negligible to minor effects on marine mammal communications.

Cruise ship noise is loud enough to cause hearing loss in marine mammals; however, marine mammals in Glacier Bay are rarely exposed to cruise ship noise for a duration that this would occur. Permanent or temporary hearing impairment is a possibility if marine mammals are exposed to very strong pulsed or transient sounds (in excess of 180 or 190 dB re 1 µPa rms (root mean squared), respectively for cetaceans or seals) or persistent continuous sounds at levels within 120 to 130 dB re 1 µPa. A recent acoustic modeling study examined noise exposure of killer whales from whale watching activities in the Haro Strait (Erbe 2002). Erbe (2002) estimated zones of noise exposure and speculated that killer whales could experience permanent hearing loss as a result of prolonged year-round noise exposure from multiple whale-watching vessel traffic with source levels of 145 to 169 dB re 1 µPa at 1 meter. On average, 21 vessels followed killer whales through Haro Strait during the peak season (mid-May through August). For comparison, the mean source level for cruise ships in Glacier Bay in 2001 was 178 dB re 1µPa at 1 meter, with a maximum of 186 dB re 1 µPa at 1 meter. Since vessels are mobile, however, and not all directed at a given species, such as those in Haro Strait, they do not remain in any given area within Glacier Bay long enough to induce temporary or permanent threshold shift in marine mammals. Motorized vessel noise that would be generated under alternative 1 would not result in temporary or permanent threshold shift, or mortality of animals. In the event that vessels remain in an area and produce sound levels sufficiently high to result in temporary or permanent threshold shift in marine mammals, it is unlikely that the marine mammals would remain in the area long enough to be affected. Effects to marine mammal hearing, therefore, are expected to range from negligible to minor. Any temporary threshold shift would be considered a moderate effect, and permanent threshold shift in individuals a major effect, but neither of these are likely to occur under alternative 1.

EFFECTS OF VESSEL COLLISIONS – ALTERNATIVE 1. Vessel speed restrictions apply to whale waters in Glacier Bay. There is no speed limit in waters outside whale waters. Vessel speeds less than 14 knots have been found to decrease the risk and severity of collisions between whales and ships (Laist et al. 2001); therefore, the potential for collisions between ships and whales outside of whale waters is higher than it is within whale waters. Overall, collisions are expected to be rare events, but a collision between a marine mammal and a ship 80 meters or greater (i.e., cruise ships) would likely kill the individual (Laist et al. 2001) and cannot be ruled out.

Small cetaceans (harbor porpoise and Dall's porpoise), harbor seals, and sea otters are unlikely to be struck by vessels as they are generally more maneuverable than large cetaceans and some use very nearshore habitats less accessible to most motorized vessels. Death of a marine mammal would be considered major, since it would violate the Marine Mammal Protection Act; however, such collisions would be rare, and the effects would be at the individual level the anticipated effects for small cetaceans, harbor seals and sea otters would be negligible.

<u>Other Effects from Motorized Vessels — Alternative 1.</u> As described under "Subsection 4.3.1 Threatened and Endangered Species," the sight and sounds of motorized vessels are known to disturb most marine mammals. The specific reaction of an individual on any particular vessel encounter cannot be predicted, since the reaction depends on many factors, including the specific sensitivity of the individual animal, the speed and course of the vessel, the specific vessel type, and an unknown number of other factors. Still, it can be assumed that the presence of vessels in Glacier and Dundas Bays startles, frightens, and/or annoys individual animals and, in some cases, causes them to flee, dive, make sounds (or stop making sounds), or leave a haul out area.

The ultimate effect is reduced energy intake and increased energy expenditure, which increases risks of harm. Such loss of energy and increased risks can reduce the health of the individual and, when considered with many other factors, might contribute to reduced reproduction and survival.

Overall, alternative 1 would have a moderate effect on marine mammals due to the potential cumulative effect on harbor seals. Over the past decade, harbor seal numbers have fallen by nearly 50 percent. The causes for this decline are unknown, but vessel traffic is known to disturb harbor seals. Alternative 1 does include protection measures for harbor seal haul outs in Johns Hopkins inlet, including seasonal vessel closures and distance requirements. This measure reduces the effect of vessel traffic.

Overall effects on other marine mammals from maintaining existing vessel quotas and operating requirements would be minor. While marine mammal populations in Glacier and Dundas Bays may be lower than would occur with lower motorized vessel use than currently allowed, marine mammal populations in Glacier and Dundas Bays are stable and self-sustaining. Current vessel use has been in effect for several years, with no notable decline in marine mammal populations, with the exception of harbor seals.

Under alternative 1, it is assumed that such disturbance and associated energy costs to marine mammals would gradually increase as vessel numbers reach the maximum allowed. Increases would be greatest in May and September due to increased demand and lack of seasonal restrictions under alternative 1 (cruise ships and tour vessels would be limited to two per day and three per day, respectfully, year round). Species-specific effects are described below.

MINKE WHALES. Effects on minke whales are expected to be similar to those described for humpback whales in subsection 4.3.1, including harassment and annoyance from the presence of vessels, complications in communication and hearing due to vessel noise, and the risk of collision. Minke whales are not common in Glacier or Dundas Bays, with reported sightings between five and eight per year. Therefore, not much is known about how effects may be specific for this species. Minke whales are relatively fast swimmers (up to 20 miles per hour), which might make them more maneuverable and able to avoid vessels better than humpback whales, but this is not known.

HARBOR PORPOISES. Harbor porpoises are much less vulnerable to collisions with vessels than are humpback whales, since they are very mobile and fast swimmers. They are, however, sensitive to disturbance and typically leave an area once a vessel approaches. Vessel traffic has been suggested as a possible reason for declines in harbor porpoise populations in Puget Sound, Washington. Because harbor porpoises rely heavily on hearing and use echolocation, vessel noise is much more likely to hinder echolocation for this species than other marine mammals. Vessel traffic might have reduced harbor porpoises use of Glacier and Dundas Bays, but there is no evidence to support this. While no Dall's porpoises have ever been reported in Glacier Bay, they are occasionally reported in Icy Strait. If an individual were to venture into Glacier Bay, the overall effects are expected to be similar to the level of effects for harbor porpoises.

KILLER WHALES. Killer whales are known to occur in some areas containing relatively high vessel traffic, but this could make them susceptible to hearing damage if they do not avoid loud noises. A recent acoustic modeling study examined noise exposure of killer whales from whale watching activities in the Haro Strait (Erbe 2002). Erbe (2002) estimated zones of noise exposure and speculated that killer whales could experience permanent hearing loss as a result of prolonged year-round noise exposure to multiple whale watching vessels with source levels of 145 to 169 decibels . In Glacier Bay, however, since vessels are mobile and not all directed at viewing a given species, such as those in Haro Strait, vessels do not remain in any given area within Glacier Bay long enough to induce temporary or permanent threshold shift in marine mammals. Under alternative 1, killer whales that use Glacier and Dundas Bays would regularly encounter vessels and may respond by leaving the area, or may remain in the area and continue their behavior. Overall, the effects on killer whales are expected to be minor.

HARBOR SEALS. Harbor seal numbers in Glacier Bay have dropped by close to 50% in the last decade, with much of the decline since 1996 (Mathews and Pendleton 1997). Some, but not all, of this decline can be attributed to the grounding of Muir glacier and the subsequent loss of ice flows that harbor seals use for haul outs. Harbor seals are less sensitive to underwater noise than are whales (Richardson et al. 1995). Harbor seals are either concentrated in a discreet area within Glacier Bay or at specific haul outs. These locations are susceptible to repeated exposure and disturbance that may result in persistent effects.

Henry and Hammill (2001) found that disturbances to harbor seals most often were caused by kayaks and canoes (33.3%) rather than motorized vessels (27.8%) or sailboats (18%). Numbers of seals hauled-out decreased after a disturbance, except during the molting period when seals seemed more reluctant to enter the water. The most severe reaction was seen with the approach of kayaks/canoes with a flushing response of 86%, compared to 74% by motorized vessels and 0% by sailboats. Lelli and Harris (2001) found that vessel traffic past a harbor seal haul-out accounted for 27% of the variability in numbers of seals hauled out. Lelli and Harris (2001) also found that 50% of the paddled boats caused seals to enter the water, whereas 11% of the motorboats did. This result was likely related to distance between the boat and the seals. The channel that vessels had to transit past the haul out was only 200 meters wide at low tide and motorized vessels were restricted to the center of the channel while non-motorized vessels could cover the entire channel. Calambokidis et al. (1983) showed that 50% of the harbor seals hauled out on ice entered the water when cruise ships approached to less than 300 meters, whereas the response occurred for kayaks, tour boats, and pleasure boats at distances less than 170 meters. Lewis and Matthews (2000) determined that 93% of the groups of people monitored in McBride Glacier Fjord in May and June 1998 disturbed harbor seals. Lewis and Matthews (2000) further determined that the visitors were in violation of the Marine Mammal Protection Act, and that human effects were much greater than previously known.

Effects from wakes potentially swamping harbor seal haul outs is expected to be minor. A technical memorandum concerning boat wakes (appendix F) determined that vessel wakes are several orders of magnitude smaller that naturally occurring waves. Furthermore, vessels are unlikely to be moving at speeds great enough to create a substantial wake in areas with high concentrations of harbor seals hauled out on glacial ice due to glacial ice striking the hull and risk of vessel damage. Cruise ships and tour vessels travel slowly (less than 8 knots) in this area because it is a destination, rather than a travel area.

The overall level of effects on harbor seals is moderate under Alternative 1. Harbor seals would be disturbed during feeding and while at haul outs. Private vessels may be more of a concern because they tend to travel closer to shore, and therefore come closer to harbor seal haul outs. The increased energy expenditures for avoiding vessels, and loss of acquiring energy by having feeding bouts disturbed, would incrementally reduce survival and reproduction. The level of effect without any other population data would be considered minor. However, since the harbor seal population is in decline these effects are considered moderate, rather than minor.

SEA OTTERS. Sea otters are not particularly sensitive to vessel traffic, but will avoid close contact with vessels. They do not rely on sound as much as other marine mammals and, therefore, effects are expected to be minor. Sea otters are unlikely to be struck by vessels as they are generally more maneuverable than large whales and use nearshore habitats mostly inaccessible to most motorized vessels. The sea otter population has increased tremendously since vessel numbers were increased in 1996, so vessel traffic does not seem to have a major effect on population size or distribution.

Cumulative Effects on Marine Mammals – Alternative 1. Marine mammals in Glacier Bay or Dundas Bay are likely to be affected by several activities external to motorized vessel traffic.

- Non-motorized vessels are known to disturb harbor seals hauled out on ice or rocks, or other marine mammals in areas larger vessels cannot reach.
- Subsistence harvests of harbor seals and sea otters outside Glacier Bay could influence the level of immigration into Glacier Bay.
- Commercial fishing may affect marine mammals by altering food availability, or by entanglement in fishing gear. The intensity of commercial fishing in the park will decline over time, thereby reducing the effects.
- Increases in tourism and human populations in Southeast Alaska may increase pressure on fish resources through commercial and sport fishing, thereby altering the distribution of available food for marine mammals in Glacier Bay. Marine mammals that move in and out of Glacier Bay may be affected by increasing human influence outside the bay.

The incremental effect of vessel traffic on the potential cumulative effects described above are anticipated to be moderate for harbor seals due to the continued decline within Glacier Bay and their sensitivity during the most intense period of vessel activity.

Impairment Analysis for Marine Mammals – Alternative 1. Two purposes of the implementing legislation for the park and preserve pertain to the continued presence of marine mammals within the park and preserve:

- Maintain sound populations of, and habitat for, wildlife species of inestimable value to the citizens, and
- Glacier Bay National Park "in large part…[is] intended to be [a] large sanctuary where fish and wildlife may roam free, developing their social structure and evolving over long periods of time as nearly as possible without the changes that extensive human activities would cause."

Any effects to marine mammals that could be interpreted as resulting in overall population declines for either local populations or regional populations would impair park resources and values. Alternative 1 will not result in population declines for any marine mammals; therefore, impairment will not occur.

Potential mitigation measures for marine mammals — alternative 1 — Due to the continued decline of harbor seals in Johns Hopkins Inlet, it is important to implement mitigation measures to protect harbor seals until the causes of the decline are determined. Permanent speed limits, seasonal no-vessel entry areas, and approach distance limits may be appropriate ways to protect harbor seals. The resulting effect would still be moderate, since the actual causes of the declines in harbor seal populations in Glacier Bay are not known, and any effects could be biologically significant.

While not specifically mitigation, studies aimed at monitoring populations and at better understanding the effects of vessel traffic on marine mammals would help NPS managers manage vessel traffic and protect marine mammals. Baseline studies for other marine mammal species would help identify downward trends or new concentration areas as well as any need for additional protection.

Conclusion, marine mammals — alternative 1 — Behavioral disturbance to marine mammals from alternative 1 would be minor. The displacement of individual whales, seals, and sea otters from Glacier Bay or Dundas Bay would be intermittent, and each event would be short term. Collisions between vessels and marine mammals would have negligible impact on populations, but any mortality would be a moderate effect since marine mammals are protected by the Marine Mammal Protection Act. The overall effects of vessel traffic under the no action alternative would be moderate, since harbor seal populations have decline substantially and vessel traffic cannot be ruled out as a contributing factor to this decline (although it is unlikely the only contributing factor).

Alternative 2 — Effects on Marine Mammals.

Direct and indirect effects on marine mammals — alternative 2 —

Estimation of Ensonified Area — Alternative 2. The maximum effect of alternative 2 at any given time would be the same as outlined for alternative 1, with a maximum area of about 12% of Glacier Bay being ensonified at any one time. However, under alternative 2, fewer cruise ships would enter Glacier Bay than are currently allowed. A total of 107 cruise ship visits would be allowed, creating the possibility of 214, seventeen minute passings (2 per cruise ship visit) where sound would be greater than 130 decibels at any given point. This represents a maximum duration of approximately 2.7 percent of the time any one point would be disturbed by cruise ship noise from June through August.

It is expected that cruise ship noise would disturb marine mammals on a regular basis, but that the duration and intensity of effect would not be sufficient to harm or otherwise cause these species to leave Glacier Bay.

Behavioral Effects of Exposure to Motorized Vessel Noise on Marine Mammals — Alternative 2. It is expected that noise from motorized vessels would have some effects on marine mammal behavior near vessels, especially those within the zone ensonified at approximately 130 decibels. It is likely, however, that behavioral changes would remain within normal behavioral ranges, persist for less than one day, and not result in physical harm or death. The smaller adjusted daily ensonified zone may result in fewer disturbances than for alternative 1; therefore, behavioral effects are expected to be moderate, but overall are reduced relative to alternative 1.

Effects of Noise and Vessel Traffic on Distribution of Marine Mammals – Alternative 2. The distribution of marine mammals in Glacier Bay or Dundas Bay may also be affected by vessel traffic under alternative 2. A shift in distribution for some marine mammals within Glacier Bay or Dundas Bay is likely to have minor to moderate effects on the populations within Glacier Bay or Dundas Bay, but negligible effects on the stocks that inhabit Southeast Alaska.

Effects of Vessel Noise on Communication and Hearing – Alternative 2. As with alternative 1, noise from vessels has the potential to mask communication between individuals; however, any masking effects are expected to be negligible to minor.

As in alternative 1, the mobile nature of vessels and marine mammals makes the probability of Temporary or permanent threshold shift low. Overall the anticipated effects to marine mammals are expected to be negligible to minor.

Effects of Vessel Collisions – Alternative 2. Current speed restrictions of 10 knots (measured relative to water speed) while in whale waters would also apply to alternative 2. As in alternative 1, the maneuverability and speed of smaller cetaceans, seals and sea otters makes the probability of vessel strikes unlikely. The effects from vessel collisions are moderate to major for individual marine mammals, but negligible to minor for their populations as a whole as for alternative 1.

Other Effects from Motorized Vessels – Alternative 2. As in alternative 1, any effects from wakes are likely to be negligible to minor for harbor seals, small cetaceans, and sea otters.

Cumulative Effects for Marine Mammals – Alternative 2. Activities and phenomena discussed in alternative 1 would also affect marine mammals under alternative 2. Overall effects may be incrementally less due to the small decrease in seasonal use, and the corresponding reduction in seasonally ensonified area; however, it is unlikely that any differences would be detectable.

Impairment Analysis for Marine Mammals – Alternative 2. Any effects on marine mammals that result in declines in the animal's population would be considered to impair park resources and values. Alternative 2 is unlikely to cause a change in populations of marine mammals in the park and therefore would not impair the parks resources.

Potential Mitigation Measures for Marine Mammals – Alternative 2. Mitigation recommended in alternative 1 is also recommended under alternative 2.

Conclusion, Marine Mammals – Alternative 2. Disturbance of marine mammals resulting from alternative 2 could range from negligible to minor. The displacement of marine mammals from Glacier Bay or Dundas Bay is likely to be short term and is unlikely to cause a change in Glacier Bay or Dundas Bay populations. A collision between vessels and whales would have negligible effect on whale populations. Harm due to permanent threshold shift is unlikely and the expected effects would be negligible; therefore, the overall effects of vessel traffic under Alternative 2 would be minor.

Alternative 3 – Effects on Marine Mammals

Direct and Indirect Effects on Marine Mammals – Alternative 3.

Estimation of Ensonified Area – Alternative 3.

Under alternative 3, additional cruise ships are assumed to be allowed into Glacier Bay than are currently allowed, thereby increasing noise exposure and potential effects. A total of 184 cruise ship visits would be allowed, creating the possibility of 184, seventeen minute passings (2 per cruise ship visit) where sound would be greater than 130 decibels at any given point. This represents a maximum duration of approximately 4.6 percent of the time any one point would be disturbed by cruise ship noise from June through September. Tour, charter, and private vessels would add to the less than 1 percent of Glacier Bay.

This amount is not expected to be sufficient to cause major effects on marine mammals due to noise, but it could cause fewer marine mammals to use certain areas of Glacier Bay. Because of uncertainties related to potential effects of additional cruise ships, this effect is considered moderate.

Behavioral Effects of Exposure to Motorized Vessel Noise – Alternative 3. It is expected that noise from motorized vessels would have some effects on marine mammal behavior near vessels, especially those within the 130 dB re 1 μPa zone. As in alternatives 1 and 2, however, it is likely that behavioral changes would remain within the normal behavioral ranges, not last for more than one day, and would not result in physical harm or death to marine mammals. Because the number of seasonal-use days is highest under alternative 3, the seasonally ensonified zone is largest and therefore, would likely result in more disturbance than for alternative 1. Effects from behavioral disturbance are expected to range from negligible to minor.

Effects of Noise and Vessel Traffic on Distribution – Alternative 3. As in alternatives 1 and 2, the distribution of marine mammals may be affected by vessel noise and traffic under alternative 3. The increase in the number of vessels present during the season may result in larger or more persistent shifts in distribution when compared to alternatives 1 and 2; however, it is unlikely that such shifts in distribution would be detectible with current monitoring efforts. A shift in distribution for some marine mammals within Glacier Bay is likely to have minor to moderate effects for the populations within Glacier Bay, but negligible effects for the stocks that inhabit Southeast Alaska.

Effects of Vessel Noise on Communication and Hearing– Alternative 3. As with alternatives 1 and 2, noise from vessels has the potential to mask communication between individuals. The seasonal increase in the number of vessels present under alternative 3 may result in more frequent or persistent masking events when compared to alternatives 1 and 2; however, effects are expected to be negligible due to the natural sound production and hearing abilities of marine mammals.

Effects of Vessel Collisions – Alternative 3. Current speed restrictions as described for alternatives 1 and 2 apply to Alternative 3. Outside of the lower bay whale waters vessel speeds are unlimited; therefore, the potential for collisions between ships and whales is greater than if more stringent speed restrictions were enforced. The maneuverability and speed of killer whales, minke whales, harbor porpoise, Dall’s porpoise, seals and sea otters make the probability of collision unlikely. Effects from vessel collisions to individual marine mammals are moderate to major, but negligible to populations and possibly minor for harbor seal populations.

<u>Other Effects from Motorized Vessels – Alternative 3</u>. As in alternatives 1 and 2, effects from wakes are expected to be negligible to marine mammals.

Cumulative Effects for Marine Mammals – Alternative 3. Marine mammals in Glacier Bay and Dundas Bay would be affected by the same external activities and processes identified in alternative 1. The overall effects may be incrementally higher under alternative 3 due to the increase in seasonal vessel traffic; however, it is unlikely that differences between the alternatives would be detectible under current monitoring practices. The cumulative effects from activities external to Glacier Bay or Dundas Bay when combined with the proposed activities are expected to range from negligible to minor and moderate for harbor seals if their population in Glacier Bay continues to decline.

Impairment Analysis for Marine Mammals – Alternative 3. Any effects on marine mammals that result in a decline in the animal's population would be considered to impair park resources and values. Under alternative 3, it is unlikely that population level changes will occur and therefore it is unlikely that impairment of the park's resources will occur.

Potential Mitigation Measures for Marine Mammals – Alternative 3 — As described under alternative 1, additional measures may be required to protect harbor seals, should harbor seal populations continue to decline.

Conclusion, Marine Mammals – Alternative 3. Disturbance to marine mammals from alternative 3 are expected to range from negligible to minor. The displacement of whales, small cetaceans, seals and sea otters from Glacier Bay or Dundas Bay is likely to be short term and would have minor to moderate effects. A collision between a vessel and a marine mammal, or permanent threshold shift resulting from noise exposure would have major effects on individual animals but are unlikely to impact marine mammal populations. The low likelihood of harm or death is expected to result in negligible effects. The overall effects of vessel traffic and noise under alternative 3 are expected to range from negligible to moderate.

Alternative 4 – Effects on Marine Mammals.

Direct and Indirect Effects on Marine Mammals – Alternative 4.

<u>Estimation of ensonified area — alternative 4.</u> Under alternative 4, cruise ships would be required to travel at 13 knots throughout the Bay. This would greatly reduce the effects of vessel noise. No

measurements of vessel speeds of 13 knots are available, but it is assumed that a much smaller area would be affected, with most shoreline areas likely being sufficiently far to have dramatically reduced time at which they are exposed to vessel noise greater than 130 decibels.

<u>Behavioral Effects of Exposure to Motorized Vessel Noise – Alternative 4</u>. Behavioral effects would be minor, but would be relatively less than those under alternatives 1 through 3 due to additional vessel closures in the East Arm and Johns Hopkins Inlet.

Under alternative 4, the East Arm of Glacier Bay (Muir Inlet and connected waters) would be closed to tour vessel and cruise ship traffic. If vessel traffic and noise influences the distribution of marine mammals, the East Arm may provide a refuge. A change in distribution for marine mammals to the East Arm would suggest a minor effect on marine mammal distribution from vessel traffic, but overall would suggest that they are able to find areas to avoid noise exposure. However, increased marine mammal abundance in the East Arm, combined with a lack of cruise ship and tour vessel traffic, could result in higher charter and private vessel use of the East Arm. Marine mammals seeking refuge from cruise and tour vessels in the East Arm may be subjected to higher levels of charter and private vessel traffic, resulting in similar exposure to vessel noise. Such changes in distribution would result in negligible to minor effects.

Harbor seals in Johns Hopkins Inlet are protected by the same seasonal closures except they apply year round under alternative 4. These added measures would provide some additional protection to reduce displacement and disturbance from important areas within the inlet; therefore minor effects on harbor seals are expected from vessel operating procedures in alternative 4.

<u>Effects of Noise and Vessel Traffic on Distribution – Alternative 4</u>. The distribution of marine mammals in Glacier Bay or Dundas Bay may be affected by vessel traffic under Alternative 4. Most evidence, as discussed for the previous alternatives indicates that changes in distribution during the feeding season result from changes in prey abundance and distribution. A shift in distribution for some marine mammals within Glacier Bay or Dundas Bay would not likely change populations within Glacier Bay, or Southeast Alaskan stocks. Under alternative 4, the East Arm of Glacier Bay (Muir Inlet and connected waters) could be closed to tour vessel and cruise ship traffic. If vessel traffic and noise influences the distribution of marine mammals the East Arm may provide a refuge. A change in distribution for marine mammals to the East Arm would suggest a minor effect on marine mammal distribution from vessel traffic, but overall would suggest that they are able to find areas to avoid noise exposure; however, increased marine mammal abundance in the East Arm, combined with a lack of cruise ship and tour vessel traffic, could result in higher charter and private vessel use of the East Arm. Marine mammals seeking refuge from cruise and tour vessels in the East

Arm may be subjected to higher levels of charter and private vessel traffic, resulting in similar exposure to vessel noise. Such changes in distribution may result in negligible to minor effects.

Harbor seals in Johns Hopkins Inlet are protected by the same seasonal closures except they apply year round under alternative 4. These added measures would provide some additional protection to reduce displacement and disturbance from important areas within the inlet; therefore minor effects on harbor seals are expected from vessel operating procedures in alternative 4.

<u>Effects of Vessel Noise on Communication and Hearing – Alternative 4</u>. As with alternatives 1 through 3, noise from vessels has the potential to mask communication between individuals; however, the mobile nature of marine mammals, and their ability to change the frequency, duration, and source levels of most calls (Lesage et al. 1999; appendix E), would result in masking effects being negligible to minor. The potential for temporary and permanent threshold shift exists under alternative 4, as for alternatives 1 through 3. The mobile nature of marine mammals and the mobile sound sources make the probability of temporary threshold shift and permanent threshold shift remote; therefore effects to marine mammal hearing are expected to be negligible to minor.

<u>Effects of Vessel Collisions – Alternative 4</u>. Vessel speed regulations under alternative 4 would change in two ways from alternatives 1 through 3. First, speed restrictions would be in place from May 1 through September 30 rather than May 15 through August 31 as in alternatives 1 through 3. Second, speed restrictions would also be based on vessel length: outside of whale waters, vessels up to 80 meters would be restricted to 20 knots, while vessels 80 meters and greater would be restricted to 13 knots. All vessels within whale waters would be restricted to 10 knots when whale waters are designated. All vessel speeds would still be measured over water.

Laist et al. (2001) reported that vessel collisions and the severity of large vessel collisions with whales were reduced when vessels operated at speeds less than 14 knots. The reduction in vessel speeds under alternative 4 would reduce the potential for collisions and the severity of collisions with larger vessels. Collisions would result in moderate to major effects to marine mammals. These effects may be reduced to a moderate level by reductions in vessel speed that would decrease the probability and severity of large vessel collisions with whales. Small cetaceans (harbor porpoise and Dall’s porpoise), pinnipeds (harbor seals), and fissipeds (sea otters) are unlikely to be struck by vessels as they are more maneuverable than large cetaceans; therefore, effects on small cetaceans, pinnipeds and fissipeds would be negligible.

<u>Other Effects from Motorized Vessels – Alternative 4</u>. As in alternatives 1 through 3, effects from wakes are likely to be negligible to minor for whales, harbor seals, small cetaceans and sea otters.

Cumulative Effects on Marine Mammals – Alternative 4. Activities and phenomena discussed in Alternative 1 would also affect marine mammals under alternative 4. Thus, under alternative 4, the cumulative effects on marine mammals would range from negligible to minor with the exception of the potential contribution to the decline in harbor seal populations – a major effect.

Impairment Analysis for Marine Mammals – Alternative 4. Any effects on marine mammals that could be interpreted as resulting in overall population declines for either the local or regional populations would impair park resources and values. Alternative 4 will not result in population level declines of the Glacier Bay marine mammals.

Potential Mitigation Measures for Marine Mammals – Alternative 4. Mitigation recommended in alternative 1, including continued acoustic data collection, and detailed vessel course and speed logs are also recommended under Alternative 4. The vessel restrictions in the East Arm and Johns Hopkins Inlet have the potential to mitigate effects on marine mammals; however, the effectiveness of these measures in Johns Hopkins Inlet to help the recovery of harbor seals can not be fully understood or appropriately applied unless statistically powerful studies are designed to detect changes in habitat use, behavior, and distribution. Additionally, studies investigating the distribution and relative abundance of marine mammals in the West and East Arms of Glacier Bay are recommended to determine if changes occur due to restrictions for cruise ships in the East Arm.

Conclusion, Marine Mammals – Alternative 4. The reduction in seasonal use days for all vessel classes would result in a smaller overall ensonified zone than would the alternative 1. If a few vessels leave and re-enter Glacier Bay or Dundas Bay, then the alternative 4 seasonally adjusted average ensonified zone is the smallest when compared to the other alternatives. Disturbance to marine mammals from alternative 4 could range from negligible to minor effects. Whales, seals, and sea otters may move from the West Arm to the East Arm to avoid cruise ship and tour vessel traffic noise. Such a change in distribution is likely to result in minor effects on the marine mammal populations of Glacier Bay or Dundas Bay; however, marine mammals in the East Arm may be subjected to higher levels of charter vessel and private vessel traffic. The overall effects of alternative 4 are expected to be minor, and relative to alternatives 1 through 3 will significantly reduce effects due to reduced vessel speeds and a reduction in vessel use of the East Arm and Johns Hopkins Inlet.

Alternative 5 – Effects on Marine Mammals.

Direct and Indirect Effects on Marine Mammals – Alternative 5.

<u>Estimation of Ensonified Area – Alternative 5</u>. The zone described for threatened and endangered species, alternative 5, applies here, as well (see section 4.3.1, table 4-18).

Like alternative 4, alternative 5 would place a speed restriction on cruise ships throughout Glacier Bay. This would greatly reduce the effects of vessel noise. No measurements of vessel speeds of 13 knots are available, but it is assumed that a much smaller area would be affected, with most shoreline areas likely being sufficiently far to have dramatically reduced time at which they are exposed to vessel noise greater than 130 decibels.

Also under Alternative 5, temporary speed limits in areas where whales are observed would be increased from 10 knots to 13 knots. This would create more noise in whale waters, since, at least in some cruise ships, underwater sound generation increases dramatically with speed increases. The exact effect of this cannot be determined since no sound signatures are available for cruise ships traveling at 13 knots. Therefore, the overall effect is considered to be moderate.

<u>Behavioral Effects of Exposure to Motorized Vessel Noise – Alternative 5</u>. It is expected that noise from motorized vessels would have some effects on marine mammal behavior near vessels, especially those within the 130 decibels. As in alternatives 1 through 4, it is likely that behavioral changes would remain within the normal behavioral ranges and would not result in physical harm or death to marine mammals; however, there is potential for repeated disturbance to marine mammals from multiple tour, charter, and private vessels (or the same vessel repeatedly). Such repeated disturbance may lead to more frequent or persistent behavioral changes. Thus, behavioral effects could range from negligible to minor.

<u>Effects of Noise and Vessel Traffic on Distribution – Alternative 5</u>. The distribution of marine mammals in Glacier Bay or Dundas Bay may change as a result of vessel traffic under alternative 5. A shift in distribution for some marine mammals within Glacier Bay or Dundas Bay is likely to have minor effects to populations within Glacier Bay, but negligible effects to Southeast Alaskan stocks.

<u>Effects of Vessel Noise on Communication and Hearing – Alternative 5</u>. As with alternatives 1 through 4, noise from vessels has the potential to mask communication between individuals. The possible and unpredictable increase in numbers of tour, charter, and private vessels using Glacier Bay or Dundas Bay under alternative 5 could result in greater masking effects to marine mammals;

however, considering the mobile nature of marine mammals, and their abilities to change the frequency, duration, or source levels of their calls, effects are expected to be negligible to minor.

The potential for temporary and permanent threshold shift exists under alternative 5, as for alternatives 1 through 4, but the probability of temporary and permanent threshold shift is remote. The possible but unpredictable increase in vessel numbers under alternative 5 makes the risk of temporary and permanent threshold shift higher, particularly if private vessels approach marine mammals too closely; however, effects to marine mammal hearing are expected to be negligible to minor.

<u>Effects of Vessel Collisions – Alternative 5</u>. Vessel speed regulations under alternative 5 would change in the same ways as under alternative 4; however, under alternative 5, vessel speed for tour vessels, charter vessels, and private vessels would be measured “over ground” rather than through the water. Please refer to the description in section 4.3.1 for alternative 5 regarding the differences in speed measurements. Any collision, whether lethal or sub-lethal, would result in moderate to major effects to the individual that was struck but negligible to minor effects on their populations. Small cetaceans (harbor porpoise and Dall’s porpoise), pinnipeds (harbor seals), and fissipeds (sea otters) are unlikely to be struck by vessels as they are generally more maneuverable than large cetaceans, and seals and sea otters are often found in nearshore habitats less accessible to most motorized vessels. Effects on small cetaceans, pinnipeds and fissipeds, therefore, would be negligible, but the probability of a collision is higher under alternative 5 than alternative 4 but lower than alternatives 1 through 3.

<u>Other Effects from Motorized Vessels – Alternative 5</u>. As in alternatives 1 through 4, effects from wakes are likely to be negligible to minor for whales, harbor seals, small cetaceans and sea otters.

Cumulative Effects on Marine Mammals – Alternative 5. Activities and phenomena discussed in alternative 1 would also affect marine mammals under alternative 5; however, speed restrictions and vessel area closures reduce the effects relative to alternatives 1 through 3. Thus, under alternative 5, the cumulative effects on marine mammals may range from negligible to minor.

Impairment Analysis for Marine Mammals – Alternative 5. Any effects on marine mammals that could be interpreted as resulting in moderate or major effects would be considered to impair park resources and values. No changes in marine mammal populations are anticipated thus the park’s resources would not be impaired.

Potential Mitigation Measures for Marine Mammals – Alternative 5. Mitigation recommended in alternative 4, including continued acoustic data collection, detailed vessel course and speed logs, statistically powerful harbor seal studies in Johns Hopkins Inlet, and the investigations of marine mammal distribution and abundance in the East and West Arms suggested in alternative 4, are recommended under alternative 5.

Conclusion, Marine Mammals – Alternative 5. Disturbance to marine mammals from alternative 5 would be moderate. Some shift in use by whales, harbor porpoises, and seals may occur from the West Arm to the East Arm to avoid cruise ship traffic noise. Such a change in distribution is likely to result in minor effects on the marine mammal populations of Glacier Bay or Dundas Bay. Decreasing the maximum speed of cruise ships to 13 knots throughout Glacier Bay would greatly reduce the effects of noise.

Summary, Marine Mammals. Under all alternatives, marine mammals would be disturbed by vessel traffic. Vessel traffic would cause individuals to avoid areas of high vessel use. Most marine mammals are highly mobile and able to avoid vessels, but it is possible individuals may by struck and injured or killed by vessels. Tangible effects are expected to be at the individual level, rather than the population level, with the possible exception of harbor seals, which are declining in Glacier Bay. The magnitude of effects is directly related to the level of vessel traffic. Alternatives 2 and 4 would have the lowest effect, while Alternatives 5, 1, and 3 would have greater effects (in that order, with 3 having the greatest effect). This change in magnitude among alternatives is not sufficient to change the overall conclusion of moderate effects on harbor seals (due to population-level effects) and moderate effects on other species of marine mammal (due to individual-level effects).

4.3.3 MARINE BIRDS AND RAPTORS

4.3.3 Marine Birds and Raptors

This section addresses the effects of each alternative on marine birds and raptors, with emphasis on the potential disturbance of breeding seabirds, raptors (particularly bald eagles), shorebirds, waterfowl (principally during their molting period), and gulls. Breeding birds are of concern because of their vulnerability to disturbance during the high-energy demands of breeding. In addition to expending energy for day-to-day living, they must also expend energy defending nesting territories; building nests; generating, laying, and incubating eggs (which constantly require the input of heat from a bird); and caring for and feeding young until they are large enough to live capably on their own. Similarly, molting waterfowl are a concern because of the high-energy demands required during the molt and their inability to fly, which make them highly sensitive to disturbance. As with birds during the breeding season, birds that are molting have high energy demands to replace all their feathers and to store the body fat necessary for migration and winter survival.

Issues of Concern Raised during Scoping. The following issues of concern related to marine birds and raptors were identified during scoping:

- The presence of vessels in the marine environment alters marine bird behavior, specifically Harlequin ducks in Dundas Bay.
- Waves from vessel wakes could swamp marine bird nests that are in low-lying areas, thus reducing reproductive success and altering marine bird feeding behavior.
- Private and charter vessels that offload visitors onshore could disturb bird colonies, specifically at McBride Glacier, as well as nesting arctic terns and mew gulls in other breeding locations, thus reducing reproductive success.
- Vessel traffic may disturb the large concentrations of black oystercatchers that congregate in Glacier and Dundas Bays prior to fall migrations.

Regulatory Framework. The regulations related to birds that were considered in regard to the potential effects of the alternatives are as follows.

> *Bald Eagle Protection Act of 1940 (16 USC 668-668d*).
>
> *"No person within the United States shall possess, sell, purchase, barter, offer to sell, transport, export, or import, at any time or in any manner, any bald eagle or golden eagle, alive or dead, or any part, nest, or egg.*
>
> *"The Secretary of the Interior can permit taking, possessing, and transporting specimens for scientific or exhibition purposes or for the religious purposes of Indian tribes, if the action is determined to be compatible with the preservation of the bald or golden eagle."*

Bald eagles are common along park's shorelines and in nearshore areas.

Endangered Species Act of 1973 (PL 93-205; 16 USC 1531 et seq., as amended). As previously discussed in section 4.3.1, the Endangered Species Act protects animal and plant species currently in danger of extinction (endangered) and those that may become endangered in the foreseeable future (threatened). No threatened or endangered bird species are present in Glacier Bay or Dundas Bay.

Migratory Bird Treaty Act of 1918 (16 USC 703-712). The Migratory Bird Treaty Act provides the following protection to migratory birds:

> *Except as allowed by implementing regulations, this act makes it unlawful to pursue, hunt, kill, capture, possess, buy, sell, purchase, or barter any migratory bird, including the feathers or other parts, nests, eggs, or migratory bird products. Public Law 95-616 also ratified a treaty with the Soviet Union specifying that both nations will take measures to protect identified ecosystems of special importance to migratory birds from pollution, detrimental alterations, and other environmental degradations."*

All birds discussed in this section are classified as migratory birds under this act.

Methodology and Assumptions. The methodology for evaluating the effects on marine birds and raptors consists of:

- identifying proposed activities that could affect birds.
- determining how those activities will affect the birds (e.g., behavioral changes, changes in mortality, changes in reproduction, changes in habitat use).
- determining the level of effect of those activities and whether the effects are adverse or beneficial.
- determining the significance of those effects in terms of the resource.

To determine whether the effects on marine birds and raptors were adverse or beneficial, the significance of those effects was evaluated according to the threshold criteria in table 4-17.

TABLE 4-17: THRESHOLD CRITERIA FOR EFFECTS ANALYSIS ON MARINE BIRDS AND RAPTORS

Negligible	Individuals may be disturbed, but disturbance would be infrequent (less than once per day), lasting less than a few minutes, and limited to the point of disturbance. No measurable reductions in the survival, reproduction, and/or habitat use of bird populations in the park would occur, and any change would be within those levels that would occur naturally.
Minor	Localized populations may be reduced, but at levels that are within the range of normal population flux. Population reductions and/or other effects would be localized.
Moderate	Disturbance would be sufficiently high to reduce local populations (such as the numbers present in a breeding colony) to a lower number than the population size that would occur without disturbance. Disturbance and resulting population declines would occur over a relatively large area, such as an entire breeding colony or island or abandonment of a cove used for shelter by molting waterfowl.
Major	Local populations of one or more species would decline to the point that large areas are essentially abandoned, such as a breeding colony or bay used during molting.

Alternative 1 (No Action) – Effects on Marine Birds and Raptors.

Direct and Indirect Effects on Marine Birds and Raptors – Alternative 1. The potential effects on marine birds and raptors were evaluated in regard to the four issues of concern previously discussed—vessel disturbance, vessel wake, propwash, and fuel spills.

Vessel Disturbance. Moving vessels disturb birds by startling them and causing them to take flight or otherwise expend energy to avoid the vessels. Some authors (Bell and Austin 1985; Edwards and Bell 1987, cited in Cryer et al. 1987) have indicated that anglers may cause substantial disturbance to birds. Every vessel traveling up Glacier Bay might disturb many birds. If disturbance is so severe that it affects the ability to breed, the birds probably will abandon an area and nest elsewhere.

COLONIAL NESTING SEABIRDS: Of the 66 seabird colonies identified in Glacier Bay proper and Dundas Bay (see figure 3-9), 23 (35%) occur within non-motorized waters and, therefore, are protected from disturbance by motorized vessels. In the areas where motorized vessels are permitted, an examination of vessel tracklines indicates that:

- cruise ships stay mid-channel and do not venture near seabird colonies except near Lone Island, which lies near the middle of the channel, and while visiting the tidewater glaciers of the East Arm (see figure 3-24).
- tour vessels typically circle colonies at South Marble Island, and most pass near the colonies on the southeastern side of Russell Island (where the attraction is bears, rather than seabirds, and the vessels are in mid-channel; see figure 3-25).
- charter vessels typically do not visit most seabird colonies, with only South Marble and Puffin Islands receiving some visitation (see figure 3-25).
- Private vessels can travel freely in Dundas and Glacier Bays and tend to have the most diverse tracklines of the four vessel categories. Burger (1998) found that vessels not following marked channels (i.e., standardized tracklines) elicited a significantly higher response in birds than did vessels following marked channels.

Seabirds on South Marble Island (Zador and Piatt 1999), which is the most intensively visited colony in Glacier Bay proper and Dundas Bay, have exhibited no signs of population declines that might be attributed to vessel disturbance, with the possible exception of two puffin species. The pelagic cormorant population on the island in 1999 was similar to that of the 1970s and was slightly lower than that known in the early 1900s. Numbers of glaucous-winged gulls are considerably higher than they were in the 1940s. Black-legged kittiwakes first colonized the island in 1989, and the colony had grown to between 160 and 260 birds by the late 1990s. The numbers of common murres and pigeon guillemots on the island are slightly higher than they were in the 1970s. While the numbers of tufted and horned puffins are lower than they were in the 1970s, data is not sufficient to identify a decline.

MURRELETS: Research suggests that vessel disturbance affects the ability of marbled murrelets to feed and might exclude them from important feeding areas (Piatt and Naslund 1995). Vessel disturbance may affect the ability of Kittlitz's murrelets to feed in preferred glacial-affected and glacial-stream-affected waters in Prince William Sound, while their abandonment of Blackstone Bay in Prince William Sound may be caused by the presence of excessive vessel traffic and related disturbance (Day and Nigro 1999).

Similarly, Kuletz (1996) found that, in Alaska waters, marbled murrelet abundance declined in proportion to the density of vessels. About 85% of murrelets on the water in Prince William Sound left the area when the vessel density exceeded one boat per transect (a 200-meter [656 feet] wide survey area that is, on average, approximately 4 kilometers long [2.5 miles]) and up to 94% left when traffic was three or more vessels per transect. In Kachemak Bay, there were approximately 46% fewer murrelets on the water when vessel density exceeded one boat per transect, and approximately 60% fewer when traffic was three or more vessels per transect. Sitakaday Narrows, Reid Inlet, much of the East Arm, and the eastern entrance of Dundas Bay are all areas where vessel traffic is expected to impact murrelets. The effect is expected to be a decline in population numbers from those that would occur if vessels were not present. Due to the sensitivity of these species, vessel traffic is expected to cause a moderate effect on marbled and Kittlitz's murrelets through regular disturbance.

Of the areas in Glacier Bay and Dundas Bay where murrelets concentrate on the water, several occur within non-motorized waters and, therefore, are protected from disturbance by motorized vessels. Those areas include the Beardslee Islands, Hugh Miller / Scidmore Inlet Complex, Rendu Inlet, and Wachusett Inlet (see figure 3-10). Other areas where murrelets concentrate, but are vulnerable to vessel-caused disturbance, include Dundas Bay (the wide, outer portion), Sitakaday Narrows, Berg Bay, Geikie Inlet, Blue Mouse Cove, outer Queen Inlet, most of Muir Inlet (especially near the mouth), from Sturgess Island to the Leland Islands, and Beartrack Cove.

RAPTORS: For raptors (hawks and eagles), individuals would be disturbed by passing vessels, but overall effects of disturbance would be negligible. Of the five species of raptors that occur in the planning area, bald eagles are of most concern due to their strong association with shorelines and open water. Sharp-shinned hawk and northern goshawk are mostly forest-associated birds and would not be affected by vessel traffic.

Research conducted on the behavioral responses of breeding bald eagles to vessel disturbance indicates that, even though eagles are likely to respond to vessels that approach within about 650 feet (200 meters), on average, the percentage of breeding eagles that may be disturbed by vessel traffic is low, particularly for adults with eggs or chicks (Anthony et al. 1991; Buehler at al. 1991; McGarigal et al. 1991; Steidl and Anthony 1991). For alternative 1, the presence of cruise ships is likely to have a negligible effect on bald eagles. Tour, charter, and private vessels would be more likely to disturb bald eagles because these vessels operate closer to shore (and closer to eagle nests) than cruise ships, and are more likely to stop or remain stationary, activities that have been found to be more disruptive. Bald eagles likely would be flushed from perches regularly, but the overall effect is not expected to cause them to leave the area or otherwise affect populations. In addition, studies indicate that animals often habituate to regular non-threatening disturbances. For example, eagles nesting in the Bay that are visited at the same time each day by the *Spirit of Alaska* tour vessel continue to produce young and do not tend to flush from the nest or nest tree (NPS, Kralovec, pers. com., April 10, 2002). At existing levels of vessel use, potential adverse effects on breeding bald eagles likely would be no more than negligible to minor and would be in compliance with the Bald Eagle Protection Act.

Osprey are freshwater-oriented, so vessel traffic would not disturb or displace this species. Peregrine falcons could be disturbed, together with their prey (other birds), but overall, the level of disturbance would be minor, since vast areas of undisturbed waters are present even with vessels in Glacier and/or Dundas Bay.

NESTING SHOREBIRDS: The effects of vessel disturbance on shorebirds are not well understood; however, in general, vessel disturbance in certain circumstances can reduce shorebird nesting success or disturb foraging. Shorebirds may respond to disturbance by: 1) flying away and not returning, 2) flying away and then returning quickly to the same or a nearby location, 3) walking away, or 4) remaining in the same location and becoming motionless or continuing to feed (Burger 1986, Fitzpatrick and Bouchez 1998, Yalden and Yalden 1990, Yalden 1992). The sensitivity to disturbance is greater during spring migration and in the summer months, to rapidly moving and nearby disturbances, when in small flocks rather than large ones, and when their young are hatching (Burger 1986 and 1995, Burger and Gochfeld 1991). Individual shorebirds may be disturbed and/or temporarily displaced from habitats, but long-term displacement of a significant proportion of the shorebird population from foraging habitats does not appear to be likely in Glacier Bay proper and Dundas Bay, and therefore impacts are expected to be minor.

GULLS: Gulls (primarily black-legged kittiwakes, mew gulls, and glaucous-winged gulls) congregate in large numbers in Glacier Bay proper, especially in the vicinity of Sitakaday Narrows, to feed on zooplankton and small fishes in the ephemeral tide rips and tidal fronts that form there. They also congregate on beaches near river mouths to feed on small fishes and other organisms (Wik 1967; Matkin 1989). Gulls might experience effects due to vessel disturbance, which could affect habitat use.

Black kittiwakes would likely be disturbed at breeding areas, since they are known to flush due to vessel disturbance. However, populations of all gulls remain healthy and stable in the park, even after the 1996 increase in vessel numbers. In addition, alternative 1 includes setbacks at known breeding colonies that are believed to be sufficient to avoid large-scale disturbance of nesting colonies. Therefore, overall effects are expected to be minor.

BREEDING SEADUCKS: The most common breeding seaduck species seen on salt water in Glacier Bay proper and Dundas Bay are harlequin duck (a species that nests inland along stream-edges) and Barrow’s goldeneye and common merganser (two species that nest in cavities in trees). Because all three species nest away from the shore, they would not be affected by vessels during incubation; therefore, any effects of vessel disturbance on this stage of nesting would be negligible.

The chick-rearing stage is when broods are most sensitive to disturbance from vessels. Harlequin ducks appear to be highly sensitive to disturbance, with females taking broods to undisturbed areas and birds abandoning chronically disturbed areas (Hunt 1998, Robertson and Goudie 1999). In Glacier Bay and Dundas Bay, the potential effects of vessel disturbance on seaducks could be substantial if vessels routinely traverse habitat used by brood-rearing seaducks; therefore, under alternative 1 any effects of vessel disturbance on the productivity of breeding seaducks would be more pronounced during the brood-rearing season (June and July) and negligible during other times. Further, the greatest effects would come from tour, charter, and private vessels because they spend so much time near the shore, where these broods occur.

NON-BREEDING AND MOLTING WATERFOWL: Vessel disturbance could affect habitat use and the survival of molting seaducks, and vessel-related disturbance could reduce molting waterfowl use and/or cause abandonment of certain areas. Disturbance could affect survival through the expenditure of excessive energy as a result of disturbed behaviors, resulting in birds entering the winter with less energy reserves than they normally would have. One study estimated that a duck with the mass of a canvasback would require an extra two days to feed in high-quality habitat if the disturbed birds were displaced into flying an extra eight hours overall (Frederickson and Reid 1988, cited in Havera et al. 1992).

Some observations of disturbance to molting waterfowl have been conducted in Glacier Bay National Park and Preserve. Babcock and Sharman (1983) indicated that molting Canada geese responded to their presence by fleeing into the ocean and swimming away; Spicer and Prussin (1989) also found that their presence could disturb Canada geese. Calambokidis et al. (1983) found that molting geese responded to disturbance by running away or entering the water and swimming away; molting geese responded to vessels at a significantly greater distance (average of 3,935 feet [1,200 meters]) than did post-molting (i.e., flight-capable) geese (average of 961 feet [293 meters]). They also found that molting geese were more sensitive to aircraft than to vessels (sometimes responding to aircraft that were heard but not seen), but that they even were sensitive to kayaks. Climo and Duncan (1991) also found that non-motorized vessels such as kayaks disturbed Canada geese.

Summering waterfowl in non-motorized waters (see figure 3-12) represent approximately 50% of the area used by molting waterfowl. This area includes the Beardslee Islands, Hugh Miller/Scidmore Inlet Complex, Adams Inlet, and Wachusett Inlet. The areas where these birds concentrate in motorized waters include Berg Bay, Whidbey Passage, Tidal Inlet, the Tlingit Point area, central Muir Inlet, and the Sturgess Island–Puffin Island area.

Due to their increased sensitivity, effects on molting waterfowl under alternative 1 would be moderate. While non-motorized waters provide some protection, it is assumed that large areas of Glacier and Dundas Bays are avoided by molting waterfowl directly because of vessel traffic.

NON-BREEDING SHOREBIRDS: Phalaropes gather and feed in large numbers in Sitakaday Narrows; however, based on the literature, this species is not vulnerable to disturbance. Wik (1967) indicated that phalaropes do not flush until they nearly are under the bow of the vessel suggesting that they are not disturbed by the presence of vessels. When disturbed, these birds simply fly a short distance (a few meters or tens of meters) and land again (R.H. Day, ABR, Inc. –Environmental Research & Services, Fairbanks, AK, pers. obs.). From these descriptions, it appears that phalaropes are not disturbed by vessels; therefore, vessel disturbance on these shorebirds would be negligible under alternative 1.

Vessel Wakes. The possibility of vessel wakes swamping colonial nesting seabirds or shorebirds must be considered for each alternative. Vessel wakes would have to be higher than seas that occur naturally during high winds and high tides, because both colonial nesting seabirds and shorebirds naturally nest high enough to avoid natural flooding under normal circumstances. Based on modeling and direct observation, cruise ships produce a wake that is less than 1 foot (0.3 meters) high (PND

2002). Vessel wakes attenuate to 1 foot high or less at a distance of 2,000 feet or more from the ship. Both colonial nesting seabirds and shorebirds typically nest at least 1 foot above the highest tide level; therefore, swamping of bird nests by vessel wakes is unlikely or would occur infrequently. The percentage of higher spring high tides during the summer is about 56% or one out of every 200 hours (PND 2002). Tide tables for Juneau, Alaska, indicate that the highest (spring) monthly tide for June 2002 was 18.3 feet (5.6 meters) and occurred on two days that month. The highest tides for May 2002 exceeded that height on four days, reaching heights of 19.3 feet (5.9 meters). During May and early June, seabirds are likely to nest at heights that keep their nests from being inundated or at heights 1 foot above those recorded in June, a month when vessel wakes could be expected to add up to 1 foot additional height to a high tide. Because the largest vessel wakes expected in either Glacier Bay or Dundas Bay are less than 1 foot in height, and because shore nesting birds generally nest more than 1 foot above the highest tide level, effects of vessel wakes on nesting birds would be negligible.

<u>Propwash</u>. Another effect to be addressed is the potential for propwash (the back trust of propellers or bow-thrusters) to churn up sediments, and thereby reduce visibility for birds that forage underwater. Propwash generally is related to vessel size, in that it would require considerably larger propellers and engine thrust to move a large ship (e.g., a cruise ship) than a small vessel (e.g., a 25-foot pleasure craft); therefore, the effects of propwash increase with increasing ship size. Wake size was evaluated based on direct observations from a tour vessel of a 778-foot-long cruise ship in Glacier Bay in June 2002 (appendix G; PND 2002). Because this ship was the largest size entering the park, propwash would be the greatest of all vessel types. No evidence of increased turbidity from this ship's wake was observed, suggesting that propwash did not cause a great amount of vertical water motion. Cruise ships displace a large amount of water from propellers, bow thrusters, and by just the sheer mass of the vessel moving through the water. It is expected that cruise ships may stir up some sediments, but overall, the vessels operate at such depth that this is not an issue. However, cruise ships can change the distribution of milky water, bringing up deeper, clearer water to the surface. This can temporarily reduce the foraging areas for Kittlitz's murrelets. Because the effect would be localized and temporary, vessel numbers under alternative 1 are expected to cause a minor amount of disruption to Kittlitz's murrelet foraging areas. Charter and private vessels, particularly ones small enough to enter shallow waters, stir up fine sediments when maneuvering near shore, but the extent of this would be isolated and temporary, so the overall effect would be minor.

<u>Fuel Spills</u>. The potential for a major fuel spill under this alternative is negligible (see section 4.4.3, "Vessel Use and Safety"). Fuel spills from vessels have obvious effects on marine birds and raptors, with effects on habitat use, productivity, or survival (Wiens 1996). The literature is extensive, and only a few papers are cited here (also see Burger and Fry 1993). Studies by Day et al. (1997a, 1997b) and Bernatowicz et al. (1996) found that fuel spills may have dramatic effects to habitat use and productivity of birds, but that the effects generally are short-lived. Nesting success could be reduced

by direct exposure of eggs or young to fuel, disturbance caused by cleanup activities, indirect effects on food availability or quality, or a host of other factors (Kuletz 1996). Populations could be affected if there was extensive mortality after a spill (Piatt et al. 1990a). In the event of a large spill, all of these factors may act in concert to cause shifts in the species composition of the entire bird community (Wiens et al. 1996); however, the overall probability of a major fuel spill is low, and therefore, this is unlikely to occur.

Summary, Direct and Indirect Effects on Marine Birds and Raptors – Alternative 1. Based on the previous analysis of the four mechanisms of concern—vessel disturbance, vessel wake, propwash, and fuel spills—the primary effects of alternative 1 on marine birds and raptors include the following:

- In general, black oystercatchers, breeding seaducks (common mergansers, harlequin ducks, and Barrow's goldeneyes), marbled and Kittlitz's murrelets, nesting cormorants, and molting waterfowl are most sensitive to vessel disturbance and noise and, therefore, would be affected the most. Overall effects are expected to be moderate because populations of these species are likely lower than they would be without vessel traffic.
- While a major fuel spill near a bird colony would result in a major effect, the likelihood of a catastrophic spill is negligible (see section 4.4.3). In most cases, spills would be small and, depending on where a fuel spill occurred and at what time of year, effects would be expected to be a minor to moderate.

Based on the threshold criteria, overall direct and indirect effects of alternative 1 on birds in Glacier and Dundas Bays would be moderate. Although there is evidence that birds are disturbed by vessels, there has been no change in the overall population numbers.

Cumulative Effects on Marine Birds and Raptors – Alternative 1. Foot traffic, non-motorized vessels (especially kayaks), and vessel traffic from administrative vessels, including research vessels, are the actions most likely to add to effects evaluated for this alternative. Several authors (e.g., Burger 1981, 1986, 1995; Bell and Austin 1985; Cryer et al. 1987) have indicated that anglers—primarily either on foot or in small vessels—may cause substantial disturbance to birds. Administrative vessel traffic can disturb marine birds and raptors in similar ways to other vessels. Helicopters and aircraft also create noise and visual disturbance that are cumulative to the actions addressed in this environmental impact statement.

Non-motorized vessels (kayaks) sometimes land on seabird (mew gull and Arctic tern) colonies on glacial outwash plains and disturb molting waterfowl, especially in McBride Glacier and Adams Inlet (e.g., Babcock and Sharman 1983, Calambokidis et al. 1983, Spicer and Prussin 1989). Fixed-wing and (especially) helicopter overflights may disturb breeding seabirds (e.g., Giese and Riddle 1999; but see Dunnet 1977), raptors (e.g., Andersen et al. 1989, Watson 1993, Grubb and Bowerman 1997), and waterfowl (e.g., Conomy et al. 1998) and (especially) to molting waterfowl (e.g., Babcock and Sharman 1983, Calambokidis et al. 1983, Spicer and Prussin 1989, Ward et al. 1999).

Considered collectively with the direct and indirect effects of alternative 1, the above actions would result in a total greater sum of disturbance, but effects are still expected to be moderate, with populations of birds expected to remain healthy and no large areas (such as an inlet) being avoided or abandoned by one or more species.

Impairment Analysis for Marine Birds and Raptors – Alternative 1. Overall effects would be moderate because of some reduction of local populations, but the effects on marine birds and raptors are not expected to result in an impairment of park resources.

Potential Mitigation Measures for Marine Birds and Raptors – Alternative 1. None considered.

Conclusion, Marine Birds and Raptors – Alternative 1. Based on the previous analysis, alternative 1 would have moderate effects on birds in Glacier and Dundas Bays. Vessels would disturb black oystercatchers, breeding seaducks, and molting waterfowl. Propwash and wake effects are not expected to change bird behavior. Although fuel spills could result in mortality to seabirds, black oystercatchers, and seaducks, the possibility of a spill is low. Although vessel traffic resulting from alternative 1 would disturb birds in Glacier and Dundas Bays, reductions in population numbers would not be likely.

Alternative 2 – Effects on Marine Birds and Raptors.

Direct and Indirect Effects on Marine Birds and Raptors – Alternative 2. As for alternative 1, the potential effects of alternative 2 were evaluated in regard to the four issues of concern identified during scoping.

<u>Vessel Disturbance</u>. Alternative 2 would reduce vessel numbers and associated levels of disturbance, but overall effects would be the same as alternative 1, with potential disturbance to tufted puffins on South Marble Island, and minor to moderate effects on murrelets on the water, with areas of concentration having moderate effects when vessel traffic is high. Because effects of disturbance on bald eagles are expected to be negligible or minor, this alternative would comply with the Bald Eagle Protection Act. The overall amount of disturbance to marine birds and raptors under alternative 2 would decline from that under alternative 1.

<u>Vessel Wakes</u>. Because the largest vessel wakes expected in either Glacier Bay or Dundas Bay are less than 1 foot in height at a distance of 500 feet from vessels, and because shore nesting birds typically nest greater that 1 foot above the highest tide level, effects of vessel wakes on nesting birds would be negligible.

Propwash. The amount of propwash in alternative 2 would be lower than that occurring in alternative 1; therefore, any effects of propwash on marine birds and raptors would be minor under alternative 2.

Fuel Spills. Alternative 2 would allow fewer seasonal use days for cruise ships than would alternative 1. Charter vessel use days also would be reduced. This reduction in use days would result in a lower probability of a fuel spill compared to alternative 1; therefore, under alternative 2, any effects of fuel pollution on breeding seabirds would be minor to moderate, but would be major if a large spill occurred, although the potential for these effects would be less than for alternative 1.

Cumulative Effects on Marine Birds and Raptors – Alternative 2. Cumulative effects under alternative 2 would be the same as with alternative 1. The above actions would result in a less disturbance, but effects would still be expected to be moderate, with populations of birds remaining healthy and no large areas (such as inlets) being avoided or abandoned by one or more species.

Impairment Analysis for Marine Birds and Raptors – Alternative 2. Overall effects would be moderate because of some reduction of local populations, but the effects on marine birds and raptors are not expected to result in an impairment of park resources.

Potential Mitigation Measures for Marine Birds and Raptors – Alternative 2. The effects predicted for the South Marble Island seabird colony possibly could be avoided by increasing the minimal approach distance to 100 meters. In addition, placing restrictions on vessel traffic within molting waterfowl areas would reduce the disturbance of molting birds.

Conclusion, Marine Birds and Raptors – Alternative 2. This alternative would reduce vessel numbers and associated levels of disturbance, but overall effects would be similar as in alternative 1, with disturbance of murrelets on the water if vessel traffic is high. Propwash and vessel wakes are not expected to affect birds. Overall effects of vessel disturbance and fuel spills for alternative 2 would be minor, but effects would be less than those predicted for alternative 1.

Alternative 3 – Effects on Marine Birds and Raptors.

Direct and Indirect Effects on Marine Birds and Raptors – Alternative 3.

Vessel Disturbance. Overall disturbance to marine birds and raptors under alternative 3 would be greater than that for alternative 1. Seabird colonies would not be disturbed significantly by vessels. Murrelets on the water would be disturbed in areas of high vessel traffic. Bald eagles are not expected to be noticeably disturbed; therefore, this alternative would comply with the Bald Eagle Protection

Act. Overall effects of vessel disturbance to other marine birds and raptors would be minor, or similar to alternative 1.

<u>Vessel Wakes</u>. As explained under the effects analysis for alternative 1, because the largest vessel wakes expected in either Glacier Bay or Dundas Bay are less than 1 foot in height within 500 feet of a vessel, and because shore nesting birds typically nest greater that 1 foot above the highest tide level, effects of vessel wakes on nesting birds would be negligible.

<u>Propwash</u>. Although the amount of propwash in alternative 3 would be higher than that occurring in alternative 1 (because of the increase in the total number of use days), any effects of propwash would still be minor.

<u>Fuel Spills</u>. Alternative 3 would allow more seasonal use days for cruise ships than would alternative 1. This increase in use days would result in a higher overall probability of significant effects of fuel pollution than alternative 1; although the probably of a large spill would be low. Any effects of fuel pollution on breeding seabirds, therefore, would be minor to moderate, but would be major if a large spill occurred. Overall risks of a spill are predicted to be slightly greater than risks for alternative 1.

Cumulative Effects on Marine Birds and Raptors –Alternative 3. Other actions that may effect birds are the same as described for alternative 1, and include disturbance of nesting birds, molting waterfowl, foraging murrelets, and all other marine birds and raptors. Cumulative actions include foot traffic, non-motorized vessels (especially kayaks), and vessel traffic from administrative vessels, including research vessels, helicopters and aircraft, and non-motorized vessels (kayaks) landing near seabird (mew gull and Arctic tern) colonies on glacial outwash plains.

Considered collectively with the direct and indirect effects of alternative 3, the above actions would result in a total greater sum of disturbance, but effects are still expected to be moderate, with populations of birds expected to remain healthy and no large areas (such as an inlet) being avoided or abandoned by one or more species. The overall effect is considered moderate.

Impairment Analysis for Marine Birds and Raptors – Alternative 3. Overall effects would be moderate because of some reduction of local populations, but the effects on marine birds and raptors are not expected to result in an impairment of park resources.

Potential Mitigation Measures for Marine Birds and Raptors – Alternative 3. None considered.

Conclusion, Marine Birds and Raptors – Alternative 3. Based on the previous analysis, alternative 3 would have minor effects on most bird species. Vessel disturbance would have moderate effects on black oystercatchers, tufted puffins, breeding seaducks, and molting waterfowl. Fuel spills would have minor effects on seabirds, black oystercatchers, and seaducks and moderate to major effects on molting waterfowl, depending on the amount of fuel spilled and its location; however, the probability of a spill is low. The overall effects of vessel disturbance and vessel noise and from fuel spills would be slightly greater than those identified for alternative 1.

Alternative 4 – Effects on Marine Birds and Raptors.

Direct and Indirect Effects on Marine Birds and Raptors – Alternative 4.

Vessel Disturbance. Because vessel disturbance is assumed to be a dose–response relationship, it is assumed that the overall amount of disturbance to marine birds and raptors in alternative 4 would decline from that in alternative 1. Any effects of vessel disturbance would be considered minor for seabird colonies, and effects to murrelets on the water would be moderate, because areas of concentration would have moderate effects if vessel traffic were high. Because effects of disturbance on bald eagles are expected to be negligible or minor, this alternative would comply with the Bald Eagle Protection Act. Effects for other marine birds and raptors would be minor.

Vessel Wakes. As explained under the effects analysis for alternative 1, because the largest vessel wakes expected in either Glacier Bay or Dundas Bay are less than 1 foot in height, and because shore nesting birds typically nest greater that 1 foot above the highest tide level, effects of vessel wakes on nesting birds would be negligible.

Propwash. The amount of propwash in this alternative would be higher than that occurring in alternative 1 due to the increase in private vessels, which tend to have more effects since they travel closer to shore and they are present in greater quantity than any other vessel.

Fuel Spills. Alternative 4 would allow fewer use days than alternative 1. This decrease in use days would result in a slightly lower overall probability of significant effects of fuel pollution than alternative 1. Any effects of fuel pollution on breeding seabirds, therefore, would be minor because the probability of a fuel spill is low.

Cumulative Effects on Marine Birds and Raptors – Alternative 4. Other actions that may affect birds are the same as described for alternative 1, and include disturbance of nesting birds, molting waterfowl, foraging murrelets, and all other marine birds and raptors. Cumulative actions include foot traffic, non-motorized vessels (especially kayaks), and vessel traffic from administrative vessels, including research vessels, helicopters and aircraft, and non-motorized vessels (kayaks) landing near seabird (mew gull and Arctic tern) colonies on glacial outwash plains.

Impairment Analysis for Marine Birds and Raptors – Alternative 4. Overall effects would be moderate because of some reduction of local populations, but the effects on marine birds and raptors are not expected to result in an impairment of park resources.

Potential Mitigation Measures for Marine Birds and Raptors – Alternative 4. None considered.

Conclusion, Marine Birds and Raptors – Alternative 4. Under alternative 4, overall effects of vessel disturbance and vessel noise would be lower than in alternative 1, with moderate effects on tufted puffin and marbled murrelet concentrations. Effects for other marine birds and raptors would be minor. The effects of a large fuel spill would be minor since the probability of a spill is low. As with all alternatives, effects from propwash and wakes would be negligible.

Alternative 5 – Effects on Marine Birds and Raptors.

Direct and Indirect Effects on Marine Birds and Raptors – Alternative 5.

<u>Vessel Disturbance</u>. Because alternative 5 allows the most use days for private vessels, the overall amount of disturbance to seabirds would be moderate and effects to murrelets on the water would be moderate, especially for areas of concentration if vessel traffic is high. The higher private vessel traffic, especially within the murrelet and vessel concentration area of Sitakaday Narrows, may cause sufficient disturbance to reduce foraging areas and/or efficiency and, therefore, reproductive success. Disturbance to breeding waterfowl would increase, since private vessel traffic may increase in remote bays or inlets currently used by molting waterfowl.

<u>Vessel Wakes</u>. As explained under the effects analysis for alternative 1, because the largest vessel wakes expected in either Glacier Bay or Dundas Bay are less than 1 foot in height, and because shore nesting birds typically nest greater that 1 foot above the highest tide level, effects of vessel wakes on nesting birds would be negligible.

<u>Propwash</u>. The amount of propwash in this alternative would be higher than that occurring in alternative 1 because of the increase in the number of use days. Charter and private and vessels, particularly ones small enough to enter shallow waters, stir up fine sediments when maneuvering near shore. Because this alternative allows for more private vessel use days, the number of incidents when propwash occurs would increase. The extent of this would be isolated and temporary, so the overall effect would be minor.

Fuel Spills. This alternative would allow more use days than would alternative 1. This increase in use days would result in a higher probability of significant effects from fuel pollution than alternative 1. However, the overall effect is minor because the probability of a fuel spill is low.

Cumulative Effects on Marine Birds and Raptors – Alternative 5. Other actions that may affect birds are the same as described for alternative 1. Considered collectively with the direct and indirect effects of alternative 5, the above actions would result in a total greater sum of disturbance. With the increase of private vessels, molting waterfowl could abandon areas, and therefore effects are considered to be moderate. Cumulative effects add incrementally to these effects but not to the point of changing primary conclusions.

Impairment Analysis for Marine Birds and Raptors – Alternative 5. Overall effects would be moderate because of some reduction of local populations, but the effects on marine birds and raptors are not expected to result in an impairment of park resources.

Potential Mitigation Measures for Marine Birds and Raptors – Alternative 5. None considered.

Conclusion, Marine Birds and Raptors – Alternative 5. Effects of vessel disturbance would be considered moderate for seabird colonies and effects to murrelets on the water would be moderate, especially for areas of concentration if vessel traffic is high. Higher traffic, especially within the murrelet and vessel concentration area of Sitakaday Narrows, may actually cause sufficient disturbance to reduce foraging areas and/or efficiency and, therefore, reproductive success. Effects on breeding waterfowl would be similar, (moderate) but greater than alternative 1, since private vessel traffic may increase in remote bays or inlets currently used by molting waterfowl, thereby causing these birds to abandon use of these areas during molting. As with the other alternatives, effects from propwash and wakes would be negligible.

Summary, Marine Birds and Raptors. All of the alternatives would result in moderate level effects on marine birds and raptors, with the most notable effects on concentration areas of brood-rearing harlequin ducks, molting waterfowl, and foraging marbled murrelets. These species are particularly sensitive to vessel traffic and are expected to experience potential local population declines. Because effects of disturbance on bald eagle would be minor under all alternatives, each alternative would comply with the Bald Eagle Protection Act.

4.3.4 MARINE FISHES

4.3.4 Marine Fishes

This section evaluates the probable effects on marine fish of implementing each of the alternatives.

Issues of Concern Raised during Scoping. Specific concerns from the public regarding fish resources in the park include:

- Airborne contaminants from ship stacks could be deposited in the marine environment and enter the marine food chains through ingestion or dermal contact.
- The presence of artificial light from vessels could alter behavior of marine fauna.
- Waves generated by wakes and prop wash could increase turbidity, affecting the intertidal environment.
- Increases in unauthorized releases of ballast water could introduce invasive species into the marine environment in the park.
- Invasive species could enter the park on the hulls of cruise ships.

Regulatory Framework. The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act; 16 USC § 1801-1882) establishes U.S. management authority over all fishing within the 200-mile Exclusive Economic Zone (EEZ), all anadromous fish throughout their migratory range, and all fish on the continental shelf. Additionally, the act mandates that eight regional fishery management councils be established to develop and prepare fishery management plans (FMPs) for the responsible management of exploited fish and invertebrate species in their regions. When Congress reauthorized this act in 1996, several reforms and changes were made. One change was to charge the National Marine Fisheries Service with designating and conserving essential fish habitat (EFH) for species managed under existing fishery management plans. "Essential fish habitat" as defined in the Magnuson-Stevens Act includes "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." This is intended to minimize, to the extent practicable, any adverse effects on habitat caused by fishing or non-fishing activities, and to identify other actions to encourage the conservation and enhancement of such habitat. Essential fish habitat (EFH) will be addressed through consultation with the National Marine Fisheries Service.

Methodology and Assumptions. Two primary habitats for fishes exist in the park: pelagic and demersal. Pelagic fishes contain an air-filled swim bladder that keeps them neutrally buoyant in the water column without significant effort. Demersal fishes lack a swim bladder, leaving them negatively buoyant, and stationary on the sea floor unless actively swimming. Both the pelagic and demersal fishes are long-lived.

This analysis focuses on the potential effects on marine fish of noise generated by vessel traffic for each alternative. Noise has a greater effect on fishes with a swim bladder, because the bladder increases the fishes' sensitivity to noise (Enger and Anderson 1967). Effects of underwater noise on fishes are typically similar for related species (Murberg 1978). The direct effects of noise on fishes include increased acoustic threshold and various avoidance behaviors (Scholik and Yan 2002, Pearson et al. 1992). These effects may result in avoidance by fishes of preferred rearing or feeding locations, increased susceptibility to predation, and decreased ability to catch prey. These effects may be temporary or permanent.

The approach to this analysis focuses on comparing locations and catches of fishes from midwater and benthic trawls and longlines with motorized vessel use of Glacier Bay. It is assumed that if the level of noise from vessel traffic is sufficiently high to produce evasive behavior by fish, they will only be found in those areas of the park seldom visited by vessels. The available data allows for a general analysis of fish population densities in various parts of Glacier Bay proper that may be related to the noise. The analysis assumes that any effects that occur to fish in Glacier Bay would be the same for fish in Dundas Bay since the sources are similar. Table 4-18 lists the threshold criteria used for the evaluation of effects on marine fish.

TABLE 4-18: THRESHOLD CRITERIA FOR EFFECTS ANALYSIS ON MARINE FISHES

Negligible	No observable changes in marine fish distribution or abundance in Glacier Bay proper or Dundas Bay related to motorized vessel passage would occur.
Minor	Fish species would leave or avoid areas with excessive noise, contaminants, or fuel spills for the duration that the stressor would be present.
Moderate	Fish species would continuously avoid areas with excessive noise, contaminants, or fuel spills, even when the stressor was not present.
Major	Fish populations would decrease and there would be continuous avoidance of areas with excessive noise contaminants, or fuel oil spills, even when the stressor was not present.

Fish may be adversely affected by other aspects of these alternatives, including fuel or contaminants that may be discharged from vessels, and by other issues raised during scoping. Generally, diesel fuel spills have little effect on fish species, as fuel floats above the water surface. The limited water-soluble fraction from diesel fuel could contaminate the water column for a short time. A large proportion of the diesel would evaporate over two days or less (Kennicutt and Sweet 1992). The effects of diesel fuel spills are, therefore, likely to cause little or no damage to pelagic or demersal fish resources.

With respect to airborne contaminants, the air quality effects analysis determined there would be a major effect from all alternatives, except alternative 4, which would be moderate, and that emissions generated would not be not at levels considered to be a risk to human health or the environment (see section 4.2.2), and therefore, are not addressed further in this section.

Artificial light is of little concern because only during a very short time each "night" for much of the summer does natural light levels drop low enough that artificial light would be noticeable. In addition, no research suggests that artificial light affects local fish populations beyond extending feeding in a small area directly around the light source.

Waves increase turbidity along the shorelines of the park. Two sources of waves include vessel wakes and waves generated by wind. Turbidity caused by vessel wake is not as likely to occur as is turbidity resulting from naturally occurring wind waves in the park (see appendix G). Vessel wakes do not directly disturb pelagic communities. Wave energy moves through the fluid medium without appreciably modifying the habitat; therefore, wakes are not considered further in this analysis. Propwash may mix the surface water deeper into the water column. This would not appreciably change the pelagic environment. Fishes are capable of quickly adjusting their depth if altered by the turbulence of propwash. Near-surface plankton are capable of controlling their buoyancy, as shown by their presence in the surface waters, so will return to near-surface waters if displaced. Plankton displaced upwards from greater depths will return to the depths as turbulence decreases.

At this time, no marine invasive species are known to have colonized the waters of Glacier Bay National Park and Preserve. The potential for introductions of invasive species into Glacier or Dundas Bays appears to be low. The Alaska Department of Fish and Game, in a recent publication (Fay 2002), listed the invasive species they consider the greatest threats to Alaska. They only two that might relate to cruise ships and other vessels are the European green crab (*Carcinus maenas*) and the Chinese mitten crab (*Eriocheir sinensis*). Both make some use of marine waters, but are primarily estuarine or freshwater species. Both crabs could possibly reach Glacier or Dundas Bay as larvae on the hulls of cruise ships, but the most likely method of transport is north-moving oceanographic currents. None of the cruise ships or other vessels entering Glacier Bay proper or Dundas Bay discharge ballast water to the environment, unless during a catastrophic event; therefore, ballast water is not a likely source of invasive species. Hines and Ruiz (2000) studied invasive species introductions in the Port of Valdez, an Alaskan harbor with temperature and salinity ranges similar to Glacier Bay. All 15 invasive species identified by Hines and Ruiz were larval; none had reached reproductive age/size. Despite the introduction of approximately 17,000,000 cubic meters of ballast water from oil tankers in 1998 alone, no permanent populations of invasive species have been found in the port (Hines and Ruiz 2000). Compliance with U.S. Coast Guard discharge regulations of bilge water is likely to keep this potential source of invasive species from being introduced into Glacier and Dundas Bays.

Alternative 1 (No Action) – Effects on Marine Fishes. If the maximum daily entries occurred, the lower portions of Glacier Bay would receive up to 72 vessel passages per day.

Direct and Indirect Effects on Marine Fishes – Alternative 1. Each passage potentially disrupts fish populations in Glacier Bay. In general, no cruise ships enter Dundas Bay. The four passages by cruise ships would produce the greatest noise, and therefore likely would produce the greatest changes in fish behavior. In contrast, areas in upper Glacier Bay would receive fewer passages than the rest of the Bay, depending on visit duration and extent of travel.

Fish studies were conducted under the existing vessel management plan and provide relevant fish distribution data. The data from two recent studies (Robards et al. 1999; Lenz et al. 2002) were used to analyze the relationship between forage fish in Glacier Bay proper and vessel use in the Bay. The results of these studies indicated that vessel traffic has little effect on fish. Beach seine sampling conducted throughout Glacier Bay proper found higher numbers of fish in the lower Bay, where there is more vessel traffic, than further up the Bay (Robards et al. 1999) The number of fish captured at two sites along the exposed western shoreline of Young Island (between 111 and 248 fish) was among the highest in Glacier Bay, with only one site at the north end of the Beardslee island group having a higher catch (over 249 fish). The western shoreline of Young Island receives more vessel traffic than any other location in the park, since all vessels passing into the park must pass this island. The largest pelagic catches were from Sitakaday Narrows, near the mouth of Glacier Bay proper, and in the middle bay near Sebree Island (Litzow et al. 2002). The catches at both stations were between 1042 and 1440 fish. Pelagic catches are dominated by capelin and walleye pollock. Capelin are found near the surface of the water, while pollock are commonly found in midwater or close to the bottom. Smaller catches, ranging between 42 and 456 fish, were made at several other sampling stations in the middle bay. The Sitakaday Narrows station is similar to the beach seine study and located in the area most heavily used by vessels in Glacier Bay proper. Another study by Hooge and Taggert (1996) identified the movements of individual halibut, a demersal fish. The perimeters of individual home ranges for these fish throughout the park were found to include high vessel use corridors.

The presence of large forage fish populations found along the shorelines and offshore at the entrance to Glacier Bay proper, where all vessel traffic passes, is a strong indicator that fish populations continue to inhabit the park despite existing noise conditions. Also supporting this conclusion is the presence of populations of forage fish and halibut in another noisy environment — the middle portion of Glacier Bay, which is close to the cruise ship corridors. By inference, it appears that the existing noise environment found in the park’s marine waters is below the threshold that would cause fish species or groups to discontinue their use of Glacier Bay; however, this conclusion should not be interpreted to mean that fish do not exhibit some changes in behavior in response to vessel noise. Available research data suggest that fish will exhibit avoidance behavior, at least temporarily, in response to loud noise like that emitted by cruise ships. Any temporary avoidance behavior by fish of those areas of Glacier Bay where vessel noise is loudest is considered to have a minor effect. By inference, fish in Dundas bay are assumed to behave similarly; therefore, the overall direct and indirect effects of this alternative would be minor.

Cumulative Effects on Marine Fishes – Alternative 1. Marine fish resources in Glacier Bay proper and Dundas Bay may be affected by several activities external to vessel traffic. These include commercial fishing, the presence of vessels in waters outside Glacier Bay proper and Dundas Bay, increases in tourism and human population in Southeast Alaska, and natural phenomena. Although commercial fishing may decrease fish populations through direct targeting of species, by-catch (unwanted fish caught along with targeted fish), or habitat alteration, the intensity of commercial fishing in Glacier Bay proper will decline over time, lessening these effects; however, changes in technology may increase commercial fishing catch efficiencies or change noise levels in the park's waters. Recreational fishing could increase the pressure on fish stocks in the park by an unknown amount. The fishing effort would not likely to measurably affect the fish resources in Glacier and Dundas Bays; however, certain specific locations, with high utilization by sport fishermen, possibly could see decreases in fish populations, especially halibut.

Vessel activity outside Glacier Bay proper and Dundas Bay may increase water pollution that reaches park waters and add pressure to fish resources through sport-fishing catches of pelagic species that move in and out of park waters. Increases in tourism and human population may increase pressure on fish resources through commercial and sport fishing. Natural phenomena, such as global warming and long-term fluctuations in North Pacific water temperatures (often referred to as decadal shift), may change the structure of fish communities in the park. The most important of these effects, commercial fish and natural phenomena, already occur. Although the above-described actions may individually contribute to potentially adverse effects to marine fish communities, the overall cumulative effects would not significantly alter the marine resources of Glacier Bay proper and Dundas Bay; therefore, the cumulative effects would be minor. Changes in kelp density by sea otters may change some fish populations in Glacier Bay proper and Dundas Bay. Otter predation may limit sea urchin populations, allowing more kelp growth. This, in turn, would provide more habitat for some fish species, potentially increasing their populations.

Impairment Analysis for Marine Fishes – Alternative 1. A long-term major effect to the park's marine fish resources that reduces the marine fish population in Glacier Bay Proper or Dundas Bay would be considered impairment. The potential effects to marine fish of implementing alternative 1 are short-term and considered minor, therefore, this alternative does not result in impairment of marine fish resources in the park.

Potential Mitigation Measures for Marine Fishes – Alternative 1. No mitigation is proposed because the severity of the effects does not warrant it.

Conclusion, Marine Fishes – Alternative 1. The potential direct and indirect adverse effects of the implementation of alternative 1 on fish resources in the park would be minor. Cumulative effects, although minor, would not sufficiently change the direct and indirect effects to change the overall effect. Impairment would not occur from the implementation of this alternative and no mitigation would be necessary; therefore, the overall effect would be minor.

Alternative 2 – Effects on Marine Fishes. From June through August, alternative 2 would permit two cruise ships, three tour vessels, six charter vessels, and 25 private vessels daily into Glacier Bay proper. At the maximum daily use entries, the lower portions of Glacier Bay would receive 72 vessel passages per day, while areas farther up the Bay would receive fewer passages. Vessel operating requirements are the same as alternative 1. No cruise ships would be expected to enter Dundas Bay under this alternative.

Direct and Indirect Effects on Marine Fishes – Alternative 2. As with alternative 1, the four cruise ship passages would produce the greatest noise, and therefore would likely produce the greatest changes in fish behavior. The difference between alternatives 1 and 2 is that, under alternative 2, there would be fewer vessel visits over the course of the season, leaving some days with fewer than the maximum daily passages. There would be no differences in Dundas Bay. Since maximum noise level, rather than frequency of noise events, is the most important consideration, no significant differences in the noise environment exist between these two alternatives. Although fish populations likely would temporarily avoid the areas where the loudest vessel-related sounds are generated (e.g., cruise ship passages), the direct and indirect effects of implementing alternative 2 would be minor.

Cumulative Effects on Marine Fishes – Alternative 2. The activities discussed in alternative 1 (commercial fishing, vessels in waters outside Glacier Bay proper and Dundas Bay, increases in tourism and human population in Southeast Alaska, and natural phenomena) may also affect marine resources under alternative 2. The overall effect, however, could be less due to the proposed decrease in vessel traffic/quotas and the decline in commercial fishing over time; therefore, the cumulative effect under alternative 2 would be minor.

Impairment Analysis for Marine Fishes – Alternative 2. The implementation of alternative 2 potentially would result in avoidance behavior by marine fish. These behaviors would be short-term and only affect individual or small groups of fish. As discussed in alternative 1, no long-term displacement would occur; therefore, this alternative would not result in impairment of marine fish resources in the park.

Potential Mitigation Measures for Marine Fishes – Alternative 2. No mitigation is proposed because the severity of the effects does not warrant it.

Conclusion, Marine Fishes – Alternative 2. The potential direct and indirect adverse effects of alternative 2 would be minor. Cumulative effects would be minor, but less than those that would occur in alternative 1. Impairment would not occur from the implementation of this alternative and no mitigation would be necessary; therefore, the overall effect of the implementation of alternative 2 on fish resources in the park would be minor.

Alternative 3 – Effects on Marine Fishes. Similar to alternative 1, if alternative 3 was implemented, two cruise ships, three tour vessels, six charter vessels, and 25 private vessels could enter Glacier Bay proper daily during the tourist season, resulting in 72 vessel passages per day. The difference of alternative 3 from alternative 1 is an increase in the number of cruise ship visits over the course of the season. No cruise ships would be expected to enter Dundas Bay.

Direct and Indirect Effects on Marine Fishes – Alternative 3. Since maximum noise level, rather than the frequency of noise events, is the most important consideration, there would be no significant differences in the noise environment between alternatives 1 and 3. Although fish populations likely would temporarily avoid the areas where the loudest vessel-related sounds are generated (e.g., cruise ship passages), the direct and indirect adverse effects of implementing alternative 3 would be minor.

Cumulative Effects on Marine Fishes – Alternative 3. Under alternative 3 the same activities described under alternative 1 (i.e., commercial fishing, vessels in waters outside Glacier Bay proper and Dundas Bay, and increases in tourism and human population in Southeast Alaska, natural phenomena) may affect marine resources. But since the overall cumulative effects would not significantly alter the marine resources of Glacier Bay proper and Dundas Bay, the cumulative effects would be minor.

Impairment Analysis for Marine Fishes – Alternative 3. The implementation of alternative 3 potentially would result in avoidance behavior by marine fish. These behaviors would be short-term and only affect individual fish or small groups of fish; therefore, this alternative would not result in impairment of marine fish resources in the park.

Potential Mitigation Measures for Marine Fishes – Alternative 3. No mitigation is proposed because the severity of the effects does not warrant it.

Conclusion, Marine Fishes – Alternative 3. The potential direct and indirect adverse effects of implementing this alternative would be minor. Cumulative effects would be minor, but slightly greater than those that would occur in alternative 1. Impairment would not occur from the implementation of this alternative and no mitigation would be necessary; therefore, the overall effect of the implementation of alternative 3 on fish resources in the park would be minor.

Alternative 4 – Effects on Marine Fishes. Alternative 4 allows two cruise ships into Glacier Bay at any point in time during the tourist season, and two tour vessels, five charter vessels, and 22 private vessels. In addition, certain areas would be closed to cruise ships and tour vessels, specifically the East Arm. Because the framework for determining daily use would change under alternative 4, an unknown number of permitted passages would occur during each day. More vessel visits could occur daily as long as one vessel left Glacier Bay proper before the next entered. The lower portions of Glacier Bay proper would receive an unknown number of vessel passages per day; however, it is unlikely to be higher than current levels. The areas further up in the Bay still would be expected to receive fewer passages. Under this alternative, cruise ships and tour vessels would be prohibited from Dundas Bay.

Direct and Indirect Effects on Marine Fishes – Alternative 4. Compared to alternative 1, alternative 4 potentially would allow fewer vessel visits at any point in time; however, this alternative would decrease the noise level in the East Arm by eliminating cruise ship and tour vessel traffic, while potentially increasing the number of cruise ship passages in the West Arm. Dundas Bay also would receive fewer vessels, lowering the noise in that area. Since maximum noise level, rather than frequency of noise events, is the most important consideration, there would be no significant differences in the noise environment between these two alternatives. Although fish populations likely would temporarily avoid the areas where the loudest vessel-related sounds are generated (e.g., cruise ship passages), the direct and indirect adverse effects of implementing alternative 4 would be minor.

Cumulative Effects on Marine Fishes – Alternative 4. Activities discussed in alternative 1, including commercial fishing, vessels in waters outside Glacier Bay proper and Dundas Bay, increases in tourism and human population in Southeast Alaska, and natural phenomena may also affect marine resources under alternative 4; however, the overall effect could be less due to the proposed decrease in vessel traffic/quotas and the decline in commercial fishing over time; therefore, the cumulative effect under alternative 4 would be minor.

Impairment Analysis for Marine Fishes – Alternative 4. The potential effects from the implementation of alternative 4 would result in marine fish avoiding areas with loud sounds, affecting only individuals and small groups of fish. These behaviors would be short-term; therefore, this alternative does not impair marine fish resources in the park.

Potential Mitigation Measures for Marine Fishes – Alternative 4. No mitigation is proposed because the severity of the effects does not warrant it.

Conclusion, Marine Fishes – Alternative 4. Implementation of alternative 4 potentially would result in minor direct and indirect adverse effects. The cumulative effects would be minor and slightly less than those that would occur in alternative 1. Impairment would not occur from the implementation of this alternative and no mitigation would necessary; therefore, the overall effect of the implementation of alternative 4 on fish resources in the park would be minor.

Alternative 5 – Effects on Marine Fishes. Alternative 5 would allow two cruise ships into Glacier Bay daily for the tourist season, along with three tour vessels, six charter vessels, and 25 private vessels. Adams Inlet and Beardslee Entrance would be closed to cruise ships and tour vessels. Because the framework for determining daily use would change under alternative 5, an unknown number of permitted passages would occur during each day. More vessel visits could occur daily as long as one vessel left Glacier Bay proper before the next entered; however, it is not expected that there would be more visits than existing levels. Dundas Bay would be closed to cruise ships, tour vessels would be allowed only in the lower portion of Dundas Bay and would be limited to one daily and 92 seasonally.

Direct and Indirect Effects on Marine Fishes – Alternative 5. The difference of alternative 5 compared to alternative 1 (no action) would be potentially fewer vessel visits at any point in time, but with an unknown change in the number of seasonal visits. The noise environment in the East Arm and Dundas Bay would decline from the exclusion of cruise ships, but could increase from increased visitation of other vessel types; however, since maximum noise level, rather than frequency of noise events, was judged to be the most important consideration, there are no significant differences in the noise environment between these two alternatives. Although fish populations likely would temporarily avoid the areas where the loudest vessel-related sounds are generated (e.g., cruise ship passages), the direct and indirect adverse effects of implementing alternative 5 would be minor.

Cumulative Effects on Marine Fishes – Alternative 5. Like all the other alternatives, various activities (i.e., commercial fishing, vessels in waters outside Glacier Bay proper and Dundas Bay, and increases in tourism and human population in Southeast Alaska, natural phenomena) could affect the marine resources under alternative 5. Due to the proposed increase in vessel traffic under this alternative, the direct effects of these activities could increase slightly; however, the cumulative effect under alternative 5 would still be minor.

Impairment Analysis for Marine Fishes – Alternative 5. The potential effects from the implementation of alternative 5 would result in marine fish avoiding areas where cruise ships are traveling; however, these behaviors would be short-term; therefore, this alternative does not impair marine fish resources in the park.

Potential Mitigation Measures for Marine Fishes – Alternative 5. No mitigation is proposed because the severity of the effects does not warrant it.

Conclusion, Marine Fishes – Alternative 5. Implementation of alternative 5 would result in potential minor direct and indirect adverse effects to fish resources in Glacier Bay and Dundas Bay. The cumulative effects would be minor, but slightly more than those that would occur in alternative 1. Impairment would not occur from the implementation of this alternative and no mitigation would be necessary; therefore, the overall effect of the implementation of alternative 5 would be minor.

Summary, Marine Fishes. The potential effects of implementation of any of the five alternatives on marine fish in Glacier and Dundas Bays would be minor. None of the alternatives would result in impairment to marine fish resources or require mitigation measures.

4.3.5 Coastal/Shoreline Environment and Biological Communities

This section evaluates the probable effects of implementing the alternatives on coastal communities in Glacier Bay proper and Dundas Bay. There is no regulatory framework for this section, since there are no regulations for coastal communities that are related to the potential effects of the alternatives.

Issues Raised during Scoping Process. Other issues raised by the public concerning coastal communities include the following:

- Vessel wakes could erode portions of the shoreline.
- Traffic at popular drop-off locations could be changed, resulting in increased physical disturbances and disturbance of intertidal communities."
- Waves could alter the behavior of terrestrial mammals that feed, roam, or sleep on the shoreline.
- Increases in unauthorized releases of ballast water could introduce invasive species into the marine environment in the park.
- Invasive species could enter the park on the hulls of cruise ships.

Methodology and Assumptions. The primary effects from cruise ships on the coastal environment in the park are physical disturbance from motorized vessel wake/waves and from vessel landings.

Bilge water and attachment to the hulls of vessels are potential vectors for invasive species. An extensive study in the Port of Valdez (Hines and Ruiz 2000) found 15 invasive species, with none of them having reached a post-larval stage. As with the Port of Valdez, there is a potential for introductions to occur in the parks' waters, however, the potential appears to be very small. Compliance with existing controls on bilge water discharge would eliminate the medium for the introduction of invasive species. The potential for importation of invasive species on ship or other vessel hulls is not known, but the evidence from the Port of Valdez suggests that it is very minor.

Concerns regarding ballast water discharge into Glacier Bay proper or Dundas Bay will not be treated in this analysis because ballast water is not discharged in the bays. Ballast water is taken on by ships to maintain sufficient stability when empty. Tankers and cargo ships typically take on ballast before ocean crossings, and discharge it before fueling or taking on cargo. When cruise ships or other vessels enter Glacier Bay proper and Dundas Bay they have less fuel and other materials than when they started their journey, and they are not likely to take on fuel while in the park, so they have no need to discharge ballast. Since there is no ballast water discharge, the potential for invasive species importation does not exist for this vector.

At this time, the only known invasive marine species that is found in Glacier Bay National Park and Preserve is the softshell clam (*Mya areanaria*) (Carlton 1992). Carlton (1992) and O'Clair and O'Clair (1998) explain that it was likely first brought to the west coast of the U.S. along with oyster spat destined for San Francisco Bay, possibly as early as the 1850s. From there the clam spread north, reaching Southeast Alaska in the 1950s. The method of expansion is not known.

A key part of the evaluation of wake-related effects to the shoreline and associated biological community was the evaluation of the physical effects to the coastline habitat (see appendix G). The technical memorandum in appendix G provides a detailed methodology for analysis of vessel wake effects on the shoreline that is applied to all sites and used for all alternatives, as well as the results for each alternative.

Physical Environment. The primary potential effect to the coastline from implementation of all the alternatives is erosion. Substrate erosion could make the physical environment unsuitable for use or habitation by wildlife. Erosion induced by vessel wakes is a function of 1) the proximity of the vessel to the shore and 2) the vessel's speed. Although vessel displacement is a factor at the vessel itself, within 500 feet from the vessel, displacement has no effect on the height of the wake. The analysis used examined vessel wakes 500 feet from the vessel. Any loss of material from erosion is of greatest concern when material is not available from another source to replenish the material that was lost. Since erosion also occurs in natural systems, it first must be determined whether the erosion is due to vessel wakes or is a naturally occurring phenomenon. A coastal geomorphological analysis was used to identify those coastal areas most likely to be affected by vessel wakes. This analysis determined the potential of a vessel wake to erode the shoreline at a faster rate than under background conditions taking into account the composition of the shoreline. These data then were compared to determine which intertidal communities would be affected, the extent of the effects, and the lateral distance of the effects.

A literature search was conducted to identify any existing evaluation models that were directly applicable to this project. Since no models were found to be directly applicable, a model was developed based on the theories underlying several existing models. Twenty-two (22) sites where vessels travel within 2,000 feet (610 meters) of the shoreline were identified. Research indicated that the wakes produced from vessels traveling at distances greater than 2,000 feet from the shore do not affect the shoreline. For each site, the wave climatology was developed. The wave climatology describes the natural level of impact from natural wind waves over a one-year period at a site. A site-specific energy index was calculated by comparing the energy generated by vessel wakes to natural wind waves. This index was used to discern the effect due to natural wind wave energy from the effect due to vessel wakes and to compare different sites with different wave climatologies.

A model was derived from existing models and information that used a "design wake," which captures the wake characteristics of all vessels that may use Glacier Bay National Park and Preserve. The wake height, and thus the energy of the wave *at the vessel*, depends vessel draft (depth, also referred to as displacement) and vessel speed through the water. A larger vessel produces a larger wake *at the vessel* than a smaller vessel when they are both traveling at the same speed. Vessel wakes dissipate in energy as they travel away from the vessel track. Research shows that all vessels have an approximately 1-foot wake 500 feet from the vessel when the vessel is traveling at 10 knots and that maximum wave height is achieved at a speed of 10 knots. The model assumes a 1-foot wake 500 feet from the vessel track since vessels typically are greater than 500 feet from shore when traveling at speeds around 10 knots. This is considered a “safe” assumption because vessels typically travel at distances greater than 500 feet from shore when at cruising speeds.

It is also important to understand that the model is not sensitive to what may be perceived as large increases in vessels. The model provides a comparison between the natural wind wave climate and the number of waves generated by vessels. The natural wind wave climatology looks at a full year of effects at each specific beach. The orientation of the beach to the wind is a significant factor in determining the beach-specific wind wave climatology. The model then looks at the number of vessels passing within 2,000 feet of the specific beach. This distance is used as an estimate of the vessels’ distance for all the alternatives at a specific beach. The analysis for each alternative examines the number of vessels allowed according to the permits and estimates how many are likely to pass within 2,000 feet of the specific beach. This number is converted into the number of waves each vessel will produce and compared to the number of waves expected to be produced naturally. This ratio provides the basis for the ranking of negligible, minor, moderate, and high for vessel wakes.

The erosion potential of the 22 sites was assigned using substrate composition and beach slope data (Coastal Resource Inventory 2002; see figure 3-13). Sites were selected by examining vessel track data supplied by the Park Service, and choosing locations where vessels traveled within 2,000 feet of the shoreline. Each site also was assigned a vessel wake energy index. A beach with moderate erosion potential (sediments) that was not affected by a significant number of vessel wakes would have negligible potential for erosion. Conversely, if the same site was affected by an increase in the number of vessel wakes (meaning more vessels are traveling within 2,000 feet of the shoreline at that site), there would be an increased potential for erosion; however, a site with negligible erosion potential (rocky substrate) that is subject to a large number of vessels traveling within 2,000 feet of the shoreline would not be potentially affected by those wakes since the substrate is resistant to erosion.

It is important to note that this evaluation examined energy over a one-year period and may not provide all the information necessary to evaluate a site during a specific season. For example, shore-nesting birds may build nests close to the high tide line. In general, waves would not swamp a nest during the typical nesting season; however, a nest could be swamped due to wakes if there is a high tide (or spring high tide) concurrent with a vessel travelling close to the shoreline. It also is possible for a nest to be swamped in a natural setting if there was a summer storm at the same time as a high tide. The analysis was conducted for two time periods: June through August (the summer season), and May and September, to account for the shoulder season.

Analysis of Dundas Bay is limited to a general evaluation of the likely affects. Data collection and mapping of substrate types was completed in the fall of 2002. Dundas Bay tends to have finer sediments and larger sandy beach areas than Glacier Bay proper. Dundas Bay has not been under the influence of glaciers for approximately 800 years, and therefore, more closely reflects a system influenced by wind and water than by glaciers. The Outer Waters Vessel Activity Survey provides information on the types of vessels using Dundas Bay in 2001 and 2002, including some place mapping to show ranges of movement. The data are not sufficient to use in the model, but are sufficient to provide an assessment of potential erosion to the shoreline. The current use of Dundas Bay is increasing and mapping indicates that almost the entire bay is used. The main user is private vessels, but use by unclassified vessels (smaller vessels that are motorized and non-motorized), tour vessels, and NPS administrative vessels is showing an upward trend. Commercial fishing vessels also use Dundas Bay.

Biological Environment. The primary effect of cruise ship movement on the park's intertidal environment is physical disturbance from motorized vessel wake/waves, which can result in changes in intertidal community structure or the physical removal or crushing of some invertebrates or plant species.

To evaluate the effects to the shoreline biological community from waves, the results of the coastal geomorphological analysis were compared to the existing conditions of the coastal habitats described in the Coastal Resource Inventory, as well as to other intertidal surveys conducted in the park to determine which intertidal communities would be affected, the extent of the effects, and the lateral distance of the effects (Sherman et al. 2002). Consistent with the Coastal Resources Inventory database, a shoreline segment of 0.2 kilometer (0.124 mile) was selected as a measurement unit for analysis. It was assumed, based on professional judgment, that effects to a coastline segment less than 0.2 kilometers in length is not likely to have an effect on the functioning of the intertidal coastal ecosystem of Glacier Bay proper.

Large changes in substrate (losses or deposition) from erosion could affect soft substrate communities by subjecting them to smothering, loss of habitat, or increased loss to predation. Clam population data for soft substrate communities (Bodkin and Kloecker 1999) were used to investigate erosion-caused changes in these communities. Clams are long-lived members of soft or mixed substrate communities. The population data for six species of clams were grouped by location (potential for wave impacts). The data for sites facing open water were further separated into those meeting the criteria defined in the coastal geomorphic analysis as being most likely to be affected by vessel wakes. The population patterns among the three groups were compared to identify effects from vessel wakes.

Threshold Criteria. Table 4-19 lists the threshold criteria used in this evaluation to assess the effects to both the physical and biological coastline environment.

TABLE 4-19: THRESHOLD CRITERIA FOR EFFECTS ANALYSIS ON COASTAL/SHORELINE ENVIRONMENT AND BIOLOGICAL COMMUNITIES

Negligible	No readily identifiable change in the vertical zonation patterns or loss of dominant community members would occur. Erosion would be limited to current levels and there would be no physical changes to the coastline.
Minor	Changes to the community structure would be localized (less than 0.2 kilometers [0.124 mile] of continuous shoreline or less than 1.0 kilometer [0.62 mile] of shoreline within a 10-kilometer [6.2-mile] segment of shoreline). Changes would consist of the loss of one dominant community member. Effects would be for two years or less. Erosion would be slightly greater than current levels and there would be no perceptible change to the coastline.
Moderate	Changes to the community structure would be localized (less than 0.2 kilometers [0.124 miles] continuous or less than 1 kilometer [0.62 mile] within a 10-kilometer [6.28-mile] segment of shoreline). There would be a loss of one dominant community member. Effects would last longer than two years. There would be visible changes to the coastline, but they would not be long term due to natural sediment transport of materials from other locations.
Major	Changes to the community structure would occur over a large area (greater than 0.2 kilometers [0.124 miles] continuous or greater than 1 kilometer [0.62 mile] within a 10-kilometer [6.28-mile] segment of shoreline), result in a loss of more than one dominant community member. Effects would last longer than two years. There would be visible changes to the coastline that would not be remedied through natural sediment transport of materials from other locations.

Alternative 1 (No Action) – Effects Analysis on Coastal/Shoreline Environment and Biological Communities.

Direct and Indirect Effects on Coastal/Shoreline Communities – Alternative 1.

<u>Physical Coastline</u>. The potential effects on the physical coastline if alternative 1 is implemented are summarized in table 4-20. Table 1 in appendix H details the overall erosion potential of these sites under alternative 1. These sites are representative of areas most likely to be negatively affected by vessel wakes due to the proximity of the coastline to vessel routes. Site 18, located in Tarr Inlet, potentially could have an overall moderate effect, most likely due to high vessel traffic in this area; this site is a narrow channel with a pebble substrate. The potential, however, may not be realized because it is based on conservative assumptions about vessel traffic in the shoulder seasons. In addition, increased vessel traffic would not change this effect.

TABLE 4-20: COMPARISON OF FIVE ALTERNATIVES – POTENTIAL EFFECTS ON THE PHYSICAL COASTLINE AT 22 SITES IN GLACIER BAY NATIONAL PARK AND PRESERVE

Site	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
1	Minor	Minor	Minor	Negligible	Minor
2	Minor	Minor	Minor	Minor	Minor
3	Negligible	Negligible	Negligible	Negligible	Negligible
4	Minor	Minor	Minor	Minor	Minor
5	Minor	Minor	Minor	Minor	Minor
6	Negligible	Negligible	Negligible	Negligible	Negligible
7	Minor	Minor	Minor	Minor	Minor
8	Minor	Minor	Minor	Negligible	Minor
9	Minor	Minor	Minor	Minor	Minor
10	Negligible	Negligible	Negligible	Negligible	Negligible
11	Minor	Minor	Minor	Minor	Minor
12	Minor	Minor	Minor	Minor	Minor
13	Minor	Minor	Minor	Minor	Minor
14	Minor	Minor	Minor	Minor	Minor
15	Minor	Minor	Minor	Minor	Minor
16	Minor	Minor	Minor	Minor	Minor
17	Minor	Minor	Minor	Minor	Minor
18	Moderate	Moderate	Moderate	Minor	Moderate
19	Negligible	Negligible	Negligible	Negligible	Negligible
20	Negligible	Negligible	Negligible	Negligible	Negligible
21	Negligible	Negligible	Negligible	Negligible	Negligible
22	Negligible	Negligible	Negligible	Negligible	Negligible

Since multiple sites would have minor erosion potentials, the overall potential effect of alternative 1 on the coastal physical environment would be minor.

The amount of vessel use in Dundas Bay under Alternative 1 is not likely to affect the shoreline. However, if all the vessels permitted were to enter Dundas Bay, there could be a significant effect to the shoreline in the form of erosion of the sandy beaches.

<u>Biological Coastal Environment</u>. The results of the coastal geomorphological analysis indicate that implementation of alternative 1 would not result in erosion that would alter the shoreline, but individual shorelines may experience a greater degree of erosion depending on how close vessels approach the shore, vessel speed, and the beach’s substrate. Those intertidal communities occupying the shorelines with the highest erosion potential are the most subject to physical disturbance. In these situations, shore sediments could be re-suspended or relocated, uncovering sediment-dwellers and leaving them susceptible to predation; however, invertebrates living in the soft sediments also are subject to these effects from natural wave action. The results of the clam study in Glacier Bay proper and Dundas Bay (Bodkin and Kloecker 1999) showed no patterns among the clam populations that could be related to vessel wakes.

In addition, the size and frequency of the vessel wakes would be unlikely to change the behavior of shoreline mammals. Under the current vessel management plan, black bears and other smaller mammals are often seen foraging at the water's edge during low tide. Tidal changes are more likely to influence behavior than vessel wakes.

Fuel spills are another source of potential effects to shoreline communities in Glacier Bay and Dundas Bay. The most likely source of a fuel spill is diesel fuel from a grounded or otherwise damaged cruise ship or smaller vessel. The potential for this occurrence is discussed in section, 4.4.3, "Vessel Use and Safety." Diesel is predominantly volatile, so much of it would evaporate from the water surface within two to three days (Kennicutt and Sweet 1992).

The results of monitoring programs at several diesel fuel spills have been followed over time. Mitchell et al. (1970) tracked the effects of a large (60,000-barrel) diesel spill by the *Tampico Maru* in 1957. Approximately one-third of the fuel spilled initially, with the other two-thirds spilling during the following nine months. During a visit to the wreck one month after the grounding, severe mortalities were found in intertidal and shallow subtidal (to 15-foot depths) communities. Mortalities included fishes, mussels, and tide pool inhabitants. At that time, four animal species and 13 plant species were found remaining near the wreck. Algae recolonized the area more rapidly than invertebrates, presumably due to a lack of grazing. Within four years, approximately 90% of the biota had recolonized the area, although abundances of some species appeared low even after twelve years.

In 1989, the *Bahia Paraiso* struck a reef in the Antarctic, spilling approximately 5,300 barrels of diesel fuel. Kennicutt et al. (1991) reported that the effects of the spill were restricted to within a few kilometers of the wreck. The intertidal received the greatest impact, with oiled macro algae, limpets, birds, and sediments. Clams and fishes were found with oil residues in their guts, believed to have come from contaminated sediments. Visible oil was gone within a few weeks from most shorelines. Macro algae were resilient, with rapid recoveries, some within a matter of days. Limpet losses were approximately 50% after the initial spill. Limpet recovery was only partial after one year, with the greatest recovery along those shorelines receiving the greatest wave impact energy. Sediments appeared to be free of the diesel fuel from the wreck when sampled after one year.

This research indicates that the intertidal environment initially would be profoundly affected by a fuel spill; however, within several years after a fuel spill occurs, recovery would begin to occur; therefore, the effects of a fuel spill would not be permanent if spill cleanup was conducted quickly. Since the probability for a spill or a collision is low (see section 4.4.3, "Vessel Use and Safety"), then the potential effects to the coastal community are negligible.

These analyses indicate that the potential effects of alternative 1 to the biological coastal environment would be negligible. Table 4-21 compares the effects of alternative 1 on both the physical and biological aspects of the park's coastal community with the other alternatives.

TABLE 4-21: COMPARISON OF THE FIVE ALTERNATIVES' EFFECTS ON COASTAL COMMUNITY RESOURCES

Effect	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Physical	Minor	Minor	Minor	Minor	Minor
Biological	Negligible	Negligible	Negligible	Negligible	Negligible
Overall	Minor	Minor	Minor	Minor	Minor

Cumulative Effects to Coastal/Shoreline Communities – Alternative 1. Activities other than those related to this alternative could affect coastal communities, include beaching or landing of vessels, or floatplanes landing on beaches. Vessels usually land along sand or gravel beaches, which are areas of high erosion potential. Cobble, boulder, and bedrock substrates are likely to cause vessel damage, although landings are made along rocky shorelines in Glacier Bay proper, as well. Regular beaching of vessels can lead to erosion both during the actual beaching and while leaving the site. Vessel beaching and leaving could supplement the degree of erosion occurring from vessel wakes. While the vessels are beached, vessel hulls also may damage invertebrates living in the soft sediments, and strong currents caused by backing a vessel off a beach may re-suspend and relocate large amounts of fine sediments. The re-suspension and relocation may uncover sediment-dwellers and leave them susceptible to predation; however, the areas involved are small when compared to the size of the park; therefore, the effects to the coastal biological communities would be negligible. The cumulative effects on the coastal environment from implementing alternative 1 in combination with other actions would be no different from the identified direct effects, and therefore, would be minor.

Changes in sea otter populations are another source of disturbance that may add to cumulative effects to shorelines and shallow subtidal areas within Glacier Bay proper and Dundas Bay. The sea otter population in Glacier Bay proper has been increasing rapidly (Bodkin et al. 2001). Only five sea otters were counted in 1995. By 2001 the count was 1,590 sea otters. Sea otters are known to eat a wide variety of invertebrates, as well as fishes (Riedman and Estes 1988; Kvitek et al. 1993; Kodkin et al. 2001). Common invertebrate prey throughout their range include abalone, crabs, and urchins. They also eat octopus, kelp crabs, snails, mussels, barnacles, scallops, sea stars, chitons, and echurioid worms. Bodkin et al. (2001) list prey from five phylums: sponges, mollusks, peanut worms (Echuria), crustaceans (arthropoda), sea stars, sea cucumbers; and sea urchins (echinodermata) and fishes (chordata). Clams were the most commonly eaten prey taken in Glacier Bay proper and Dundas Bay (Bodkin et al. 2001), as well as in larger areas of Southeast Alaska (Kvitek et al. 1993). The effect of sea otter expansion into Glacier Bay proper and Dundas Bay is likely causing a decrease in prey item populations and a reorganization of some benthic and intertidal communities. This may include lower numbers of clams and urchins, and increases of some algal species consumed by the urchins.

Impairment Analysis for Coastal/Shoreline Communities – Alternative 1. Impairment of the coastal environment would result from a long-term major effect. In this case, impairment would mean the structure of the intertidal community would change over a large area, or there would be a loss of a vertical zonation community, or there would be a loss of more than one dominant community member. In addition, there would be visible changes to the coastline that could not be remedied through natural sediment transport of materials from other locations. The analysis of the potential effects of implementing alternative 1 concluded that the effects would be minor; therefore alternative 1 would not result in the impairment of coastal community resources.

Potential Mitigation Measures for Coastal/Shoreline Communities – Alternative 1. Although the number of vessels permitted in Glacier Bay proper under alternative 1 would not create a significant effect on Glacier Bay's coastal environment as a whole, one area would have moderate erosion potential. In addition, if Dundas Bay were used to the fullest extent possible, then there could be significant erosion potential. If vessels traveling at cruising speed between observation areas remained more than 2,000 feet from the shore, vessel wake energy would be dissipated before reaching shore. Establishment of a 500-foot no-wake zone with a speed limit of 3 miles per hour along the entire shoreline would limit the size and energy of the vessel wakes within 500 feet of shore. To additionally reduce the effects of vessel wakes, the speed limit for the area between 500 feet and 1,000 feet from the shore would be 5 miles per hour in relation to the water and 8 miles per hour for the area between 1,000 feet and 2,000 feet from shore.

Another mitigation measure to limit the potential for erosion is to limit the number of permitted vessel beaching locations to those areas where the erosion potential is negligible.

Conclusion, Coastal/Shoreline Environment and Biological Communities – Alternative 1. The implementation of alternative 1 would have a minor effect on the coastal communities within Glacier Bay proper, in general. Cumulative effects would not significantly contribute to direct effects to coastal community resources. Moreover, the implementation of alternative 1 would not impair coastal community resources in the park.

Alternative 2 – Effects Analysis on Coastal/Shoreline Environment and Biological Communities.

Direct and Indirect Effects on Coastal/Shoreline Communities – Alternative 2.

Physical Coastline. The erosion potentials of vessel wakes generated under alternative 2 are the same identified for alternative 1 and would be minor to negligible. Table 2 in appendix H details the overall erosion potential of these sites under alternative 2. The potential effects of alternative 2 on the physical coastline are summarized and compared to the other alternatives in table 4-24.

The amount of vessel use in alternative 2 is not likely to affect the Dundas Bay shoreline; however, if all the vessels permitted were to enter the bay, there could be erosion of sandy beaches.

The effect of vessel wakes on the shoreline under alternative 2 would be the same as for alternative 1; therefore, the effect to the physical coastal environment from the implementation of alternative 2 would be minor, based on the number of sites that would have minor erosion potentials.

Biological Coastal Environment. The results of the coastal geomorphological analysis for alternative 2 are similar to those for alternative 1; therefore, it can be inferred that the effects to the biological coastal environment would be similar as well, with the degree of sediment erosion, re-suspension, or relocation being the same as current conditions and not significantly different from natural wave action. In addition, it is unlikely that the size and frequency of the vessel wakes would change the behavior of shoreline mammals; rather tidal changes are more likely to influence behavior than vessel wakes. The probability of a fuel spill is low. The potential effects of alternative 2 to the biological coastal environment would be negligible. Table 4-25 compares the effects of alternative 2 on both the physical and biological aspects of the park's coastal community with the other alternatives.

Cumulative Effects on Coastal/Shoreline Communities – Alternative 2. Alternative 2 would have similar cumulative effects as alternative 1. Similarly, the cumulative effects of vessel landings in conjunction with the effects of this alternative would not significantly alter the direct effects on coastal communities resources of Glacier Bay proper and Dundas Bay.

Impairment Analysis for Coastal/Shoreline Communities – Alternative 2. The implementation of alternative 2 potentially would result in minor effects to the coastal community; therefore, this alternative would not result in impairment of coastal community resources in the park.

Potential Mitigation Measures for Coastal/Shoreline Communities – Alternative 2. Although the number of vessels permitted in Glacier Bay proper under alternative 2 would not create a significant effect on Glacier Bay's coastal environment as a whole, one area would have moderate erosion potential. If vessels traveling at cruising speed between observation areas remained more than 2,000 feet from the shore, vessel wake energy would be dissipated before reaching shore. Establishment of a 500-foot no-wake zone with a speed limit of 3 miles per hour along the entire shoreline would limit the size and energy of the vessel wakes within 500 feet of shore. To additionally reduce the effects of vessel wakes, the speed limit for the area between 500 feet and 1,000 feet from the shore would be 5 miles per hour in relation to the water and 8 miles per hour for the area between 1,000 feet and 2,000 feet from shore.

Another mitigation measure to limit the potential for erosion is to limit the number of permitted beaching locations to those areas where the erosion potential is negligible. Implementation of these mitigation measures in Dundas Bay would provide added protection of sandy beaches in that area.

Conclusion, Coastal/Shoreline Environment and Biological Communities – Alternative 2. The potential effects of alternative 2 on coastal community resources would be minor. Cumulative effects would not contribute significantly to direct effects to coastal community resources. Moreover, the implementation of alternative 2 would not impair coastal community resources in the park.

Alternative 3 – Effects Analysis on Coastal/Shoreline Environment and Biological Communities.

Direct and Indirect Effects on Coastal/Shoreline Communities – Alternative 3.

<u>Physical Coastline</u>. The erosion potentials of the implementation of alternative 3 are the same as described for alternative 1. Table 3 in appendix H details the overall erosion potential of these sites under alternative 3. The potential effects of alternative 3 on the physical coastline are summarized and compared to the other alternatives in table 4-24.

The vessel use in Alternative 3 is not likely to affect the Dundas Bay shoreline; however, if all the vessels permitted were to enter the bay, there could be erosion of sandy beaches.

The effect of vessel wakes on the shoreline under alternative 3 would be the same as for alternative 1. Based on the number of sites that would have minor potential for erosion, the effect to the physical coastal environment from implementing alternative 3 would be minor.

<u>Biological Coastal Environment</u>. The results of the coastal geomorphological analysis for alternative 3 are the same as described for alternative 1. The effects to the biological coastal environment would be similar as well. Sediment erosion, re-suspension, or relocation would be the same as current

conditions and therefore, not significantly different from natural wave action. Given that black bears and other smaller mammals forage in the intertidal zone during low tide under current management conditions, the vessel wake effects would not be likely to change the behavior of shoreline mammals. In addition, the probability for a fuel spill is low. The potential effects to the biological coastal environment of alternative 3 would be negligible. Table 4-25 compares the effects of alternative 3 on both the physical and biological aspects of the park's coastal community with the other alternatives.

Cumulative Effects on Coastal/Shoreline Communities – Alternative 3. Alternative 3 would have similar cumulative effects as alternative 1. Similarly, the cumulative effects of vessel landings in conjunction with the effects of this alternative would not significantly alter the direct effects on coastal community resources of Glacier Bay proper and Dundas Bay.

Impairment Analysis for Coastal/Shoreline Communities – Alternative 3. Implementation of alternative 3 would result in minor potential effects to the coastal community; therefore, this alternative would not result in impairment of coastal community resources in the park.

Potential Mitigation Measures for Coastal/Shoreline Communities – Alternative 3. The effects of the implementation of alternative 3 would be similar to alternative 1; one area would have moderate erosion potential. If vessels travelling at cruising speed remained more than 2,000 feet from the shore, vessel wake energy would be dissipated before reaching shore. Establishment of a 500-foot no-wake zone with a speed limit of 3 miles per hour along the entire shoreline would limit the size and energy of the vessel wakes within 500 feet of the shore. To additionally reduce the effects of vessel wakes, the speed limit for the area between 500 feet and 1,000 feet from the shore would be 5 miles per hour in relation to the water and 8 miles per hour for the area between 1,000 feet and 2,000 feet from shore. Another mitigation measure to limit the potential for erosion is to limit the number of permitted vessel beaching locations to those areas where the erosion potential is negligible. Implementation of these mitigation measures in Dundas Bay would serve to protect sandy beaches from additional erosion.

Conclusion, Coastal/Shoreline Environment and Biological Communities – Alternative 3. The potential effects of alternative 3 on coastal community resources would be minor. Cumulative effects would not contribute significantly to direct effects to coastal community resources. Moreover, the implementation of alternative 3 would not impair coastal community resources in the park.

Alternative 4 – Effects Analysis on Coastal/Shoreline Environment and Biological Communities.

Direct and Indirect Effects on Coastal/Shoreline Communities – Alternative 4.

<u>Physical Coastline</u>. Like alternative 1, the erosion potentials produced under alternative 4 would be negligible to minor. Table 4 in appendix H details the overall erosion potential of these sites under alternative 4. The potential effects of alternative 4 on the physical coastline are summarized and compared to the other alternatives in table 4-24.

Implementation of alternative 4 would not likely change the use of Dundas Bay in the short term. The primary user of Dundas Bay is private vessels, which will continue to have unlimited use under this alternative. The small increase in use by tour vessels in 2002 would be eliminated with the implementation of alternative 4. Charter vessels would have a quota implemented, which may reduce the number of vessels in Dundas Bay over the long term. This alternative limits the potential effects of vessel wakes to the shoreline by limiting the number of vessels.

Alternative 4 would have a vessel wake-induced effect on the shoreline of Glacier Bay proper that is similar to alternative 1 and less in Dundas Bay. No sites would have greater than minor effects under this alternative. Although more sites would have negligible effects under this alternative than under the other alternatives, the effects to the physical coastal environment from the implementation of alternative 4 would be minor based on the number of sites that would have minor erosion potentials.

<u>Biological Coastal Environment</u>. The results of the coastal geomorphological analysis for alternative 4 were similar to those for alternative 1, but the effects to the biological coastal environment would be slightly greater in intensity due to increased private vessel seasonal-use days and elimination of entry limits. Sediment erosion, re-suspension, or relocation would be slightly greater than current conditions; however, the disturbance to the intertidal environment would not change the community structure. In addition, the physical disturbance caused by terrestrial mammals that forage in the intertidal zone during low tide would not be likely to change. Also, the probability of a fuel spill is low; therefore, the potential effects to the biological coastal environment would be negligible. Table 4-25 compares the effects of alternative 4 on both the physical and biological aspects of the park's coastal community with the other alternatives.

Cumulative Effects on Coastal/Shoreline Communities – Alternative 4. Cumulative effects resulting from implementation of alternative 4 would be similar to those resulting from implementation of alternative 1. The cumulative effects of vessel landings would not contribute significantly to the direct effects on coastal community resources of Glacier Bay proper and Dundas Bay.

Impairment Analysis for Coastal/Shoreline Communities – Alternative 4. Minor potential effects to the coastal community would result from implementation of alternative 4; therefore, this alternative would not result in impairment of coastal community resources in the park.

Potential Mitigation Measures for Coastal/Shoreline Communities – Alternative 4. No mitigation is necessary because the severity of the effects does not warrant it, but the mitigation measures proposed for the other alternatives would be applicable and would be protective of the more sensitive shorelines.

Conclusion, Coastal/Shoreline Environment and Biological Communities – Alternative 4. The potential effects of alternative 4 on coastal community resources would be minor; however, the effects to the coastal community resources may be slightly greater with the increase in private vessels use in the Lower Bay. Cumulative effects would not contribute significantly to direct effects to coastal community resources. Moreover, the implementation of alternative 4 would not impair coastal community resources in the park.

Alternative 5 – Effects Analysis on Coastal/Shoreline Environment and Biological Communities.

Direct and Indirect Effects on Coastal/Shoreline Communities – Alternative 5.

<u>Physical Coastline</u>. Similar to alternative 1, the erosion potentials for alternative 5 would range from negligible to moderate. Table 5 in appendix H details the overall erosion potential of these sites under alternative 5. The potential effects of alternative 5 on the physical coastline are summarized and compared to the other alternatives in table 4-24.

Implementation of alternative 5 would have similar effects as alternative 4 in Dundas Bay. Alternative 5 employs quotas for tour vessels and charter boats while prohibiting cruise ships completely. There are not limits on the use of Dundas Bay by private vessels. Alternative 5 also restricts access to the upper portions of the bay to tour vessels and charter boats. This alternative limits the potential effect of vessel wakes to the shoreline by limiting the number of vessels.

The vessel wake-induced shoreline effects for alternative 5 would be similar to those identified for alternative 1. Alternative 5 permits the most number of vessels when the vessel entry numbers are averaged over the entire year. The potential effects to the physical coastline of alternative 5 would be minor.

<u>Biological Coastal Environment</u>. The coastal geomorphological analysis for alternative 5 is slightly greater than those described for alternative 1. The effects to the biological coastal environment would be similar, but slightly greater due to an increase in private vessel seasonal use days and the elimination of entry limits. Sediment erosion, re-suspension, or relocation would be slightly greater

than current conditions; however, the disturbance to the intertidal environment would not be expected to change the community structure. In addition, the foraging behaviors of terrestrial mammals would not likely change their behavior. Also, the probability of a fuel spill is low; therefore, the potential effects to the biological coastal environment of alternative 5 would be negligible. Table 4-25 compares the effects of alternative 5 on both the physical and biological aspects of the park's coastal community with the other alternatives.

Cumulative Effects on Coastal/Shoreline Communities – Alternative 5. Cumulative effects as the result of implementation of alternative 5 would be similar to those resulting from the implementation of alternative 1, except at one site. The cumulative effects of vessel landings would not be expected to contribute significantly to the direct effects on coastal communities resources of Glacier Bay proper and Dundas Bay.

Potential Mitigation Measures for Coastal/Shoreline Communities – Alternative 5. Although the number of vessels permitted in Glacier Bay under alternative 5 would not create a significant effect to Glacier Bay's coastal environment as a whole, one area would have moderate erosion potential. Changes in the vessel operating requirements could mitigate these effects. If vessels traveling at cruising speed between observation areas remained more than 2,000 feet from the shore, vessel wake energy would be dissipated before reaching shore. Establishment of a 500-foot no-wake zone with a speed limit of 3 miles per hour along the entire shoreline would limit the size and energy of the vessel wakes within 500 feet of shore. To additionally reduce the effects of vessel wakes, the speed limit for the area between 500 feet and 1,000 feet from the shore would be 5 miles per hour in relation to the water and 8 miles per hour for the area between 1,000 feet and 2,000 feet from shore.

Another mitigation measure to limit the potential for erosion is to limit the number of permitted beaching locations to those areas where the erosion potential is negligible. These mitigation measures would be useful to implement in Dundas Bay to protect sandy beaches.

Conclusion, Coastal/Shoreline Environment and Biological Communities – Alternative 5. The potential effects of alternative 5 on coastal community resources would be minor. Cumulative effects would not contribute significantly to direct effects to coastal community resources. Moreover, the implementation of alternative 5 would not impair coastal community resources in the park.

Summary, Coastal/Shoreline Environment and Biological Communities. In conclusion, the quotas in all five alternatives would not damage or impair the shoreline resources of Glacier Bay proper or Dundas Bay. Where appropriate, operating requirements have been recommended as mitigation that would preserve the shoreline for future generations. Table 4-24 summarizes the effects of each alternative on the physical shoreline; table 4-25 summarizes and compares the alternatives' overall effects on the park's coastal communities.

4.4.1 Cultural Resources

4.4 HUMAN ENVIRONMENT

4.4.1 Cultural Resources

This subsection evaluates the probable effects of implementing the alternatives on the following cultural resources: archaeological resources, historic structures, ethnographic resources, and the cultural landscape (collectively referred to as "historic property"). This subsection describes the regulatory framework used for assessing the effects of the proposed alternatives on cultural resources; characterizes the direct, indirect, and cumulative effects of the proposed alternatives; discusses the potential for the proposed alternatives to impair the park's cultural resources and values; and provides a conclusion summarizing the results of this evaluation.

Issues of Concern Raised during Scoping. Information was sought from individuals and organizations, including Native American organizations. The issues identified during the scoping process include the following:

- air and water pollution could defile sacred elements of Glacier Bay, including the glaciers, mountain goats, and harbor seals.
- effects on harbor seals could change opportunities for traditional seal hunting.
- waves generated from vessels could erode portions of the shoreline, thus changing the geological composition of the shoreline, and possibly exposing anthropological and archaeological resources present in interstadial geologic layers, including preglacial forests.
- increase in traffic at popular drop-off locations could increase physical disturbances and potential vandalism of anthropological resources.

Regulatory Framework. The relevant regulations for this evaluation of effects on cultural resources are the National Environmental Policy Act and section 106 of the National Historic Preservation Act (NHPA). The National Environmental Policy Act requires a review of project and program effects on the cultural environment, which generally includes historic properties, other culturally valued places, cultural use of a biophysical environment, and sociocultural attributes (e.g., social cohesion, social institutions, lifeways, religious practices, and/or other cultural institutions). CEQ regulations require that the effects of alternatives and their component actions be disclosed. For this analysis, an effect is considered adverse (for section 106) and major (for the National Environmental Policy Act) when the effect diminishes the significant characteristics of a "historic property" to the extent that it is no longer considered eligible for the National Register of Historic Places.

Section 106 of the National Historic Preservation Act requires that prior to the approval of an undertaking, the lead federal agency must take into account the effects of the undertaking on “historic properties” and provide the Advisory Council on Historic Preservation (ACHP) with a reasonable opportunity to comment with regard to the undertaking. As defined by the National Historic Preservation Act (NHPA section 800.16[y]; 36 CFR 800.3[a][1]), an action is an undertaking if it is done by or for a federal agency; is carried out with federal assistance; requires a federal permit, license, or approval; or is subject to federal delegation or oversight. The evaluation process involves (NHPA, 16 USC 470a, Title I, section 101):

- the identification and evaluation of “historic properties” in the area of potential effect (APE).
- the identification and evaluation of the effects of the undertaking on “historic properties.”
- the development and implementation of agreements (done in consultation with the state historic preservation office [SHPO] and other concerned parties) regarding the means by which adverse effects on such properties will be considered (e.g., the 1995 programmatic agreement among the Park Service, the Advisory Council on Historic Preservation, and the National Conference of Historic Preservation Officers [NCHPO]).
- the provision for the disposition of Native American cultural items from federal or tribal land in a manner consistent with Section 3(c) of the Native American Graves Protection and Repatriation Act (NAGPRA; 25 USC 3002[c]; NHPA section 110[a][2]).

Methodology and Assumptions. All parks, including those established primarily for their natural or recreational resources, have responsibilities to identify “historic properties” potentially affected by undertakings (NPS, ACHP, and NCHPO 1995). For the purposes of section 106 of the National Historic Preservation Act, “historic properties” are defined as prehistoric and historic districts, sites, buildings, structures, and objects listed or eligible for inclusion on the national register, including artifacts, records, and material remains related to the property (NHPA, 16 USC 470w, section 301.5). The Park Service subdivides cultural resources (“historic properties”) into five categories: archaeological resources, prehistoric and historic structures, ethnographic resources, cultural landscapes, and museum objects (NPS 2001d, 1997a). For the purposes of this effects analysis, cultural resources are equivalent to “historic properties” and consist of four property types: archaeological resources, historic structural resources (HSR), ethnographic resources, and cultural landscapes; museum objects are not considered in this analysis (NPS 2002d).

The assessment of effects on cultural resources is based on the regulations of the Advisory Council on Historic Preservation (36 CFR 800). The steps involve:

1. determining whether the action being considered is an undertaking as defined by the National Historic Preservation Act.

2. coordinating with other reviews (e.g., NEPA, Native American Graves Protection and Repatriation Act, American Indian Religious Freedom Act [AIRFA], and Archaeological Resources Protection Act [ARPA]), identifying the state historic preservation officer and other likely consulting parties, and planning to involve the public.
3. identifying "historic properties" using the Secretary of the Interior's standards (36 CFR 800.4). This identification involves:
   - establishing the area of potential effect.
   - reviewing available data.
   - seeking information from others.
   - identifying issues.
   - gathering information from Native American organizations that may place a religious or cultural significance on "historic properties" (e.g., ethnographic resources/traditional cultural properties and cultural landscapes) in the area of potential effect.
   - evaluating all "historical properties" (e.g., cultural resources) for national register eligibility on the basis of their significance (e.g., historical, archaeological, and/or cultural; see 36 CFR 60.4).

The Park Service determined that the proposed action is an "undertaking." During the scoping process and the development of the section 106 consultation, the second and third steps were addressed. Although few formal determinations of eligibility have been made for historic properties in the park, all are considered potentially eligible for the national register. The EIS defined the area of potential effect as Glacier Bay and Dundas Bay. A literature search was completed to access available data.

Analysis of effects on the full range of historic properties varies with resource type. Potential effects on tangible resources (archaeological sites and historic structures) can be analyzed using physical parameters (e.g., cubic meters of erosion and intact structural components), whereas effects on the intangible aspects of ethnographic resources (traditional cultural properties [TCPs] and cultural landscapes) are quantifiable in terms of people's perceptions and assumed responses, and is, by nature, a much more subjective exercise. For example, a perception that the ethnographic resource is degraded (polluted and desanctified) may elicit a behavioral response of decreased visitation or cessation of traditional activities that could result in loss of knowledge of and cultural association with a site or sites — the key attributes that give traditional cultural properties and cultural landscapes their national register significance. In this regard, the Huna Tlingit perception of ecological "pristineness" is a paramount attribute in the connection they feel to their homeland, and the potential degree to which the proposed alternatives degrade that "pristineness," and therefore influence Huna Tlingit responses to them, determines the effects to be analyzed.

The cultural resources threshold criteria (see table 4-26) address the effects of the proposed alternatives on “historic properties” in the area of potential effect (e.g., archaeological, historic structural and ethnographic resources, and cultural landscapes). In the following analysis, “historic properties” in the area of potential effect were evaluated with respect to their eligibility for the national register and whether the effects due to the implementation of the proposed alternatives would change the eligibility of that “historic property.” For a cultural resource (e.g., districts, sites, buildings, structures, and objects) to be eligible for the National Register of Historic Places, it must possess integrity of location, design, setting, materials, workmanship, feeling, and/or association. In addition, the cultural resource must:

- be associated with events that have made a significant contribution to the broad patterns of our history.
- be associated with the lives of persons significant in our past.
- embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction.
- yield, or be likely to yield, information important in prehistory or history (36 CFR 60.4).

Table 4-26 lists the specific threshold criteria used in this evaluation.

TABLE 4-26: THRESHOLD CRITERIA FOR CULTURAL RESOURCES EFFECTS ANALYSIS

Negligible	Perceptible and/or measurable effect would not occur; effect would occur to a single “historic property”; any effect would last less than two years. The eligibility (e.g., integrity and association) of a “historic property” (i.e., cultural resource) eligible for or listed on the National Register of Historic Places would not be affected.
Minor	Perceptible and/or measurable effect would occur; effect would occur to a single “historic property”; effect would last less than two years. The eligibility (e.g., integrity and association) of a “historic property” (i.e., cultural resource) eligible for or listed on the National Register of Historic Places would not be affected.
Moderate	Perceptible and/or measurable effect would occur; more than one “historic property” or a district would be affected; duration would be two years or longer; the character of a “historic property” or district would be affected; the integrity and association of a “historic property” or district eligible for or listed on the National Register of Historic Places would be affected, but national register eligibility would not be affected.
Major	Perceptible and/or measurable effect would occur; multiple “historic properties” or a district would be affected; duration would be two years to permanent; the character of a “historic property” or district would be affected; the integrity and association of a “historic property” or district eligible for listing on the national register would be affected to the extent that it would no longer be eligible for listing on the National Register of Historic Places.

Alternative 1 (No Action) – Effects on Cultural Resources. Alternative 1 (the no-action alternative) would maintain current vessel quotas and operating requirements (1996 levels).

Direct and Indirect Effects on Cultural Resources – Alternative 1.

<u>Archaeological and Historic Structural Resources</u>. Archaeological resources are prehistoric Native American cultural resources and historic archaeological resources of Native American and Euro-American origin. Due to the geologic processes encountered in the park, most prehistoric archaeological sites are located on or near a terrace (e.g., the Spruce Terrace) that stands above and removed from the current beach and wake-affected zone. Historic structural resources are the remains of structures that housed humans and their activities in the past and listed on the List of Classified Structures. Historic structural resources are still standing; if collapsed or otherwise open to the elements, they fall into the archaeological resources category. The park's policy on historic structures, based on the 1984 general management plan (NPS 1984), outlined a policy of "benign neglect," directing the Park Service to allow historic structures to deteriorate naturally, eventually to be reclaimed by the landscape. According to the general management plan, these sites should be managed as "discovery sites" — with no on-site interpretation, reconstruction, or stabilization.

Nine archaeological sites in Glacier Bay were evaluated for effects of erosion and contamination (JUN-001, JUN-026, JUN-050, XMF-062, XMF-063, XMF-081, XMF-082, XMF-083, and XMF-084). The two historic structural resources documented for Glacier Bay, the Ibach Cabin and a shed in Reid Inlet, also were evaluated. Because the current effect of wakes on the coast is minimal (PND 2002) and no documented archaeological resources and historic structural resources are located in the wake-affected zones, vessel wakes would have a negligible effect on archaeological resources and historic structural resources located near the coast. Although accidental oil discharges / fuel spills could contaminate archaeological sites and historic structures along the coastlines of the park, the sites are sufficiently distant from the shoreline to be safe.

The duration of alternative 1 would be long-term. The area affected would be the waters and coastal areas of Glacier Bay and lower Dundas Bay. The effect on archaeological resources and historic structural resources would not be perceptible in vessel wake zones and would have no effect on national register eligibility for potentially eligible archaeological sites and historic structural resources. Given the park's current policy, the low number and ruinous condition of the documented historic structural resources in Glacier Bay, and the low potential for damage to undocumented historic structural resources and archaeological resources due to erosion from vessel wakes and contamination from oil discharges / fuel spills, alternative 1 would have negligible effects on archaeological and historic structural resources (see table 4-26).

Ethnographic Resources. Ethnographic resources consist of traditional arts, Native languages, religious beliefs, special places in the natural world, structures with historic associations, traditional cultural properties, natural materials, and consumptive uses (discussed in the next subsection; NPS 1997a). A traditional cultural property is a "historic property" that is eligible for inclusion on the National Register of Historic Places because of its association with cultural practices or beliefs of a living community that are rooted in that community's history and important in maintaining the continuing cultural identity of the community (Parker and King 1998a; NPS 2001d). For a discussion of ethnographic resources / traditional cultural properties, see subsection 3.4.1, "Cultural Resources."

Huna Tlingit culture is a recognized ethnographic cultural resource in the park (Howell 2002). The Huna Tlingit perceive Glacier Bay to be the cradle of their culture. It is the place where the Huna Tlingit evolved from the animals, mountains, and ice; gave identity to Huna Tlingit clans; and gives order to Huna Tlingit social relations, today and into the future. Glacier Bay has sustained the Huna Tlingit nutritionally and spiritually for generations. The Huna Tlingit refer to Glacier Bay as their most important place, their "homeland," their "Ice Box," their "Garden of Eden," and their "Holy Land." The Huna Tlingit believe that it is imperative that the ancestral homeland remains unpolluted, and that the subsistence food base remains pure (Hoonah Indian Association [HIA] 2002). Continued access, participation in traditional cultural activities rooted in the park, and intergenerational transference of the cultural meanings of ancestral places in the park maintain the continuing cultural associations with Glacier Bay and the Huna Tlingit's cultural identity. See subsection 3.4.1, "Cultural Resources," for further discussion about the Huna Tlingit relationship with Glacier Bay.

From the perspective of the Huna Tlingit (scoping), alternative 1 would affect ethnographic resources in the park by the diminution of the quality of resources, and thus degrade the Huna Tlingit ancestral homeland. If the ancestral homeland is degraded by air or water pollution, the threat of a fuel spill, or other perceived degrading vectors, Huna Tlingits may become disconnected from their homeland and may become disinclined to visit and conduct traditional activities. Therefore, relationships with the homeland are susceptible to deterioration, resulting in the erosion of cultural identity. Continued cultural identity of the community with ethnographic resources (i.e., traditional cultural properties) is necessary for national register eligibility. Conversely, a lack of cultural identity with ethnographic resources results in ineligibility for the national register. Currently, the Huna Tlingit have retained their cultural identity with Glacier Bay.

Six potential traditional cultural properties in Glacier Bay were evaluated for potential effects of alternative 1 (TCP ID #1 [Bartlett Cove], TCP ID #2 [Pt. Gustavus], TCP ID #4 [Berg Bay], TCP ID #5 [South Marble Island], TCP ID #6 [Sealer's Island], and TCP ID #7 [Tidewater Glaciers]. The Huna Tlingit believe that they are "stewards" of Glacier Bay and have expressed concerns about the effects of contamination (air and water pollution) and harm or displacement of marine mammals (e.g., seals and whales) associated with cruise ships (HIA 2002). Alternative 1, while supported by the Hoonah Indian Association (HIA 2002), may have a moderate effect on the ethnographic landscape (e.g., traditional cultural properties) in that it would affect the relationship between the Huna Tlingit and the traditional cultural properties because cruise ships and other vessels lessen the perceived environmental quality of the park.

The effect of alternative 1 would be long-term, would encompass all of Glacier Bay, and would potentially affect the integrity and association of eligible or potentially eligible ethnographic resources / traditional cultural properties in Glacier and Dundas Bays; however, the effects of alternative 1 would not affect these ethnographic resources' eligibility for the national register because the Huna are likely to maintain their cultural identity with Glacier Bay. As long as the community maintains its cultural identity with traditional Glacier Bay places and activities, the ethnographic resource (e.g., traditional cultural properties) will continue to be eligible for the national register. Thus, the effect of alternative 1 on ethnographic resources would be moderate (see table 4-26).

<u>Cultural Landscapes</u>. Cultural landscapes are "historic properties" that are geographic areas, including natural and cultural resources, associated with historic events, activities, and/or people. At the broadest scale, the cultural landscape encompasses entire landscapes (e.g., the entirety of Glacier Bay) or component landscapes (e.g., Dundas Bay or Bartlett Cove). The following discussion summarizes environmental consequences of alternative 1 on cultural landscapes in Glacier and Dundas Bays. For further discussion of cultural landscapes, see subsection 3.4.1.

The effects analysis for ethnographic resources also applies to cultural landscapes, because the cultural landscape is an extension of the ethnographic resource. The Glacier Bay cultural landscape is a compilation of all landscape features, cultural resources, and natural resources that combined have meaning and significance to the Huna Tlingit. Alienation of the Huna Tlingit from the resources and landscape of the park would change their relationship to their homeland, their traditional places, and the basis of their cultural identity. The effect of alternative 1 would be long-term, would encompass all of Glacier Bay, and may affect the integrity and association of eligible or potentially eligible cultural landscapes in Glacier and Dundas Bays. Effects of alternative 1, however, would not affect these cultural landscapes' eligibility for the national register because the Huna are likely to maintain their cultural identity with Glacier Bay. Alternative 1 would have a moderate effect on cultural landscapes (see table 4-26).

Cumulative Effects on Cultural Resources – Alternative 1. Passengers offloaded from tour and charter vessels, kayakers, and other backcountry visitors have the potential to cumulatively alter eligibility of cultural resources for the national register through looting, vandalism, and/or unintentional damage to cultural resources. The Park Service has reported minor vandalism at exposed cultural resource sites (NPS 1995a).

Due to the effects of alternative 1, the Huna Tlingit may perceive diminished opportunities for spiritually connecting with their landscape and sharing their culture with others due to the perceived diminished integrity of their ancestral homeland as park use increases (i.e., more vessels and tourists result in a less pristine environment). Increases in vessel and visitor traffic to the park have the potential to further alienate the Huna Tlingit from their ancestral homeland by diminishing the quality of the relationship between the Huna Tlingit and the park. If this effect is severe enough that the relationships with the cultural resources (e.g., ethnographic resources and cultural landscapes) decline to the point that there is no cultural identity with them, these resources and landscapes would no longer be eligible for the national register.

The Huna Tlingit believe they have been alienated or expelled from the park due to park designation, subsistence limitations, and prior access limitations (e.g., some Huna Tlingit are unwilling to compete for limited private vessel entry permits during the busy summer season; Howell 2002). Huna Tlingit access issues are being resolved through government-to-government negotiations between the Park Service and the Hoonah Indian Association. The Park Service has been working with the Huna Tlingit to encourage participation in currently authorized activities, such as berry picking and fishing, while exploring resumption of others, such as gull-egg gathering. These negotiations, in addition to multiple studies, educational programs, and increased Huna Tlingit participation in all aspects of park planning and management, illustrate the importance of Tlingit culture in the mission and purpose of the park.

Impairment Analysis for Cultural Resources – Alternative 1. An effect may constitute an impairment "to the extent that it affects a resource or value whose conservation is necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park; key to the natural or cultural integrity of the park or to opportunities for enjoyment of the park; or identified as a goal in the park's general management plan or other relevant NPS planning documents" (NPS 2000b). The park's purpose and mission statement states that the park will recognize and perpetuate "values associated with the Tlingit homeland"; preserve "historic value"; protect, restore, and maintain "cultural resources and [their] associated values in good condition"; and manage these "resources within their broader ecosystem and cultural context" (NPS 1997c, 1998a).

Based on the overall severity (moderate), duration (long-term), and timing of the effect (June through August); the effects of alternative 1 on ethnographic resources and cultural landscapes (e.g., perception of degradation of connection to the ethnographic resource and/or cultural landscape); and the cumulative effects of alternative 1 (moderate; NPS 2000b), alternative 1 would not result in impairment of cultural resources in the park.

Potential Mitigation Measures for Cultural Resources – Alternative 1. Continuing visitor education regarding the effects of intentional and unintentional damage to archaeological resources and closing sensitive areas to visitor use could mitigate the effects of minor vandalism at exposed cultural resource sites, as discussed in the cumulative effects subsection.

Conclusion, Cultural Resources – Alternative 1. The potential effects of alternative 1 would be negligible for eligible or potentially eligible archaeological and historic structural resources, but moderate for eligible or potentially eligible ethnographic resources (e.g., traditional cultural properties) and cultural landscapes due to the unavoidable perceived degradation of the Huna Tlingit homeland by vessel traffic. The overall effect of alternative 1 on cultural resources would be moderate. The cumulative effect of alternative 1 would be moderate. Alternative 1 would not impair cultural resources in the park.

Alternative 2 – Effects on Cultural Resources. Under this alternative, vessel management would revert to the quotas and operating requirements established in 1985, reversing the increases defined in the 1996 decision (107 cruise ships between June 1 and August 31). Alternative 2 represents a decrease in vessel traffic from alternative 1.

Direct and Indirect Effects on Cultural Resources – Alternative 2.

<u>Archaeological and Historic Structural Resources</u>. The potential changes to archaeological resources and historic structural resources as a result of alternative 2 are the same as those of alternative 1. As described

under alternative 1, the effects of vessel wakes and potential fuel spills would be negligible because the known archaeological and historic structural resources are physically above the area affected by wave/wake action. Alternative 2 would have no effect on national register eligibility for potentially eligible archaeological sites and historic structural resources, and would have a negligible effect on known archaeological resources and historic structural resources despite the long duration and large area of potential effect (see table 4-26).

<u>Ethnographic Resources</u>. Alternative 2 would have a moderate effect on ethnographic resources. Although alternative 2 would decrease cruise ship traffic from alternative 1, and thus present a reduced threat of pollution (air and water), contamination (fuel spills), and marine mammal injuries — factors that could enhance the Huna Tlingit relationship with their homeland — the reduction is not sufficient to reduce the effect to minor, because those potential threats would still be noticeably present. Alternative 2 would not affect the integrity and association of the eligible or potentially eligible ethnographic resources and would not effect their eligibility for the national register because the Huna Tlingit are likely to maintain their cultural identity with Glacier Bay. Thus, the effect of alternative 2 on ethnographic resources would be moderate (see table 4-26).

<u>Cultural Landscape</u>. Alternative 2 would have a moderate effect on cultural landscapes in Glacier Bay because the Huna Tlingit have maintained their connection to the Bartlett Cove cultural landscape as discussed in alternative 1. Although the effects of alternative 2 on the Glacier Bay cultural landscapes would be long-term and encompass all of Glacier Bay, they would not affect the integrity and association of eligible or potentially eligible cultural landscapes in Glacier Bay and thus would not affect these cultural landscapes' eligibility for the national register. Thus, Alternative 2 would have a moderate effect on the Glacier Bay cultural landscape (see table 4-26).

Cumulative Effects on Cultural Resources – Alternative 2. Alternative 2 would have the same cumulative effects as alternative 1; however, the cumulative effects would be reduced due to the proposed decrease in vessel traffic/quotas.

Impairment Analysis for Cultural Resources – Alternative 2. Though the duration is long-term, the overall severity of the alternative 2 effect is negligible for archaeological and historic structural resources and moderate for ethnographic resources and cultural landscapes. Thus, no impairment to these resources would result from alternative 2.

Potential Mitigation Measures for Cultural Resources – Alternative 2. The effect on ethnographic resources and the cultural landscape could be mitigated by the formation of a task force comprising of the Hoonah Indian Association and NPS officials. This task force would identify potential adverse effects in the park and design a cooperative management plan to address them.

Conclusion, Cultural Resources – Alternative 2. The potential effects of alternative 2 would be negligible for eligible or potentially eligible archaeological and historic structural resources, and moderate for eligible or potentially eligible ethnographic resources (e.g., traditional cultural properties) and cultural landscapes. The overall effect of alternative 2 on cultural resources would be moderate. The cumulative effects of alternative 2 would be minor. Alternative 2 would not result in impairment to cultural resources.

Alternative 3 – Effects on Cultural Resources. Alternative 3 allows for an increase in vessel traffic up to the quotas authorized in the 1996 vessel management plan (or two ships a day, every day, from June 1 through August 31). Alternative 3 proposes a 32% increase in vessel traffic/quotas from alternative 1.

Direct and Indirect Effects on Cultural Resources – Alternative 3.

<u>Archaeological and Historic Structural Resources</u>. Despite the increase in vessel traffic/quotas proposed under alternative 3, the effects to archaeological resources and historic structural resources would be the same as those of alternative 1. As with alternative 1, archaeological and historic structural resources in Glacier Bay could be disturbed or destroyed by erosion caused by cruise-ship-induced wakes on coastal archaeological and historic sites and contamination from possible oil discharge or fuel spills. According to subsection 4.4.6, “Coastal/Shoreline Environments and Biological Communities,” the erosion potential would be the same as that for alternative 1, and although erosion would increase slightly, there would be no visible changes to the shoreline. The wave action and the potential for contamination to these resources, therefore, are the same as those of alternative 1, and the effect on archaeological resources and historic structural resources would be negligible.

<u>Ethnographic Resources</u>. Alternative 3 would have a moderate effect on the ethnographic resources in Glacier Bay because it would increase the effects from alternative 1 due to the 32% increase in vessel traffic/quotas. Under existing conditions, the Huna Tlingit perceive the environment of the park as degraded as described under alternative 1. Because of the vessel increase, alternative 3 has the potential to have a moderate effect on ethnographic resources (e.g., traditional cultural properties) in that it could adversely affect the relationship between the Huna Tlingit and the traditional cultural properties if cruise

ships further degrade perceived environmental quality in the park; however, the level of increase would not be sufficient to cause Huna Tlingits to abandon such ingrained cultural traditions.

Alternative 3 could potentially affect the integrity and association of eligible or potentially eligible ethnographic resources to the extent that perceived degradation of the environment reduces the integrity of the Huna Tlingit relationship with their homeland. Alternative 3 would not affect these ethnographic resources' eligibility for the national register, however, because the Huna Tlingit are likely to maintain their cultural identity with Glacier Bay. As long as the community maintains its cultural identity with traditional Glacier Bay places and activities, the ethnographic resource (e.g., traditional cultural properties) will continue to be eligible for the national register. Thus, the effects of alternative 3 on ethnographic resources would be moderate.

Cultural Landscape. Alternative 3 would have a moderate effect on cultural landscapes because cultural landscapes are an extension of ethnographic resources and the Huna Tlingit have maintained their connection to the Bartlett Cove cultural landscape (see alternative 1).

Cumulative Effects on Cultural Resources – Alternative 3. Alternative 3 would have a similar cumulative effect as alternative 1, although the effect would be somewhat greater due to the increase in vessel traffic/quotas. The cumulative effects of the actions external to this plan (e.g., increased tourism, tourists who go ashore, restricted access to the park, and subsistence limitations) could significantly alter the effects on the cultural resources of Glacier Bay and Dundas Bay; therefore, the cumulative effect would be moderate.

Impairment Analysis for Cultural Resources – Alternative 3. Despite the long duration, the overall severity of the effect on archaeological and historic structural resources for alternative 3 is negligible. For ethnographic resources and cultural landscapes, the severity of the effect is moderate, the duration is long-term, the timing of the effect is June through August (a period of Huna Tlingit use of the park), the effects include Huna Tlingit perception of a diminution of their connection to their homeland, and the cumulative effects would be moderate (see table 4-26). Because the overall severity of alternative 3 is moderate**,** this alternative would not result in impairment on cultural resources in the park.

Potential Mitigation Measures for Cultural Resources – Alternative 3. The effect on ethnographic resources and the cultural landscape could be mitigated by the formation of a task force comprising the

Hoonah Indian Association and NPS officials. This task force would identify potential adverse effects in the park and design a cooperative management plan to address them.

Conclusion, Cultural Resources – Alternative 3. The potential effects of alternative 3 would be negligible for eligible or potentially eligible archaeological and historic structural resources, but moderate for eligible or potentially eligible ethnographic resources (e.g., traditional cultural properties) and cultural landscapes. The overall effect of alternative 3 on cultural resources would be moderate. The cumulative effects of alternative 3 would be moderate. Alternative 3 would not result in impairment to cultural resources in the park.

Alternative 4 – Effects on Cultural Resources. Alternative 4 decreases cruise ship vessel quotas to pre-1985 levels and reduces daily vessel quotas for tour, charter, and private vessels from the current conditions. Alternative 4 extends the vessel seasonal restrictions for all vessel classifications to May 1 (instead of June 1) until September 30 (instead of August 31), proposes vessel quotas for charter vessels in Dundas Bay (a daily vessel quota of 3 and a seasonal-use day limit of 459), restricts tour vessels from entering Dundas Bay, closes wilderness waters to cruise ships and tour vessels and proposes to identify a cruise ship route. This alternative also modifies vessel-operating requirements (e.g., vessel speeds, whale water boundaries, and vessel operations).

Direct and Indirect Effects on Cultural Resources – Alternative 4.

<u>Archaeological and Historic Structural Resources</u>. Alternative 4 would have a negligible effect on archaeological resources through erosion or contamination. The effects of alternative 4 on archaeological resources in Glacier Bay would be less than those of alternative 1 (which are negligible) due to a longer but restricted entry season, slower vessel speeds, and additional restricted waters. Alternative 4 could affect, through vessel wakes and contamination, 15 coastal archaeological sites in Dundas Bay, nine archaeological sites in Glacier Bay, and four historic structural resources in Dundas Bay (see figure 3-18). As with the other alternatives, because the known archaeological and historic structural resources within Glacier and Dundas Bays are located above the wake zone, there would be a negligible effect from vessel wakes and oil discharge or fuel spills. This alternative also would have a negligible effect on archaeological and historic structural resources in Dundas Bay because charter traffic is more limited under this alternative than with current conditions. Alternative 4 would have no effect on national register eligibility for potentially eligible archaeological sites and historic structural resources and thus would

have a negligible effect on archaeological resources and historic structural resources despite the long duration and large area of potential effect (see table 4-26).

Ethnographic Resources. Alternative 4 would have a moderate effect on the ethnographic resources in Glacier Bay. The effects of alternative 4 on ethnographic resources in Glacier Bay would be less than those of alternative 1 due to longer restricted entry season, slower vessel speeds, and additional restricted waters. Alternative 4 also restricts cruise ships and tour vessels from and limits charter vessel entries for Dundas Bay, thus reducing potential effects on ethnographic resources. Alternative 4 would not affect the integrity and association of the eligible or potentially eligible ethnographic resources or their eligibility for the national register. Thus, the effects of alternative 4 on ethnographic resources would be moderate (see table 4-26).

Cultural Landscape. Alternative 4 would have a moderate effect on the cultural landscapes in Glacier Bay because the Huna Tlingit have maintained their connection to the Bartlett Cove cultural landscape. Alternative 4 would have less of an effect on the Bartlett Cove cultural landscape than alternative 1. The park has documented a cultural landscape in Dundas Bay that contains the archaeological remains of two Huna Tlingit villages with accompanying oral history and other cultural resources (e.g., cemetery, house pilings, smokehouse debris, and fragments of a dugout canoe), stone cairns (believed to be Tlingit shrines), traditional berry-picking areas (one Native name for the area translates as “Berry Land”), and was known historically as a place for harvesting seals and salmon. Alternative 4 would result in a moderate effect on the Dundas Bay cultural landscape because of proposed limited vessel activity. The effects of alternative 4 would not affect these cultural landscapes’ eligibility for the national register, and thus would have a moderate effect on cultural landscapes in the park.

Cumulative Effects on Cultural Resources – Alternative 4. The cumulative effects of the actions external to this plan (e.g. increased tourism, tourists who go ashore, restricted access to the park, and subsistence limitations) would not significantly alter the effects on the cultural resources of Glacier Bay and Dundas Bay; therefore, the cumulative effect would be moderate.

Impairment Analysis for Cultural Resources – Alternative 4. Although the duration would be long-term and the timing of the effect is a period of Huna Tlingit use of the park (May through September), the overall severity of effect of alternative 4 would be moderate. Thus, no impairment would occur to these resources under alternative 4.

Potential Mitigation Measures for Cultural Resources – Alternative 4. The effect on ethnographic resources and the cultural landscape could be mitigated by the formation of a task force comprising of the Hoonah Indian Association and NPS officials. This task force would identify potential adverse effects in the park and design a cooperative management plan to address them.

Conclusion, Cultural Resources – Alternative 4. The potential effects of alternative 4 would be negligible for eligible or potentially eligible archaeological and historic structural resources, and minor for eligible or potentially eligible ethnographic resources (e.g., traditional cultural properties) and cultural landscapes. The contribution of cumulative effects from other actions would be minor. The overall effect to cultural resources would be minor, and no impairment would occur.

Alternative 5 – Effects on Cultural Resources. Alternative 5 maintains seasonal vessel entry quotas at current levels but extends the season for cruise ships and modifies vessel operating requirements for all vessels (e.g., vessel speeds, whale water boundaries, and vessel operations). For Dundas Bay, alternative 5 proposes 276 seasonal-use days and no daily vessel quota for charter vessels, allows one tour vessel into lower Dundas Bay per day, and restricts cruise ships and tour vessels from entering wilderness waters.

Direct and Indirect Effects on Cultural Resources – Alternative 5.

<u>Archaeological and Historic Structural Resources</u>. Alternative 5 would have a negligible effect on archaeological resources in Glacier and Dundas Bays through erosion or contamination. Alternative 5 has the potential to affect nine coastal archaeological sites in Glacier Bay, 15 coastal archaeological sites in Dundas Bay, and four historic structural resources in Dundas Bay through vessel-induced wakes and contamination caused by possible fuel spills. Alternative 5 would cause a negligible effect to these resources even though the implementation of this alternative would result in erosion that is slightly greater that current levels, but there would be no perceptible change to the coastline (see subsection 4.4.6). As with the other alternatives, because the known archaeological and historic structural resources within Glacier and Dundas Bays are located above the wake zone, there would be a negligible effect from vessel wakes and oil discharge or fuel spills. The effect of alternative 5 on archaeological resources and historic structural resources would have no effect on national register eligibility for archaeological sites in Glacier and Dundas Bays. Thus, alternative 5 would have a negligible effect on known archaeological resources despite the long duration and large area of potential effect (see table 4-26).

Ethnographic Resources. Alternative 5 could potentially affect eight traditional cultural properties in Glacier and Dundas Bays. Alternative 5 proposes maintenance of current vessel entries with a longer restricted entry season for cruise ships (May through September), decreasing potential perceived effects. The addition of vessel restrictions (e.g., no cruise ships or tour vessels in wilderness waters) may have beneficial effects for the relationship between the Huna Tlingit and the park by reducing potential effects. Alternative 5 would not affect the potential eligibility of the ethnographic resources / traditional cultural properties for the national register because the Huna Tlingit have maintained their cultural connection to the ethnographic resources. Thus, alternative 5 would have a moderate effect on ethnographic resources in Glacier and Dundas Bays.

Cultural Landscape. Alternative 5 could potentially affect two cultural landscapes, Bartlett Cove and Dundas Bay, and would have a moderate effect on cultural landscapes in Glacier and Dundas Bays because cultural landscapes are an extension of ethnographic resources. Alternative 5 may affect the integrity and association of eligible or potentially eligible cultural landscapes in Glacier and Dundas Bays, but would not affect these cultural landscapes' eligibility for the national register because the Huna Tlingit have maintained their cultural connection to the cultural landscape. Thus, alternative 5 would have a moderate effect on the Glacier Bay cultural landscape.

Cumulative Effects on Cultural Resources – Alternative 5. Alternative 5 would have a similar cumulative effect as alternative 1, although the cumulative effect would be less due to the proposed decrease in vessel traffic/quotas in Dundas Bay and more stringent operating requirements. It is unlikely the cumulative effects would affect the eligibility of ethnographic resources and cultural landscapes so long as the Huna Tlingit desire to maintain their connection/relationship with culturally significant places in Glacier and Dundas Bays.

Impairment Analysis for Cultural Resources – Alternative 5. Although the duration is long, the overall severity of alternative 5 would be negligible for archaeological and historic structural resources. For ethnographic resources and cultural landscapes, the severity of the effect would be moderate, the duration would be long-term, the timing of the effect would be May through September (a period of Huna Tlingit use of the park), the effect would include the Huna Tlingit perception of degradation of connection to the ethnographic resource and cultural landscape, and the cumulative effect of alternative 5 would be moderate. Because the overall severity of alternative 5 would be moderate, this alternative would not result in impairment on cultural resources in the park.

Potential Mitigation Measures for Cultural Resources – Alternative 5. The effect on ethnographic resources / traditional cultural properties and the cultural landscape could be mitigated by the formation of a task force (Huna Tlingit and NPS officials) that would address potential adverse effects to ethnographic resources and cultural landscapes in the park. This task force would also design a cooperative management plan to address adverse effects.

Conclusion, Cultural Resources – Alternative 5. The potential effects of alternative 5 would be negligible for eligible or potentially eligible archaeological and historic structural resources, but moderate for eligible or potentially eligible ethnographic resources (e.g., traditional cultural properties) and cultural landscapes. The overall effect of alternative 5 on cultural resources would be moderate. The cumulative effects of alternative 5 would be moderate. Alternative 5 would not result in impairment of cultural resources in Glacier and Dundas Bays.

Summary, Cultural Resources. The effect of the implementation of the alternatives on cultural resources ranges from negligible to moderate. Cumulative effects could contribute additional moderate direct or indirect effects, ranging from minor to moderate. Mitigation measures could include the formation of a Huna Tlingit and NPS task force. This task force would identify potential adverse effects in the park and design a cooperative management plan to address them. Implementation of the alternatives would not impair the park's cultural resources.

4.4.2 VISITOR EXPERIENCE

4.4.2 Visitor Experience

This section evaluates the potential effects of implementing the proposed alternatives on visitor experience. The regulatory framework is presented first, followed by the effects analysis for each alternative. This discussion also includes an evaluation of cumulative effect on visitor experience. Conclusions summarize the results of each evaluation.

Issues of Concern Raised during Scoping. The issues related to visitor experience that were identified during scoping are:

- the presence of large cruise ships could diminish the experience of visitors from smaller vessels due to the visual effects and loss of wilderness experience.
- vessel noise could intrude on visitor solitude in Glacier Bay.
- the presence of vessels may provide a backcountry user with a greater sense of security knowing that help is nearby if an emergency occurs.
- the presence of vessels may scare wildlife and thereby could diminish the visitor experience of those expecting to see wildlife.

Regulatory Framework. Managing how the public uses the parks is one of the fundamental missions of the Park Service. The importance of visitor experience is addressed under NPS policies (NPS 2001b) and essentially all other planning documents related to the park, including the park's general management plan (NPS 1984). The Organic Act of 1916, which created the Park Service and its mission, also mandates the Park Service to provide for the public's enjoyment of the parks.

Methodology and Assumptions. This evaluation of the alternatives' effects on visitor experience focuses on the quality of visitor experience and the opportunities for visitors to visit Glacier Bay. Visitor opinions and overall impression of the park were determined based on two studies, one conducted in 1989 (Johnson 1990) and another in 1999 (Littlejohn 2000). The 1989 study, *Glacier Bay National Park Tour Boat Passenger Visitor Survey,* measured the effect of vessel sightings on the experience of tour vessel passengers while viewing Grand Pacific Glacier. While more than 10 years old and limited to tour vessel passengers only, the study provides qualitative information that was used to judge the motorized vessel visitor's current experience and how the alternatives would affect visitor experience. The 1999 study, *Bartlett Cove Visitor Study,* provides the results of 545 questionnaires distributed to visitors at Bartlett Cove. The Alaska Travel Industry Association's *Images of Alaska 2000* (GMA Research Corporation 2001) and earlier editions provide data regarding the importance of visiting national parks while in Alaska among past and prospective visitors. *The Backcountry Distribution and Use Report* (Kralovec 2001) also provides some information about visitor reactions to seeing motorized vessels and aircraft.

To provide additional information regarding visitor experience for this EIS, the EIS team interviewed cruise line marketing and customer relations managers, tour vessel operators, and charter operators. These interviews provide qualitative data regarding the perceived relationship between the volume of vessel traffic in the Bay and the quality of visitors' Glacier Bay experience.

The EIS study team used professional judgment to characterize the level of effects of the alternatives on visitor experience for the following types of visitors: cruise ship passengers, charter and other tour vessel passengers, private vessel users, and backcountry (non-motorized) users. This evaluation compares the existing visitor experience with the experience that would likely occur under each alternative and rates the changes as negligible, minor, moderate, or major. Visitor experiences, particularly for backcountry visitors, and the degree to which they experience intrusion from motorized vessels and aircraft, may vary by the geographical area within Glacier Bay or Dundas Bay. The threshold criteria identified here are used to refer to the Bays as whole entities, not to particular regions within each Bay. Estimating the potential effects by different regions within each Bay is beyond the scope of this analysis. Based on the two perspectives related to visitor experience (quality and opportunity), the intensities of effects on visitor experience are described in table 4-27.

TABLE 4-27: THRESHOLD CRITERIA FOR VISITOR EXPERIENCE EFFECTS ANALYSIS

Negligible	The effect on visitor experience would be barely detectable and would affect few visitors. Visitors would experience the same level of satisfaction with the Glacier Bay experience, and the same level of opportunity to visit the Bay as with the no-action alternative (1).
Minor	The effect would be minor if there were a detectable, but slight, decline in the quality of the experience for visitors traveling in the Bay or in the opportunity for visitors to experience the Bay (defined as reduction in capacity of less than 10% among all vessel categories combined).
Moderate	Moderate effects would include a readily apparent decline in the quality of the visitor experience or a clear reduction in the opportunity for visitors to experience the Bay (defined as a 10% to 20% reduction in capacity).
Major	Severe, obvious decline in the quality of the visitor experience or severe reduction in the opportunity for visitors to experience the Bay (defined as a 20% or more reduction in capacity) would be major effects.

Alternative 1 (No Action) – Effects on Visitor Experience.

Direct and Indirect Effects on Visitor Experience – Alternative 1. Overall, existing management provides a wide range of opportunities for park visitors. Some visitor conflicts occur, including the diminished experience for some individuals upon seeing cruise ships and other vessels.

Quality of Experience. The diminished experience is a result of not only the presence of the ship itself but also the associated noise, air pollution, and disturbance to wildlife. Non-motorized wilderness provides opportunities to experience the park without the presence of motorized vessels. Alternative 1 would have negligible short-term effects on opportunities to visit Glacier Bay. Under current vessel management requirements, the effects of other vessels on the experience of tour vessel passengers would continue to be minor. Based on the low number of negative comments reported in the 1989 NPS survey of tour vessel passengers, the sighting of other vessels is unlikely to detract from the enjoyment of park resources by this visitor group (Johnson 1990). In fact, an almost equal number of respondents said that the sighting of other vessels added to their enjoyment. Conclusions from this study are supported by the results of a 1999 park visitors survey that found that among private, charter, and tour vessel passengers collectively, 76% reported no adverse effect on their experience from sightings of cruise ships and 92% reported no adverse effects from sightings of other vessels (Littlejohn 2000). The same survey found that vessel sightings at glaciers did not bother 86% of private, charter, and tour vessel passengers; therefore, under alternative 1, a minor segment of tour vessel passengers would be either adversely or positively affected by the sighting of other vessels.

Similarly, the effects of other vessel sightings among cruise ship passengers are likely to be minor. Although no survey data regarding this visitor group exist, they are similar to tour vessel passengers in that they experience Glacier Bay with a large number of other people. Their experience does not hinge on an atmosphere of individual solitude and isolation; however, cruise ship visitors still find it important to experience some level of solitude and quiet in Glacier Bay. Cruise ship captains try to communicate with other cruise ships so that two ships are not at any tidewater glacier at the same time. There is likely a minority of cruise passengers who, like tour passengers, would report a positive or negative effect on their experience from the sighting of other vessels. In the overall visitor population, however, this effect would continue to be minor.

Visitors experiencing Glacier Bay and/or Dundas Bay on charter vessels are likely to continue to experience the presence of other vessels in the Bay. The negative impression of other vessels might be somewhat greater than for visitors on cruise ships or tour vessels because, as small-vessel travelers, their experience is more likely to be dependent on an atmosphere of undisturbed wilderness. The sights and sounds of other vessels, especially large cruise ships, are likely to detract from the wilderness experience for some visitors. Charter use in Dundas Bay is expected to increase over time under alternative 1. This increase would likely have minor to moderate adverse effects on the quality of charter visitors' experience in Glacier Bay, as wildlife sightings could be less frequent because charter vessel traffic may displace certain species.

Private vessel visitors are similar to charter vessel visitors in that they are seeking a more solitary wilderness experience. Some of these visitors would likely continue to be disturbed by the current level of vessel activity in the park.

For backcountry users (non-motorized), an overall moderate level effect would occur due to the presence of cruise ships and other vessels. A two-cruise-ship-per-day limit with seasonal limits would be imposed. Because of the seasonal limit, there potentially could be days without cruise ships. By viewing the cruise ship itinerary ahead of time, backcountry users could plan trips around the cruise ship schedule and experience the Bay without the sights, sounds, and smells of cruise ships. Also under this alternative, motorized use of wilderness waterways would be seasonally restricted, except for the upper end of Dundas Bay and the Beardslee Entrance, to allow for increased opportunities to experience the Bay in the absence of motorized vessels. Alternative 1 also provides alternating seasonal closures for Wachusset and Muir Inlets, allowing opportunities for non-motorized wilderness recreation.

Backcountry visitors travel throughout all areas of the park, with concentration near the shorelines, visiting major attractions, experiencing natural features, and viewing wildlife. Motorized vessels, particularly charter and private vessels, may anchor for 12 hours or more near wilderness and are visible from some campsites. Such anchorages would continue in alternative 1, and it is likely that their distribution and number would continue at current patterns and levels.

Watercraft can diminish the experience of backcountry visitors. Visitor use surveys conducted in 1979 and 1984 indicated that 55% and 60% of backcountry users, respectively, experienced disturbance from motorized watercraft (Johnson 1979; Salvi and Johnson 1985). In the 1984 study, 25% of the respondents — the largest single percentage — suggested limiting watercraft when asked for recommendations for new regulations. More than 63% of the respondents stated that the number of watercraft and aircraft sighted resulted in a strong or great contribution to their perception of being crowded. In 1979 and 1984, approximately 88% of respondents preferred to see no increase in cruise ships, 90% preferred to see no increase in tour vessels, and a substantial majority preferred to see no increase in other motorized vessel categories.

<u>Opportunity</u>. Currently, about half of the people who visit Alaska via cruise ships visit Glacier Bay. Under alternative 1, the current number of cruise ships would be maintained. If the Alaska cruise market continues its growth, a smaller percentage of the market would have the opportunity to visit the park. Because passenger capacity of cruise ships is increasing, however, the number of passengers traveling to the Bay would increase somewhat before leveling off. As an example of the effect of increasing capacity, the number of cruise ship passengers hit an all-time high in Glacier Bay in 2002, despite six cancellations and the lowest number of cruise ships visiting since 1996 (Parish 2002). New cruise ship capacity is as high as 2,600 passengers.

Use during May and September could also increase, resulting in an overall increase in visitation to the Bay. According to cruise line executives, the Glacier Bay experience is in very high demand among cruise passengers; this demand is likely to continue to be greater than the level of opportunity. Overall, alternative 1 would be expected to have minor to moderate adverse effects on future visitors' opportunity, to the extent that it would constrain future opportunity to visit the Bay via cruise ship and continue to leave demand for opportunities to visit the Bay unsatisfied. In addition, alternative 1 could lower the proportion of Alaska's visitors having the opportunity to experience Glacier Bay, and further, could shift visitor-related environmental effects (mainly cruise-related) to alternative destinations, such as Tracy Arm in Southeast Alaska, Hubbard Glacier near Yakutat, and Prince William Sound in Southcentral Alaska.

Alternative 1 would continue to offer 276 entries per season to tour vessels. In recent years, the number of actual tour vessel entries was substantially less than the number allowed (200 in 2002, 228 in 2001, and 224 in 2000). In the small cruise ship market, most itineraries include Glacier Bay, making it widely available to these visitors. If the small-ship cruise market increases, there would likely be room for those additional entries. The primary day tour vessel, the *Spirit of Adventure*, meets the current level of demand (with daily departures throughout the summer, the vessel rarely runs at capacity); therefore, under alternative1, sufficient opportunity for day vessel passengers to experience the park would continue.

Alternative 1 would offer 312 entries per season to charter vessels. In general, this limit would continue to meet charter vessel demand. From June through August 2001, there were 172 charter vessel entries (out of the allowable 312) and 247 total use days (out of the allowable 552). Alternative 1 would, in the absence of other concession management changes, perpetuate the perceived shortage of permits for Elfin Cove, Hoonah, and other local charter operators who wish to have entry permits, but do not at this time. This is particularly true for charter vessel operators wishing to use Dundas Bay. Alternative 1 perpetuates this perceived shortage because charter vessel permit quotas would not be changed from the current situation.

Among visitors who experience the park in private vessels, alternative 1 would continue to offer 468 total entries from June through August. Over the last several years, the limit has provided some opportunity for this market — 414 private vessels entered the park in the 2000 season, followed by 385 in 2001. In addition to the seasonal limit, there are also daily limits. Alternative 1 would provide for three entries per day from June 1 to June 10, six entries per day from June 11 to August 2, five entries per day from August 3 to August 15, and three entries per day from August 15 to August 31. This may continue to result in periods when the daily demand for park entry exceeds the number of allowable entries.

For backcountry visitors, particularly those sensitive to seeing motorized vessels, the presence of vessels could reduce opportunities to engage in experiences that rely on a sense of wildness, remoteness, quiet, and solitude.

Vessels, although intermittent during the day, would continue to be visible to backcountry visitors almost every day from May to September. This could lead some visitors either to choose not to engage in a backcountry visit or to choose restricted, non-motorized waters, thus increasing use levels and congestion there. Exposure to noise, sights, and smells of motorized vessels diminishes opportunities for solitude among backcountry visitors. The recurrent nature of this disturbance to backcountry visitors is considered a moderate effect.

Cumulative Effects on Visitor Experience – Alternative 1. Alaska's visitor industry is expected to increase. Cruise ship traffic is expected to increase more rapidly than independent visitor traffic. This would increase demand for opportunities to visit Glacier Bay. More locally, development of a new visitor's center in Glacier Bay, development of a private cruise ship port in Hoonah, and growth in the number of people wishing to visit Glacier Bay could result in increasing demand to visit Glacier Bay by cruise ship, tour vessel, charter vessel, or private vessel. This increasing demand could exacerbate the existing imbalance between the desire to visit Glacier Bay while on a cruise ship and the available opportunities to see the Bay aboard a cruise ship. Eventually, these same factors could increase the demand to visit the Bay aboard tour vessels, charter vessels, and private vessels to levels above those possible under alternative 1. Other than this long-term consideration, the cumulative effect on quality of visitor experience and visitor opportunities associated with alternative 1 would be minor.

Impairment Analysis for Visitor Experience – Alternative 1. Visitor experience is not a resource subject to impairment evaluation.

Potential Mitigation Measures for Visitor Experience – Alternative 1. Scheduling of cruise vessels to arrive at the upper end of Glacier Bay at about the same time would reduce negative effects for backcountry and small-vessel visitors.

Conclusion, Visitor Experience – Alternative 1. Under alternative 1, visitors using motorized vessels would continue to be provided with a wide range of park-related opportunities. Backcountry visitors would continue to experience a loss of opportunity to experience solitude, resulting in a moderate effect. Alternative 1 would have negligible short-term effects on opportunities to visit the Bay. Vessel quotas set forth in alternative 1 could lower the proportion of Alaska’s visitors having the opportunity to experience Glacier Bay, and further, could shift visitor-related environmental effects (primarily cruise-related) to alternative destinations, such as Tracy Arm in Southeast Alaska, Hubbard Glacier near Yakutat, and Prince William Sound in Southcentral Alaska.

Alternative 2 – Effects on Visitor Experience.

Direct and Indirect Effects on Visitor Experience – Alternative 2.

<u>Quality of Experience</u>. Among tour vessel passengers, alternative 2 would have negligible effects on the quality of visitors’ experience. This finding is based on data from the 1989 and 1999 NPS surveys of motorized vessel passengers on the effects of vessel traffic and sightings on visitors’ experience. The majority of respondents said that such sightings were irrelevant to the level of their enjoyment. For a small group of visitors, the sighting of a cruise ship or a pleasure vessel would detract from their enjoyment. Conversely, a small percentage of respondents indicated that the sighting of other vessels would be enjoyable.

Among cruise passengers, alternative 2 would have negligible effects on the quality of visitors’ experience. Although no survey data exist regarding the effects of vessel sightings on cruise ship passengers’ experience, it can be assumed that the survey data quoted above would correspond closely with cruise passengers' attitudes. Both cruise ship and tour vessel visitors are experiencing Glacier Bay aboard vessels with a large number of other people. Their experience is not dependent on a feeling of isolation from the civilized, developed world. While the sighting of other vessels represents moderate beneficial or detrimental effects for a minority of passengers, overall, the lesser amount of vessels proposed in alternative 2 would have negligible effects on the quality of cruise passengers' experience.

Among charter vessel visitors, alternative 2 represents a minor beneficial effect. There is no survey data regarding this market; however, charter vessel passengers generally visit Glacier Bay and Dundas Bay on smaller vessels and tend to seek a more remote, undisturbed experience when compared to the tour vessel or cruise passenger market. A reduction of 23% of cruise ship entries would likely improve the experience for these visitors.

Among private vessel visitors, alternative 2 represents a minor beneficial effect. As in the case of charter vessel visitors, private vessel visitors tend to seek a remote wilderness experience. The sight and sound of a large cruise ship represent an infringement upon this solitary experience. It can be assumed that a moderate proportion of private vessel visitors would have a more enjoyable experience with fewer cruise ship entries. A reduction of 23% in cruise ship entries would be beneficial to the overall private vessel visitor market.

Under the current management scheme, backcountry visitors enjoy seasonal closures to motorized travel in seasonally closed non-motorized waterways, including the Beardslee Islands (except the Beardslee Entrance), the Hugh Miller / Scidmore complex, Adams Inlet, Wachusset Inlet, Rendu Inlet, Muir Inlet (north of McBride Glacier), and Johns Hopkins Inlet. Cruise ships and tour, charter, and private vessels could travel through all other areas of the park. Motorized travel would be allowed throughout Dundas Bay, including the wilderness waters of Dundas Bay. Backcountry visitors would travel throughout all areas of the park with concentration near the shorelines, visiting major attractions, experiencing natural features, and viewing wildlife.

<u>Opportunity</u>. Among cruise passengers, alternative 2 would decrease the opportunity to the park, with 23% fewer seasonal entries by cruise ships allowed. This would represent a major adverse effect on the opportunity for cruise passengers to visit the park.

Because the number of tour vessel entries into Glacier Bay would remain the same in alternative 2 as in alternative 1, there would be a negligible effect on the opportunity for tour vessel passengers to visit the park.

Alternative 2 would create a moderate adverse effect on the opportunity for charter vessel visitors to visit the park, because it would decrease the allowable entries (compared to alternative 1) by 13%.

Among private vessel visitors, alternative 2 would create a moderate adverse effect on the opportunity to visit the park. The allowable entries would decrease by 13% from alternative 1.

Backcountry users would enjoy increased opportunities to experience solitude under this alternative due to the 23% decrease in cruise ship use days, 7% decrease in charter vessel use days, and a 13% decrease in private vessel use days. As mentioned in alternative 1, approximately 88% of respondents to backcountry surveys (Johnson 1979; Salvi and Johnson 1985) preferred to see no increase in cruise ships, 90% preferred to see no increase in tour vessels, and a substantial majority preferred to see no increase in other motorized vessel categories. With seasonal limits, there would potentially be days without cruise ships. By viewing the cruise ship itinerary, backcountry users could plan their schedule and experience the Bay without cruise ships. The potential effects of anchorages on visitor experiences would be slightly reduced from alternative 1.

Opportunities to engage in experiences that rely on a sense of wildness, remoteness, quiet, and solitude are slightly increased under this alternative because of the decrease in use days for two of the categories of large motorized vessels, and the decrease in private vessel use days. Because backcountry visitors place such a high value on opportunities to experience solitude in the backcountry, and this alternative provides a slight increase in those opportunities, it is anticipated that this alternative would improve the quality of their backcountry experience. This effect would last the life of this plan and would occur in a wilderness backcountry setting that is relatively rare in the National Wilderness Preservation System. Because this alternative would produce some intrusion into the ability of backcountry visitors to achieve their desired experience, and it is recurrent, this effect is considered minor.

Cumulative Effects on Visitor Experience – Alternative 2. Other than the indirect effects associated with increasing demand for opportunities to visit Glacier Bay while the number of actual opportunities is declining (as described under the cumulative effects of alternative 1 subsection), all cumulative considerations would result in negligible changes in the quality of visitors' experience in Glacier Bay, or the opportunity to visit Glacier Bay aboard motorized vessels.

Impairment Analysis for Visitor Experience – Alternative 2. Visitor experience is not a resource subject to impairment evaluation.

Potential Mitigation Measures for Visitor Experience – Alternative 2. Loss of opportunities to visit the park is an effect of reducing cruise ship numbers and cannot be avoided. (Note that as cruise ships become larger and carry more passengers, the loss of opportunities can be somewhat offset, but this is not considered a mitigation measure.)

Conclusion, Visitor Experience – Alternative 2. In summary, alternative 2 would improve the experience for backcountry visitors and visitors traveling aboard motorized vessels with the reduced presence of cruise ships. The 23% reduction in cruise ship entries would result in a loss of opportunity for cruise ship passengers, which would be a major effect.

Alternative 3 – Effects on Visitor Experience. Alternative 3 would continue the current vessel quotas, management activities, and operating restrictions, but would allow for potential future increases in vessel traffic up to the quotas authorized in the 1996 vessel management plan, depending on results of environmental studies. Cruise ship entries would still be restricted to a maximum of two per day, but the total number of allowable entries for the season could increase from 139 to 184 (which would be two cruise ships per day, every day of the season). For the purposes of this analysis, the maximum seasonal-use day level is assumed. All other vessel quotas would remain the same as in alternative 1. Alternative 3 does not propose any changes in the management or vessel entries in Dundas Bay.

Direct and Indirect Effects on Visitor Experience– Alternative 3.

<u>Quality of Experience</u>. Among tour vessel passengers, alternative 3 would have negligible effects on the quality of visitors' experience. This finding is based on data from the 1989 and 1999 NPS studies, as described under alternative 1. The 1999 survey (Littlejohn 2000) included private and charter vessel visitors, but produced generally the same findings as the 1989 study.

The effects of alternative 3 on cruise passengers' experience would be similar to those on tour vessel passengers. Both visitor groups are experiencing Glacier Bay aboard vessels with a large number of other people. Their experience is not completely dependent on a feeling of isolation from the civilized, developed world. While there may be a small minority of passengers who expect to find a sense of isolation and solitude from their cruise ship, overall the greater amount of cruise vessels proposed in alternative 3 would have negligible effects on the quality of cruise passengers' experience.

Among charter vessel visitors, alternative 3 represents a minor adverse effect. Charter vessel passengers generally visit Glacier Bay on smaller vessels and tend to be seeking a more remote, undisturbed experience when compared to the tour vessel or cruise passenger market. An increase of 32% in the number of cruise ships would likely detract from the quality of experience, including wildlife sightings, for some charter vessel visitors. Most charter vessel visitors would notice little difference when compared to alternative 1, because the number of cruise ships allowed per day would remain at two. However, there would be fewer days and potentially no days, during the visitation season when no cruise ships would be present in the Bay.

For private vessel visitors, alternative 3 represents a minor adverse effect. As in the case of charter vessel visitors, private vessel visitors tend to be seeking a remote wilderness experience. An increase of 32% in the number of cruise ships would detract from the quality of the experience for some private vessel visitors.

Because this alternative includes provisions for additional increases in cruise ships and because cruise ships have a greater effect on backcountry visitors' experience of solitude, the effects on backcountry visitor's ability to experience solitude would be greater for this alternative than alternative 1. The increased number of cruise ships may lead to more backcountry visitors seeking non-motorized wilderness, leading to loss of solitude in those areas. The potential effects of anchorages on visitor experiences would be similar to alternative 1. This effect would last the life of this plan and occurs in a wilderness setting that is relatively rare in the National Wilderness Preservation System. Because of the recurrent nature of this disturbance and the potential loss of opportunities to experience the backcountry with no cruise ships present, the effects on backcountry visitors would be considered major.

<u>Opportunity</u>. Among cruise passengers, alternative 3 represents a major beneficial effect on the opportunity to experience the park. This alternative would allow for 32% more cruise ship entries, and thus a substantial increase in the opportunity to visit the park on a cruise ship.

Because the number of tour, charter, and private vessel entries into Glacier Bay would remain the same in alternative 3 as in alternative 1, there would be a negligible effect on the opportunity for these passengers to visit the park.

Opportunities to experience wilderness waters without motorized boats would be the same as those in alternative 1.

Cumulative Effects on Visitor Experience – Alternative 3. All cumulative considerations under alternative 3 would result in negligible changes in the quality of visitors' experience in Glacier Bay, or the opportunity to visit Glacier Bay aboard motorized vessels. Opportunities to experience wilderness waters without motorized boats would be the same as in alternative 1.

Impairment Analysis for Visitor Experience – Alternative 3. Visitor experience is not a resource subject to impairment evaluation.

Potential Mitigation Measures for Visitor Experience – Alternative 3. Scheduling of cruise vessels to arrive at the upper end of Glacier Bay at about the same time would reduce the negative effects for backcountry and smaller vessel visitors.

Conclusion, Visitor Experience – Alternative 3. Among motorized vessel passengers, alternative 3 would lower the quality of the visitor experience with the increase in cruise ships, resulting in minor adverse effects. For backcountry visitors, this effect would be major. In terms of visitor opportunity, there would be an increased opportunity for cruise ship passengers to visit Glacier Bay, which would be a major beneficial effect.

Alternative 4 – Effects on Visitor Experience. Under alternative 4, the quota season would be extended to include May and September. Seasonal entry quotas for cruise ships would decrease to 92 (June through August). Tour vessels would be limited to two vessels per day, a reduction from the three-per-day limit under alternative 1. June through August, tour vessel seasonal-use days would be reduced from 276 to 184. Charter vessel entries would be reduced from six to five per day, with seasonal-use days reduced from 552 to 460 in Glacier Bay. Daily entries for private vessels would be reduced from 25 to 22, though seasonal-use days would increase from 1,971 to 2,024. Vessel operating requirements would be modified for vessel speeds, whale water boundaries, and vessel operations. Tour vessels would no longer be allowed to enter Dundas Bay under alternative 4.

Direct and Indirect Effects on Visitor Experience – Alternative 4.

Quality of Experience. Among tour vessel passengers, alternative 4 would have minor effects on the quality of visitors' experience. This finding is based on data from the 1989 and 1999 NPS surveys of motorized vessel passengers on the effects of vessel traffic on visitors' experience.

The effects of alternative 4 on cruise passengers' experience would be similar to those on tour vessel passengers. While there may be a small minority of passengers for whom the sighting of other vessels improves or detracts from their experience, overall, the decrease in cruise vessels would have negligible effects on the quality of cruise passengers' experience.

Among both charter vessel and private vessel passengers, alternative 4 would result in moderate beneficial effects. As stated previously, these visitors tend to be seeking a more remote, undisturbed experience when compared to the tour vessel or cruise passenger market. The sight and sound of a large cruise ship represents an infringement upon this solitary experience. A decrease of 34% in the number of cruise ships would likely enhance the quality of experience for some of these visitors. In addition, alternative 4 would prohibit any tour vessels allowed into Dundas Bay and the East Arm of Glacier Bay, which would further improve the experience, including wildlife sightings, for these passengers.

Backcountry non-motorized visitors could visit most areas of the park on some days without the presence of cruise ships. Sea kayakers dropped off near Muir Point could travel throughout the Bays and inlets in the East Arm away from the sights and sounds of most large motorized vessels (including cruise ships and tour vessels, not charter vessels). Overall, the daily number of motorized vessels of all classes would be lowered under this alternative from the current situation (see alternative 1, no action).

Under alternative 4, backcountry visitors would be able to plan a trip outside of the sights, sounds, and smells of cruise ships. The itinerary for cruise ships would be available to them prior to their trip and half of the days in the summer season could potentially be free of cruise ships. Also, exact cruise ship routes would be known to visitors allowing them to plan trips in places and times when cruise ships are not present. This alternative also closes Dundas Bay to both cruise ships and tour vessels (although cruise ships currently choose not to enter Dundas Bay) allowing for more solitude from the sights and sounds of large motorized vessels (private motorized boats can still visit Dundas Bay wilderness waters, however).

<u>Opportunity</u>. Regarding opportunities for cruise ship passengers to experience Glacier Bay, alternative 4 would have a major adverse effect with the 34% decrease in allowable cruise ship seasonal use days. Alternative 4 also would have a major adverse effect on tour vessel passengers' opportunities to visit Glacier Bay with a 33% decrease in allowable tour vessel entries. The effect to charter vessel passengers would be moderate because of a 17% decrease in charter vessel seasonal use days. Because private vessel seasonal use days into Glacier Bay would increase slightly in alternative 4 compared to alternative 1, there would be a negligible effect on the opportunity for these passengers to visit the park.

The opportunity to visit Dundas Bay and the East Arm of Glacier Bay would be reduced under alternative 4. While private vessels would continue to be allowed entry into these areas, tour vessels would be prohibited, creating a major adverse effect on these passengers' opportunities to visit the area. Charter vessels also would be more restricted than in alternative 1 — limited to three vessels per day in Dundas Bay. This restriction, coupled with loss of opportunities to take a tour vessel to Dundas Bay or the East Arm, would create a moderate adverse effect on tour and charter vessel visitors' opportunities.

For backcountry visitors, this alternative would provide increased opportunities to experience solitude, particularly for those visitors who do the proper planning and are aware of the cruise ships schedule; therefore, it is anticipated that this alternative would increase the likelihood of a positive experience for non-motorized backcountry visitors. This effect would last the life of this plan and occur in a wilderness backcountry setting that is relatively rare in the National Wilderness Preservation System. Because the reduction of motorized craft and the closure of the East Arm to some vessel classes increase opportunities to experience solitude and wildness, the anticipated effects would be moderately positive.

Cumulative Effects on Visitor Experience – Alternative 4. All cumulative considerations under alternative 4 would result in negligible changes in the quality of visitors' experience in Glacier Bay, or the opportunity to visit Glacier Bay aboard motorized vessels, in addition to those stemming from alternative 4 alone.

Impairment Analysis for Visitor Experience – Alternative 4. Visitor experience is not a resource subject to impairment evaluation.

Potential Mitigation Measures for Visitor Experience – Alternative 4. The loss of opportunities to visit the park associated with reducing cruise ship numbers cannot be avoided.

Conclusion, Visitor Experience – Alternative 4. Alternative 4 would reduce the numbers of all vessel classes except private vessels, which would be beneficial to the quality of visitor experience. In terms of visitor opportunity, however, there would be major adverse effects for cruise ship and tour vessel passengers, moderate effects on opportunities for charter vessel passengers, and negligible effects on private vessel visitor travel in the Bay.

Alternative 5 – Effects on Visitor Experience. Under alternative 5, cruise ship entries would remain at 139 from June through August and would be limited to 92 days in May and September. (Under current regulations, up to 62 cruise ships can enter the Bay each May and each September, although this limit has never been attained). This alternative also includes additional vessel operating requirements on speed restrictions and location of whale waters. In Dundas Bay, one tour vessel per day would be allowed in the lower Bay only; charter vessels would not have a daily limit, but would be allowed 459 total use days, and private vessels would have unlimited entries.

Direct and Indirect Effects on Visitor Experience – Alternative 5.

<u>Quality of Experience</u>. The effects of alternative 5 on passengers of both cruise ships and tour vessels would be negligible. It can be assumed that the quality of the cruise and tour passenger experience is unlikely to be affected by the fewer cruise ships proposed in alternative 5 because, as described for other alternatives, their experience is largely independent of the presence of other vessels.

Alternative 5 would represent minor beneficial effects for both charter vessel and private vessel passengers. While the fewer number of cruise ships would improve the wilderness experience for a minority of these visitors, the decrease is 25%, and would occur only in May and September, when fewer charter vessels and private vessels are visiting the park. Although a small percentage of charter vessels and private vessels would benefit from decreased vessel disturbance and increased isolation, the effects on the overall experience would be minor.

For Dundas Bay under alternative 5, cruise ships would not be permitted. This would not affect visitor experience because currently cruise ships do not enter Dundas Bay because of the navigational hazards there. Tour vessels would only be allowed in non-wilderness waters in the lower portion of the Bay and would be limited by daily vessel quotas and seasonal use days (June 1 through August 31). Charter vessels would be limited by seasonal use days, June 1 through August 31, although there would be no daily vessel quota. There would be no limit for private vessels. Compared with alternative 1, alternative 5 would have a beneficial effect on the quality of experience for private vessel passengers.

There would be no limits on private vessel use in any portions of Dundas Bay. Backcountry non-motorized visitors would be free to visit any and all areas of the park except those areas closed because of sensitive bird or seal habitat or problem bears. The effects to non-motorized backcountry visitor experience under this alternative would be the similar as those listed for alternative 1, with two exceptions. First, setting a limit of six on charter vessels in Dundas Bay during the period of June 1 to August 31 could increase the opportunities for solitude that many backcountry visitors seek by decreasing the total numbers of larger motorized vessels and the associated sounds, smells, and sightings of them, if current use levels are lower than six per day. This alternative would potentially slightly increase the adverse effects of anchorages on backcountry visitor experiences. Also, if these charter vessels discharge sea kayakers to Dundas Bay, limiting the numbers of these charter vessels could decrease the total numbers of sea kayakers in the Bay, as well. Due to a lack of monitoring, however, it is unclear what type of activities charter vessels currently are bringing to Dundas Bay; therefore, it is impossible to gauge the effect this change would have over alternative 1. Second, because of the 17% increase in private vessel seasonal-use days under this alternative, opportunities to experience Glacier Bay free from the intrusions of motorized vessel sounds, smells, and sights are further decreased from alternative 1.

Opportunity. Alternative 5 would have a moderate adverse effect on the opportunity for cruise visitors to experience Glacier Bay. Total allowable cruise entries for May through September would decrease 11%, from 261 in alternative 1 to 231.

Alternative 5 introduces no changes in the number of entries for tour vessels, charter vessels, and private vessels when compared to alternative 1 (the seasonal use day limit for private vessels would be greater); therefore, it would represent negligible effects on the opportunity for passengers aboard these vessels to experience Glacier Bay.

Alternative 5 represents a minor beneficial effect on the opportunity to experience Dundas Bay for charter vessel passengers, because it provides for unlimited daily entries for this vessel type; however, the seasonal-use days (276) would be imposed. This alternative represents a minor detrimental effect on the opportunity among tour vessel passengers, because it limits their entries to one per day, and prohibits them from the upper Bay. The opportunity for private vessel passengers to experience Dundas Bay would be unchanged under alternative 5.

Exposure to noise, sights, and smells of motorized vessels diminishes opportunities for solitude among backcountry visitors. This effect would last the life of this plan and occurs in a wilderness backcountry setting that is relatively rare in the National Wilderness Preservation System. The recurrent nature of this disturbance to backcountry visitors is considered a moderate effect.

Cumulative Effects on Visitor Experience – Alternative 5. Cumulative considerations under alternative 5 would result in negligible changes in the quality of visitors' experience in Glacier Bay, or the opportunity to visit Glacier Bay aboard motorized vessels.

Impairment Analysis for Visitor Experience – Alternative 5. Visitor experience is not a resource subject to impairment evaluation.

Potential Mitigation Measures for Visitor Experience – Alternative 5. Although effects would be minor, coordination among the cruise lines so that vessels arrive at the upper end of Glacier Bay at about the same time would reduce the effects to backcountry and smaller vessel visitors.

Conclusion, Visitor Experience – Alternative 5. Under alternative 5, cruise ship passengers and tour vessel passengers would continue to see other vessels, but the effect to the quality of visitor experience would be negligible. Among visitors on charter and private vessels, the reduction in cruise ships would have a minor beneficial effect. In terms of visitor opportunity, alternative 5 would lower the opportunity for cruise visitors to experience Glacier Bay, which would be considered a moderate effect. There would be negligible effects on opportunity for tour vessel, charter vessel, and private vessel visitor opportunities in Glacier Bay.

Summary, Visitor Experience. Visitor experience would change among the alternatives in three primary ways. First, since more than 85% of visitors to Glacier Bay experience the park on a cruise ship, changes in the numbers of cruise ships allowed would greatly affect opportunities for the most common method of viewing the Bay. Opportunities vary from a low of 92 cruise ship entries from June through August in alternative 4 to a high of 184 entries under alternative 3. Reducing cruise ship numbers to 92 is considered a moderate effect, because opportunities to visit Glacier Bay would be reduced by more than one-third.

Second, providing opportunity in the form of cruise ship entry also removes opportunities and reduces the quality of visits for people who wish to experience the Bay without cruise ships. Under all alternatives, non-motorized areas provide opportunities to experience the Bay without cruise ships, but reducing cruise ship numbers increases this opportunity throughout the Bay. Backcountry experiences would be enhanced for charter and private vessel users, non-motorized vessel users, and hikers, under alternative 4 by closing the East Arm of Glacier Bay to cruise ships and tour vessels. The loss of opportunity for tour vessel visitors is considered a moderate level effect.

Third, alternative 4 increases opportunities for solitude and quiet in Dundas Bay by closing it to tour vessels and limiting charter use to three vessels per day. Alternative 5 provides more opportunities for charter vessels to use Dundas Bay by providing flexibility to allow an unlimited number of charters on any particular day, with a seasonal-use day limit of 276. The loss of opportunity to tour vessels is considered a moderate level effect.

4.4.3 VESSEL USE AND SAFETY

4.4.3 Vessel Use and Safety

This subsection evaluates the probable effects of implementing the alternatives on vessel use and safety in Glacier Bay and Dundas Bay.

Issues of Concern Raised during Scoping. The issues related to vessel use and safety that were identified during scoping include:

- Increasing vessels or vessel speed could increase the risk of vessel-vessel and vessel-marine mammal collisions.
- The 10-knot vessel speed restriction could decrease maneuverability of large vessels, causing an increased risk to visitor safety.
- The 10-knot speed limit in whale waters should be retained and a 14-knot vessel speed restriction should be instituted in non-whale waters to protect whales transiting throughout the park.
- Smaller vessels are more maneuverable than larger vessels and should be allowed to travel at faster speeds because they could avoid most potential hazards.
- Waves generated from larger vessels could swamp kayaks or small vessels on the water. Additionally, these waves could swamp landed kayaks and small vessels. All vessels are vulnerable in ice-filled waters. Protocols should be developed to limit the possibility of accidents and reduce the possible incidence of oil spills in ice-filled waters.
- Increasing fines for noncompliance of regulations, for example excess emissions, could decrease the incidence of regulations violations and increase safety throughout the park.
- Increasing the user friendliness of the operating requirements could increase the possibility that vessel operators would adhere to the rules and decrease the possibility of accidents.
- Cruise and tour vessels should have strict protocols and routes to minimize the risk of vessel groundings that could cause resource damage or risks to visitor safety.

Regulatory Framework.

Marine Safety Regulations. The following is a discussion of marine safety regulations applicable to most vessels operating in the park. These regulations serve to ensure that vessels operate with appropriate safety standards to provide for the protection of the passengers, other vessels, and the environment.

All vessels operating offshore, including those operating under foreign registrations, are subject to the requirements that are applicable to vessel construction, condition, and operation. The U.S. Coast Guard conducts compliance inspections of vessels to verify that foreign-flagged vessels operating in U.S. waters comply with applicable international conventions, and with all United States laws and regulations (required under Title 46 of the United States Code). The purpose of these inspections is to establish that the vessel is properly built and equipped and that the crew possesses adequate knowledge and training to operate the vessel safely.

When vessels do not comply with applicable laws or regulations, the U.S. Coast Guard imposes controls to bring them into compliance. The U.S. Coast Guard's responsibility is to identify and eliminate substandard ships from U.S. waters. In general, a vessel is substandard if the hull, machinery, or equipment, including that related to lifesaving, firefighting, and pollution prevention, is below the standards required by U.S. laws or international conventions.

The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) regulates pollution and spills from ships. MARPOL 73/78 contains measures to prevent accidental and operational causes of marine pollution. Regulations covering design, equipment, operations, and survey requirements for the prevention of pollution are provided in five annexes to the convention. These annexes include regulations for prevention of pollution by oil (1983), regulations for the control of pollution by noxious liquid substances (1987), and regulations for the prevention of pollution by garbage (1988). Fuel and other spills from vessels are described in detail in the water quality section (see subsection 3.2.4)

The International Convention on Standards of Training, Certification and Watchkeeping (STCW 78) sets forth training, certification, and qualification requirements for shipboard personnel. It establishes basic principles to be observed in keeping navigational and engineering watches, and specifies minimum knowledge required for certification of the crew. STCW 78 was completely amended and revised in 1995. The training required under this convention includes oil spill prevention and countermeasures. This series of regulations is consistent and in many cases more stringent than U.S. guidelines. U.S. Coast Guard reviews the ship's compliance with these international agreements during compliance inspections.

The Convention on the International Regulations for Preventing Collisions at Sea, 1972, sets forth the basic "rules of the road," such as rights-of-way, safe speed, action to avoid collision, and procedures to observe in narrow channels and restricted visibility. The convention also details the technical parameters of navigation lights, shapes, and sound signals.

Special vessel construction standards are established in regard to watertight integrity and carriage of dangerous articles and substances aboard foreign vessels. These regulations are set forth in 46 USC 2101(12) and 3306(a)(5), and 49 USC 1801-1812. In addition, the load line requirements for foreign vessels pertaining to the maximum draft permitted for safe operating conditions are set forth in 46 USC 5101-5116 and in the International Convention on Load Lines, 1966. All of these regulations are intended to require ships to operate with adequate equipment and under safe conditions.

Park Boating Safety Regulations. Park boating regulations limit the number of vessels that can be in the park at any one time through vessel quotas. In addition, there are the following speed restrictions:

- From May 15 through August 31 in the waters of the lower Bay motor vessel are restricted to a speed through the water of no more than 20 knots or no more than 10 knots when the superintendent has designated a maximum speed of 10 knots (due to the presence of whales); and
- From July 1 through August 31, motor vessels are restricted to a speed through the water of 10 knots in Johns Hopkins Inlet south of an imaginary line running due west from Jaw Point.

Implementation of the vessel quotas and speed restrictions serve to supplement the USCG and MARPOL safety regulations to minimize the potential for collisions and groundings.

Methodology and Assumptions. The evaluation of the potential effects on vessel use and safety focused on many of the issues raised during public scoping. The analysis of the effects of implementing the alternatives on the overall safety of vessels, vessel traffic, and the risks of major vessel accidents is based on vessel traffic and safety data and known factors related to vessel incidents. Vessel traffic and safety data were obtained through interviews with park staff and vessel operators and park incident records related to vessel accidents. Park records are assumed to contain all major incidents since major incidents are easily detectable and normally involve radio transmissions from the vessels involved. For this analysis, any vessel collision, grounding, or other vessel incident that results in the death or serious injury of individuals on board the vessel, or the subsequent discharge of at least 25 gallons of fuel oil into the water is classified as a "major" incident. Minor incidents are assumed to be underreported in the more remote areas of Glacier and Dundas Bays, but overall records are assumed to form a good representation of overall vessel incidents.

A fire or explosion could result in the loss of life and/or severe damage to the vessel. A fire or explosion could cause the release of hazard materials to the sea or air. A risk of a marine fire, or explosion, while present, is low because the types of activities that commonly contribute to marine fire and explosion do not occur. The fuel used for the marine vessels is diesel, which is a fire hazard when exposed to standard temperature and pressure conditions; however, diesel fuel is considered a combustible substance, rather than flammable, according to U.S. Department of Transportation (DOT) regulations. The Department of Transportation defines flammable liquids as those with a flash point below 37.8 degrees Celsius (°C; 100° Fahrenheit [F]) and combustible liquids as those with a flash point between 37.8 degrees Celsius (100°F) and 75.5 degrees Celsius (200°F).

For each effects analysis, use was assumed to be at the maximum level of use allowed during seasons when limits are in place. Factors related to traffic patterns were based on tracking records and known vessel use patterns, as illustrated in chapter 3. The vessel safety analysis was based on known factors related to vessel incidents, considered collectively with the specific operating conditions in place and proposed for the particular alternative being evaluated.

This analysis assumes that each vessel present in the park represents an extremely small but measurable risk of being involved in a major accident. As a result, greater numbers of vessels necessarily result in a corresponding increase in the overall risk of major accidents. Depending upon circumstances, however, it is possible for the overall risk of major accidents to remain low or extremely low despite incremental increases in the number of vessels allowed within Glacier Bay; however, small boat capsizings are a concern because large vessel wakes are often generated well after the originating vessel has passed through an area, and they are often unanticipated.

The potential exists for waves generated by larger vessels to swamp kayaks or small boats on the water or landed on the beach; however, based on the wake analysis report conducted as part of this EIS (see appendix G), the low vessel speeds in the Bay generate wakes that are generally small in comparison to naturally occurring waves in Dundas Bay and/or Glacier Bay.

Determinations regarding the overall significance of effects were based on the effects thresholds listed in table 4-28.

TABLE 4-28: THRESHOLD CRITERIA FOR THE VESSEL USE AND SAFETY EFFECTS ANALYSIS

Negligible	The risk of vessel accidents leading to serious injury, death, or fuel oil spills over 25 gallons would be extremely low.
Minor	The risk of vessel accidents leading to serious injury, death, or fuel oil spills over 25 gallons would be low.
Moderate	A slightly elevated risk of vessel accidents leading to serious injury, death, or fuel oil spills over 25 gallons would exist.

TABLE 4-28: THRESHOLD CRITERIA FOR THE VESSEL USE AND SAFETY EFFECTS ANALYSIS

Major	A significantly elevated risk of vessel accidents leading to serious injury, death, or fuel oil spills over 25 gallons would exist.

Alternative 1 (No Action) - Effects on Vessel Use and Safety.

Direct and Indirect Effects on Vessel Use and Safety – Alternative 1. Effects of the implementation of alternative 1 potentially could alter the overall safety of vessels, vessel traffic, and the risks of major vessel accidents.

Overall Vessel Safety and Vessel Traffic. Since the vessel management plan was implemented in 1996, no cruise ships have been involved in collisions or groundings; however, there were two onboard fires. One fire was in a trashcan, while the other involved inhalation injuries. A commercial crab-fishing vessel, fishing in the winter, sank, and one tour vessel has grounded. In a separate incident, another tour vessel struck an iceberg in Tarr Inlet and suffered hull damage. There was no fuel spill associated with this incident. Twenty-one other vessels (mostly private vessels) have grounded, but with only minor damage reported. Other types of accidents commonly reported include vessels going adrift or dragging anchor and minor collisions. Table 4-29 lists 58 vessel incidents recorded by the Park Service between 1994 and 2001.

TABLE 4-29: SUMMARY OF VESSEL-RELATED INCIDENTS AT GLACIER BAY, 1994-2001

Date	Incident	Description	Location
15-Feb-94	Vessel Accident	fishing vessel sinks during crab season – fuel spill	Strawberry Island
25-May-94	Vessel Grounding	private vessel grounds – damage and diesel spill	Bartlett River
30-May-94	Vessel Adrift	private vessel runs out of fuel – no damage	North Passage
28-Jun-94	Vessel Accident	NPS vessel strikes rock – damage	Beardslee Islands
26-Jul-94	Vessel Grounding	charter vessel scrapes rock – no damage	Geikie Inlet
11-Aug-94	Vessel Grounding	inflatable tender grounds – no damage	Bartlett Cove
01-Sep-94	Vessel Grounding	charter vessel scrapes rock – no damage	Fingers Bay
18-May-95	Vessel Grounding	private vessel drags anchor at low tide – no damage	Bartlett Cove
05-Jun-95	Vessel Adrift	private dinghy anchored in closed area drags anchor	Bartlett Cove
11-Jun-95	Vessel Fire	tour vessel suffers smoke damage from electrical short in engine	Bartlett Cove
13-Jun-95	Vessel Grounding	private vessel grounds, then refloats – no damage	Bartlett Cove
04-Jul-95	Vessel Adrift	private vessel has engine problems – towed in by NPS	Young Island
04-Jul-95	Vessel Fire	private vessel fire in engine compartment – engine damage	Lower Bay
13-Jul-95	Vessel Grounding	anchored charter vessel grounds and refloats	Gloomy Knob
16-Jul-95	Vessel Grounding	fishing vessel runs aground and refloats – hull damage	Pt. Carolus
20-Jul-95	Vessel Grounding	private sailboat runs aground and refloats – no damage	Blue Mouse Cove
26-Jul-95	Vessel Adrift	anchored charter vessel drags anchor – no damage	Bartlett Cove
20-Aug-95	Vessel Accident	dinghy capsizes and dumps operator – no injuries/damage	Bartlett Cove
06-Jul-96	Vessel Grounding	private vessel grounds then refloats – no damage	Bartlett River Cut
26-Aug-96	Vessel Accident	tourboat strikes iceberg and suffers hull damage	Tarr Inlet
24-Jun-97	Vessel Adrift	private vessel w/engine problems towed in by NPS	Reid Inlet
23-Jul-97	Vessel Adrift	research skiff w/engine problems towed in by NPS	Garforth Island
28-Aug-97	Vessel Adrift	charter vessel drags anchor/strikes vessel – minor damage	Bartlett Cove

TABLE 4-29: SUMMARY OF VESSEL-RELATED INCIDENTS AT GLACIER BAY, 1994-2001

Date	Incident	Description	Location
15-Feb-98	Vessel Grounding	fishing vessel strikes reef – minor fuel spill	Beardslee Islands
20-May-98	Vessel Accident	anchored private vessel drags anchor – minor damage	Bartlett Cove
26-May-98	Vessel Grounding	private vessel strikes rock – minor damage	North Fingers Bay
08-Jun-98	Vessel Grounding	private sailboat grounds while docking – no damage	Bartlett Cove
15-Jun-98	Vessel Adrift	research vessel out of gas gets NPS tow	Strawberry Island
15-Jun-98	Vessel Grounding	private vessel strikes rock – minor damage	South Fingers Bay
12-Aug-98	Vessel Accident	tourboat wraps buoy line around prop – minor damage	Bartlett Cove
12-Jun-99	Vessel Aground	tourboat strikes rock, remains grounded – minor fuel spill	Dundas Bay
08-Jul-99	Vessel Adrift	anchored skiff drags anchor, striking vessel – minor damage	Bartlett Cove
17-Jul-99	Vessel Adrift	private vessel w/stuck rudder gets tow by tourboat	Lone Island
17-Sep-99	Vessel Adrift	anchored private vessel drags anchor – no damage	Bartlett Cove
23-May-00	Vessel Fire	cruiseship suffers fire onboard – damage and inhalation injuries	Tarr Inlet
04-Jun-00	Vessel Adrift	private vessel w/engine problems gets tow to dock by NPS	Lester Island
04-Jun-00	Vessel Grounding	tourboat strikes sandbar – no damage	Reid Inlet
13-Jun-00	Vessel Fire	cruiseship reports trashcan fire on board – minor damage	Tarr Inlet
05-Jul-00	Vessel Grounding	private vessel runs aground – minor damage	N. Fingers Bay
14-Jul-00	Vessel Adrift	private sailboat w/engine problems gets towed in by NPS	Bartlett Cove
17-Jul-00	Vessel Adrift	NPS vessel runs out of gas	Ripple Cove
03-Aug-00	Vessel Grounding	private vessel grounds on rocks – minor damage	Hugh Miller Rocks
14-Aug-00	Vessel Accident	private vessels collide while anchoring – minor damage	Bartlett Cove
07-Sep-00	Vessel Adrift	anchored private vessel drags anchor – no damage	Bartlett Cove
16-Sep-00	Vessel Accident	anchored NPS skiff capsizes – no damage	Tidal Inlet
25-Sep-00	Vessel Grounding	private vessel strikes reef – minor damage	Berg Bay
11-Mar-01	Vessel Grounding	private vessel breaks docklines and drifts – major salvage	Bartlett Cove
16-May-01	Vessel Blackout	cruiseship Regal Princess suffers brief power outage	Up Bay
01-Jun-01	Vessel Adrift	anchored private boat drags anchor – no damage	Bartlett Cove
07-Jun-01	Vessel Grounding	private vessel strikes submerged reef – minor damage	Fingers Bay
23-Jun-01	Vessel Adrift	anchored private boat drags anchor – no damage	Bartlett Cove
06-Jul-01	Vessel Adrift	anchored tugboat drags anchor/ snags hydrophone cable	Bartlett Cove
15-Jul-01	Vessel Adrift	anchored private boats repeatedly contact/minor damage	Bartlett Cove
21-Jul-01	Vessel Grounding	private vessel strikes rock on floodtide – no damage	Muir Pt.
24-Jul-01	Vessel Accident	anchored private boats repeatedly contact/minor damage	Bartlett Cove
10-Aug-01	Vessel Accident	door damage to docked private vessel from water wake	Bartlett Cove
07-Sep-01	Vessel Adrift	anchored oil spill response barges drag anchor/no damage	Bartlett Cove
07-Sep-01	Vessel Adrift	anchored private vessel drags anchor – no damage	Bartlett Cove

Based on an analysis of vessel accidents in the park between 1994 and 2001, cruise ships, tour vessels, charter vessels, and private vessels have a good safety record for operations in Glacier Bay. The U.S. Coast Guard has concluded that traveling on a cruise ship from a U.S. port is the safest form of transportation available (USCG 1995). Additionally, this report found that there appears to be no evidence of trends or heightened risks associated with oceangoing cruise ships from U.S. ports. Clearly, cruise ship operations are not without risks. In 1994, a crew member from a cruise ship drowned after falling into the water during a personnel transfer operation involving an NPS interpreter. A cruise ship fire in Tarr Inlet in May 2000 resulted in damage to the vessel, as well as smoke inhalation injuries. An analysis of the available vessel accident data suggests that experiencing Glacier Bay and Dundas Bay from a vessel is a safe activity under current vessel quotas and operating restrictions. Given the low incidence of injury, the effect of implementation of alternative 1 on overall vessel safety would be negligible.

Current controls on vessel entry strictly limit the density of vessels in Glacier Bay. Excluding commercial fishing vessels and administrative vessels, the density of vessels in Glacier Bay at full capacity is estimated to be one vessel for every 12.3 square miles (31.9 square kilometers) of water. Although this calculation assumes a uniform distribution of vessels, it illustrates the relatively low density of vessels within Glacier Bay. The areas of Glacier Bay most likely to experience higher densities are:

- the inlets containing tidewater glaciers at Tarr Inlet and Johns Hopkins Inlet in the West Arm.
- Bartlett Cove in the vicinity of Park Headquarters.

Because most administrative and support functions associated with vessel activity in Glacier Bay occur at Bartlett Cove, vessels tend to congregate in this area. Vessel accident data shows a concentration of minor vessel incidents in the Bartlett Cove, but not Tarr Inlet. The congestion in these locations has not translated into major vessel incidents; therefore, under alternative 1, the effect of vessel traffic would be negligible.

<u>Risk of Major Vessel Accidents</u>. The International Regulations for Preventing Collisions at Sea, 1972 (72 COLREGS) seek to reduce the risk of collision. The 72 COLREGS apply to all of the waters within the park (see 33 CFR 80.1705). Professional and recreational vessel operators are required to understand and comply with the 72 COLREGS; however, as with the risk of fire and explosion, the risk of collision is present. The risk of collisions is increased with additional marine traffic, navigational hazards, or severe weather conditions. These risks are reduced through the use of navigational aids and weather restrictions.

Of the 58 vessel incidents recorded by the Park Service between 1994 and 2001, 25 occurred in Bartlett Cove (see accident data in table 4-29). The majority of these incidents involved vessels dragging anchor or otherwise operating at slow speed with minor or no damage. The large number of vessel incidents in Bartlett Cove is understandable given the operating patterns of vessels within Glacier Bay. Bartlett Cove is the center of vessel operations within Glacier Bay. Most charter vessels depart from this location and private vessels are required to check in with NPS officials at the Bartlett Cove Visitor Center to obtain a permit before operating in other areas of Glacier Bay. Tour vessels, including the daily tour vessel *Spirit of Adventure*, also pick up and discharge passengers at the Bartlett Cove Public Use Dock, further contributing to vessel congestion. There is no requirement for cruise ships to enter Bartlett Cove and, historically, they have not done so. Higher vessel densities also occur at the popular tidewater glaciers at Tarr Inlet and Johns Hopkins Inlet. Despite the higher concentrations of vessels, few major accidents were reported in these areas between 1994 and 2001.

Vessel speed limits would remain the same as in existing regulations and the park compendium (see appendix B). For vessels with traditional propellers and rudders, it can be difficult to maintain control when the vessel is proceeding with the current unless adequate speed through the water is maintained. A 10-knot speed limit through the water generally provides sufficient steerageway to maintain control of these vessels. The park superintendent may impose a speed limit of 10 knots in lower Glacier Bay whale waters due to the presence of whales. The success of these whale water speed restrictions is examined in greater detail in the discussion on marine mammals (see subsection 4.3.2). There were no reports of high-speed collisions between vessels in Glacier Bay or Dundas Bay between 1994 and 2001.

The accident data from 1994 through 2001 does not show any significant collisions between vessels underway in Glacier Bay or Dundas Bay. Vessel groundings were more common during this period with a total of 22. Two tour vessels have grounded on rocks in Glacier Bay and Dundas Bay. The *Wilderness Adventurer* grounded in Dundas Bay during 1999. An estimated 25 to 30 gallons of mixed lubrication oil and diesel leaked from the vessel. The *Yorktown Clipper* grounded in 1993; the ship released an estimated 50 gallons of diesel into Glacier Bay.

Table 4-30 lists the vessels that entered Glacier Bay in 1999, their sizes, draft, number of visits, and maximum number of gallons of fuel stored onboard.

TABLE 4-30: PHYSICAL VESSEL STATISTICS FOR 1999 GLACIER BAY ENTRIES

Vessel type	Size Range[a]	Draft (feet)	Annual Visits	Maximum Fuel Onboard (gallons)[b]
Cruise Ship (19 ships operated by 10 companies)	4,500- 109,000 GT, 295-951 feet	20-28	217	405,000 – IFO
Small Passenger Vessel (13 vessels operated by 5 companies)	18-120 GT, 25-219 feet	6-15	297	12,000 - diesel
Fuel Barge	Approximately 250 feet	13 (loaded)	12 (Bartlett Cove)	1.5 million (2 x 750,000) – non-persistent oil
Commercial Fishing Vessel	20-50 feet	4-8	By permit	Less than 4,000 – diesel

TABLE 4-30: PHYSICAL VESSEL STATISTICS FOR 1999 GLACIER BAY ENTRIES

Vessel type	Size Range[a]	Draft (feet)	Annual Visits	Maximum Fuel Onboard (gallons)[b]

Source: Eley 2000.

a. Size ranges based on 2002 entries
b. A spill of this maximum amount would essentially require total break-up of the vessel and/or fuel tank.

GT = gross tons.
IFO = intermediate fuel oil.

Based on park incident records, less than one powered grounding in five results in any fuel being spilled. No cruise ship collisions or groundings were reported during the 1994–2001 period. No major fuel spills during this period caused by collisions and groundings occurred.

A concern expressed by the public was the possibility of a fuel spill in ice-filled water near the glaciers. In 1996, a tour vessel struck an iceberg and suffered hull damage but no fuel spill occurred. According to NPS personnel, no spills are known to have occurred in ice-filled waters (NPS, Nemeth, pers. com., unknown date). Even with the most current spill clean up technology, clean up of a fuel spill in ice-filled waters would be difficult. The water quality section of this chapter concludes that a fuel release in ice-filled waters constitutes a potential major effect due to the lack of effective clean up technology and the direct effect of spilled fuel on water quality and wildlife resources. A recent report concluded, however, that the probability of a fuel spill as a result of a collision with ice in Glacier Bay is low (Eley 2000). Eley (2000) reported the following observations of marine pilots who regularly operate in Glacier Bay:

- the southern-most boundary for ice in Glacier Bay during the cruise ship season is Composite Island.
- north of Composite Island, cruise ships travel at maneuvering speed of less than 8 knots during daylight.
- ice not pushed away from the hull by Lattimer flow makes only incidental contact with the cruise ship.

While no fuel spills have occurred in ice-filled waters, the potential effects to water quality and wildlife resources is major. Although no major fuel spills have occurred in ice-filled waters in Glacier Bay, the possibility that such a spill could occur still exists. The probability of such a spill, however, is low; therefore, the effect of the implementation of alternative 1 on the risk of a major vessel accident is minor.

Implementing alternative 1 would have negligible effects on vessel safety and vessel traffic, but the risk of a major vessel accident is minor due to the remote possibility of a fuel spill in ice-filled waters; therefore, the overall direct and indirect effect would be expected to be minor.

Cumulative Effects on Vessel Use and Safety – Alternative 1. Activities other than those proposed in this plan could affect vessel safety, specifically the presence of commercial fishing and administrative vessels in the park. Commercial fishing is currently occurring in the park, but will decrease over time. The above analysis of effects already accounts for the presence of commercial fishing and administrative vessels since they have been operating in the park during the period analyzed; therefore, the contribution of this activity is already addressed and would not provide additional effects.

Impairment Analysis for Vessel Use and Safety – Alternative 1. Vessel safety is not a park resource and, therefore, cannot be impaired.

Potential Mitigation Measures for Vessel Use and Safety – Alternative 1. None required.

Conclusion, Vessel Use and Safety – Alternative 1. The direct and indirect adverse effects of implementing alternative 1 would be minor. The cumulative effects of other activities would not alter this effect. Impairment is not applicable to this topic and mitigation is not necessary. The overall effect of implementing alternative 1 on vessel traffic and safety would be minor.

Alternative 2 - Effects on Vessel Use and Safety. Alternative 2 reduces vessel quotas to the 1985 levels, reducing cruise ship seasonal entries and seasonal use days to 107 from the current total of 139. Alternative 2 reduces seasonal entries for charter vessels by slightly more than 13% while seasonal use days are reduced by a little more than 2%. Seasonal use days for private vessels likewise decline slightly more than 13% to 1,714. No changes would occur for vessel use in Dundas Bay.

Direct and Indirect Effects on Vessel Use and Safety – Alternative 2. The overall direct and indirect effects of alternative 2 on vessel traffic and safety would be very similar to that described for alternative 1, but are not identical.

<u>Overall Vessel Safety and Vessel Traffic</u>. Alternative 2 would result in incremental improvements in vessel safety and slight reductions in overall vessel traffic over alternative 1. There would be days when overall vessel traffic would be equivalent to current levels, but there would be more days when the

maximum daily quota would not be reached because of seasonal entry and seasonal use day restrictions. With fewer cruise ships entering Glacier Bay and the reduction in the number of charter vessel and private vessel seasonal entries and seasonal use days, vessel traffic would be reduced. Alternative 2 would expose Glacier Bay to fewer overall vessel entries. These reductions would result in a marginal improvement in vessel safety; therefore, the effect would be negligible. No changes would occur in Dundas Bay.

<u>Risk of Major Vessel Accidents</u>. Relative to alternative 1, implementing alternative 2 would result in a marginal decrease in the risk of cruise ship-related accidents because cruise ships would be present on fewer days. There would be a corresponding marginal reduction in the overall risk of fuel spills from cruise ships because 23% fewer cruise ship visits to Glacier Bay would occur. There would be no change in Dundas Bay. The reductions in vessel traffic in Glacier Bay would decrease the risks of collisions, groundings, and fuel spills from alternative 1, and the effect of implementation of this alternative would be negligible.

The direct and indirect effects of implementation of alternative 2 would have negligible effects on vessel safety, vessel traffic, and the risk of a major vessel accident due to the reduction of vessel traffic; therefore, the overall direct and indirect effects would be expected to be negligible.

Cumulative Effects on Vessel Use and Safety – Alternative 2. The presence of administrative vessels and activities such as commercial fishing could affect vessel safety and traffic. As discussed in alternative 1, these effects are accounted for in the above analysis and would not contribute to any additional direct effects; therefore, the contribution of this activity is already addressed and would not provide additional effects.

Impairment Analysis for Vessel Use and Safety – Alternative 2. Vessel safety is not a park resource and, therefore, cannot be impaired.

Potential Mitigation Measures for Vessel Use and Safety – Alternative 2. None required.

Conclusion, Vessel Use and Safety – Alternative 2. Implementation of alternative 2 would have negligible direct and indirect adverse effects on vessel traffic and safety. The cumulative effects of other activities would not alter this effect. Impairment is not applicable to this topic and mitigation is not necessary. The overall effect of implementing alternative 2 on vessel traffic and safety is negligible.

Alternative 3 - Effects on Vessel Use and Safety.

Direct and Indirect Effects on Vessel Use and Safety – Alternative 3. Alternative 3 has the potential to increase cruise ship traffic from 139 to as much as 184 over the 92-day, June-through-August, visitor season.

Overall Vessel Safety and Vessel Traffic. The overall direct and indirect effects of alternative 3 on vessel traffic and safety are expected to be very similar to those discussed for alternative 1. Alternative 3 would increase vessel traffic because more cruise ships would enter Glacier Bay; however, no changes would occur in Dundas Bay. Vessel traffic and congestion would be identical to current "high-use" days when two cruise ships call on Glacier Bay. The cruise ship industry attempts to stagger the entry of cruise ships into Glacier Bay, which has served to reduce congestion caused by two cruise ships attempting to visit the same area simultaneously. Overall, cruise ship operations from U.S. ports are very safe. The effects of implementing alternative 3 on vessel traffic and safety are expected to be negligible.

Risk of Major Vessel Accident. There would be a marginal increase in the risk of cruise ship related accidents because there would be more cruise ships calling on Glacier Bay each season. There would also be an increase in the overall risk of fuel spills from cruise ships because there would be 45 additional cruise ship entries each season. The overall risk of vessel accidents and fuel spills would remain extremely low under alternative 3. Current vessel operating requirements (mandatory use of pilots, staggered cruise ship entry schedule) have successfully reduced the risk of accidents involving cruise ships. There have been no collisions, groundings, or fuel spills from cruise ships in Glacier Bay; however, there is a low probability of a fuel spill in ice-filled waters. The effects of implementing alternative 3 on major vessel accidents would be similar to alternative 1; therefore the effect would be minor.

The direct and indirect adverse effects on vessel safety and vessel traffic of implementing of alternative 3 would be negligible, but the risk of a major vessel accident would be minor due to the low probability of a fuel spill in ice-filled waters; therefore, the overall effect would be expected to be minor.

Cumulative Effects on Vessel Use and Safety – Alternative 3. Activities such as commercial fishing and the presence of administrative vessels could affect vessel safety and traffic. As discussed in alternative 1, the effect of commercial fishing and administrative vessels is accounted for in the above analysis and would not contribute any additional direct effects.

Impairment Analysis for Vessel Use and Safety – Alternative 3. Vessel safety is not a park resource and, therefore, cannot be impaired.

Potential Mitigation Measures for Vessel Use and Safety – Alternative 3. None required.

Conclusion, Vessel Use and Safety – Alternative 3. The direct and indirect adverse effects of implementing alternative 3 would be minor. The cumulative effects of other activities would not alter this effect. Impairment is not applicable to this topic and mitigation is not necessary. The overall effect of implementing alternative 3 on vessel traffic and safety would be minor.

Alternative 4 - Effects on Vessel Use and Safety. Alternative 4 establishes a new system of vessel quotas that focuses on the total number of vessels within Glacier Bay rather than the total number of "daily entries." Alternative 4 expands the current June through August "season" for vessel quotas to include both May and September. It modifies current vessel operating requirements regarding vessel speeds, whale water locations, and vessel routes and destinations.

Alternative 4 reduces cruise ship quotas to an average of no more than one per day and East Arm north of Sebree Island and Beardslee Entrance would be closed to cruise ships. The daily vessel quota for cruise ships would remain two. Tour vessel quotas would be reduced from three to a maximum of two per day and would not be allowed in the East Arm of Glacier Bay north of Muir Point, Beardslee Entrance, Berg Bay, and Fingers Bay. Charter vessel quotas would decline from six per day to five. Private vessel quotas would decline from 25 to 22 per day. A separate daily quota of three charter vessels would be established for Dundas Bay from May through September under alternative 4. Cruise ships and tour vessels would be restricted from Dundas Bay. Private vessels would not be limited to Dundas Bay.

Direct and Indirect Effects on Vessel Use and Safety – Alternative 4.

<u>Overall Vessel Safety and Vessel Traffic</u>. Alternative 4 results in a proportional decrease in vessel traffic. Although the daily vessel quota for cruise ships would remain two, cruise ships entries into Glacier Bay would average no more than one per day between May and September, thus reducing the volume of traffic.

Restricting cruise ships and tour vessels from Dundas Bay could reduce congestion in this relatively small (37.2 square miles) body of water. In fact, cruise ships have not requested to enter Dundas Bay, although they are not prohibited under current vessel management regulations. Restricting tour vessels from Dundas Bay represents a change from current practice since tour vessels currently use this area. Under alternative 4, Dundas Bay would experience less vessel congestion due to the prohibition on cruise ships and tour vessels and restriction of charter vessels to a maximum of three.

Alternative 4 proposes significant changes to vessel speed limits. Vessel speed limits would apply from May 1 through September 30. Vessels under 80 meters in length would be limited to 20 knots (through the water) unless the superintendent had designated a 10 knot speed (through the water) due to the presence of whales. Vessels over 80 meters in length would be limited to less than 13 knots (through the water) unless the superintendent had designated a 10 knot speed (through the water) due to the presence of whales. The higher speed limits for smaller vessels results, in part, from the fact that these vessels are more maneuverable than larger vessels and can slow down or stop in a shorter distance to protect whales and other marine life. These speed limits, as measured through the water, are adequate to provide steerageway for vessels with traditional propellers and rudders proceeding with the water current.

It is an accepted fact of vessel operations that smaller vessels are more maneuverable than larger ones, all other things being equal. Generally smaller vessels can turn sharper and slow down faster than larger vessels. This increased maneuverability can help a smaller vessel avoid a hazard sighted in its path, whereas a larger vessel might not be able to avoid the same hazard under identical conditions. Although some larger vessels are built with specialized thrusters or rudders to improve their stopping and turning characteristics, as a general rule, smaller vessels are more maneuverable than larger ones.

Alternative 4 prohibits cruise ships from entering wilderness areas, but would allow them to enter the West Arm, Tarr Inlet, and Johns Hopkins Inlet up to Jaw Point. Cruise ships and tour vessels also would not be allowed into the East Arm (tour vessels would be allowed in the entrance waters of East Arm). Most importantly, for vessel traffic and safety is the fact that alternative 4 formally defines cruise ship routes (typically in mid-channel). A cruise ship route would be drawn using the current typical cruise ship traffic pattern. While this measure is being proposed for a number of different reasons, it results in a significant improvement in vessel safety. Formally defining cruise ship routes at or near mid-channel significantly reduces the risk that the ship will run aground and potentially cause a fuel spill. This measure also provides an increased margin of safety in the event the cruise ship temporarily loses power. A position in mid-channel provides the ship’s crew more time to restore power before the ship drifts toward submerged hazards or the exposed shoreline. Formally designating the cruise ship route also would remove the temptation of a vessel master to bring the ship closer to shore (toward more hazardous waters) to provide passengers with a better view of wildlife or scenery. Formally designating cruise ship routes would represent a significant contribution to vessel safety in Glacier Bay, a beneficial effect.

The reductions in vessel entries in conjunction with the speed limits and cruise ship route designations will increase vessel safety and decrease vessel traffic, resulting in negligible effects.

<u>Risks of Major Vessel Accidents</u>. Reductions in the numbers of vessels visiting Glacier Bay would result in a marginal decrease in the overall risk of major vessel accidents corresponding in magnitude to the reduction in vessel use. Excess speed was not indicated as a primary cause in any of the major vessel incidents listed in the 1994 through 2001 Glacier Bay vessel accident data. Reducing vessels over 80 meters in length to a maximum speed of 13 knots while in whale waters (unless a 10-knot maximum speed has been designated by the park superintendent) is not expected to result in a measurable improvement in vessel safety. Formally designating cruise ship routes is, however, expected to contribute significantly to overall vessel safety by providing a larger margin of safety, especially with respect to groundings. Implementing alternative 4 would result in decreased vessel traffic, improved vessel traffic routing, and marginal improvements in vessel safety resulting in negligible effects, since decreased vessel traffic and speed limits would increase overall vessel safety.

The overall direct and indirect adverse effects of alternative 4 on vessel traffic and safety are expected to be negligible, but positive.

Cumulative Effects on Vessel Use and Safety – Alternative 4. The presence of administrative and commercial fishing vessels in the park could affect vessel safety. As discussed in alternative 1, the effect of the presence of these vessels is accounted for in the above analysis and would not contribute any additional direct effects.

Impairment Analysis for Vessel Use and Safety – Alternative 4. Vessel safety is not a park resource and, therefore, cannot be impaired.

Potential Mitigation Measures for Vessel Use and Safety – Alternative 4. None are required.

Conclusion, Vessel Use and Safety – Alternative 4. Implementation of alternative 4 would have positive direct and indirect effects on vessel traffic and safety, because the number of vessels in the Bay would be decreased and operating requirements would be established. The cumulative effects of other activities would not alter this effect. Impairment is not applicable to this topic and mitigation is not necessary; therefore, the overall effect of implementing alternative 4 on vessel traffic and safety would be positive.

Alternative 5 - Effects on Vessel Use and Safety. Daily vessel quotas under alternative 5 are set at current levels for cruise ships, tour vessels, charter vessels and private vessels with an extended season (May through September) for cruise ships. However, seasonal-use days for private vessels would increase from 1,971 to 2,300. For Dundas Bay, cruise ships would be prohibited. Tour vessels would be prohibited from entering wilderness waters, however, one tour vessel per day could enter the non-wilderness waters with a limit of 92 seasonal-use days. Charter vessels would have no daily vessel quota but 276 seasonal-use days. No limit would be placed on private vessels in Dundas Bay.

Direct and Indirect Effects on Vessel Use and Safety – Alternative 5.

<u>Overall Vessel Safety and Vessel Traffic</u>. Vessel operating requirements are similar for alternative 5 and alternative 4 with the exception of how vessel speed is determined. Alternative 5 prescribes that vessel speed will be measured “over the ground.” This change will allow vessel operators to use installed GPS units to calculate vessel speed. Maximum whale water speed limits would be identical to alternative 4. The whale water season would extend from May 15 through September 30. Measuring vessel speed “over the ground” could be problematic for some vessels transiting through whale waters. In cases where a vessel is proceeding with the current (of up to 8 knots in some locations), a 10-knot speed over the ground may be insufficient to maintain adequate steerageway. Without adequate steerageway, a vessel may be extremely difficult to steer or the operator may totally lose control of the vessel. This represents a potential safety hazard for vessels proceeding down current but measuring vessel speed over the ground. In some cases, a vessel might be proceeding at only 2 knots through the water (10 knots over ground minus 8 knots of current). This proposed operational requirement may cause a significant impediment to vessel safety because it may be inadequate to maintain control, given existing current patterns. Alternative 5 also proposes to formally designate cruise ship routes. As discussed in alternative 4, formally designating cruise ship routes constitutes a significant safety enhancement.

Vessel entries into Dundas Bay are not separately regulated under the current Glacier Bay vessel management plan. Thus, the density of vessels in Dundas Bay under the current vessel management plan can theoretically be equal to or greater to that allowed under alternative 5.

Implementing alternative 5 is expected to produce a minor to moderate effect on vessel traffic and safety. This minor to moderate effect is driven almost entirely by the expected reduction in safety that would be caused by measuring vessel speed “over the ground” as opposed to “through the water.” A 10-knot vessel speed over the ground may be inadequate for some vessels to maintain control while proceeding with a strong (up to 8 knots in some places) current.

Risk of Major Vessel Accident. Measuring vessel speeds “over the ground could increase the risk of major vessel accidents. Under alternative 5, the overall risk of major vessel accidents would be expected to increase incrementally over current conditions. Conversely, vessel accident rates and the risk of fuel spills are expected to be similar to those described for alternative 1 since daily vessel quotas are nearly identical. Designating formal cruise ship routes would be expected to result in a significant improvement in overall vessel safety and reduce the potential of large vessel collisions or groundings. The effects of implementing alternative 5 on major vessel accidents would be minor due to the low probability of an fuel spill in ice-filled waters.

In summary, the overall direct and indirect effects of alternative 5 on vessel traffic and safety are expected to be moderate due to the potential change in vessel safety resulting from a change how speed is measured.

Cumulative Effects on Vessel Use and Safety – Alternative 5. Commercial fishing and administrative vessels in the park could affect vessel safety. As discussed in alternative 1, the effect of commercial fishing is accounted for in the above analysis and would not contribute to any additional direct effects.

Impairment Analysis for Vessel Use and Safety – Alternative 5. Vessel safety is not a park resource and, therefore, cannot be impaired.

Potential Mitigation Measures for Vessel Use and Safety – Alternative 5. None are necessary.

Conclusion, Vessel Use and Safety – Alternative 5. Implementation of alternative 5 would have minor to moderate direct and indirect adverse effects on vessel traffic and safety. The cumulative effects of other activities would not alter this effect. Impairment is not applicable to this topic. Mitigation is necessary. The overall effect of implementing alternative 5 on vessel traffic and safety would be minor to moderate.

Summary, Vessel Use and Safety. The effect of the implementation of the alternatives ranges from negligible to minor. Cumulative effects would not contribute additional direct or indirect effects. Impairment was not evaluated because vessel traffic and safety is not considered a park resource.

4.4.4 Wilderness Resources

4.4.4 Wilderness Resources

This section evaluates the effects of each alternative on wilderness as a resource. The focus is on how the purposes, values, and characteristics of the wilderness contained within the park as defined in the Wilderness Act of 1964 and managed under the Alaska National Interest Lands Conservation Act (ANILCA) of 1980 would be affected by the proposed actions. Wilderness is a distinct park resource, separate from visitor experience, therefore, other aspects of visitor experience within the wilderness of Glacier Bay and Dundas Bay are evaluated in subsection 4.4.2, "Visitor Experience."

Issues of Concern Raised during Scoping. The primary issues of concern raised during public scoping with regard to wilderness resources include:

- An increase in vessel quotas could allow more people to experience a wilderness area intimately. In addition, wilderness would be more accessible.
- An increase in vessel quotas could diminish the value of wilderness by increasing the sense of crowdedness.
- The presence of large vessels could diminish the wilderness values.
- Increases in off-vessel activity could result in more trash and degradation of the terrestrial environment.

Regulatory Framework. The Wilderness Act of 1964 (Section 2c), the NPS Act of 1916 (Organic Act, Section 1), and the Alaska National Interest Lands Conservation Act (Section 101) call for providing recreational opportunities that emphasize viewing scenery or solitude, or that are primitive and unconfined. The concept of wilderness is defined in the Wilderness Act of 1964 (Public Law 88-577) as:

> *"an area of underdeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value."*

The 1916 Organic Act of the Park Service states that the purpose of the national parks is to "conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (16 USC 1).

Public lands in Alaska designated as wilderness under the provisions of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980 differ from those designated outside of Alaska (see appendix I). Section 1110 of the act permits, " . . . the use of snow machines, motorboats, airplanes, and non-motorized surface methods for traditional activities . . . such use shall be subject to reasonable regulations by the Secretary to protect the natural and other values of the conservation system unit." This makes administration of wilderness in Alaska's national parks different than the administration in non-Alaskan national parks because some modes of transportation that are considered incompatible with the wilderness concept in other locations are allowed to occur in Alaskan wilderness. Those motorized uses, however, can only be permitted if they are for traditional activities.

Methodology and Assumptions. This section addresses effects on wilderness as a resource, with a focus on two major elements of wilderness: freedom (an open, untrammeled landscape), and naturalness (encompassing opportunities for solitude, or a primitive and remote experience). These qualities of wilderness are established in the literature (e.g., Aplet 2000). The freedom dimension incorporates primarily the character of the landscape and ecosystem (i.e., the notion of a place not under the control of human beings). The naturalness dimension of wilderness is directly affected by changes to the natural environment brought on by disturbance because of human activity, such as auditory and visual pollution, and water pollution due to fuel or other vessel spills. Motorized vessel traffic is more likely to affect characteristics of naturalness than freedom, and thus are given greater weight in this analysis.

Because wilderness consists of functioning ecosystems and natural processes, effects on wilderness are based largely on the effects analyses of the other topics addressed in this EIS. To qualitatively assess changes that would occur to existing wilderness resources through the implementation of each alternative, projections of future wilderness resource conditions were estimated. For the freedom dimension of wilderness, the characteristics used in this analysis are:

- the degree to which land provides opportunities for solitude.
- the remoteness of the land from human activities and development.
- the degree to which ecological processes remain uncontrolled by human agency.

For the naturalness dimension of wilderness, the characteristics used in this analysis are:

- the degree to which the area can provide opportunity for solitude.
- the degree to which the wilderness maintains natural composition.
- the degree to which it remains unaltered by artificial human structure.
- the degree to which it is unpolluted.

Each of these characteristics need not exist at an absolute maximum in wilderness, but collectively they define the qualities of freedom and naturalness, and therefore, facilitate the measurement of wildness in wilderness.

Based on these characteristics just described, the threshold criteria shown in table 4-31 were developed to measure and describe the intensity of effects on wilderness.

TABLE 4-31: THRESHOLD CRITERIA FOR WILDERNESS RESOURCES EFFECTS ANALYSIS

Negligible	Human activity and products of that activity (e.g., air, water, noise pollution) would be present, but would be localized and last less than one day. Overall wilderness values would remain unchanged.
Minor	Human activity and products of that activity (e.g., air, water, noise pollution) would be present, but would be localized and last less than one week.
Moderate	Human activity and products of that activity (e.g., air, water, noise pollution) would be present, occur over a relatively large area or "place," such as an inlet, and last longer than one week or occur so frequently as to be essentially continuous.
Major	Human activity and products of that activity (e.g., air, water, noise pollution) would substantially reduce both the naturalness and freedom dimensions of the wilderness resource at the scale of the entire park. Also, any major effect, within the wilderness area, on another resource, as identified in this EIS, would be considered a major effect on wilderness.

Alternative 1 (No Action) - Effects on Wilderness Resources.

Direct and Indirect Effects on Wilderness Resources – Alternative 1. Throughout most of the Glacier Bay Wilderness, including the expansive glaciers and rugged mountains, vessel traffic is not noticeable, since these areas are remote and isolated from the traffic. Because most wilderness use is shoreline based, and motorized vessels are the primary modes of transportation in the park, human activity affects wilderness mainly along the shoreline in both Glacier and Dundas Bays. Under alternative 1, some currently motorized waters in designated wilderness, upper Dundas Bay and the Beardslee Entrance, would be retained as such.

Overall, the vessel traffic allowed under the current management framework slightly affects wilderness as a resource. The presence of motorized craft creates noise (from engine operation, horns, and public address systems) and contributes pollutants to the air and water. Other effects of vessel traffic include disturbances in feeding and breeding of both marine mammals and birds in Glacier Bay, the intrusion of vessel exhaust into wilderness, and the visual presence of vessels. These effects become greater where and when vessels concentrate, such as near the tidewater glaciers, but cruise ships only enter one designated wilderness area. Most of the area remains remote with fully functional ecosystems and opportunities for solitude, so the freedom dimension of the landscape would be maintained.

Vessel traffic affects natural conditions in wilderness by emitting air pollutants, particularly where vessel traffic comes near designated wilderness. Depending upon air currents, operating systems, and the amount of ship traffic, particulates from cruise ship emissions may drift over the park's designated wilderness areas; however, emissions would affect only a small fraction of designated wilderness because air emissions disperse, and would be short-lived. Noise can intrude upon the naturalness of the shoreline wilderness. Engine noise can be heard from many places within designated wilderness, particularly where vessels travel close to shore (e.g., South Marble Island). The public address systems of tour and cruise ships also can be heard within wilderness areas.

As a result, motorized vessels do and would continue to decrease the naturalness present in nearby wilderness sections of the park, but would not decrease the freedom dimension, which involves aspects of wilderness at the landscape and/or ecosystem level. Reductions in naturalness would be localized and would not change the overall structure of wilderness in Glacier Bay or Dundas Bay. Seasonal closures to motorized vessels in wilderness waters reduce, but do not completely eliminate the potential for changes to naturalness. Wilderness waters that would remain open to motorized use (Dundas Bay and Beardslee Entrance) would continue to experience decreased naturalness.

Current operating requirements for motorized craft are designed to minimize wildlife disturbance and collisions with whales, and to reduce liquid waste discharges; however, within the narrow inlets/fjords vessel traffic would be concentrated, especially on peak use days. In particular, Tarr and Johns Hopkins inlets, both of which contain spectacular tidewater glaciers, are susceptible to congested conditions and, as described in section 4.2.2, "Air Quality," inversions can sometimes trap vessel emissions, creating a temporary yet noticeable layer of haze that would detract from the natural character of the wilderness shorelines and slopes.

Another area subject to motorized vessels is the Beardslee Entrance. This area is the opening between Young and Strawberry Islands, which is within designated wilderness. This is the only place where cruise ships enter designated wilderness; however, in 2002, only one cruise ship out of 139 entered this area.

Under alternative 1, tour vessels would continue to visit Dundas Bay and the East Arm of Glacier Bay, except during the 6-week periods when Muir and Wachusett Inlets are closed. The shorelines of these areas, like almost all shorelines of the park outside of Bartlett Cove, would be exposed to these vessels, along with private and charter vessels. Some tour vessels are quite large and, within the relatively small Dundas Bay, may be imposing. In addition, tour vessels drop off kayakers who travel in relatively large groups that create noise and visual intrusions into the naturalness of wilderness shorelines of the East Arm and Dundas Bay.

Tour vessels have a relatively high risk factor for grounding and, due to their size, carry significant amounts of fuel, so the presence of tour vessels within Dundas Bay and the East Arm introduces greater potential risk of effects on the wilderness resource from fuel spills. Cruise ships occasionally travel up the East Arm, but since the retreat of the major glaciers in that area, such use would be infrequent, as would the resulting effects of seeing and hearing these vessels.

Dundas Bay, the northern portion of which is designated wilderness, also would remain open without daily limits. Use would be expected to increase for charter vessels, because Dundas Bay provides opportunities for fishing; wildlife viewing; and off-vessel activities, such as kayaking and shore walking — activities ideal for charter operations. In addition, Dundas Bay is one of the few places that remains usable when strong westerly winds (westerlies) blow through Icy Strait. Charter use within Dundas Bay, therefore, could peak on certain days so that 12 or more vessels could be present. Due to the small size of the Bay, this would create a strong human presence and detract from natural conditions, as perceived from the shoreline and from the wilderness waters located in the upper Bay. Peak off-boat activities also would detract from the naturalness of the Bay. This level of activity is expected to disturb wildlife use of the shoreline as well, further reducing the naturalness of the shoreline. The overall direct effects to wilderness resources would be moderate due to the fact that human activity would be localized and short-term.

Cumulative Effects on Wilderness Resources – Alternative 1. The presence of motorized vessels, and the associated effects on wilderness, would be additive to other effects currently detracting from the character of wilderness in the park. Most notable are the effects of hikers and non-motorized boaters within the wilderness. While relatively dispersed, these uses create trails, campsites, and other signs of human use that can detract from the character of the wilderness; so, too, would continued overflights of floatplanes, helicopters, and other aircraft. The Park Service is considering granting mountaineering permits for Mt. Fairweather, located in the Glacier Bay Wilderness Area, that would involve aircraft overflights. These flights, and the noise from other flightseeing and recreational drop-off operations, would detract from natural conditions. The Park Service itself makes numerous motorized administrative and research trips into the Bay.

Collectively, the effects of these human activities are and would continue to remain minor, since the overall character and functioning of the wilderness would remain intact. These effects have been occurring within the Glacier Bay Wilderness for decades, and the wilderness has remained a wild place, with a functioning natural ecosystem and plentiful opportunities for solitude in the rugged and beautiful landscape.

Impairment Analysis for Wilderness Resources – Alternative 1. Because effects are expected to be minor, the wilderness resource would not be impaired by continued management under the existing regulations.

Potential Mitigation Measures for Wilderness Resources – Alternative 1. A potential way to reduce effects at areas of concentrated use or at attractions such as Tarr and Johns Hopkins Inlets would be to schedule use so that cruise ship and tour vessels would arrive at these places at approximately the same time. Focusing use temporally would concentrate pollutants during one particular time period, and leave more time when no pollutants would be present. This could enhance the naturalness dimension of the wilderness.

Conclusion, Wilderness Resources – Alternative 1. Throughout most of Glacier Bay's remote and rugged wilderness, vessel traffic would not affect the wilderness character of the park. However, within Johns Hopkins and Tarr Inlets the effects of vessel noise and air pollution can be heightened due to the concentrated use in these areas, and the naturalness of upper Dundas Bay and Beardslee Entrance would be impaired because these bodies of water would remain open to motorized vessel use. Coordinating the scheduled arrivals of cruise ships and tour vessels to concentrate traffic and provide more time without traffic could mitigate these effects. Overall, the effect to wilderness resources of alternative 1 would be moderate because the effects occur over a relatively large area (entire bays and inlets) and do so frequently.

Alternative 2 - Effects on Wilderness Resources.

Direct and Indirect Effects on Wilderness Resources – Alternative 2. Overall, alternative 2 would affect wilderness in a manner similar to that described under alternative 1, with relatively minor effects due to the visual presence of vessels, and vessel noise and emissions into the air and water. The vast majority of the Glacier Bay Wilderness would be unaffected by motorized vessel traffic, except for upper Dundas Bay and Beardslee Entrance. Shoreline areas would be most affected due to their proximity to vessel traffic.

Under alternative 2, fewer cruise ships, charter vessels, and private vessels would be allowed within Glacier Bay during the summer season than are currently allowed. This would result in a slight proportional reduction in associated effects, including, as described in other sections of this EIS, noise disturbances in feeding, nesting, and migration of marine mammals and birds in Glacier Bay, the intrusion of air emissions into wilderness, and the visual presence of vessels. Overall, effects would remain about the same as alternative 1, including the introduction of noise, water, and air emissions to the wilderness shoreline.

As with all alternatives, the motorized vessel-related effects would be localized in concentrated use areas, including Tarr and Johns Hopkins Inlets. Even with fewer vessels allowed over the season, the overall effect would be the same as alternative 1 because the effect would occur during peak use, daily entry limits would be the same as under the current situation.

As with alternative 1, Dundas Bay would remain open to tour vessels and would not have restrictions on entries for any vessel category, resulting in peak use days of charter vessels where up to 12 vessels may be present. The direct effects of alternative 2 on wilderness resources, therefore, would be minor since they are localized and short term.

Cumulative Effects on Wilderness Resources – Alternative 2. Since alternative 2 would affect wilderness in the same manner as alternative 1, the cumulative effect also would be similar and would remain minor for the shoreline of Glacier Bay. Collectively, the effects of backcountry users, aircraft, administrative vessels, and other human activities would remain minor, since the overall character and functioning of the wilderness would remain intact.

Impairment Analysis for Wilderness Resources – Alternative 2. Since the overall character and functioning of the wilderness would remain intact, even when considering cumulative effects, alternative 2 would not impair the Glacier Bay Wilderness resource.

Potential Mitigation Measures for Wilderness Resources – Alternative 2. As described under alternative 1, scheduling use and the timing of vessel entries in concentrated areas could minimize potential reductions of naturalness within designated wilderness.

Conclusion, Wilderness Resources – Alternative 2. Overall effects on wilderness would be similar to the existing situation, with no changes to most of Glacier Bay's wilderness and some reduction of naturalness due to the effects of noise and releases of air and water pollution. Most effects would occur in wilderness waters and along the shorelines. Private vessel numbers under alternative 2 would be the lowest allowed over the summer among all the alternatives, and the number of cruise ships would be reduced, but since peak numbers allowed would remain the same, the overall effect would be essentially the same. While alternative 2 would reduce overall vessel traffic within Johns Hopkins and Tarr Inlets, the effects of vessel noise and air pollution (i.e., reducing "naturalness" along the shorelines and slopes) could be heightened due to the concentrated vessel use in these areas. Cumulative effects from other activities would not substantially contribute to direct effects from alternative 2; therefore, the overall effects are minor based on the localized and short-term nature of the effects described above. Wilderness resources would not be impaired under this alternative.

Alternative 3 - Effects on Wilderness Resources.

Direct and Indirect Effects on Wilderness Resources – Alternative 3. Like alternative 2, the overall effects on wilderness from alternative 3 would be similar to those described under alternative 1. As described in other sections of this EIS, these consequences include noise disturbances in feeding, nesting, and migration to marine mammals and birds in Glacier Bay, the intrusion of air emissions into wilderness, and the visual presence of vessels.

The primary factor that would change from current conditions is that cruise ship numbers could increase to 184 cruise ships from June through August, allowing two cruise ships a day, every day, throughout the summer season. This number of cruise ships would increase the number of events during which congestion would occur in inlets, along with the associated reduction in the character of naturalness. Using the increased percentage of cruise ships (32.4%) under this alternative, the frequency of congestion events when wilderness would be affected would increase by about one-third. The absolute effects of each congestion event would not change, since peak limits (daily entry quotas) would remain the same as under the current management scheme. As with all alternatives, shoreline areas would be most affected due to their proximity to vessel traffic.

Overall effects would remain approximately the same as alternative 1, but would occur more frequently and for a longer seasonal duration, including the introduction of noise, water, and air emissions to the wilderness shoreline. These effects would remain localized. As with alternative 1, Dundas Bay would remain open to tour vessels and would not have restrictions on entries for any vessel category, resulting in peak use days of charter vessels where up to 12 vessels may be present.

Cumulative Effects on Wilderness Resources – Alternative 3. Since alternative 3 would result in similar effects on wilderness as alternative 1, cumulative effects would be similar and would remain minor. Collectively, the effects of backcountry users, aircraft, administrative vessels, and other human activities would continue to remain minor, since the overall character and functioning of the wilderness would remain intact.

Impairment Analysis for Wilderness Resources – Alternative 3. Since the overall character and functioning of the wilderness would remain intact, even when considering cumulative effects, alternative 3 would not impair the Glacier Bay Wilderness resource.

Potential Mitigation Measures for Wilderness Resources – Alternative 3. As described under alternative 1, scheduling use and the timing of vessel entries in concentrated areas could reduce potential reductions of naturalness within designated wilderness.

Conclusion, Wilderness Resources – Alternative 3. Overall effects on wilderness would be similar to alternative 1, and would be minor, although there would be no effects throughout most of Glacier Bay's wilderness. Some reduction of naturalness would occur due to the effects of noise and releases of air and water pollution. Most effects would occur in wilderness waters and along the shorelines. Since alternative 3 allows for up to two cruise ships a day, every day, throughout the summer, crowding events where within Johns Hopkins and Tarr Inlets would occur more frequently. Cumulative effects to wilderness resources from other activities in the park would not significantly contribute to the direct effects of this alternative. Wilderness resources would not be impaired under alternative 3.

Alternative 4 - Effects on Wilderness Resources.

Direct and Indirect Effects on Wilderness Resources –Alternative 4. Several major changes would occur under alternative 4 that would reduce effects to wilderness from those occurring under alternative 1:

- the East Arm, Beardslee Entrance, and Dundas Bay would be closed to cruise ships and tour vessels.
- daily vessel quotas would be reduced across all vessel categories.
- daily and seasonal vessel quotas would be set for charter use in Dundas Bay.
- cruise ships would be required to follow designated travel lanes.
- seasonal limits would be extended to May and September (currently they only apply from June through August).

Closing the East Arm and Dundas Bay to cruise ships and tour vessels would eliminate effects on naturalness within wilderness that are now occurring from these vessels. These include emissions into the air and water, visual and noise intrusions, and shoreline disturbance and noise resulting from off-vessel activities.

Reducing vessel quotas also would reduce the congestion anticipated in alternatives 1, 2, and 3 that are occurring at the concentration points of Tarr and Johns Hopkins Inlets (and potentially Reid Inlet). The reduction in daily quotas could reduce peak use in these areas, but the daily limit of two cruise ships would remain; however, by keeping the daily limit open to two cruise ships, use could be staggered so that on some days, two cruise ships would enter Glacier Bay, and on other days, none would enter.

By requiring cruise ships to follow a central route up and down Glacier Bay, the distance to wilderness areas would be maximized, thereby providing more of a buffer and lower potential for effects on wilderness. In particular, Beardslee Entrance would be closed to cruise ships under this alternative, thereby eliminating the one place where cruise ships enter designated wilderness. Finally, by extending the period for seasonal restrictions into May and September, the number of days where maximum vessel use occurs would be reduced.

Other effects of vessel traffic, while somewhat reduced, would remain similar to those that would occur under alternatives 1, 2, and 3. As described in other sections of this EIS, these consequences include disturbances in feeding, nesting, and migration to both sensitive marine mammals and birds in Glacier Bay, the intrusion of vessel exhaust into wilderness, and the visual presence of vessels. The direct effects of alternative 4 on wilderness resources would be minor because noise, air emissions, and congestion would be localized and short term.

Cumulative Effects on Wilderness Resources – Alternative 4. As described under the previously addressed alternatives, the presence of motorized vessels, and the associated effects on wilderness, would be additive to other effects. Most notable are the effects of hikers and non-motorized boaters within the wilderness and overflights of floatplanes, helicopters, and other aircraft. Collectively, the effects of these human activities are and would continue to remain minor, since the overall character and functioning of the wilderness would remain intact.

Impairment Analysis for Wilderness Resources – Alternative 4. Because effects would be expected to be minor, the wilderness resource would not be impaired by continued management under the existing regulations and this alternative represents a refinement of the current operations.

Potential Mitigation Measures for Wilderness Resources – Alternative 4. As described under alternative 1, scheduling use and the timing of vessel entries in concentrated areas could reduce potential reductions of naturalness within designated wilderness.

Conclusion, Wilderness Resources – Alternative 4. Overall effects on wilderness would be similar to the existing situation and would be minor throughout most of Glacier Bay's wilderness. Some reduction of naturalness would occur due to the effects of noise and releases of air and water pollution. Most effects would occur in wilderness waters and along the shorelines. Since alternative 4 provides for the fewest cruise ships among the alternatives, effects related to crowding and air emissions within narrow fjords would be the lowest compared to the other alternatives, including the existing situation. Cumulative effects on wilderness resources from other activities in the park would not significantly contribute to direct effects. Wilderness resources would not be impaired by alternative 4.

Alternative 5 - Effects on Wilderness Resources.

Direct and Indirect Effects on Wilderness Resources – Alternative 5. Most of the same changes that would occur under alternative 4 would also be implemented under alternative 5. The objective of alternative 5 includes, in addition to protecting park resources and values, to increase a variety of use levels and opportunities for park visitors; therefore, vessel levels would remain at current levels, as would most of the effects on wilderness, which are mostly minor. Vessel congestion would continue to occur at two major inlets of the West Arm; however, alternative 5 would contain protective actions, including:

- closing the entrance to Adams Inlet to cruise ships and tour vessels.
- closing Dundas Bay to cruise ships and upper Dundas Bay to tour vessels.
- setting seasonal vessel quotas for charter use (but no daily limit) in Dundas Bay.

- extending seasonal limits to May and September for cruise ships (currently they only apply from June through August).

Closing Dundas Bay to cruise ships would cause a negligible reduction in effects since cruise ships rarely, if ever, currently travel there. Effects of tour vessels would continue in lower Dundas Bay, including noise and air pollution at minor levels (i.e., affecting localized areas and effects lasting no more than a few hours).

Contrasted with alternative 4, alternative 5 would not require cruise ships to follow a central route up and down Glacier Bay; however, Beardslee Entrance would be closed to cruise ships under this alternative, thereby eliminating cruise ships' entryway into designated wilderness.

As opposed to the other alternatives, vessel speed restrictions under alternative 5 would be based on ground speed, rather than speed over the water (see chapter 2 for a detailed discussion). As a result, vessel noise could increase at times when vessels are moving against the current, because the current speed would be added to the ground speed and the vessel would be moving through the water at a faster rate, thereby requiring more engine power and associated noise. Overall, this effect would be minor and would probably represent a negligible change over the existing situation, because most vessels already navigate based on ground speed, even though, technically, they should be using in-water speed. The overall direct effects to wilderness resources under this alternative would be minor because they would be localized and short term.

Cumulative Effects on Wilderness Resources – Alternative 5. As described under the previously addressed alternatives, the presence of motorized vessels, and the associated effects on wilderness, would be additive to other effects. Most notable are the effects of hikers and non-motorized boaters within the wilderness and overflights of floatplanes, helicopters, and other aircraft. Collectively, the effects of these human activities are and would continue to remain minor, since the overall character and functioning of the wilderness would remain intact.

Impairment Analysis for Wilderness Resources – Alternative 5. Because effects are expected to be minor, the wilderness resource would not be impaired by continued management as described under this alternative.

Potential Mitigation Measures for Wilderness Resources – Alternative 5. Scheduling of cruise ships and other vessels could serve to reduce effects in some areas.

Conclusion, Wilderness Resources – Alternative 5. The overall effect to wilderness resources would be minor, although the closure of wilderness waters in Dundas Bay to both tour vessels and cruise ships indicates alternative 5 would have marginally lower effect levels than the current situation. Protective operating requirements would reduce overall effects on the wilderness resource from those currently occurring for cruise ships, and tour and charter vessels. Vessel activity would remain at current levels, as would most of the effects on wilderness, but these are minor because the effects occur at isolated locations and are short term. As with all alternatives, effects would be greatest near the most popular areas, including Tarr and Johns Hopkins Inlets. Cumulative effects from other activities in the park would not significantly contribute to direct effects. Wilderness resources would not be impaired under this alternative.

Summary, Wilderness Resources. None of the alternatives would significantly affect wilderness resources as compared to alternative 1. Most of the Glacier Bay wilderness would remain unaffected by motorized vessel traffic. Shoreline areas would be most affected due to their proximity to vessel traffic, but such effects would be minor, with the exception of the two sensitive areas cited above where scheduling of ships could reduce adverse effects. While overall effects of the alternatives are characterized as minor, alternatives 4 and 5 would have marginally lower effect levels due to reduced vessel quotas and operating requirements.

4.4.5 Local and Regional Socioeconomics

4.4.5 Local and Regional Socioeconomics

This section evaluates the potential effects of implementing the proposed alternatives on local and regional socioeconomics. The effects analysis methodology is presented first, followed by the effects analysis for each alternative. This discussion also includes an evaluation of cumulative effect on local and regional socioeconomics. Conclusions summarize the results of each evaluation.

Impairment is not addressed for this topic because socioeconomics is not a park resource or value subject to the non-impairment standard defined in section 1.3.1 and further defined in NPS policy 1.4.6 (NPS 2001b). As described in chapter 1, the Park Service sets vessel access limits to protect park resources and values. The Park Service has a congressional mandate to protect park resources and values, while no such mandate exists to support local economies; however, mitigation measures are discussed for those alternatives that would have a moderate effect. The park recognizes its role in supporting local economies. As mentioned in this section, Glacier Bay is a major tourist attraction due to its outstanding natural resources, but protection of these resources comes first. Protection of resources does, in fact, protect the economic benefits they provide by leaving them unimpaired for the enjoyment of future generations, as mandated by the Organic Act of 1916.

Issues of Concern Raised during Scoping. The issues related to local and regional socioeconomics that were raised during scoping are:

- Increasing the vessel quota for private and charter vessels and providing access to Dundas and Taylor Bays could improve local economies and lifestyles. Revenues generated from local wildlife viewing and sightseeing charter and tour vessels could replace loss of livelihood resulting from the Glacier Bay commercial fishing phase-out.
- Increasing the number of permits allocated to local owners and operators could benefit the local economy, but the number of vessel entries should not increase.
- Increasing the vessel quota for tour vessels could benefit the economy of local communities by providing additional entries to local operators. Increased restrictions on local resident access could have detrimental effects to local economies.
- Increasing the vessel quota for private, locally based vessels would benefit inn and lodge operators by increasing their access to Glacier, Dundas, and Taylor Bays for their guests.

Issues raised during scoping related to the cumulative effect on the environment from the incremental effect of other actions include the following:

- Commercial fishing is being phased out of Glacier Bay and Dundas Bay wilderness waters, but will continue until all current permit holders cease to fish. (The waters outside Glacier Bay are open to commercial fishermen.)

- Some commenters have the perception that tourism in Southeast Alaska is leveling out, and fewer independent travelers are coming to the park. These conditions may alter demand and the type of visitor experience preferred.
- The number of charter vessel operators is increasing, which could result in increased demand for permits.

Methodology and Assumptions. The analysis of effects on local and regional socioeconomics is focused on businesses and the local economies within which they operate. It identifies businesses that currently economically benefit, either directly or indirectly, from access to Glacier Bay based on NPS vendor and permit lists and other sources. Several research tools were used to assess business response to changing vessel quotas, including an analysis of cruise line and other business reactions (i.e., itinerary changes, pricing adjustments, etc.) to past changes in Glacier Bay permits, interviews with cruise line marketing managers, as well as professional judgement and experience in Alaska cruise and tourism marketing strategies and considerations in the development of Alaska itineraries.

Each alternative is analyzed in terms of its potential effect on local personal income. The change in personal income in each community resulting from each alternative is assumed by be proportional the change in permitted vessel traffic. This assumption is based on the fact that Glacier Bay is the premiere attraction in Southeast Alaska, and vessel bookings would be significantly lower for trip itineraries that do not include a visit to the park. For example, if it is assumed that cruise ship-related activity in Juneau accounts for 6% of that community's total personal income and an alternative results in a 33% reduction in cruise ship access to Glacier Bay, it can be further assumed that this alternative would result in a 2% reduction in personal income in Juneau. This relationship between Glacier Bay vessel traffic and local area personal income is described in more detail in chapter 3. This analysis includes indirect effects, those that occur as a result of a change in activity by directly affected businesses, such as purchases of goods and services by individuals who are employed directly by vessel-related businesses.

Finally, cumulative effects, including total changes in income are overlain on the baseline community and regional socioeconomic environment to assess the relative importance of economic change resulting from higher or lower vessel quotas. Baseline community and regional data is drawn from secondary data sources, including the 2000 U.S. Census, Alaska Department of Labor and Workforce Development, Bureau of Economic Analysis, and others. The intensities of effects on communities are described in table 4-32.

TABLE 4-32: THRESHOLD CRITERIA FOR LOCAL AND REGIONAL SOCIOECONOMICS EFFECTS ANALYSIS

Negligible	The effect would not be detectable and would not change the socioeconomic environment, including individuals, businesses and communities with economic linkages to the park.
Minor	A community-level economic effect would be measurable, but small relative to the size of overall economies. In the smaller communities (Gustavus, Hoonah, Pelican, Skagway, or Elfin Cove) effects would be considered minor if there could be an overall (economy-wide) change in employment and personal income of less than 5%. In larger communities (Juneau, Sitka, and Haines) effects would be considered minor if there could be an overall (economy-wide) change in employment and personal income less than 1%.
Moderate	The effect would be clearly detectable and could reduce the socioeconomic environment. In the smaller communities (Gustavus, Hoonah, Pelican, Haines, or Elfin Cove) effects would be considered moderate if there could be an overall (economy-wide) change in employment and personal income of greater than 5%, but less than 10%. In larger communities (Juneau, Sitka, or Ketchikan) effects would be considered moderate if there could be an overall (economy-wide) change in employment and personal income greater than 1%, but less than 3%.
Major	The effect would have a substantial, highly noticeable, potentially permanent influence on the socioeconomic environment. More than one-quarter of people and businesses with economic linkages to the park would be affected. In the smaller communities effects would be considered major if there could be an overall (economy-wide) change in employment and personal income of greater than 10%. In larger communities effects would be considered major if there could be an overall (economy-wide) change in employment and personal income of greater than 3%.

Alternative 1 (No Action) – Effects on Local and Regional Socioeconomics.

Direct and Indirect Effects on Local and Regional Socioeconomics – Alternative 1. The economic linkages between visitation in the park and local and regional economies are widespread and complex. Alternative 1, however, would have negligible direct or indirect effects on the local economies of Southeast Alaska, including cruise line ports of call such as Haines, Skagway, Juneau, Sitka, and Ketchikan. These communities benefit from cruise ship passenger spending, cruise line spending (moorage fees, stevedoring, etc.), and the tax revenues stemming from that spending. Cruise passengers spent just under $200 million in southeast communities in 1999, the latest available data (McDowell 2000d). Cruise ship passengers spend an average of $120 each in Juneau, approximately $100 in Ketchikan and Skagway, and lesser amounts in Sitka and Haines. Cruise lines spent another $22 million on maritime services and other goods in services in direct support of their Southeast Alaska operations (McDowell 2000d). Access to Glacier Bay is linked to the economic well-being of these ports-of-call because the inclusion of Glacier Bay in a cruise itinerary can determine which communities are also included in the itinerary, and whether or not the ship travels cross-Gulf. The seven cruise ship lines, five tour vessel operators, 13 charter vessels, and other private vessels would continue to operate.

Similarly, the economies of park neighboring communities of Gustavus, Hoonah, Pelican, and Elfin Cove would not be directly affected in alternative 1. The economies of these communities have adjusted to the current number of vessel entries. Under alternative 1, there would be no change in local employment, payroll, tax revenues, or other economic indicators. These small communities have varying levels of economic dependence on Glacier Bay visitation. Gustavus is most dependent, as the gateway community for most the park's independent (non-cruise) visitors. Gustavus is also the location of Park headquarters. Hoonah, Pelican and Elfin Cove are less economically dependent, with links primarily associated with access to the park for charter boats. Hoonah has important socio-cultural links to the park, as described in chapter 3. The local communities would continue to benefit from visitor fees collected and spent locally by the Park Service.

Alternative 1 would have negligible direct effects on Glacier Bay-dependent businesses, charter boat operators, lodging establishments, cruise lines, and tour boat operators. As the no action alternative, no increase or decrease in business sales would be associated with alternative 1; however, there would be a minor long-term effect on Alaska's visitor industry. For example, for the cruise industry, Glacier Bay is the premier attraction on an Alaska cruise itinerary, and cruise ship passenger demand exceeds the available opportunities to visit the Bay, based on the high level of interest among cruise lines in acquiring Glacier Bay permits and on interviews with cruise line marketing managers. The opportunity to view glaciers is the single most important reason visitors travel to Alaska (GMA Research Corporation 2000). In general, Alaska cruises that include Glacier Bay in the itinerary are more popular and sell faster than cruise itineraries without Glacier Bay, according to cruise industry officials, but alternative glaciers accessible by vessels exist. Although some scoping comments included the perception that tourism in southeast Alaska is declining, Alaska's cruise industry is expected to see growth in passenger capacity averaging five to six percent a year over the next five years, including a 10 percent increase in 2003 (based on unpublished McDowell Group data; McDowell 2002a). In the absence of additional cruise ship entries, cruise lines would not increase the number of tours that include Glacier Bay, resulting in a potentially smaller proportion of the total number of visitors to Alaska who travel to Southeast Alaska.

Similarly, businesses in the smaller communities with linkages to Glacier Bay, such as Elfin Cove sport fishing lodge operators, would not experience a change in sales or employment as a result of alternative 1. Some operators would, however, continue to experience difficulty in obtaining permits for Dundas Bay, as expressed in public hearings held during the scoping phase of this project.

Alternative 1, would not directly affect local and regional economies in Southeast Alaska. Alternative 1 would maintain personal income and employment for businesses and local economies that are dependent on Glacier Bay at current levels. Future growth in Alaska's visitor industry would be limited to the extent that the demand for access to Glacier Bay exceeds the vessel quotas, if any, a minor effect; therefore the overall direct and indirect effects of implementing alternative 1 would be minor.

Cumulative Effects on Local and Regional Socioeconomics – Alternative 1. A broad range of factors influence the local and regional economies of Southeast Alaska. Some smaller communities, such as Pelican, will continue to struggle with changing conditions in the seafood industry, including commercial fishing restrictions in Glacier Bay, declining fish markets, and recent changes in fisheries management, such as the individual fisherman's quota system for the halibut and blackcod fisheries, which has adverse effects on remote processors. Some residents of Pelican, Hoonah, and Gustavus hold the opinion that changes in vessel management in Glacier Bay, such as setting more permits for local charter operators, could benefit their local economies; however, alternative 1 does not include such changes.

These communities and local residents are slated to receive monetary compensation from the federal government for lost income due to the Glacier Bay closures. The Glacier Bay Compensation Plan Economic Assessment predicted potential economic losses to fishermen, processors, communities and others between $23 million and $59 million. The federal government has made available a total of $31 million for the compensation program (McDowell 2000a). Assuming that changes in personal income and employment would increase in proportion to the percent employed in visitor-affected businesses and the 5% or 6 % annual growth of the visitor industry, this effect would be minor to communities such as Hoonah, Pelican, Juneau, and Sitka and moderate in Gustavus, Elfin Cove, Haines, and Yakutat.

Insofar as alternative 1 will not produce changes in local and regional economies, the cumulative economic effects are negligible.

Impairment Analysis for Local and Regional Socioeconomics – Alternative 1. Socioeconomics is not a park resource or value, and so is not subject to the non-impairment standard defined in section 1.3.1 and further defined in NPS policy 1.4.6.

Potential Mitigation Measures for Local and Regional Socioeconomics – Alternative 1. None required.

Conclusion, Local and Regional Socioeconomics – Alternative 1. The direct and indirect adverse effects of the implementation of alternative 1 are minor. The cumulative considerations would not produce any independent changes to local and regional economies. No mitigation measures would be necessary and impairment does not apply to this resource; therefore, the overall effects of this alternative are minor adverse effects.

Alternative 2 – Effects on Local and Regional Socioeconomics. Under alternative 2, vessel management would revert to the quotas and operating requirements that were established in 1985 and were in place prior to the 1996 decision to increase vessel numbers. Cruise ship seasonal entries would decrease from the current 139 entries to 107; charter boat entries would decrease from 312 to 271; private boat entries would decrease from 468 to 407; and tour vessel entries would remain the same. Also under alternative 2, management or vessel entries in Dundas Bay would not change.

Direct and Indirect Effects on Local and Regional Socioeconomics –Alternative 2. Communities whose economies benefit from cruise, charter, and private boat tourism in Glacier Bay would experience lower business sales and lower employment, causing a minor to moderate effect on local personal income. The actual distribution of adverse economic effects among communities would depend on the specifics of the quotas, i.e., how the reductions would be implemented, which has not been determined. Personal income for local residents of the neighboring communities of Gustavus, Hoonah, Pelican, and Elfin Cove would be expected to decline due to reduced business activity for charter operators stemming from a 13% reduction in charter permits and reduced local spending associated with private vessel traffic (also 13%). As described in the methodology, personal income reductions in these smaller communities of less than 5% are considered a minor adverse effect. In Gustavus, where a significant amount of charter activity is based, and where there is some economic dependence on cruise ship passenger fees, reductions of about 5% would be predicted; therefore adverse effects in Gustavus would be considered moderate.

Economic effects of a 23% reduction in cruise permits on the cruise port of call communities of Skagway, Haines, Juneau, and Sitka (as well as other Southeast ports of call) would be moderate, depending on the community. Juneau and Sitka would be expected to experience, over the long-term, declines in personal income of about 1% annually, considered a moderate effect. Skagway, the Southeast community with the highest level of economic dependence on cruise traffic, could experience an annual personal income decline of about 5%, also defined as a moderate effect. In the short-term, cruise line traffic could increase or decrease to any given community because, with Glacier Bay not available (or less available) cruise lines will look for other glacier experiences to offer their passengers, such as Tracy Arm. Some communities could see an increase in the number of port calls, while others might experience some decline. It is not possible to predict which communities would experience short-term reductions or increases in cruise ship traffic.

It is important to that note even over the short-term the potential adverse consequences of alternative 2 on any single community are significant. For example, if one ship that now visits Haines were to re-deploy (because of changes in Glacier Bay vessel quotas) to a cross-Gulf itinerary and drop Haines, the community could lose $2 million in local passenger spending, assuming 22 stops per season, 2,000 passengers per stop, and average spending of $55 per passenger (McDowell 2000b). This loss in local spending would translate into less personal income for Haines residents and, potentially, less employment. Over the long-term, reductions in cruise ship access to Glacier Bay would be expected to push more traffic cross-gulf resulting in fewer Southeast port calls. This would result in lower personal income in these communities, as described above.

In summary, the economies of communities with economic linkages to Glacier Bay would experience minor to moderate adverse income and employment effects form alternative 2. Gustavus is the community most likely to experience moderate adverse economic effects, though other communities could also experience moderate effects, depending on cruise decisions on rerouting vessels. The overall direct and indirect effects of alternative 2 would be moderate.

Cumulative Effects on Local and Regional Socioeconomics – Alternative 2. Moderate cumulative adverse effects would be associated with alternative 2. Personal income in Gustavus, Pelican, Hoonah, and Elfin Cove have been and will remain depressed due to commercial fishing closures and restrictions in Glacier Bay, and other management and market issues facing the fishing industry as a whole. These effects may be partially offset by positive short-term effects from the monetary compensation to commercial fishers by the federal government. The effects of commercial fishing restrictions, coupled with the reduction in the number of vessel entry permits for the Bay, would result in moderate employment and income losses in the smaller communities in the Glacier Bay area. Effects to the larger communities would be moderate, although potentially major in communities where cruise ships would cease to call.

Impairment Analysis for Local and Regional Socioeconomics – Alternative 2. Socioeconomics is not a park resource and so is not subject to the non-impairment standard.

Potential Mitigation Measures for Local and Regional Socioeconomics – Alternative 2. Measures that could mitigate the adverse cumulative effects of alternative 2 could include using the preferred operator criteria (36 CFR 13.83) for selecting charter vessel permits, which could mitigate effects in Gustavus, Hoonah, Elfin Cove, and Pelican.

Conclusion, Local and Regional Socioeconomics – Alternative 2. The overall direct and indirect effects would be moderate. Including cumulative effects, all of the park's smaller neighboring communities could experience moderate adverse economic effects, which could be mitigated to some extent by using preferred operator criteria. Impairment does not apply to this topic. The overall effect on local and regional socioeconomics of implementing alternative 2 would be moderate.

Alternative 3 – Effects on Local and Regional Socioeconomics. Alternative 3 would continue the current vessel management activities and operating restrictions, but would allow future increases in vessel traffic up to the quotas authorized in the 1996 vessel management plan. Cruise ship entries would still be restricted to a maximum of two per day, but the total number of allowable entries for the season would increase from 139 to 184. All other vessel quotas would remain the same as in alternative 1. Alternative 3 does not propose any changes in the management or vessel entries in Dundas Bay.

Direct and Indirect Effects on Local and Regional Socioeconomics –Alternative 3. Alternative 3 would have moderate positive effects on local economies dependent on cruise ship traffic in Southeast Alaska. It is possible that more ships could operate as Inside Passage cruises, rather than as cross-Gulf cruises, and as a result there would be more passenger spending in ports-of-call, as well as more tax and ship fee revenue collected by local governments and private dock owners. More local spending associated with an increase in traffic would increase employment and payroll in Southeast Alaska ports-of-call.

Economic effects in the smaller communities near the park and the effects associated with other vessel traffic would be the same as described in alternative 1. That is, effects would be negligible. The one exception would be Gustavus, which would benefit from increased NPS revenues from cruise ship passenger fees.

In summary, alternative 3 would have moderate positive effects on Southeast Alaska ports-of-call. Effects on other communities would be negligible, with the exception of Gustavus, which would benefit from increased passenger fees flowing to the Park Service; therefore, the overall direct and indirect effects would be moderate positive effects.

Cumulative Effects on Local and Regional Socioeconomics – Alternative 3. There are no cumulative considerations under alternative 3 that would result in effects measurably different from those identified for alternative 3 alone.

Impairment Analysis for Local and Regional Socioeconomics – Alternative 3. Socioeconomics is not a park resource and so is not subject to the non-impairment standard.

Potential Mitigation Measures for Local and Regional Socioeconomics – Alternative 3. No mitigation is necessary under alternative 3.

Conclusion, Local and Regional Socioeconomics – Alternative 3. Implementation of alternative 3 would result in moderate positive direct and indirect effects. No mitigation measures would be necessary and impairment does not apply to this topic. The overall effect of this alternative would be moderate positive effects.

Alternative 4 – Effects on Local and Regional Socioeconomics. Under alternative 4, the season would be extended to May through September. Seasonal entry quotas for cruise ships would decrease to 92 June through August. Tour vessels would be limited to two vessels per day, a reduction from the three per day limit under alternative 1. June through August tour vessel seasonal-use days would be reduced from 276 to 184. Charter boat entries would be reduced from six to five per day, with seasonal-use days reduced from 552 to 460 in Glacier Bay. Daily entries for private vessels would be reduced from 25 to 22, though seasonal-use days would increase from 1,971 to 2,024. For Dundas Bay, tour vessels would no longer be allowed under alternative 4, and charter vessels would be restricted to three per day and 459 seasonal use days in the season.

Direct and Indirect Effects on Local and Regional Socioeconomics – Alternative 4. Moderate adverse local and regional economic effects would be associated with alternative 4, with the exception of Gustavus, where effects would be major. Personal income for local residents within Gustavus, Hoonah, Pelican, and Elfin Cove could decline as a result of a potential 17% reduction in business activity for charter operators. Gustavus's economy would be adversely affected by a 34% reduction in June-to-August cruise ship passenger fees paid to the Park Service. The community's economy also would be affected by the 33% reduction in tour vessel use days during the June through August period; however, this effect may be positive for the community of Gustavus. If tour vessel quotas are reduced, it would not be the *Spirit of Adventure*, which is the only tour boat contributor to the Gustavus economy. If one or more of these tour boats were eliminated, then a percentage of the visitors who might otherwise have booked passage on that boat might be inclined to stay in Gustavus or at Glacier Bay Lodge and take the *Spirit of Adventure*. So, reduction of tour boats by 33% would not have a negative effect on Gustavus's economy, but could have a positive one. As described in Chapter 3, it is assumed that about two-thirds (65%) of Gustavus's economy (measured in terms of personal income) is dependent on visitor travel. Cruise (10%), tour (50%) and charter (15%) activity are assumed to collectively account for about 75% of the local visitor economy. A 34% reduction in cruise-related income in the economy, 33% reduction in tour vessel related income, and a 17% reduction in charter-related income in the economy would result in an overall local personal income loss of about 15%.

The communities of Hoonah, Elfin Cove, and Pelican, which are not economically dependent on Glacier Bay cruise or tour vessel activity, would experience minor adverse effects, associated with a decline in charter vessel permits, with overall personal income declines of less than 5%.

The cruise line port of call communities of Skagway, Haines, Juneau, and Sitka could experience adverse economic effects (ranging from minor to major, depending on location) from alternative 4. In the short-term, these communities could experience some change in cruise line traffic, as a result of rerouting of cruise itineraries. As described under alternative 2, with fewer Glacier Bay entry opportunities, cruise lines will look for other glacier experiences to offer their passengers, such as Tracy Arm or Hubbard Glacier. This may or may not result in a decline in traffic to a particular community. A decline in cruise ship traffic to a community can affect local spending by cruise lines and cruise passengers, which can result in reduced local employment and income. If the 34% reduction in were to, over the long-term, result in 34% less cruise traffic to Southeast Alaska ports-of-call, the effects would be relatively greatest in Skagway, which is most dependent on the cruise industry. A 34% reduction in cruise traffic to Skagway could result in a 10% decrease in annual personal income. This estimate is based on the assumption that about 60% of Skagway's economy is dependent on cruise ship traffic, and about half of that traffic also visits Glacier Bay. If alternative 4 results in a 34% reduction in the Glacier Bay component of Skagway's cruise traffic (meaning a 17% reduction in total Skagway cruise traffic), the community could expect to experience a 10% decline in total personal income. This is defined as a major effect. Using the same basic methodology, Juneau, Sitka and Haines, could experience personal declines of between 1% (Juneau) and 3% (Haines), considered moderate adverse effects.

In summary, communities with economic linkages to Glacier Bay would experience major adverse economic effects from alternative 4. Gustavus, and potentially Skagway are the communities that could experience major economic effects. Including cumulative effects, all the parks' smaller neighboring communities would experience major adverse economic effects associated with alternative 4. The overall direct and indirect adverse effects resulting from implementation of this alternative would be major.

Cumulative Effects on Local and Regional Socioeconomics –Alternative 4. The cumulative economic effects associated with alternative 4 would be similar, but more adverse, than those described under alternative 2. The economies of Gustavus, Pelican, Hoonah, and Elfin Cove are reduced due to the combination of commercial fishing closures and restrictions in Glacier Bay and restricted visitor vessel entry permits for the Bay. This cumulative effect of alternative 4 would result in moderate (up to 10%) employment and income losses in the smaller communities in the Glacier Bay area. The employment and income losses could be up to 20% in Gustavus, a major adverse effect.

Impairment Analysis for Local and Regional Socioeconomics – Alternative 4. Socioeconomics is not a park resource and so is not subject to the non-impairment standard.

Potential Mitigation Measures for Local and Regional Socioeconomics – Alternative 4. Mitigation measures under alternative 4 are similar to those identified under alternative 2. Using the preferred operator criteria (36 CFR 13.83) for selecting charter vessel permits could mitigate effects to Gustavus, Hoonah, Elfin Cove, and Pelican to some extent.

Conclusion, Local and Regional Socioeconomics – Alternative 4. Implementation of alternative 4 would result in major adverse direct and indirect effects to local and regional economies. Cumulative adverse effects would be moderate; therefore, mitigation measures could alleviate this effect to some extent. Impairment does not apply to this topic. The overall effect of this alternative on local and regional socioeconomics would be major adverse effects, depending on the location.

Alternative 5 – Effects on Local and Regional Socioeconomics. Under alternative 5, cruise ship entries would remain at 139 from June through August and would be limited to 92 in May and September. (Under current regulations, up to 62 cruise ships can enter the Bay in May and 60 may enter in September.) This alternative also includes additional vessel operating requirements on vessel speeds, location of whale waters, and pollution control measures. In Dundas Bay, no cruise ships would be allowed; one tour vessel per day would be allowed in the lower Bay only; charter vessels would not have a daily limit, but would be allowed 276 total use days; and private vessels would have unlimited entries.

Direct and Indirect Effects on Local and Regional Socioeconomics – Alternative 5. The economic effects of alternative 5 generally would be similar to those described under alternative 1. That is, there would be negligible effects on local economies and businesses. Regarding effects on cruise lines, the reduced number of May and September cruise ship entries exceeds the actual number of cruise ship entries during those two months in 2001; therefore, the economic effects would be negligible.

The changes in Dundas Bay management included in alternative 5 could have minor positive economic effects on commercial users of Dundas Bay. Dundas Bay is typically a secondary attraction or destination for charter boat visitors, many of whom are in the area primarily to saltwater sport fish from lodges in Elfin Cove. Primary saltwater sport-fishing areas are in the Cross Sound area; however, Dundas Bay is an important alternative destination when bad weather pushes the charter boats off the prime fishing grounds, and for wildlife viewing, crab fishing, and other activities. In alternative 5, charter vessels frequenting Dundas Bay will have no daily vessel quota and separate charter vessel quotas will be established for Glacier Bay. The seasonal use days limits under alternative 5 are the same as current use-day limits for charters. This should provide more flexibility for charter operators and may allow for slightly more visitation than is now occurring.

In summary, the overall direct and indirect effects of this alternative on local and regional socioeconomics would be minor positive effects.

Cumulative Effects on Local and Regional Socioeconomics – Alternative 5. Cumulative economic effects would be similar to those described under alternative 1. Alternative 5 will not produce measurable direct or indirect adverse changes in local and regional economies, therefore the cumulative economic effects are considered negligible.

Impairment Analysis for Local and Regional Socioeconomics – Alternative 5. Socioeconomics is not a park resource and so is not subject to the non-impairment standard.

Potential Mitigation Measures for Local and Regional Socioeconomics – Alternative 5. No mitigation measures are necessary for alternative 5.

Conclusion, Local and Regional Socioeconomics – Alternative 5. Implementation of alternative 5 would result in negligible adverse and minor positive direct and indirect effects to local and regional economies. Cumulative considerations would not produce any independent changes to local and regional economies. Mitigation measures would not be necessary if this alternative is implemented. Impairment does not apply to this topic. Alternative 5 would result in negligible effects on local and regional economies in Southeast Alaska.

Summary, Local and Regional Socioeconomics. Alternatives 1 and 5 would have minor effects on local communities and ports-of-call for the cruise industry. Alternatives 2 and 4 would result in major reductions in direct and indirect spending by cruise lines and passengers. Alternative 3 would provide moderate economic benefits to local communities and cruise ship ports of call. Because other economic activities such as fishing and timber harvesting are declining, the cumulative effects on the visitor industry of changes in vessel quotas would be greater than the vessel quotas alone, but would remain moderate.

4.5 MANDATORY TOPICS RELATED TO THE EFFECTS ANALYSIS

Director's Order 12 (NPS 2001a) requires that the following topics be addressed in an environmental impact statement. This section describes the topics either by reference to where they are addressed or by describing them as irrelevant to the environmental impact statement and thus excluded from the analysis.

Possible Conflicts Between the Proposal and Land Use Plans, Policies, or Controls for the Area Concerned. Establishing vessel quotas and operating requirements are consistent with existing plans. As described in chapter 1, sections 1.1.2 and 1.1.3 (purpose and need, respectively) the proposed action is prompted and required by numerous plans, policies, and laws.

Energy Requirements and Conservation Potential. While vessel fuel is the primary energy requirement related to vessel management, this environmental impact statement is not addressing that use or fuel conservation potential since both topics are outside the scope of this environmental impact statement. In addition, most vessels are designed for relatively good fuel efficiency, since fuel is often one of the greatest operating expenses for vessels.

Natural or Depletable Resource Requirements and Conservation Potential. All alternatives strive to protect natural resources, since such protection is one of the fundamental missions of the National Park Service and one of the three major goals the Park Service intends to achieve by implementing the proposed action. Potential effects on natural resources are described under each resource topic in chapter 4.

Urban Quality, Historic and Cultural Resources, and Design of the Built Environment. The proposed action involves no urban areas and is a plan that would involve actions outside of the built environment. Historic and cultural resources are addressed in chapters 3 and 4.

Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (Executive Order 12898). Presidential Executive Order 12898, "Environmental Justice," states:

> *To the greatest extent practicable and permitted by law, agencies must make achieving EJ part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects on minority populations and low-income populations in the United States and it territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.*

Environmental justice concerns the disproportionate burden of cost, or denial of benefits, to a particular minority social, economic, or ethnic group, stemming from changes in vessel management in Glacier Bay. With respect to the communities around Glacier Bay, this could include disproportionate adverse economic effects resulting from a particular management alternative, or the disproportionate denial of future economic opportunity related to motorized vessel access to Glacier Bay.

Environmental Justice – Alternative 1. As the no-action alternative, the only potential environmental justice issues would stem from the denial of economic opportunity to a particular minority group. This denial could stem from the loss of future economic opportunity that could result from increased motorized vehicle access to the Bay. The economic opportunity costs associated with alternative 1 are potentially most pronounced for the residents of Hoonah, a community with a population that is 61% Alaska Native, and with per capita income of $16,097 in 2000, which is 25% below the U.S. average of $21,587 and 29% below the Alaska average of $22,660. While Hoonah currently has little economic dependence on Glacier Bay visitor traffic, the community is looking to the visitor industry for future local economic development, including the Pt. Sophia project. Increased motorized vessel access to the Bay could facilitate those economic development efforts, or conversely, more limited access could constrain those efforts.

Environmental justice is also a concern with respect to cumulative effects. Hoonah seafood processors and fishermen are among those who have had some degree of economic dependence on commercial fishing in Glacier Bay. Commercial fishing in Glacier Bay is being phased-out, with some areas of the Bay entirely closed to commercial fishing, and other areas open only to lifetime access permit holders.

Environmental Justice – Alternatives 2, 4, and 5. The environment justice issues concerning alternatives 2, 4, and 5 are the same as those described under alternative 1. The concerns relate to reduced opportunity for the people of Hoonah to expand their local economy through visitor industry development. Hoonah does not currently have strong tourism-related linkages to Glacier Bay; however, changes in motorized vessel permits could change the community’s ability to build such linkages. Concerns around cumulative effects also are the same as described for alternative 1.

Environmental Justice – Alternative 3. There are no environmental justice concerns associated with alternative 3. Alternative 3 would provide for increased motorized vessel access to Glacier Bay. Depending on specifically how the alternative was implemented, it could afford equal opportunity for neighboring communities to benefit economically from that increased access.

Wetlands and Floodplains. As described in section 4.3.6, "Coastal/Shoreline Environment and Biological Communities," none of the actions being considered would be anticipated to have a major adverse affect to shoreline communities. The planning area contains coastal wetlands, but none are anticipated to be adversely affected by any of the alternatives. There is no known data on floodplains in the planning area.

Prime and Unique Farmlands. No prime or unique farmlands are present within the park.

Endangered or Threatened Plants and Animals and their Habitats. No endangered or threatened plants are present in the park. The endangered humpback whale and threatened Steller sea lion are discussed in depth in chapters 3 and 4.

Important Scientific, Archeological, or other Cultural Resources. One of the primary purposes of Glacier Bay National Park and Preserve is to support scientific research related to glaciating and other natural processes. Vessel traffic can and occasionally does interfere with research activities. No specific conflict or interference was identified during scoping, so no actions were considered to reduce such conflicts. Archeological and cultural resources are addressed in detail in chapters 3 and 4.

Ecologically Critical Areas, Wild and Scenic Rivers, or Other Unique Natural Resources. No wild and scenic rivers are present within the marine areas that are being evaluated. The planning area contains many ecologically critical areas, and, in fact, the entire park can be considered an ecologically critical area. Adverse effects are presented in chapter 4 under the various resource topics.

Public Health and Safety. Public health and safety are addressed in section 4.4.3 "Vessel Use and Safety."

Coastal Zone Management Act. The Coastal Zone Management Act (CZMA) of 1972 (16 USC 1451, as amended) provides assistance to states, in cooperation with federal and local agencies, for developing land and water use programs in coastal zones. Section 307 of the Coastal Zone Management Act stipulates that federal projects that affect coastal resources or uses in a state's coastal zone must be consistent to the maximum extent practicable with the relevant enforceable policies of that state's federally-approved coastal zone management plan. As "lands the use of which is by law subject solely to the discretion of…the Federal Government, its officers, or agents," the Glacier Bay National Park and Preserve is statutorily excluded from the Coastal Zone Management Act's definition of Alaska's "coastal zone" (16 USC § 1453[1]). Based on the assessment of potential effects documented in this environmental impact statement, the Park Service has determined that implementation of the proposed vessel management plan would only affect coastal resources and uses within the boundaries of federally controlled property and would have no effects outside these boundaries. Consequently, the CZMA Section 307 federal consistency requirement does not apply and coordination with the State of Alaska is not required.

Sacred Sites. Sacred sites are described in section 4.4.1 “Cultural Resources.”

Indian Trust Resources. No known Indian trust resources are present within the planning area.

4.6 UNAVOIDABLE ADVERSE EFFECTS RESULTING FROM THE PROPOSED ACTION

Under all alternatives, vessel traffic would result in air and water pollution, disturb marine birds and mammals (including the threatened humpback whale), and reduce experiences for some visitors that travel in both motorized and non-motorized vessels (such as kayaks) and that hike along the shorelines. Collisions with humpback whales and other marine mammals could occur.

Most of the effects are similar among the five alternatives, in terms of overall impact conclusions (i.e., negligible, minor, moderate, or major). Most adverse effects would occur in direct proportion to the number of vessels. Alternatives 2 and 4 have lower vessel numbers than the other alternatives and, in most cases, the magnitude of environmental effects also would be lower than would be expected for the other alternatives. Alternative 2 would allow the fewest private vessel use days among the alternatives, while alternative 4 would allow the fewest cruise ships (see chapter 2). Alternative 3 could allow an increase of up to 184 cruise ships, which is the highest being considered, and would maintain existing levels of tour, charter, and private vessels; therefore, alternative 3 has the highest level of effects on the environment. Conversely, economic benefits and visitor opportunities (in terms of total numbers) would decline with alternatives 2 and 4 due to the lower cruise ship levels.

Alternatives 4 or 5 would have new operating requirements, intended, in part, to reduce environmental effects of vessel traffic, including designated speed limits and travel lines for cruise ships that would reduce effects on humpback whales and on shoreline backcountry use.

4.6.1 Physical Environment

Soundscape. Under all alternatives, vessel noise (along with sight) would annoy some visitors seeking non-motorized experiences within the backcountry and throughout Glacier and Dundas Bays, including visitors at the tidewater glaciers. Vessel noise, such as public address systems, also can disturb visitors on other motorized vessels. Vessel noise would cause individuals or groups of fish and marine mammals to leave an area, or temporarily reduce their ability to forage or rest. Population levels of fish or marine mammals would likely lower in some areas due to vessel noise, such as at the popular destination areas of upper Glacier Bay.

Air Quality. Alternative 3 would produce the highest annual emissions, most likely increasing visibility problems. All alternatives will result in moderate effects, but implementation of alternative 4 would result in the lowest level of effects of all the alternatives. The emissions of nitrogen oxides in Glacier Bay under all alternatives would be above the 250-tons-per-year thresholds; however, based on the size of the area, the fact that all the sources are mobile and dispersed, and using Juneau's air quality for comparison, it is unlikely that these emissions would exceed air quality standards. Proposed speed restrictions and quota changes under alternatives 4 and 5 could reduce visibility problems, although increases to private vessel quotas under these alternatives would off-set some of this improvement.

Water Quality. A potential major effect to water quality would occur in the unlikely event of a large oil discharge or fuel spill. While the analysis determined that such a spill is very unlikely, the addition or reduction in vessels entering Glacier Bay may incrementally increase or decrease, respectively, the likelihood of the event over the long term. Eliminating cruise ships and tour vessels from Dundas Bay would reduce risks of accidents for these vessels in that area, which includes several areas of shallow waters and other navigational hazards.

4.6.2 Biological Environment

Threatened and Endangered Species. All alternatives would cause some individual whales and sea lions to move away from passing vessels in Glacier Bay or Dundas Bay; however, because whale distribution has been shown to be more a factor of prey abundance than avoidance of vessels, overall effects are expected to be at the individual level and, therefore, minor to moderate. Collisions with ships would be rare, but cannot be ruled out under any of the alternatives and, over time, is probably inevitable. Killing a humpback whale would be considered a major effect, even though the level of effect would still be at the individual level and would not be sufficiently severe to counter the general increasing trend in humpback whale populations. The risk and potential frequency of such collisions increases with vessel traffic increases, so alternative 3 would have the highest potential level of risk for whale deaths due to vessel strikes. Alternatives 4 and 5 include speed restrictions to 13 knots for cruise ships, a speed that has been shown to greatly reduce the likelihood of whale collisions.

Marine Mammals. Under all alternatives, marine mammals would be disturbed by vessel traffic. Vessel traffic would cause individuals to avoid areas of high vessel use. Most marine mammals are highly mobile and able to avoid vessels, but individuals may be struck and injured or killed by vessels. The context of effects are expected to be at the individual level, rather than the population level, with the possible exception of harbor seals, whose populations in Glacier Bay are declining.

Marine Birds and Raptors. Vessel traffic would disturb concentration areas of brood-rearing harlequin ducks, molting waterfowl, and foraging marbled murrelets. These species are particularly sensitive to vessel traffic and are expected to experience potential local population declines. Alternative 5, which has the highest level of private vessel use days, would also have the greatest potential for disturbing shore birds and colonial nesting birds, since these vessels can travel closer to shore than larger vessels.

Marine Fishes. Some fish may avoid areas near vessels, but no major effects are expected.

Coastal/Shoreline Environmental and Biological Communities. Implementation of any of the alternatives would have a minor effect on coastal/shoreline communities.

4.6.3 HUMAN ENVIRONMENT

4.6.3 Human Environment

Cultural Resources. From the perspective of the Huna Tlingit (scoping), vessel traffic affects ethnographic resources in the park by reducing the quality of resources and, thus, degradation of the Huna Tlingit ancestral homeland.

Visitor Experience. Visitor experience would change among the alternatives in three primary ways. First, since more than 85% of visitors to Glacier Bay experience the park on a cruise ship, changes in the numbers of cruise ships allowed would greatly affect opportunities for the most common method of viewing the Bay. Second, providing opportunity in the form of cruise ship entry also removes opportunities and reduces the quality of visits for people who wish to experience the Bay without cruise ships. Third, alternative 4 would increase opportunities for solitude and quiet in Dundas Bay and the East Arm of Glacier Bay by closing them to tour vessels. In addition, alternative 4 would limit charter vessels to three per day. Alternative 5 would provide more opportunities for charter vessels to use Dundas Bay by providing flexibility to allow more than three charters on any particular day, so long as an average of three from June to August is not exceeded.

Vessel Use and Safety. Risks of major vessel accidents resulting in large fuel spills and major loss of life are not expected. Occasional groundings with associated small fuel leaks would be expected under any of the alternatives.

Wilderness Resources. The sights and sounds of vessel traffic would change the naturalness of some wilderness areas (which include essentially all shoreline areas of Glacier and Dundas Bays). Alternative 4 would eliminate cruise ships and tour vessel use in Dundas Bay, Beardslee Entrance, and the East Arm (tour vessels would be allowed in the entrance waters), which would increase the naturalness of shoreline areas.

Local and Regional Socioeconomics. Alternative 2 would reduce direct and indirect spending by cruise lines and passengers, and the associated fees and taxes paid by cruise ship companies. Alternative 3 would benefit local communities and cruise ship ports of call by increasing cruise ship entries. Alternatives 2 and 4 could result in lost employment and local incomes due to the loss of cruise ship revenues and related employment. Alternative 4 would reduce charter and tour vessel entries, as well as associated employment.

4.7 SUSTAINABILITY AND LONG-TERM MANAGEMENT

Director's Order 12 requires that Park Service managers consider the long-term impacts and the effect of foreclosing future options from actions being considered. These are defined in two ways, as presented in the following two sections.

The Relationship between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity. This required consideration addresses the question of whether the proposed action would be providing short-term benefits at the cost of future generations.

Based on the analyses presented under the physical, biological, and human environments, no long-term loss of productivity is expected. Should vessels be banned from Glacier and Dundas Bays, most effects would immediately cease and most others would soon pass with time. Glacier Bay and Dundas Bay areas show the remarkable ability of ecosystems to recover from major changes, considering most of these areas were under a vast ice sheet just 200 years ago. Even damages from a major fuel spill, while determined to be unlikely, would eventually diminish.

In addition, the primary goals of the project, as specified in chapter 1 of this environmental impact statement, are to protect the park resources from vessel traffic, to provide high-quality opportunities to park visitors, and to simplify vessel management. All of these goals are meant to protect the park's values and resources over the long-term.

Irreversible and Irretrievable Commitments of Resources. Irreversible effects are those that cannot be reversed except in the extreme long term. An example of irreversible effects is the cutting of old growth trees. Irretrievable effects are those that are lost for a period of time. An example of irretrievable effects is loss of use of resources, such as recreational use, as a result of prohibiting access to an area to protect a sensitive wildlife species.

As stated above, most effects of vessel traffic would be eliminated immediately or soon after their removal, should such an action be taken; therefore, none of the effects described in this chapter are considered irreversible.

The proposed action, which is to set vessel quotas and operating requirements, would cause irretrievable loss of recreational opportunities, including loss for non-motorized experiences in much of Glacier and Dundas Bays, as well as loss of opportunities for people to enter the either area via cruise ship, tour vessel, charter vessel, and private vessel. Rather than recite the alternatives here, it is sufficient to note that proposed limits and closure of areas to all or some vessel types represents an irretrievable loss of access to those areas. Likewise, allowing cruise ships and other vessels access to most of the central portions of Glacier Bay represents an irretrievable loss to experience these areas in the absence of vessels.

CONSULTATION AND COORDINATION

GLACIER BAY
NATIONAL PARK AND PRESERVE, ALASKA

VESSEL QUOTAS AND OPERATING REQUIREMENTS • DRAFT ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 5. CONSULTATION AND COORDINATION

This chapter describes the history of public involvement leading up to and during development of the final EIS. Public participation in the planning process helps to ensure that the Park Service fully understands and considers the public's interest. Through public involvement, the Park Service shared information about the planning process, issues, and proposed actions. In turn, the planning teams were informed of the concerns and values of those groups and individuals who participated in the process. Also as part of public involvement and in compliance with laws and regulations, management agencies and other public constituencies were consulted. With the help of the public's involvement, the Park Service is able to make informed decisions and improved plans.

5.1 HISTORY OF PUBLIC INVOLVEMENT

The scoping period began on February 22, 2002, with publication of the Notice of Intent to Prepare an EIS in the *Federal Register* (67 *Federal Register* 8313, February 22, 2002) and ended on June 7, 2002. During the scoping period, the Park Service published a scoping newsletter in May 2002 and conducted seven public meetings in:

- Hoonah, Alaska (May 20, 2002).
- Gustavus, Alaska (May 21, 2002).
- Pelican, Alaska (May 23, 2002).
- Elfin Cove, Alaska (May 23, 2002).
- Anchorage, Alaska (May 28, 2002).
- Juneau, Alaska (May 29, 2002).
- Seattle, Washington (May 30, 2002).

A total of 83 persons attended the scoping meetings in Hoonah, Gustavus, Pelican, Elfin Cove, Juneau, Anchorage, and Seattle. The Park Service received comments during these scoping meetings and more than 5,000 electronic-mail messages, postcards, and comment letters from organizations, and private citizens.

Other scoping activities included:

- conducting an internal scoping meeting with park staff on April 18 and 19, and May 8, 2002.
- conducting a meeting with the US Biological Research Division at park headquarters on May 9, 2002, and with the National Marine Fisheries Service on May 29, 2002, in Juneau.
- conducting a meeting with representatives of the Alaska Land Act Coordinating Committee (ALACC) on June 12, 2002.

- mailing 755 brochures with scoping questionnaires (July 2002).
- publishing meeting notice advertisements in major newspapers.
- distributing flyers to all the communities where scoping meetings were conducted and mailing flyers to the harbormasters or port directors of the city or borough offices of Hoonah, Pelican, Juneau, Sitka, Petersburg, Ketchikan, Haines, and Yakutat, Alaska, as well as to the Alaska Women's Environmental Network for their electronic announcement page.
- distributing public service announcements and press releases via facsimile and electronic mail to the following newspapers and radio stations: *Alaska Business Monthly*; *Alaska Journal of Commerce*; *Alaska Magazine*; *Alaska Star*; *Anchorage Daily News*; *Anchorage Press*; *Anchorage Times*; Alaska Public Radio Network; Alaska Rural Communication Service; Associated Press; *Capital City Weekly*; *Chilkat Valley News*; Coast Alaska, Inc.; *Daily Sitka Sentinel*; *Eagle Eye News*; *Island News*; Jeanie Green Productions; *Juneau Empire*; KCAW-FM; *Ketchikan Daily News*; KINY-AM; KNBA-FM; KRBD-FM; KRSA-AM; KSKA-FM; KTKN-AM; KTOO-FM; Native Voice Communications; Reuters America; *The Alaskan Southeaster*; and *The Chamber*.
- posting the brochure and the comment form on the park's website.
- receiving comments via the website.

The Park Service established an internal team to assist in identifying significant issues and the range of alternatives for the EIS. The team consists of representatives from the park and preserve and the NPS Alaska Support Office.

Table 5-1 lists specific people and agencies contacted in the preparation of this EIS and the resources that were addressed.

TABLE 5-1: AGENCIES CONSULTED

Contact	Organization	Resource
Mary Kralovec	Glacier Bay National Park and Preserve	Marine Birds and Mammals
David Nemeth	Concessions, Glacier Bay National Park and Preserve	Air, Water
Chuck Young	Chief Ranger, Glacier Bay National Park and Preserve	Air, Water
Carolyn Morehouse	Alaska Department of Environmental Conservation	Air, Water
Bill Borrie, Ph.D.	University of Montana	Wilderness, Visitor Experience
Prof. Matt Carroll	Washington State University	Wilderness, Visitor Experience
Prof. Ed Krumpe	University of Idaho	Wilderness, Visitor Experience
Gary Drew	U.S. Geological Survey, BRD	Marine Birds
Rusty Yerxa	Glacier Bay National Park and Preserve	Marine Birds
James Bodkin	U.S. Geological Survey, BRD	Marine Birds
Steve Brockman	U.S. Fish and Wildlife Service, Ecological Services	Marine Birds
Richard Gordon	Concerned Citizen	Marine Birds
Gus van Vliet	Concerned Citizen	Marine Birds
Dan Esler	Canadian Wildlife Service	Marine Birds
Kathy Kuletz	U.S. Fish and Wildlife Service	Marine Birds
Dan Gibson	University of Alaska Museum	Marine Birds
Robert Ritchie	ABR, Inc.	Marine Birds
Michael Payne	National Marine Fisheries Service	Endangered Species
Kaja Brix	National Marine Fisheries Service	Endangered Species

5.2 MAJOR ISSUES RAISED DURING SCOPING

Many comments were received from the public during the scoping period. Major issues raised during scoping are described below.

5.2.1 Collisions with Marine Mammals. The public expressed concerns about humpback whale mortality or injury risk resulting from collisions with vessels. Many people pointed out that a pregnant humpback whale was killed by a cruise ship collision. There was also concern regarding the importance of the lower Bay and the entrance to it for the humpback whale, and the need for continued vessel quotas and speed limits in the area.

5.2.2 Effect of Noise on Whales. Public comments expressed concern about the potential for disturbing humpback whale behavior and injury risk from vessel noise.

5.2.3 Pollution Generated from Cruise Ships. Many public comments addressed the topic of the pollution generated by cruise ships, including air and water pollutants, and the potential of an oil spill in ice-filled waters. They were concerned about the effects of air pollutants from stack emissions and the effects of air pollution on visitor experience. In addition, they pointed out that an increase in vessel numbers might have a detrimental effect on the park's air and water quality, and could adversely affect many wildlife species. Public comments suggested that the EIS should consider the potential for ice damage to vessels traveling in the upper Bay and that protocol for vessel operations in ice-filled waters should be developed. In conjunction with the vessel hazards in ice-filled waters, if there were an oil spill in these areas, the public expressed concern that there are no mechanisms to clean and contain the oil. In addition, comments questioned the quality and capability of oil spill response equipment available in the park.

5.3 AGENCY CONSULTATIONS

The Park Service is not formally designating any cooperating agencies for this EIS. The final decision and its implementation are the sole responsibility of the Park Service. However, other agencies have jurisdiction under other laws that the Park Service must adhere to, and/or have special expertise or knowledge that is required for complete analysis and coordination of the alternatives. These agencies include the NOAA Fisheries (formerly known as the National Marine Fisheries Service), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Coast Guard. State, local, and tribal agencies that were consulted include the State of Alaska Office of History and Archaeology / State Historic

Preservation Officer, the Alaska Department of Fish and Game, the Alaska Department of Environmental Conservation, and the Hoonah Indian Association.

5.3.1 U.S. Fish and Wildlife Service and National Marine Fisheries Service

The Endangered Species Act of 1973, as amended, (16 USC 1531 et seq.) requires all federal agencies to consult with the U.S. Fish and Wildlife Service to ensure that any action authorized, funded, or carried out by the agency does not jeopardize the continued existence of listed species or critical habitat. Because the threatened and endangered species of concern for this EIS — the Pacific Northwest humpback whale and Steller sea lion — are marine mammals, the Park Service also is consulting with the NOAA Fisheries (National Marine Fisheries Service) under section 7 of the Endangered Species Act. The NOAA Fisheries (National Marine Fisheries Service) will issue a biological opinion that determines whether the proposed action will affect the Pacific Northwest humpback whale and Steller sea lion populations. This biological opinion will update the biological opinion issued by the NOAA Fisheries (National Marine Fisheries Service) in 1993. This EIS is intended to fulfill the information requirements for a biological assessment for section 7 consultation.

Based on the consultation with the U.S. Fish and Wildlife Service, no threatened or endangered species under their jurisdiction are present in Glacier Bay and Dundas Bay; therefore, the project would have no effect (USFWS case number 02-14V).

5.3.2 State of Alaska Office of History and Archaeology / State Historic Preservation Officer

To comply with section 106 of the 1966 National Historic Preservation Act (NHPA), as amended in 1992, and the Alaska Historic Preservation Act (1970), the Park Service is consulting with the state historic preservation officer (SHPO) regarding undertakings that may affect historic properties. The state historic preservation officer must concur that cultural resources would not be adversely affected as a result of the proposed action. This concurrence must be received before promulgation of new vessel management regulations.

On January 29, 2003, the Park Service met with the state historic preservation officer. During the meeting, it was determined that the section 106 requirements will be integrated into the EIS for this project. The Park Service sent a letter per a request by the state historic preservation officer on February 21, 2003 (see appendix J). As stated in the letter, the Park Service is consulting with the Hoonah Indian Association. The Park Service has prepared a report that documents surveys and inventories for cultural resources in the area of potential affect (APE), and is seeking concurrence with the finding of “no historic properties affected.”

5.3.3 Alaska Department of Fish and Game

The Alaska Department of Fish and Game (ADFG) holds responsibility for the overall management and protection of wildlife in the State of Alaska. The Park Service consulted with the Alaska Department of Fish and Game because of this responsibility, ADFG management activities in adjacent areas (e.g., Icy Strait), and their expertise in wildlife and fish in the park and surrounding regions. However, the Alaska Department of Fish and Game does not issue permits or exercise regulatory authority related to any actions resulting from this EIS.

5.3.4 Alaska Department of Environmental Conservation

The Park Service is consulting with the Alaska Department of Environmental Conservation, Division of Air and Water Quality, to obtain data concerning motorized vessel compliance with opacity (opaqueness), water quality, and commercial passenger vessel environmental compliance regulations in the park and Southeast Alaska. The Alaska Department of Environmental Conservation supplied recently generated reports concerning cruise ship compliance with opacity and commercial passenger vessel environmental compliance regulations and data concerning air quality in the City of Juneau.

5.3.5 Hoonah Indian Association

The Park Service is consulting with the Hoonah Indian Association regarding their concerns about the decline in the seal population in Glacier Bay and their role as a cultural resource for Glacier Bay. Other issues discussed include effects on air and water quality and the whale population.

5.4 RECIPIENTS OF THE DRAFT AND FINAL ENVIRONMENTAL IMPACT STATEMENTS

This list includes all agencies, organizations, and people who are receiving copies of this EIS.

Alaska congressional delegation:

- Congressman Don Young
- Senator Lisa Murkowski
- Senator Ted Stevens

Federal agencies:

- Alaska Public Lands Information Center
- Coast Guard
- Department of Agriculture
- Department of Interior
  - Fish and Wildlife Service

National Park Service, Alaska Region
National Park Service, Washington Office
Special Assistant to the Secretary for Alaska
Environmental Protection Agency
Marine Mammal Commission
National Oceanic and Atmospheric Administration, Fisheries
Naval Surface Warfare Center
Navy
United States Forest Service, Tongass National Forest

Native corporations and organizations:

Alaska Federation of Natives
Aukquan Traditional Council
Central Council, Tlingit and Haida Indian Tribes of Alaska
Goldbelt, Inc.
Huna Totem
Hoonah Indian Association
Indian Tribes of Alaska
Klukwan, Inc.
Kootnoowoo, Inc.
Sealaska Corporation
Shee Atik, Inc.
Sitka Tribe of Alaska
Thirteenth Regional Corporation
Yak-tat Kwaan, Inc.
Yakutat Tlingit Tribe

State of Alaska:

Alaska Department of Fish and Game
Alaska Department of Law
Alaska Department of Natural Resources
Alaska Department of Public Safety
Alaska Department of Transportation and Public Facilities
Alaska Marine Highway
Alaska State Historic Preservation Officer
Alaska State Parks
Division of Government Coordination
Governor Frank Murkowski

Other government agencies:

British Columbia Parks
City and Borough of Juneau
City and Borough of Yakutat
Hoonah Indian Association
Mayor, City of Hoonah
Mayor, City of Pelican
Pelican City Council
Parks Canada, Kluane National Park
Yukon Parks and Historic Sites

Organizations:

Alaska Center for the Environment
Alaska Conservation Alliance
Alaska Conservation Foundation
Alaska Convention and Visitor Bureau
Alaska Environmental Lobby
Alaska Mental Health Trust Land Office
Alaska Natural Heritage Program
Alaska Natural History Association
Alaska Outdoor Council
Alaska Public Interest Research Group
Alaska Quiet Rights Coalition
Alaska State Chamber of Commerce
Alaska Tourism Industry Association
Alaska Travel Industry Association
Alaska Trollers Association
Alaska Wilderness Recreation and Tourism Association
Alaska Wildlife Alliance
Alaska Wildlife Federation
Alaska Women of Wilderness
Allied Fisherman of Southeast
Anchorage Audubon Society
Angoon Community Association
Anchorage Convention and Visitors Bureau
AWRTA
Chamber of Commerce
Coastwise Pilots
Convention and Visitors Bureau
Cruise Line Agencies of Alaska
Earth Justice Legal Defense Fund
Elfin Cove Community Council
Friends of Glacier Bay
Gustavus Community Association
Gustavus Visitors Association
National Audubon Society
National Outdoor Leadership School
National Park Foundation
National Parks Conservation Association, Anchorage
National Parks Conservation Association, Washington, D.C.
National Wildlife Federation
Northwest Cruise Ship Association
Resource Development Council for Alaska, Inc.
Sealaska Heritage Foundation
Seaplane Pilots Association
Sierra Club, Alaska Field Office
Skagway Convention and Visitors Bureau
Southeast Alaska Conservation Council
Southeast Alaska Pilots Association
Southeast Alaska Tourism Council
Southeast Conference
The Conservation Fund
The Nature Conservancy of Alaska
The Thirteenth Regional Corporation

The Wilderness Society
Trustees of Alaska
Wilderness Watch
Wildlife Federation of Alaska

Businesses:

The draft EIS will be sent to businesses that fall into the following categories:

Accommodations/lodge
Charter vessel companies
Cruise ship companies
Fishing services
Flying services
Hiking services
Leisure services
Mountaineering services
Raft and kayak services
Tour vessel companies
Transportation services
Wilderness schools

Educational institutions:

Alaska Pacific University
Alaska Resource Library/Information Services
Alaska State Historical Library, Juneau
Juneau Library
University of Alaska-Anchorage
Gustavus Public Library
Z.J. Loussac Public Library

Media:

Alaska Journal of Commerce
Alaska Magazine
Alaska Welcomes You
Anchorage Daily News
Anchorage Press
Anchorage Times
APRN
Associated Press
Daily Sitka Sentinal
Jeanie Greene Productions
Juneau Empire
KCAW-FM
Ketchikan Daily News
KFQD-AM
KIMO-TV
KINY-AM
KNBA-FM
KOAHNIC Broadcast Corporation
KRBD-FM
KTKN-AM
KTOO-FM
Native Voice Communications
Reuters America

5.5 PREPARERS

Tables 5-2 and 5-3 list the people who participated in the development of this document.

TABLE 5-2: AGENCY CONTRIBUTORS

Name	Organization	Position
Chris Brockman	U.S. Department of the Interior	Alaska Region Solicitor
Joan Darnell	National Park Service, Alaska Support Office	Environmental Resources Team Manager
Glen Yankus	National Park Service, Alaska Support Office	Environmental Protection Specialist
Bud Rice	National Park Service, Alaska Support Office	Environmental Protection Specialist
Bruce Greenwood	National Park Service, Alaska Support Office	Environmental Protection Specialist
Tomie Lee	Glacier Bay National Park and Preserve	Superintendent
Nancy Swanton	Glacier Bay National Park and Preserve	EIS Project Manager
Mary Kralovec	Glacier Bay National Park and Preserve	Assistant Chief of Resource Management
Denise Healy	Glacier Bay National Park and Preserve	Administrative Assistant
Mary Beth Moss	Glacier Bay National Park and Preserve	Chief of Resource Management
Dave Nemeth	Glacier Bay National Park and Preserve	Chief of Concessions
Kris Nemeth	Glacier Bay National Park and Preserve	Chief of Interpretation
Chuck Young	Glacier Bay National Park and Preserve	Chief Ranger
Chris Gabriele	Glacier Bay National Park and Preserve	Wildlife Biologist
Janet Doherty	Glacier Bay National Park and Preserve	Biological Science Technician (Wildlife)
Wayne Howell	Glacier Bay National Park and Preserve	Cultural Resource Specialist
Rusty Yerxa	Glacier Bay National Park and Preserve	Writer/Editor
Bill Echenlaub	Glacier Bay National Park and Preserve	Database Manager
Allison Banks	Glacier Bay National Park and Preserve	Recreation Planner
Lewis Sharman	Glacier Bay National Park and Preserve	Coastal Ecologist
Chad Soiseth	Glacier Bay National Park and Preserve	Fisheries Biologist
Eric Knudsen	U.S. Geological Survey Alaska Field Office, Biological Resource Division	Chief, Marine and Freshwater Resources

TABLE 5-3: CONSULTANTS

Name	Project Role	Years Exp.	Highest Degree/Discipline	Affiliation
Steve Hall	Project Manager	15	B.S., Wildlife and Wildland Recreation Management	E & E
Louise Flynn	Assistant Project Manager	13	M.E.S./Environmental Studies	E & E
Bill Richards	Project Director	15	B.S., Environmental Science	E & E
Bruce Wattle	Air Quality	22	B.S., Atmospheric Science	E & E
Laurie Kutina	Air Quality	9	M.A., Architecture	E & E
William Daughdrill	Vessel Use and Safety	24	M.A., Public Administration	E & E
Patti Murphy	Water Quality	14	B.A., Environmental Studies / Natural History	E & E
Dawn Roderique	Quality Assurance Officer	20	M.S., Urban and Environmental Studies	E & E
Cheryl Karpowicz	Principal-in-Charge	29	B.A., Interdepartmental Studies	E & E
Elke Rank	Water Quality	3	M.S., Environmental Planning	E & E
Aarti Joshi	Alternatives	3	M.S., Urban and Environmental Planning	E & E
Jennifer Rouda	Purpose and Need / Alternatives	6	M.S., Environmental Science	E & E
Amy Liddicoat	Purpose and Need	7	B.S., Landscape Architecture	E & E
Gina Edwards	Editor	18	B.S., Communications	E & E
Hilary Hoffman	Publications	3	B.S., English	E & E
Renee Nordeen	Publications	5	N.D., Publications	E & E
Ben Martich	Effects Analysis	6	B.S., Mathematics	E & E
Bob Hardy	Editor	10	B.S., Journalism	E & E
Liza Sanden	GIS	3	B.A., Biology	E & E
John Pickering	Fjord Dynamics and Oceanic Processes / Wave Dynamics	25	M.S., Environmental Quality Engineering (thesis pending); MBA, Management and Finance; B.S., Forest Engineering; B.A., Mathematics and Physics	PND
Jennifer Wilson	Fjord Dynamics and Oceanic Processes / Wave Dynamics	8	M.S., Environmental Studies	PND
Alan Christopherson	Fjord Dynamics and Oceanic Processes / Wave Dynamics	27	M.S., Civil Engineering; B.S., Civil Engineering	PND
Orson Smith, Ph.D.	Fjord Dynamics and Oceanic Processes / Wave Dynamics	29	Ph.D., Physical Oceanography; M.S., Civil Engineering	Univ. of Alaska Anchorage
Sandra Donohue	Fjord Dynamics and Oceanic Processes / Wave Dynamics	2	B.S., Civil Engineering; M.S., Mathematics	PND
Stephen R. Braund	Cultural Resources	21	M.A., Anthropology	SRBA

TABLE 5-3: CONSULTANTS

Name	Project Role	Years Exp.	Highest Degree/Discipline	Affiliation
Roger K. Harritt	Cultural Resources	23	Ph.D., Anthropology	SRBA
Elizabeth D. Grover	Cultural Resources	7	M.A., Anthropology	SRBA
John Richardson	Marine Mammals	25	Ph.D., Animal Behavior	LGL
Charles Malme	Acoustics	43	E.E., Acoustics	LGL
Mike Williams	Marine Mammals	15	M.S., Zoology	LGL
Steve Maclean	Marine Mammals	10	M.S., Wildlife and Fisheries	LGL
Howard Teas	Marine Fish and Benthic Invertebrates	20	M.A., Marine Sciences	LGL
Bob Day	Marine Birds	25	Ph.D., Oceanography	ABR
Steve McCool	Wilderness and Visitor Experience	32	Ph.D., Recreation Management	University of Montana
Chuck Besacon	Wilderness and Visitor Experience	5	Ph.D., In Progress	Independent Consultant
Susan Bell	Visitor Experience	20	N.D., Public Relations	McDowell
Jim Calvin	Socioeconomic Analysis	15	M.S., Mineral Economics	McDowell

Affiliations Key:
- ABR = Alaska Biological Resources, Inc.
- E & E = Ecology and Environment, Inc.
- LGL = LGL Alaska Research Associates.
- McDowell = McDowell Group.
- PND = Peratrovich, Nottingham, & Drage, Inc.
- SRBA = Stephen R. Braund and Associates.

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6.3 Glossary

°C – degrees Celsius
°F – degrees Fahrenheit
μPa – micropascal
AAC – Alaska Administrative Code
ABSC – Alaska Biological Science Center
ACHP – Advisory Council on Historic Preservation
AD – Anno Domini
ADCED – Alaska Department of Community and Economic Development
ADEC – Alaska Department of Environmental Conservation
ADFG – Alaska Department of Fish and Game
ADLWD – Alaska Department of Labor and Workforce Development
ADNR – Alaska Department of Natural Resources
ACFEC – Commercial Fisheries Entry Commission
AHRS – Alaska Heritage Resource Survey
AIRFA – American Indian Religious Freedom Act
ANCSA – Alaska Native Claims Settlement Act
ANILCA – Alaska National Interest Lands Conservation Act (1980)
AOU – American Ornithologist's Union
APE – area of potential effect
AQI – Air Quality Index
AQRV – Air Quality Related Values
ARPA – Archaeological Resources Protection Act
ATIA – Alaska Travel Industry Association
AVHRR – Advanced Very High Resolution Radiometry
BMP – best management practice
bpd –barrels per day
CAA – Clean Air Act
CEQ – Council on Environmental Quality
CFR – Code of Federal Regulations
CLAA – Cruise Line Agency of Alaska
CLI – Cultural Landscapes Inventory
CLIA – Cruise Lines International Association
CO – carbon monoxide
CO_2 – carbon dioxide
COLREG – International Regulations for Preventing Collisions at Sea
COW – California/Oregon/Washington (stock)
CPVEC – Commercial Passenger Vessel Environmental Compliance (Program)
CR – critical ratios
Ct. Cl –Court Civil Law
CWA – Clean Water Act; i.e., Federal Water Pollution Control Act
CZMA – Coastal Zone Management Act
dB – decibel
dB re 1 μPa – decibels relative to 1 micropascal
DEIS – draft environmental impact statement
Department of Environmental Conservation, the – Alaska Department of Environmental Conservation
Department of Fish and Game, the – Alaska Department of Fish and Game
Department of Interior, the – U.S. Department of Interior
DOJ – U.S. Department of Justice
DOT – U.S. Department of Transportation
double thermocline – four layers of water
Dundas Bay – all contiguous marine waters with Dundas Bay lying north of an imaginary line between Point Dundas and Point Wimbledon
e.g. – *exempli gratia,* for example
EA – environmental assessment
EEZ – Exclusive Economic Zone
EFH – essential fish habitat
EIS – environmental impact statement
ENP – eastern north Pacific (stock)
Environmental Protection Agency, the – U.S. Environmental Protection Agency
EPA – U.S. Environmental Protection Agency
et seq. – *et sequentes*, and the following
Executive Order 12898 –Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
FEIS – final environmental impact statement
Fish and Wildlife Service, the – U.S. Fish and Wildlife Service
Fisheries Service, the – National Marine Fisheries Service
FMP – fishery management plan

FONSI – finding of no significant impact
GAO – General Accounting Office
GBNPP – Glacier Bay National Park and Preserve
GIS – geographic information system
Glacier Bay – Glacier Bay proper; all marine waters contiguous with Glacier Bay lying north of an imaginary line between Point Gustavus and Point Carolus
GPS – Global Positioning System
GT – gross tons
HAL – Holland America Line
HAZWOPER – Hazardous Waste Operations and Emergency Response
HC – hydrocarbons
HIA – Hoonah Indian Association
HSR – historic structural resources
Hz – hertz
i.e. – *id est,* that is
IBP – incidental business permits (which is correct)
ICCL – International Council of Cruise Lines
IFO – intermediate fuel oil
isostatic rebound – the rising of land after the removal of glacial weight as the glacier retreats
IWC – International Whaling Commission
JCVB – Juneau Convention and Visitors Bureau
kHz – kilohertz
kWh – kilowatt-hour
lbs/day – pounds per day
LCS – List of Classified Structures
L_s – ? (see table 3-1b – needs key)
Magnuson-Stevens Act – Magnuson-Stevens Fishery Conservation and Management Act
MARPOL – The International Convention for the Prevention of Pollution from Ships
mixed semidiurnal tidal cycle – two high and two low tides per day of unequal heights
MLLW – mean lower low water
MMPA – Marine Mammal Protection Act of 1972
MSD – marine sanitation devices
NA – Not applicable
NAAQS – National Ambient Air Quality Standards
NAGPRA – Native American Graves Protection and Repatriation Act
NCHPO – National Conference of Historic Preservation Officers
n.d. – no date
NEPA – National Environmental Policy Act of 1969
NESHAPS – National Emission Standards for Hazardous Air Pollutants
NHPA – National Historic Preservation Act
NiCad – nickel-cadmium
NMFS – National Marine Fisheries Service (not NOAA Fisheries)
NO_2 – nitrogen dioxide
NOI – notice of intent
NOAA – National Oceanic and Atmospheric Administration (formerly NMFS)
NOV – notice of violation
NO_X – nitrogen oxides
NPS – National Park Service
NSWC – Naval Surface Warfare Center
NWPS – National Wilderness Preservation System
O_3 – ozone
OCS – Outer Continental Shelf
OPA – Oil Pollution Act (1990)
Organic Act – National Park Service Act of 1916
OSRO – oil spill removal organization
P.L. – public law
Park Service, the – National Park Service
park, the – Glacier Bay National Park
Pb – lead
PERC – perchloroethylene
PL – Public Law
planning area, the – the two areas of Glacier Bay and Dundas Bay evaluated in this environmental impact statement
PM – particulate matter
PM_{10} – particulate matter of 10 microns or less
$PM_{2.5}$ – particulate matter of 2.5 microns or less
PND – Peratrovich, Nottingham, and Drage, Inc.
PSD – Prevention of Significant Deterioration
PTS – permanent threshold shift
RAC – response action contractor
RCRA – Resource Conservation and Recovery Act
rms – root mean squared. The integration of the noise pulse divided by the duration of the pulse. The duration of the pulse can be an arbitrary value; therefore, rms refers to the fact that most acousticians now

determine the duration of the pulse by the amount of time in which 90 % of the energy of the pulse is received.

ROD – record of decision

SAIP – System-Wide Archaeological Inventory Program

SEAPRO – Southeast Alaska Petroleum Resource Organization

Service, the – National Park Service

SHPO – state historic preservation officer

sill – a shoal of underwater glacial deposit

SO_2 – sulfur dioxide

SOA – *Spirit of Adventure*

SOPEP – Shipboard Oil Pollution Emergency Plan

SPCC – spill prevention control and countermeasures

Stat. – statute

STCW – International Convention on Standards of Training, Certification and Watchkeeping

TCP – traditional cultural properties

thermocline – stratification

TL – transmission loss

TPY – tons per year

TTS – temporary threshold shift

USC – United States Code

USCG – U.S. Coast Guard

USDI – U.S. Department of Interior

USFS – U.S. Forest Service

USFWS – U.S. Fish and Wildlife Service

USGS – U.S. Geological Survey

W/m^2 – watts per square meter

WTTC – World Travel and Tourism Council

6.4 Index

GLACIER BAY

NATIONAL PARK AND PRESERVE, ALASKA

VESSEL QUOTAS AND OPERATING REQUIREMENTS • DRAFT ENVIRONMENTAL IMPACT STATEMENT

APPENDIX A

36 Code of Federal Regulations 13.65
Vessel Operating Requirements for Glacier Bay National Park and Preserve

§ 13.65 Glacier Bay National Park and Preserve.

(a) *Commercial fishing: authorizations, closures and restrictions*—(1) *What terms do I need to know?* (i) *Commercial fishing* means conducting fishing activities under the appropriate commercial fishing permits and licenses as required and defined by the State of Alaska.

(ii) *Glacier Bay* means all marine waters within Glacier Bay National Park, including coves and inlets, north of an imaginary line drawn from Point Gustavus to Point Carolus.

(iii) *Outer waters* means all of the non-wilderness marine waters of the park located outside of Glacier Bay.

(2) *Is commercial fishing authorized in the marine waters of Glacier Bay National Park?* Yes—Commercial fishing is authorized within the outer waters of the park and within the non-wilderness waters of Glacier Bay, subject to the provisions of this chapter.

(i) Commercial fishing shall be administered pursuant to A cooperatively developed State/federal park fisheries management plan, international conservation and management treaties, and existing federal and Non-conflicting State law. The management plan shall provide for the protection of park values and purposes, the prohibition on any new or expanded fisheries, and the opportunity to study marine resources.

(ii) Commercial fishing or conducting an associated buying or processing operation in wilderness waters is prohibited.

(iii) A new or expanded fishery is prohibited. The Superintendent shall compile a list of the existing fisheries and gear types used in the outer waters and follow the procedures in §§ 1.5 and 1.7 of this chapter to inform the public.

(iv) Maps and charts showing which marine areas of Glacier Bay are closed to commercial fishing are available from the Superintendent.

(3) *What types of commercial fishing are authorized in Glacier Bay?* Three types of commercial fishing are authorized in Glacier Bay non-wilderness waters: longline fishing for halibut; pot and ring fishing for Tanner crab; and trolling for salmon.

(i) All other commercial fishing, or a buying or a processing operation not related to an authorized fishery is prohibited in Glacier Bay.

(ii) On October 1, 2000, each fishery will be limited to fishermen who qualify for a non-transferable commercial fishing lifetime access permit (see paragraph (a)(4) of this section). Commercial fishing without a permit issued by the superintendent, or other than in accordance with the terms and conditions of the permit, is prohibited.

(iii) The Superintendent shall include in a permit the terms and conditions that the superintendent deems necessary to protect park resources. Violating a term or condition of the permit is prohibited.

(4) Who is *eligible for a Glacier Bay commercial fishing lifetime access permit?* A Glacier Bay commercial fishing lifetime access permit will be issued by the superintendent to fishermen who have submitted documentation to the superintendent, on or before October 1, 2000, which demonstrates to the satisfaction of the superintendent that:

(i) They possess valid State limited entry commercial fishing permits for the district or statistical area encompassing Glacier Bay for each fishery for which a lifetime access permit is being sought; and,

(ii) They have participated as limited entry permit holders for the district or statistical area encompassing Glacier Bay for each fishery for which a lifetime access permit is being sought.

(A) For the Glacier Bay commercial halibut fishery, the Applicant must have participated as a permit holder for at least two years during the period 1992–1998.

(B) For the Glacier Bay salmon or Tanner crab commercial fisheries, the applicant must have participated as a permit holder for at least three years during the period 1989–1998.

(5) *What documentation is required to apply for a commercial fishing lifetime access permit?* The required documentation includes:

(i) The applicants full name, date of birth, mailing address and phone number;

(ii) A notarized affidavit, sworn by the applicant, attesting to his or her history of participation as a limited permit holder in Glacier Bay, during the qualifying period, for each fishery for which a lifetime access permit is being sought;

(iii) A copy of the applicant's current State of Alaska limited entry permit and in the case of halibut an International Pacific Halibut Commission quota share, that is valid for the area that includes Glacier Bay, for each fishery for which a lifetime access permit is sought;

(iv) Proof of the applicant's permit and quota share history for the Glacier Bay fishery during the qualifying period;

(v) Documentation of commercial landings for the Glacier Bay fishery during the qualifying periods, i.e., within the statistical unit or area that includes Glacier Bay: for halibut, regulatory sub-area 184; for Tanner crab, statistical areas 114–70 through 114–77. For salmon, the superintendent will consider landing reports from District 114; however, the superintendent may require additional documentation that supports the applicant's declaration of Glacier Bay salmon landings. For halibut and Tanner crab, the superintendent may consider documented commercial landings from the unit or area immediately adjacent to Glacier Bay (in Icy Strait) if additional documentation supports the applicant's declaration that landings occurred in Glacier Bay.

(vi) Any additional corroborating documentation that might assist the superintendent in a timely determination of eligibility for the access permits.

(6) *Where should the documentation for a lifetime access permit be sent?* Before October 1, 2000, all required information (as listed in paragraph (a)(5) of this section) should be sent to: Superintendent, Attn: Access Permit Program, Glacier Bay National Park and Preserve, P.O. Box 140, Gustavus, Alaska 99826.

(7) *Who determines eligibility?* The superintendent will make a written determination of an applicant's eligibility for the lifetime access permit based on information provided. A copy of the determination will be mailed to the applicant. If additional information is required to make an eligibility determination, the applicant will be notified in writing of that need and be given an opportunity to provide it.

(8) *Is there an appeals process if a commercial fishing lifetime access permit application is denied?* Yes—If an applicant's request for an a commercial fishing lifetime access permit is denied, the superintendent will provide the applicant with the reasons for the denial in writing within 15 days of the decision. The applicant may appeal to the Regional Director, Alaska Region, within 180 days. The appeal must substantiate the basis of the applicant's disagreement with the Superintendent's determination. The Regional Director (or his representative) will meet with the applicant to discuss the appeal within 30 days of receiving the appeal. Within 15 days of receipt of written materials and the meeting, if requested, the Regional Director will affirm, reverse, or modify the Superintendent's determination and explain the reasons for the decision in writing. A copy of the decision will be forwarded promptly to the applicant and will be the final agency action.

(9) *How often will commercial fishing lifetime access permit be renewed?* The superintendent will renew lifetime access permit at 5-year intervals for the lifetime of a permittee who continues to hold a valid State limited entry commercial fishing permit, and for halibut an International Pacific Halibut Commission quota share, and is otherwise eligible to participate in the fishery under federal and State law.

(10) *What other closures and restrictions apply to commercial fishermen and commercial fishing vessels?*—The following are prohibited:

(i) Commercial fishing in the waters of Geikie, Tarr, Johns Hopkins and Reid Inlets.

(ii) Commercial fishing in the waters of the west arm of Glacier Bay north of 58°50′N latitude, except commercial fishermen who have been authorized by the superintendent to troll for salmon may troll for king salmon during the period October 1 through April 30, in compliance with state commercial fishing regulations.

(iii) Commercial fishing in the east arm of Glacier Bay, north of an imaginary line running from Point Caroline through the southern point of Garforth

Island and extending to the east side of Muir Inlet, except commercial fishermen who have been authorized by the superintendent to troll for salmon may troll for king salmon south of 58°50′N latitude during the period October 1 through April 30, in compliance with state commercial fishing regulations.

(b) *Resource protection and vessel management*—(1) *Definitions.* As used in this section:

Charter vessel means any motor vessel under 100 tons gross (U.S. System) or 2,000 tons gross (International Convention System) that is rated to carry up to 49 passengers, and is available for hire on an unscheduled basis; except a charter vessel used to provide a scheduled camper or kayak drop off service.

Commercial fishing vessel means any motor vessel conducting fishing activities under the appropriate commercial fishing licenses as required and defined by the State of Alaska.

Cruise ship means any motor vessel at or over 100 tons gross (U.S. System) or 2,000 tons gross (International Convention System) carrying passengers for hire.

Entry means each time a motor vessel passes the mouth of Glacier Bay into the bay; each time a private vessel activates or extends a permit; each time a motor vessel based at or launched from Bartlett Cove leaves the dock area on the way into Glacier Bay, except a private vessel based at Bartlett Cove that is gaining access or egress to or from outside Glacier Bay; the first time a local private vessel uses a day of the seven use-day permit; or each time a motor vessel is launched from another vessel within Glacier Bay, except a motor vessel singularly launched from a permitted motor vessel and operated only while the permitted vessel remains at anchor, or a motor vessel launched and operated from a permitted motor vessel while that vessel is not under way and in accordance with a concession agreement.

Glacier Bay means all marine waters contiguous with Glacier Bay, lying north of an imaginary line between Point Gustavus and Point Carolus.

Motor vessel means any vessel, other than a seaplane, propelled or capable of being propelled by machinery (including steam), whether or not such machinery is the principal source of power, except a skiff or tender under tow or carried on board another vessel.

Operate or *Operating* includes the actual or constructive possession of a vessel or motor vessel.

Private vessel means any motor vessel used for recreation that is not engaged in commercial transport of passengers, commercial fishing or official government business.

Pursue means to alter the course or speed of a vessel or a seaplane in a manner that results in retaining a vessel, or a seaplane operating on the water, at a distance less than one-half nautical mile from a whale.

Speed through the water means the speed that a vessel moves through the water (which itself may be moving); as distinguished from ''speed over the ground.''

Tour vessel means any motor vessel under 100 tons gross (U.S. System) or 2,000 tons gross (International Convention System) that is rated to carry more than 49 passengers, or any smaller vessel that conducts tours or provides transportation at regularly scheduled times along a regularly scheduled route.

Transit means to operate a motor vessel under power and continuously so as to accomplish one-half nautical mile of littoral (*i.e.*, along the shore) travel.

Vessel includes every type or description of craft used as a means of transportation on the water, including a buoyant device permitting or capable of free flotation and a seaplane while operating on the water.

Vessel use-day means any continuous period of time that a motor vessel is in Glacier Bay between the hours of 12 midnight on one day to 12 midnight the next day.

Whale means any humpback whale (*Megaptera novaeangliae*).

Whale waters means any portion of Glacier Bay, designated by the superintendent, having a high probability of whale occupancy, based upon recent sighting and/or past patterns of occurrence.

(2) *Permits.* The superintendent will issue permits for private motor vessels in accordance with this part and for cruise ships, tour vessels, and charter vessels in accordance with National

Park Service concession authorizations and this part.

(i) *Private vessel permits and conditions.* Each private motor vessel must have a permit to enter Glacier Bay June 1 through August 31.

(A) The superintendent may establish conditions regulating how permits can be obtained, whom a vessel operator must contact when entering or leaving Glacier Bay, designated anchorages, the maximum length of stay in Glacier Bay, and other appropriate conditions.

(B) June 1 through August 31, upon entering Glacier Bay through the mouth, the operator of a private motor vessel must report directly to the Bartlett Cove Ranger Station for orientation.

(*1*) Failing to report as required is prohibited.

(*2*) The superintendent may waive this requirement before or upon entry.

(ii) *Commercial vessel permits and conditions.* Each commercially operated motor vessel must have the required permit(s) to enter Glacier Bay.

(A) To obtain or renew an entry permit, a cruise ship company must submit and, after approval, implement a pollution minimization plan. The plan must ensure, to the fullest extent possible, that any ship permitted to travel within Glacier Bay will apply the industry's best approaches toward vessel oil-spill response planning and prevention and minimization of air and underwater noise pollution while operating in Glacier Bay. The superintendent will approve or disapprove the plan.

(B) Each cruise ship company must assess the impacts of its activities on Glacier Bay resources pursuant to the NPS research, inventory and monitoring plan as specified in the applicable concession permit.

(C) The superintendent at any time may impose operating conditions to prevent or mitigate air pollution, water pollution, underwater noise pollution or other effects of cruise ship operation.

(D) The superintendent will immediately suspend the entry permit(s) of any cruise ship that fails to submit, implement or comply with a pollution minimization plan or additional operating condition.

(E) A commercial vessel, except a commercial fishing vessel, is prohibited from entering Glacier Bay unless the operator notifies the Bartlett Cove Ranger Station of the vessel's entry immediately upon entry or within the 48 hours before entry.

(F) Off-boat activity from a commercial vessel is prohibited, unless the superintendent allows it under conditions that the superintendent establishes.

(iii) *Exceptions from entry permit requirement.* A permit is not required to enter Glacier Bay when:

(A) A motor vessel is engaged in official business of the state or federal government.

(B) A private motor vessel based at Bartlett Cove is transiting between Bartlett Cove and waters outside Glacier Bay, or is operated in Bartlett Cove in waters bounded by the public and administrative docks.

(C) A motor vessel is singularly launched from a permitted motor vessel and operated only while the permitted motor vessel remains at anchor, or a motor vessel is launched and operated in accordance with a concession agreement from a permitted motor vessel while that vessel is not underway.

(D) A commercial fishing vessel otherwise permitted under all applicable authorities is actually engaged in commercial fishing within Glacier Bay.

(E) The superintendent grants a vessel safe harbor at Bartlett Cove.

(iv) *Prohibitions.* (A) Operating a motor vessel in Glacier Bay without a required permit is prohibited.

(B) Violating a term or condition of a permit or an operating condition or restriction issued or imposed pursuant to this chapter is prohibited.

(C) The superintendent may immediately suspend or revoke a permit or deny a future permit request as a result of a violation of a provision of this chapter.

(v) *Restrictions on vessel entry.* The superintendent will allow vessel entry in accordance with the following table:

Type of vessel	Allowable vessel use days per day	Total entries allowed	Total vessel use days allowed	Period covered by limitation
Cruise ship	2	(1)	(1)	Year round.
Tour vessel	3	....	....	Year round.
Charter vessel	6	312	552	June 1–Aug. 31.
Private vessel	25	468	1,971	June 1–Aug. 31.

[1] See paragraphs (b)(2)(v) (A) through (C) of this section.

(A) By October 1, 1996, the superintendent will reinitiate consultation with the National Marine Fisheries Service (NMFS) and request a biological opinion under section 7 of the Endangered Species Act. The superintendent will request that NMFS assess and analyze any effects of vessel traffic authorized by this section, on the endangered and threatened species that occur in or use Glacier Bay National Park and Preserve.

(*1*) Based on this biological opinion, applicable authority, and any other relevant information, the director shall reduce the vessel entry and use levels for any or all categories of vessels in this section effective for the 1998 season or any year thereafter, if required to assure protection of the values and purposes of Glacier Bay National Park and Preserve.

(*2*) The director will publish a document in the FEDERAL REGISTER on any revision in the number of seasonal entries and use days under this paragraph (b)(2)(v), with an opportunity for public comment.

(B) By October 1, 1997, the superintendent will determine, with the director's approval, whether studies have been completed and sufficient scientific and other information has been developed to support an increase in cruise ship entries for the 1998 summer season (June 1 through August 31) while assuring protection of the values and purposes of Glacier Bay National Park and Preserve. Any increase will be subject to the maximum daily limit of two vessel use-days. If the superintendent recommends an increase, the superintendent will publish a document of the increase in the FEDERAL REGISTER with an opportunity for public comments.

(C) By October 1 of each year (beginning in 1998), the superintendent will determine, with the director's approval, the number of cruise ship entries for the following summer season (June 1 through August 31). This determination will be based upon available scientific and other information and applicable authorities. The number will be subject to the maximum daily limit of two vessel use-days. The superintendent will publish a document of any revision in seasonal entries in the FEDERAL REGISTER with an opportunity for public comment.

(D) Nothing in this paragraph will be construed to prevent the superintendent from taking any action at any time to assure protection of the values and purposes of Glacier Bay National Park and Preserve.

(3) *Operating restrictions.* (i) Operating a vessel within one-quarter nautical mile of a whale is prohibited, except for a commercial fishing vessel actually trolling or setting or pulling long lines or crab pots as otherwise authorized by the superintendent.

(ii) The operator of a vessel accidentally positioned within one-quarter nautical mile of a whale shall immediately slow the vessel to ten knots or less, without shifting into reverse unless impact is likely. The operator shall then direct or maintain the vessel on as steady a course as possible away from the whale until at least one-quarter nautical mile of separation is established. Failure to take such action is prohibited.

(iii) Pursuing or attempting to pursue a whale is prohibited.

(iv) *Whale water restrictions.* (A) May 15 through August 31, the following Glacier Bay waters are designated as whale waters.

(*1*) Lower bay waters, defined as waters north of an imaginary line drawn from Point Carolus to Point Gustavus; and south of an imaginary line drawn from the northernmost point of Lars Island across the northernmost point of Strawberry Island to the point where it intersects the line that defines the Beardslee Island group, as described in paragraph (b)(3)(vii)(A)(*4*) of this section, and following that line south and west to the Bartlett Cove shore.

(*2*) [Reserved]

(B) June 1 through August 31, the following Glacier Bay waters are designated as whale waters.

(*1*) Whidbey Passage waters, defined as waters north of an imaginary line drawn from the northernmost point of Lars Island to the northernmost point of Strawberry Island; west of imaginary lines drawn from the northernmost point of Strawberry Island to the southernmost point of Willoughby Island, the northernmost point of Willoughby Island (proper) to the southernmost point of Francis Island, the northernmost point of Francis Island to the southernmost point of Drake Island; and south of the northernmost point of Drake Island to the northernmost point of the Marble Mountain peninsula.

(*2*) East Arm Entrance waters, defined as waters north of an imaginary line drawn from the southernmost point of Sebree Island to the northernmost point of Sturgess Island, and from there to the westernmost point of the unnamed island south of Puffin Island (that comprises the south shore of North Sandy Cove); and south of an imaginary line drawn from Caroline Point across the northernmost point of Garforth Island to shore.

(*3*) Russell Island Passage waters, defined as waters enclosed by imaginary lines drawn from: the easternmost point of Russell Island due east to shore, and from the westernmost point of Russell Island due north to shore.

(C) The superintendent may designate temporary whale waters and impose motor vessel speed restrictions in whale waters. Maps of temporary whale waters and notice of vessel speed restrictions imposed pursuant to this paragraph (b)(3)(iv)(C) shall be made available to the public at park offices at Bartlett Cove and Juneau, Alaska, and shall be submitted to the U.S. Coast Guard for publication as a ''Notice to Mariners.''

(D) Violation of a whale water restriction is prohibited. The following restrictions apply in designated whale waters:

(*1*) Except on vessels actually fishing as otherwise authorized the superintendent or vessels operating solely under sail, while in transit, operators of motor vessels over 18 feet in length will in all cases where the width of the water permits, maintain a distance of at least one nautical mile from shore, and, in narrower areas will navigate in mid-channel: *Provided, however,* that unless other restrictions apply, operators may perpendicularly approach or land on shore (*i.e.*, by the most direct line to shore) through designated whale waters.

(*2*) Motor vessel speed limits established by the superintendent pursuant to paragraph (b)(3)(iv)(C) of this section.

(v) *Speed restrictions.* (A) May 15 through August 31, in the waters of the lower bay as defined in paragraph (b)(3)(iv)(A)(*1*) of this section, the following are prohibited:

(*1*) Operating a motor vessel at more than 20 knots speed through the water; or

(*2*) Operating a motor vessel at more than 10 knots speed through the water, when the superintendent has designated a maximum speed of 10 knots (due to the presence of whales).

(B) July 1 through August 31, operating a motor vessel on Johns Hopkins Inlet south of 58°54.2′N. latitude (an imaginary line running approximately due west from Jaw Point) at more than 10 knots speed through the water is prohibited.

(vi) *Closed waters, islands and other areas.* The following are prohibited:

(A) Operating a vessel or otherwise approaching within 100 yards of South Marble Island; or Flapjack Island; or any of the three small unnamed islets approximately one nautical mile southeast of Flapjack Island; or Eider Island; or Boulder Island; or Geikie Rock; or Lone Island; or the northern three-fourths of Leland Island (north of 58°39.1′N. latitude; or any of the four small unnamed islands located approximately one nautical mile north (one island), and 1.5 nautical miles east (three islands) of the easternmost point of

Russell Island; or Graves Rocks (on the outer coast); or Cormorant Rock, or any adjacent rock, including all of the near-shore rocks located along the outer coast, for a distance of 1½ nautical miles, southeast from the mouth of Lituya Bay; or the surf line along the outer coast, for a distance of 1½ nautical miles northwest of the mouth of the glacial river at Cape Fairweather.

(B) Operating a vessel or otherwise approaching within 100 yards of a Steller (northern) sea lion (*Eumetopias jubatus*) hauled-out on land or a rock or a nesting seabird colony: *Provided, however,* that vessels may approach within 50 yards of that part of South Marble Island lying south of 58°38.6′N. latitude (approximately the southern one-half of South Marble Island) to view seabirds.

(C) May 1 through August 31, operating a vessel, or otherwise approaching within ¼ nautical mile of, Spider Island or any of the four small islets lying immediately west of Spider Island.

(D) May 1 through August 31, operating a cruise ship on Johns Hopkins Inlet waters south of 58°54.2′N. latitude (an imaginary line running approximately due west from Jaw Point).

(E) May 1 through June 30, operating a vessel or a seaplane on Johns Hopkins Inlet waters south of 58°54.2′N. latitude (an imaginary line running approximately due west from Jaw Point).

(F) July 1 through August 31, operating a vessel or a seaplane on Johns Hopkins Inlet waters south of 58°54.2′N. latitude (an imaginary line running approximately due west from Jaw Point), within ¼ nautical mile of a seal hauled out on ice; except when safe navigation requires, and then with due care to maintain the ¼ nautical mile distance from concentrations of seals.

(G) Restrictions imposed in this paragraph (b)(3)(vi) are minimum distances. Park visitors are advised that protection of park wildlife may require that visitors maintain greater distances from wildlife. *See,* 36 CFR 2.2 (Wildlife protection).

(vii) *Closed waters, motor vessels and seaplanes.* (A) May 1 through September 15, operating a motor vessel or a seaplane on the following water is prohibited:

(*1*) Adams Inlet, east of 135°59.2′W. longitude (an imaginary line running approximately due north and south through the charted (*5*) obstruction located approximately 2¼ nautical miles east of Pt. George).

(*2*) Rendu Inlet, north of the wilderness boundary at the mouth of the inlet.

(*3*) Hugh Miller complex, including Scidmore Bay and Charpentier Inlet, west of the wilderness boundary at the mouth of the Hugh Miller Inlet.

(*4*) Waters within the Beardslee Island group (except the Beardslee Entrance), that is defined by an imaginary line running due west from shore to the easternmost point of Lester Island, then along the south shore of Lester Island to its western end, then to the southernmost point of Young Island, then north along the west shore and east along the north shore of Young Island to its northernmost point, then at a bearing of 15° true to an imaginary point located one nautical mile due east of the easternmost point of Strawberry Island, then at a bearing of 345° true to the northernmost point of Flapjack Island, then at a bearing of 81° true to the northernmost point of the unnamed island immediately to the east of Flapjack Island, then southeasterly to the northernmost point of the next unnamed island, then southeasterly along the (Beartrack Cove) shore of that island to its easternmost point, then due east to shore.

(B) June 1 through July 15, operating a motor vessel or a seaplane on the waters of Muir Inlet north of 59°02.7′N. latitude (an imaginary line running approximately due west from the point of land on the east shore approximately 1 nautical mile north of the McBride Glacier) is prohibited.

(C) July 16 through August 31, operating a motor vessel or a seaplane on the waters of Wachusett Inlet west of 136°12.0′W longitude (an imaginary line running approximately due north from the point of land on the south shore of Wachusett Inlet approximately 2¼ nautical miles west of Rowlee Point) is prohibited.

(viii) *Noise restrictions.* June 1 through August 31, except on vessels in transit or as otherwise permitted by the superintendent, the use of generators or other non-propulsive motors (except a windless) is prohibited from 10:00 p.m. until 6:00 a.m. in Reid Inlet, Blue Mouse Cove and North Sandy Cove.

(ix) *Other restrictions.* Notwithstanding any other provision of this part, due to the rapidly emerging and changing ecosystems of, and for the protection of wildlife in Glacier Bay National Park and Preserve, including but not limited to whales, seals, sea lions, nesting birds and molting waterfowl:

(A) Pursuant to §§1.5 and 1.6 of this chapter, the superintendent may establish, designate, implement and enforce restrictions and public use limits and terminate such restrictions and public use limits.

(B) The public shall be notified of restrictions or public use limits imposed under this paragraph (b)(3)(ix) and the termination or relaxation of such, in accordance with §1.7 of this chapter, and by submission to the U.S. Coast Guard for publication as a ''Notice to Mariners,'' where appropriate.

(C) The superintendent shall make rules for the safe and equitable use of Bartlett Cove waters and for park docks. The public shall be notified of these rules by the posting of a sign or a copy of the rules at the dock. Failure to obey a sign or posted rule is prohibited.

(x) Closed waters and islands within Glacier Bay as described in paragraphs (b)(3) (iv) through (vii) of this section are described as depicted on NOAA Chart #17318 GLACIER BAY (4th Ed., Mar. 6/93) available to the public at park offices at Bartlett Cove and Juneau, Alaska.

(xi) Paragraphs (b)(3) (i) through (iii) of this section do not apply to a vessel being used in connection with federally permitted whale research or monitoring; other closures and restrictions in this paragraph (b)(3) do not apply to authorized persons conducting emergency or law enforcement operations, research or resource management, park administration/supply, or other necessary patrols.

(4) *Marine vessel visible emission standards.* Visible emissions from a marine vessel, excluding condensed water vapor, may not result in a reduction of visibility through the exhaust effluent of greater than 20 percent for a period or periods aggregating more than:

(i) Three minutes in any one hour while underway, at berth, or at anchor; or

(ii) Six minutes in any one hour during initial startup of diesel-driven vessels; or

(iii) 12 minutes in one hour while anchoring, berthing, getting underway or maneuvering in Bartlett Cove.

(5)–(6) [Reserved]

(7) The information collection requirements contained in paragraph (b)(3) of this section have been approved by the Office of Management and Budget under 44 U.S.C. 3507 and assigned Clearance Number 1024–0016. The information is being collected to allow the superintendent to issue permits to allow vessels into Glacier Bay during the whale season. This information will be used to grant administrative benefits.

[50 FR 19886, May 10, 1985, as amended at 61 FR 27016, May 30, 1996; 64 FR 56463, Oct. 20, 1999]

§ 13.66 Katmai National Park and Preserve.

(a) [Reserved]

(b) *Fishing.* Fishing is allowed in accordance with §13.21 of this chapter, but only with artificial lures and with the following additional exceptions:

(1) Bait, as defined by State law, may be used only on the Naknek River during times and dates established by the Alaska Department of Fish and Game, and only from markers located just above Trefon's cabin downstream to the park boundary.

(2) Flyfishing only is allowed on the Brooks River between Brooks Lake and the posted signs near Brooks Camp.

(3) No person may retain more than one fish per day caught on Brooks River, on the waters between the posted signs 200 yards from the outlet of Brooks lake, or on the water between the posted signs 200 yards from the mouth of the Brooks River on Naknek Lake.

[54 FR 18493, May 1, 1989]

APPENDIX B

Glacier Bay National Park and Preserve 2002 Compendium

GLACIER BAY NATIONAL PARK AND PRESERVE
2002 COMPENDIUM

National Park Service (NPS) regulations applicable to the protection and equitable public use of units of the National Park System grant specified authorities to a park superintendent to allow or restrict certain activities. NPS regulations are found in Titles 36 and 43 of the Code of Federal Regulations (CFR) and created under authority and responsibility granted the Secretary of Interior in Titles 16 and 18 of the United States Code. The following compendium comprises a listing of all NPS regulations that provide the Superintendent with discretionary authority to make designations or impose public use restrictions or conditions. The larger body of NPS regulations that do not provide discretionary authority to the Superintendent is not cited in this compendium. A complete and accurate picture of regulations governing use and protection of the park can only be gained by viewing this compendium in context with the full body of applicable regulations found in Titles 36 and 43 CFR. *Please contact Glacier Bay National Park and Preserve, Gustavus, Alaska at (907) 697-2230 for questions relating to information provided in this compendium.*

TITLE 36 CODE OF FEDERAL REGULATIONS

PART 1. GENERAL PROVISIONS

1.5 Closures and public use limits

(a)(1) Visiting hours, public use limits, closures

See specific sections in this document for additional information regarding closures, visiting hours, and public use limits.

(a)(2) Designated areas for specific use or activity or conditions

Sledding is permitted on park roads if persons or other traffic control devices are posted to warn approaching motorists.
This restriction is intended to provide maximum safety to sledders and motorists using the park road.

See specific sections in this document for additional information regarding designated areas and conditions for engaging in certain activities.

1.6(f) Compilation of activities requiring a permit

- Scientific research, (1.5)
- Collecting research specimens, (2.5)
- Operating a power saw in developed areas, (2.12(a)(2))
- Operating a portable motor or engine in undeveloped areas, (2.12(a)(3))
- Operating a public address system, (2.12)(a)(4))
- Air delivery, (2.17(a)(3))
- Noncommercial soliciting, (2.37)
- Using, possessing, storing, or transporting explosives, blasting agents, or explosive materials, (2.38(a))
- Special events, (2.50(a))
- Public assemblies and meetings, (2.51(a))
- Sale and distribution of printed matter, (2.52(a))
- Residing on federal lands, (2.61(a))
- Installing a monument, (2.62(a))
- Grazing, (2.60(a)-(b))
- Commercial notices or advertisements, (5.1)
- Commercial operations, (5.3)
- Commercial photography or filming, (5.5)
- Repair or construction of any structure or facility, road, trail, or airstrip on federal lands, (5.7)
- Mining operations (9.9(a)) or an approved Plan of Operations (in lieu of permit))
- Abandoned property, leaving property unattended for over 12 months, (13.22(b))
- Cabins on federal lands-

- ◊ General use and occupancy, (13.17(e)(1), (2))
- ◊ Commercial fishing, (13.17(e)(3))
- ◊ Subsistence-exclusive use, (13.17(e)(4)(i))
- ◊ Temporary (over 14 days) facilities in Preserve for taking of fish and wildlife, (13.17(e)(7))
- ◊ Cabins otherwise authorized by law, (13.17(e)(8))

- Backcountry camping, (13.30(d)(2))
- Cutting of live standing timber greater than 3 inches in diameter for non-commercial subsistence uses, (13.49(a)(1))
- Commercial fishing in the marine waters of Glacier Bay National Park, (13.65(a)(3)(ii))
- Private vessels in Glacier Bay marine waters unless exempted under 13.65(b)(2)(iii), (13.65(b)(2)(i))
- Cruise ships, tour vessels, and charter vessel in Glacier Bay marine waters unless exempted under 13.65(b)(2)(iii), (13.65(b)(2)(ii))
- Access to inholding where access is not made by aircraft, snowmachine, motorboat or nonmotorized surface transportation, (43 CFR 36.10(b))
- Nonmotorized watercraft on the Alsek River, (43 CFR 36.11(d), (h))
- Salvaging, removing, possessing aircraft, (43 CFR 36.11 (f)(3)(ii))
- Helicopter landings, (43 CFR 36.11(f)(4))
- Off-road vehicle (ORV) use, (43 CFR 36.11(g)(2))
- Temporary access across federal land for survey, geophysical or exploratory work, (43 CFR 36.12(c))

PART 2. RESOURCE PROTECTION, PUBLIC USE AND RECREATION

2.1(a)(4) Designated areas for collection of dead and downed timber for firewood

Dead and down wood, other than interstadial wood (aged wood preserved in glacial deposits) may be collected for use as fuel within the former Glacier Bay National Monument.

Superseded by 13.20(b)(4) in the Park additions and Preserve, which allows the collection of dead or downed timber by hand for personal use for firewood. Subsistence use in the Preserve comes under 13.49(b) and allows federally qualified subsistence users to collect dead or downed timber for firewood.

2.1(a)(5) Designated areas and conditions for walking, climbing on archeological cultural resource sites

No designations or conditions at present.

2.1(b) Designating trails

No designations at present.

2.1(c)(1-3) Designated fruits and berries, to harvest by hand

The following may be gathered by hand for personal use or consumption in the former Glacier Bay National Monument:

- Unoccupied seashells
- All edible berries and fruits
- Edible mushrooms
- Clams or mollusks taken in accordance with state regulations

Superseded by 13.20(b)(4) in the Park additions and Preserve, which allows the collection of fruits, berries, mushrooms, and other natural plant food items by hand for personal use. Subsistence use in the Preserve comes under 13.49(b) and allows federally qualified subsistence users to collect fruits, berries, mushrooms, and other natural plant food items.

2.2(d) Established conditions and procedures for transporting lawfully taken wildlife through the Park area

Wildlife legally taken outside the Park may be transported by motor vehicle or vessel to private residences within the Park for personal consumption.
Wildlife legally taken outside the Park may be transported through the Park provided the transporter contacts the superintendent verbally or in writing prior to entering the Park and provides the following information:

* Where the hunting took place
* Names and addresses of hunters
* Means of access (aircraft/vessel descriptions and registration numbers)
* Species hunted and taken
* Agreement to show or locate kill location on map if contacted.

This requirement is intended to allow transport of legally taken game across Park lands.

2.2(e) Designated areas for wildlife viewing with artificial light

No areas designated for closure. For sport hunting in the Preserve, state law determines if artificial light may be used for taking wildlife. For subsistence hunting the Preserve, 50 CFR 100 determines if artificial light may be used for taking wildlife.

2.3(d)(2) Designated waters open to bait fishing in fresh water

All waters open to commercial and sport fishing with bait in accordance with State law. Bait may be used for subsistence fishing in accordance with 50 CFR 100 in the Preserve.

2.3(d)(8) Designated areas open for fishing from public boat docks, bridges, etc.

Fishing is allowed from all swimming beaches, surfing areas, and public boat docks except for the Bartlett Cove fuel dock.

2.4(a)(2)(i) Carrying of weapons at designated locations and times

Weapons and traps may not be carried within areas designated as in the former Glacier Bay National Monument. (Note: see 2.4(a)(3), which authorizes possession of unloaded, inoperable, and inaccessible weapons in vehicles and vessels). Superseded by 13.19(b) in the Park additions and Preserve.

The intent of this requirement is to provide maximum wildlife protection by not allowing the carrying of weapons or traps within the Park unless the weapon is broken down and made inaccessible during transport. Weapons or traps may be carried within the Preserve during times the taking of fish or wildlife is authorized by State law.

2.4(a)(2)(ii) Designated locations for target practice

No designated locations.

2.10(a) Camping-conditions and permits

Superseded in part by 13.18(a).

Bartlett Cove Campground

- Overnight registration for use of the Bartlett Cove Campground is required May 1 - September 30.
  The above restriction serves to prevent resource damage associated with long term use.

Outside the Bartlett Cove Campground-January 1-November 30

- A non-fee permit is required for all persons camping overnight in the backcountry of Glacier Bay proper between May 1 through September 30.
  This requirement will allow NPS to better track overall backcountry use and distribution within Glacier Bay proper. This requirement does not apply to other areas of the park. Backcountry permits may be obtained from the park's Visitor Information Station on a first-come, first-serve basis.

2.10(d) Food storage - designated areas and methods

Bartlett Cove Campground Food Preparation

The cooking, consumption or preparation of food within the limits of the Bartlett Cove campground is prohibited. Food will be cooked, prepared and consumed in the intertidal zone adjacent to the campground.

Storage/Security Requirements

All food, fish, garbage, and equipment used to cook or store food (not being transported, consumed, or prepared for consumption) must be cached:

- Bartlett Cove- In a sealed motor vehicle, vessel (excluding kayaks), building, approved bear resistant food container, bear resistant trash receptacle or designated food cache.
- All Other Forested Areas- Secured in an approved bear-resistant container or

suspended in a tree, at least 10 feet from the ground and 4 feet horizontally from the trunk and at least 4 feet down from the supporting branch, or in a vessel (excluding kayaks) anchored offshore.

- All Other Unforested Areas- At least 100 yards from a campsite inside an approved, bear resistant container or in a vessel (excluding kayaks) anchored offshore.

The intent of these requirements is to prevent bears and other wildlife from obtaining and habituating to food and garbage, thus protecting wildlife and park visitors alike.

2.11 Picnicking - designated areas

Superseded by 13.18(b).

2.13(a)(1) Fires - Designated areas and conditions

Campfires may be lighted and maintained in the following areas:

Within 1 mile of Bartlett Cove – Unless otherwise authorized by the superintendent, fires are only allowed in the designated campground beach fire ring(s).

Within 1/2 mile of the Alsek River - Fires must be contained inside a fire pan, except at Dry Bay.

All Other Areas - Fires are allowed in backcountry areas below the high tide line, or more than one-quarter mile from marine shorelines. For the purposes of this section, *high tide* is defined as the line delineated in the intertidal area by the last high water mark of the preceding highest tide.

The intent of this requirement is to allow for fires in the backcountry while ensuring that resource impacts associated with fires are minimized.

2.14(a)(2) Sanitation and refuse - using government receptacles

Dumping of refuse brought into the park in the NPS landfill or trash receptacles is prohibited unless otherwise authorized by the superintendent. This does not preclude PRIVATE boaters from using trash receptacles at the Public Use Dock.

This requirement is intended to ensure the refuse handled by the park is generated by activities occurring within the park.

2.14(a)(5) Sanitation - designated areas for bathing and washing

No designated areas.

2.14(a)(7) Sanitation - designated areas for disposal of fish remains

No designated areas. Modified by 13.65(b)(3)(ix)(C) for Bartlett Cove.

2.14(a)(8) Sanitation - human waste in developed areas

Use of existing fixtures and facilities at Bartlett Cove required.

2.14(a)(9) Sanitation - designated areas for disposal of human waste in undeveloped areas

Within 1/4 mile of shoreline, human body waste will be deposited in salt water or the intertidal zone, or in cat-holes dug at least 100 feet from any surface freshwater source. Toilet paper will be burned or removed as trash.

This requirement is intended to ensure that proper disposal of human waste occurs in the backcountry to protect water quality and visitor safety.

2.14(b) Sanitation- conditions concerning disposal, carrying out of human waste

Alsek River – Disposal of human body waste within one-half mile of the Alsek River is prohibited. Solid waste must be carried to the NPS dump station provided at Dry Bay.

The intent of this requirement to ensure adequate disposal methods of human waste are complied with within the intensively-used Alsek River corridor, especially where popular campsites are used repeatedly throughout the summer and human waste disposal has been an issue and problem.

2.15(a)(1), (a)(3), (a)(5), (b), (e) Pets

Within Area Designated as Park - Pets on leash, crated, or otherwise under physical restraint are permitted in the developed area of Bartlett Cove from the Public Use Dock area to the Park Service administration area. Outside of the developed area, pets must be within 100 feet of established roads or parking areas. Pets are prohibited in backcountry areas, except in a vessel on the water.

Within the Preserve - Pets must be kept on a leash or under control and attended at all times.

This restriction limits the free-range of pets within the park to protect wildlife and park visitors from harassment. .

2.16(a)-(c) Horses and pack animals
Superseded by 43 CFR 36.11(e).
Access for subsistence purposes under 36 CFR 13.46(a) supersedes this section.

2.17(a)(1) Aircraft operation
Superseded by 43 CFR 36.11(f)(1).
Access for subsistence purposes under 36 CFR 13.45 supersedes this section.

2.17(a)(2) Aircraft operation near docks, piers, swimming beaches and other designated areas
No areas prohibited at present. Aircraft access to the Public Use Dock in Bartlett Cove is permitted. See also 13.65(b)(3)(ix)(C) regarding dock use restrictions.

2.17(c)(1) Removal of downed aircraft
Superseded by 43 CFR 36.11(f)(3)(ii).

2.18(c) Snowmobiles-designated areas for use (Non-traditional activities)
All areas open to snowmachine use (superseded in part by 43 CFR 36.11(c)).
Access for subsistence purposes under 36 CFR 13.45 supersedes this section.

2.19(a) Winter activities-designated areas
All areas open to winter use.

2.20 Skating and skateboards
Superseded by 43 CFR 36.11(e).

2.21 Smoking
All public buildings are closed to smoking unless specifically permitted and signed as a designated smoking area. Smoking is prohibited on the Fuel Dock and within 100 feet of the underground fuel storage facility.
These restrictions are intended to protect public safety from fire or explosion around fuel storage and dispensing facilities on and adjacent to the dock.

2.22 Property - leaving property unattended for 24 hours
Superseded by 13.22.

2.35(a)(3)(i) Alcoholic beverages - areas closed to consumption
No restrictions at present.

2.38(b) Explosives - areas designated for using fireworks
No areas designated for use of fireworks. Fireworks are prohibited.

2.51(e) Public assemblies/meetings - designated areas
All areas of the park are open to public assemblies with a permit from the superintendent.

2.52(e) Sale and distribution of printed matter-areas designated for such use
All areas of the park are open to distribution with a permit from the superintendent.

2.60(a)(3) Designated areas for grazing
No areas are designated for agricultural grazing of livestock.

2.62(b) Memorialization-designation of areas for scattering ashes
All areas of the park are open to scattering of ashes without a permit.

PART 3. BOATING AND WATER USE ACTIVITIES

3.3 Permits

- Commercial fishing vessels in the marine waters of Glacier Bay National Park must have a permit pursuant to (13.65(a)(3)(ii))
- Private vessels in Glacier Bay marine waters must have a permit unless exempted under 13.65(b)(2)(iii) pursuant to 13.65(b)(2)(i)
- Cruise ships, tour vessels, and charter vessel in Glacier Bay marine waters must have a permit unless exempted under 13.65(b)(2)(iii) pursuant to 13.65(b)(2)(ii))
- Users of nonmotorized watercraft on the Alsek River must have a permit pursuant to 43 CFR 36.11(d), (h)

3.6(i) Boating, prohibited operations - designated launching areas

All areas of the park are open to launching of boats.

3.6(j) Operating a vessel not directly accessible by road

Superseded by 43 CFR 36.11(d).
Access for subsistence purposes under 36 CFR 13.46(a) supersedes this section.

3.6(k) Launching or operating airboats

Superseded by 43 CFR 36.11(d)
Access for subsistence purposes under 36 CFR 13.46(a) supersedes this section.

3.6(l) Operating a vessel in excess of designated size

No maximum size designations at present.

3.20(a) Water skiing-designated waters

All park waters are open to water skiing.

3.21(a)(1) Swimming and bathing-areas designated as closed

All park areas are open to swimming and bathing.

3.23(a) SCUBA and snorkeling - designated conditions in swimming areas, docks, etc.

SCUBA diving is authorized at the Public Use Dock and in the mooring area at Bartlett Cove to inspect and repair vessels, or retrieve equipment.

PART 4. VEHICLES AND TRAFFIC SAFETY

4.10 Travel on park roads and designated routes-areas designated for off-road use in Preserves

See ANILCA §205; 43 CFR 36.10, 36.11(c), (g).
Access for subsistence purposes under 36 CFR 13.46(a) supersedes this section.

4.11(a) Load weight and size limits - permit requirements and restrictive conditions

A 30,000 lbs. load limit is established for the Bartlett Cove Public Use Dock. Exceeding this limit is prohibited.

4.21(b)-(c) Speed limits-designation of a different speed limit

The speed limit in the Bartlett Cove developed area, and on the park road between Bartlett Cove and Gustavus, is 15 mph, except as otherwise posted.
The reduced speed limit in Bartlett Cove is for public safety. Pedestrians and bicyclists often use the roadway and visibility is limited due to road design and vegetation.

4.30(a) Bicycles-closed areas

Superseded by 43 CFR 36.11(e).
Access for subsistence purposes under 36 CFR 13.46(a) supersedes this section.

4.30(d)(1) Wilderness closed to bicycle use

Superseded by 43 CFR 36.11(e).

Access for subsistence purposes under 36 CFR 13.46(a) supersedes this section.

4.31 Hitchhiking-designated areas

All areas of the park are open to hitchhiking.

PART 5. COMMERCIAL AND PRIVATE OPERATIONS

5.7 Construction of buildings, roads, trails, airstrips, or other facilities

Maintenance of established landing strips utilizing non-motorized hand tools is not considered construction or repair and no permit is required. Any other construction requires a permit.

PART 13. ALASKA REGULATIONS

SUBPART A – PUBLIC USE AND RECREATION

13.17(d)(8)(ii), (iv) Established conditions for removal of cabin for which a cabin permit has been denied, expired, or revoked

No conditions established at present (may require access permit).

13.17(e)(4)(i) Designated existing cabins, shelters or temporary facilities that may be shared for subsistence use without a permit

All subsistence use of existing cabins, shelters, or temporary facilities requires a permit from the superintendent. During the Federal subsistence moose hunt, the East River Public Use Cabin at Dry Bay may be reserved by local rural residents at no charge via the NPS Office in Yakutat.
This provision allows subsistence users to share and use the East River Public Use Cabin during the federal subsistence moose hunt.

13.17(e)(4)(vi) Established conditions and standards governing the use and construction of temporary structures and facilities for subsistence purposes, published annually

No conditions or standards established.

13.17(e)(5)(i) Designated cabins or other structures for general public use

The East River cabin in the Preserve is designated as a public use cabin. All other cabins, not otherwise under NPS permit, are open for <u>short-term</u> public use (less than 14 days/year).
The East River cabin is a short-term, public use cabin.

13.17(e)(5)(ii) Established conditions and allocation system to manage the use of designated public use cabins

A reservation and permit, available through the NPS Ranger Station in Yakutat, are required for use of the East River Public Use Cabin. An overnight public use fee will be charged for the cabin, with exception noted under § 13.17(e)(4)(i) of this compendium.
This requirement allows for equitable public use of the East River Cabin and recovery of costs associated with maintenance of the facility and adjacent airstrip.

13.17(e)(7)(iv)(B) Established conditions for removal of temporary facility (more than 14 days)

Individuals must remove facility, all personal property, and return the site to its natural condition.
These conditions are intended to protect the park from impacts to vegetation and soil and to ensure that personal items are not left in the park.

13.18(a) Restricted areas for camping

Areas temporarily restricted or closed to camping are listed under 13.30(d)(2).

13.18(b) Picnicking-areas where prohibited by posted signs

No restrictions at present.

13.19(b) Carrying firearms

Temporary restrictions are listed under 13.30(d)(2).

See 2.4(a)(2)(i) for the former Glacier Bay National Monument.

13.21(c) Commercial Fishing-ATV use

Use of ATVs to support commercial fishing activities is permitted in the Temporary Fish Camp Zone identified on a map in Appendix C.

13.22(c) Designate areas where personal property may not be left unattended for any time period, limits on amounts and types, manner in which property is stored

Personal property, including personal or commercial fishing gear of any type left past legal fishing periods established by ADFG/IPHC, may not be stored or left unattended for more than 14 consecutive days without written permission from a park ranger, except that personal kayaks and small boats may be stored from May 1 to September 30, within 150 yards. of the administrative dock or above the intertidal area between the Public Use Dock and the barge ramp.

This restriction is intended to limit abandonment of personal property in the park and impacts to resources and other park users. Provisions are provided for longer-term storage of gear where warranted with permission of the superintendent.

13.30(d)(1) Temporary closures and restrictions relating to the use of aircraft, motorboats, and non-motorized surface transportation or to the taking of fish and wildlife

See 13.65 (b)(3)(ix)(C), Public Use Dock and Bartlett Cove use restrictions.

13.30(d)(2) Temporary closures and restrictions (other)

Camping

<u>Bartlett Cove–January 1-November 30, except as otherwise noted</u>

- Camping in the Bartlett Cove Campground for more than 14 days between January 1-November 30 is prohibited unless otherwise authorized by the superintendent.
  This limitation is intended to prevent residential use of the campground.
- Overnight registration for use of the Bartlett Cove Campground is required May 1 - Sept 30 under 36 CFR 2.10(a).
  The above restriction serves to prevent resource damage associated with long term use.
- Camping is prohibited within 1 mile of Bartlett Cove, except inside the boundary of the Bartlett Cove Campground.
  This is intended to minimize camper impacts on the numerous other visitors to the Bartlett Cove area.

<u>Outside Bartlett Cove Campground–January 1-November 30, except as otherwise noted</u>

- A non-fee permit is required for all persons camping overnight in the backcountry of Glacier Bay proper between May 1 through September 30 under 36 CFR 2.10(a).
  This requirement will allow NPS to better track overall backcountry use and distribution within Glacier Bay proper. This requirement does not apply to other areas of the park. Backcountry permits may be obtained from the park's Visitor Information Station on a first-come, first-serve basis.
- Camping for more than 3 consecutive nights in one location is prohibited unless otherwise authorized by the superintendent.
  This limitation is derived from the park's Wilderness Visitor Use Management Plan, July 1989, and is intended to "prevent long term occupancy of campsites other groups may wish to use, minimize campsite deterioration and disruption of wildlife use patterns."
- Group size is limited to a maximum of 12 persons. The superintendent may authorize an exception for educational groups.
  This restriction is also derived from the Wilderness Visitor Use Management Plan and is intended to minimize impacts on resources and other park visitors.
- Between May 1 – Sept 30, the number of overnight, non-commercial backcountry visitors in Glacier Bay proper is limited to no more than 1870.
  This limitation on backcountry use in Glacier Bay proper is necessary to protect park resources and the quality of the backcountry visitor's experience. The cap precludes continuing growth in backcountry use until an updated backcountry management plan and implementing regulations are in place. Commercial, guided backcountry groups are already limited in number through concession permits and are not included in the visitor use limit described. This limitation only

applies to backcountry use associated with Glacier Bay proper and does not affect backcountry use in other, less visited areas of the park.

Alsek River–January 1-November 30

- Group size is limited to a maximum of 15 persons, except specific commercial groups limited to 25 persons under concession permit.
  The limitation on group sizes is derived from the 1989 Alsek River Visitor Use Management Plan and is intended to minimize impacts on resources and other visitors.
- Campers may camp only one night at each of the following areas: Walker Glacier, Alsek Spit and Gateway Knob. However, campers may choose to layover one additional night at one of these areas. (4 camping nights allowed among these 3 locations.)
  This restriction is intended to provide equitable public use of these very popular Alsek River campsites.

Areas Closed to Overnight Camping

- The landmass from Wolf Creek to a point directly east of the southern tip of Garforth Island including Puffin Island and the two unnamed islands in North Sandy Cove, and the one unnamed island in South Sandy Cove, from sea level to any elevation is closed to overnight camping due to a high concentration of bears, May 1 - August 15. (See Appendix B)
  This restriction is intended to minimize conflicts between backcountry campers and bears in an area habitually used and important to bear. The restriction on overnight camping does not preclude day use of this area for hiking and other activities.
- The landmass between Margerie Glacier and Toyatte Glacier from sea level to any elevation is closed to overnight camping to all campers other than an organized group of 10-12 with an experienced wilderness leader with experience camping in bear country unless otherwise authorized by the superintendent due to a history of bear/human incidents, May 1 - August 15. (See Appendix B)
  This restriction is intended to minimize conflicts between backcountry campers and bears in an area habitually used and important to bear. The restriction on overnight camping does not preclude day use of this area for hiking and other activities. The allowance for a organized group with an experienced wilderness leader is intended to verify if the closure in the past has had an impact on the bear behavior. Large groups have experienced less bear encounters than smaller groups camping in bear frequented areas.

SUBPART B – SUBSISTENCE

13.49(a)(1) May permit cutting in accordance with specifications of permit for subsistence timber harvest (house logs & firewood)

Cutting of live standing trees greater than 3” in the Park is prohibited. The superintendent may allow subsistence harvest of live standing trees greater than 3” in the Preserve subject to the terms and conditions of a permit issued by the superintendent.

13.49(a)(2) Restrictions on cutting of live timber less than 3" in diameter for subsistence purposes

Cutting of live timber is not authorized within the Park. Verbal or written permission from a park ranger is required to cut live timber less than 3" in diameter in the Preserve, except as necessary to clear designated vehicle routes and airstrips.

SUBPART C – SPECIAL REGULATIONS, SPECIFIC PARK AREAS

13.65 Glacier Bay National Park and Preserve Special Regulations

(a)(2)(iii) New or expanded fisheries prohibited. List of existing fisheries and gear types:

In progress

(a)(2)(iv) Maps and charts showing marine waters of Glacier Bay that are closed to commercial fishing

See Appendix D.

(b)(2)(i)(A) Private vessel permits and conditions

Obtaining Private Vessel Permits

Private motor vessel permits are only required for Glacier Bay proper, and only for the months of June, July, August. The following procedures and conditions apply to the issuance and use of private motor vessel entry permits:

- Permits may be obtained via telephone (907-697-2627), marine band radio (KWM20Bartlett Cove), by mail or in person at Glacier Bay headquarters at Bartlett Cove.
- Permits may be reserved up to 60 days in advance of an entry and are issued on a first received priority basis.
- Permits must be reconfirmed within 48 hours of the scheduled entry. Permits not reconfirmed by 10:00 a.m. on the date of issue, will be canceled and made available for reissue.
- Three of the daily 25 maximum permitted vessels, are reserved for local private vessels; these are restricted to residents of the Icy Straits/Cross Sound area, including the communities of Elfin Cove, Excursion Inlet, Gustavus, Hoonah, Pelican. These permits will be valid for any 7 use days, not necessarily consecutive ones, and may be issued up to 48 hours in advance.

Administration of Private Permits

- June 1 - August 31, the following schedule will generally be used to allocate daily vessel entries within Glacier Bay proper:
  June 1 - 10: 3 entries per day
  June 11 – August 2: 6 entries per day
  August 3 - 15: 5 entries per day
  August 16 - 31: 3 entries per day
  The above allocations are necessary to ensure entry permits (limited in total number by NPS regulation) are available for visitor use throughout the June – August permit season. Park staff may vary the daily entry numbers to maximize opportunities for public access, consistent with allowable use day and season entry limits.
  Unused daily entries will be carried forward and issued.
- All private vessel entries will be allocated in a manner that will prevent the maximum daily presence of more than 36 motorized vessels of all types in Glacier Bay on any given day.
- The total number of private vessel entries will not exceed 468 for the period June 1 – August 31.
  No more than 25 private motor vessels will be permitted on any day.
- The total number of vessel use days will be limited to 1,971 for the period June 1 to August 31.
- A private boater may apply for and hold up to 2 permits at one time. However, a second private vessel permit will not be issued during the peak boater use period, June 11–August 2.
  The intent of this limitation is to ensure first time visitors are provided a priority opportunity for a Glacier Bay entry permit over returning visitors during the period of highest demand.

Length of Stay

- Private motor vessels that entered Glacier Bay prior to June 1 may remain in the Bay until June 6 without an entry permit, however the vessel use days will be counted toward the allowable vessel use day total.
- Permits are valid for up to 7 consecutive days. An extension permit may be requested and issued for an additional 7 days, provided days are available. Request for an extension permit must be made between 8:00 AM and 7:00 PM on the last day of the initial permit.
- If an extension permit is unavailable, a vessel may remain anchored for up to seven additional days without motorized operation at Blue Mouse Cove, Sandy Cove, or Bartlett Cove. If the vessel leaves an anchorage without obtaining an extension permit it must proceed directly out of the Bay. After using an extension, a vessel must leave the bay for at least 7 days prior to applying for another vessel permit.

Notification Requirements Upon Entry/Departure

- Motor vessel operators are required to notify park headquarters by telephone (907-697-2627) or marine band radio (KWM20 Bartlett Cove on Channels 12 or 16) prior to entering or departing Glacier Bay.
  This requirement allows NPS to track the number of vessel permits in Glacier Bay each day and reallocate available permits when boaters fail to arrive or depart early.

(b)(3)(ix)(A) Other restrictions for the protection of wildlife.

No restrictions at present.
(See 13.30(d)(2) Temporary closures and restrictions (other) re: areas closed to camping)

(b)(3)(ix)(C) Rules for the safe and equitable use of Bartlett Cove waters and docks.
The following use restrictions are for the safe and equitable use of park facilities and are in effect during the primary visitor use season, <u>May 1 - September 30</u>, unless otherwise noted.

<u>Bartlett Cove Public Use Dock</u> (See Appendix A)

- Vessels may dock for a maximum of three hours in any 24-hour period, unless otherwise authorized by a park ranger.
  This provides flexibility to allow longer docking periods on a space available basis to complete boat repairs, etc.
- Dinghies may dock in the designated area (see Appendix A) for up to 24 hrs.
  This allows overnight docking of small vessels (<10') commonly used as tenders for larger vessels.
- Aircraft are restricted to use of the designated aircraft float and are limited to three hours in any 24-hour period. Pilots must remain with aircraft or provide notice of their location to a park ranger.

  Space exists for only one floatplane on the aircraft float at a time.
- Trailers specifically designed for transport of kayaks and canoes are allowed on the dock when authorized by a park ranger. However, when backing, the trailers must be detached from the tow vehicle and backed by hand. All other trailers and commercial passenger-carrying vehicles (such as B&B vans, taxis and buses) are prohibited from driving onto the dock unless authorized by a park ranger.

<u>(January 1 - December 31)</u>

- From Sep 15 to April 30, vessels may tie up to the Public Use Dock for up to seven consecutive days. Vessels must leave the dock for at least one 24 hr. period for each period of 7 consecutive days. All vessels tying up to the dock must register with a park ranger on the initial day of each docking period.
- Dock space is assigned for use by private vessels, NPS vessels, Glacier Bay Lodge, Inc. vessels, and aircraft as depicted in Appendix A. Parking in a space otherwise reserved is prohibited.
- Motor vehicles may not be left unattended on the Public Use Dock or parked overnight in the parking lot adjacent to the dock.
  Vehicles parked on the dock block access and limit use of the facility; the parking lot at the head of the dock is not large enough to accommodate overnight use during the visitor use season.
- The load limit on the Public Use Dock is 30,000 pounds GVW. No vehicle exceeding this limit is permitted on the dock, unless authorized by the Superintendent.
  This is necessary for public safety and to prevent structural damage to the dock facility.
- Unattended personal property may not be left on or attached to the floats or pier without prior permission from a park ranger.
  Prevents clutter from accumulating on the dock/floats.
- Processing of commercially-caught fish on the surface of the Public Use Dock is prohibited.
- Commercial fish buying or selling is prohibited on or over the Public Use Dock unless otherwise authorized in writing by the superintendent.
- Public access not directly related to fueling or pumpout is not permitted on the fuel dock. Unattended vessels are prohibited on the fuel dock.
  This dock is only to be used for fueling and waste pumpout.
- Vessels may not use electrical shore power unless otherwise authorized by a park ranger.
- Residing on a vessel within Bartlett Cove is prohibited unless otherwise authorized by the superintendent.

<u>Bartlett Cove Waters</u>

- The discharge of "blackwater" (water contaminated with human waste) is prohibited in Bartlett Cove waters.
  This requirement is to limit the discharge of human waste that might complicate the water quality monitoring by the park.
- The placement of temporary moorings is authorized to the north or east of the Public Use Dock,

provided they are at least one-quarter mile from the dock. These moorings must meet applicable marking requirements, may not be installed prior to April 1, and must be removed by November 1 in a given calendar year. Contact must be made with the Protection Ranger prior to placement of a mooring and Mooring Buoy Agreement signed.
These limitations are necessary to ensure that fixed moorings not preempt the most convenient anchorage locations or impede access to the dock, are properly tended, and are temporary rather than permanent fixtures.

- Anchoring vessels within 300 ft. of the Public Use Dock is prohibited. The No Anchor Zone is depicted in Appendix A of this compendium. The placement of buoys, markers, or lines (including fishing gear) is authorized to the north or east of the Public Use Dock, provided they are at least one-quarter mile from the dock.
  This limitation is necessary to ensure adequate room for safe maneuvering of vessels and aircraft accessing and departing from the Public Use Dock.

<u>Bartlett Cove Inner Lagoon and Administrative Dock</u>
The Administrative Dock is reserved for NPS vessels. The superintendent may authorize employee use of the dock on a space available and fee basis consistent with applicable Federal law.

- A park ranger may authorize temporary public use of the Administrative Dock on a space available basis. Use will be limited to 3 consecutive days during the peak use season, May 1 - September 30, and 7 consecutive days the remainder of the calendar year.
  This accommodates visitor and local resident use of the administrative dock for repairs, etc., on a space available basis.
- Anchoring in the inner lagoon area is limited to 7 consecutive days unless otherwise authorized by a park ranger, January 1 – December 31.
  The inner lagoon is known and used by local residents as a storm anchorage. These limitations are intended to accommodate short-term use of the lagoon, which is limited in size, but preclude long-term use that limits opportunity for use by other visitors or local residents.
- No buoys or lines may be placed inside the inner lagoon unless otherwise authorized by a park ranger.
  This limitation is intended to ensure clear and safe passage for all vessels transiting the inner lagoon, and availability of the lagoon for temporary storm anchorage use.

43 CFR, PART 36 TRANSPORTATION AND UTILITY SYSTEMS (Access Regulations)

36.11(c) Temporary closures or restrictions on the use of snowmachines for traditional activities
No closures or restrictions at present.

36.11(d) Temporary closures or restrictions on use of motorboats
The use of motorized boats is prohibited on the Alsek River at Alsek Lake above Gateway Knob between January 1 – November 30 in accordance with the approved Alsek River Visitor Use Management Plan (1989).
See also 13.65 and 13.30(d)(1).
This restriction is to ensure the wilderness experience of visitors rafting the Alsek River is minimally disrupted by powerboats. Congress directed that the Alsek River corridor be managed to preserve its outstanding wilderness characteristics.

36.11(e) Temporary closures or restrictions on use of non-motorized surface transportation
<u>Vessels-</u> A permit is required for non-commercial vessels operating on the Alsek River above Gateway Knob between January 1 – November 30.
This requirement is necessary to manage public use of the Alsek River in accordance with the Alsek River Visitor Use Management Plan (1989). The Plan seeks to manage use for no more than one party launching (and departing) on the river each day. This use level would be exceeded without the current permit and management system. Permits for the Alsek River can be obtained by contacting the NPS office in Yakutat, Alaska, phone (907) 784-3370.

<u>Bicycles</u>- Bicycles are prohibited on the Forest Loop, Bartlett River and Bartlett Lake Trail between April1 through October 31.
This limitation is necessary to minimize resource damage to what are generally wet and muddy trails.

36.11(t)(1) Temporary closures or restrictions on landing areas for fixed-wing aircraft

No closures or restrictions at present.

36.11(t)(3)(ii) Established procedure for salvaging and removing downed aircraft.

A permit is required from the superintendent before downed aircraft may be salvaged and removed from the park; violation of the terms and conditions of the permit is prohibited. *This requirement allows the superintendent to establish terms and conditions for salvage operations as necessary to protect resources, provide for public safety, and minimize impacts on visitors.*

36.11(g)(1) Use of off-road vehicles (ORV) on established trails
In Glacier Bay National Preserve, off-road vehicles are allowed with a pennit only on the existing trails shown on the map in Appendix C and on existing trails to and from gill net sites.

List of Attachments

Appendix A: Restrictions on the Use ofBartlett Cove Docks, 13.65 (b)(3)(ix)(C) Appendix B: Areas Closed to Overnight Camping, 13.30(d)(2)
Appendix C: Areas Open to ATVs, 13.21(c), 43 CFR 36.ll(g)(1)
Appendix D: Maps and Charts of Glacier Bay Marine Waters Closed to Commercial Fishing

This compendium is approved and rescinds all previous compendiums issued for Glacier Bay N ational Park and Preserve.

Tomie Patrick Lee — June 24, 2002

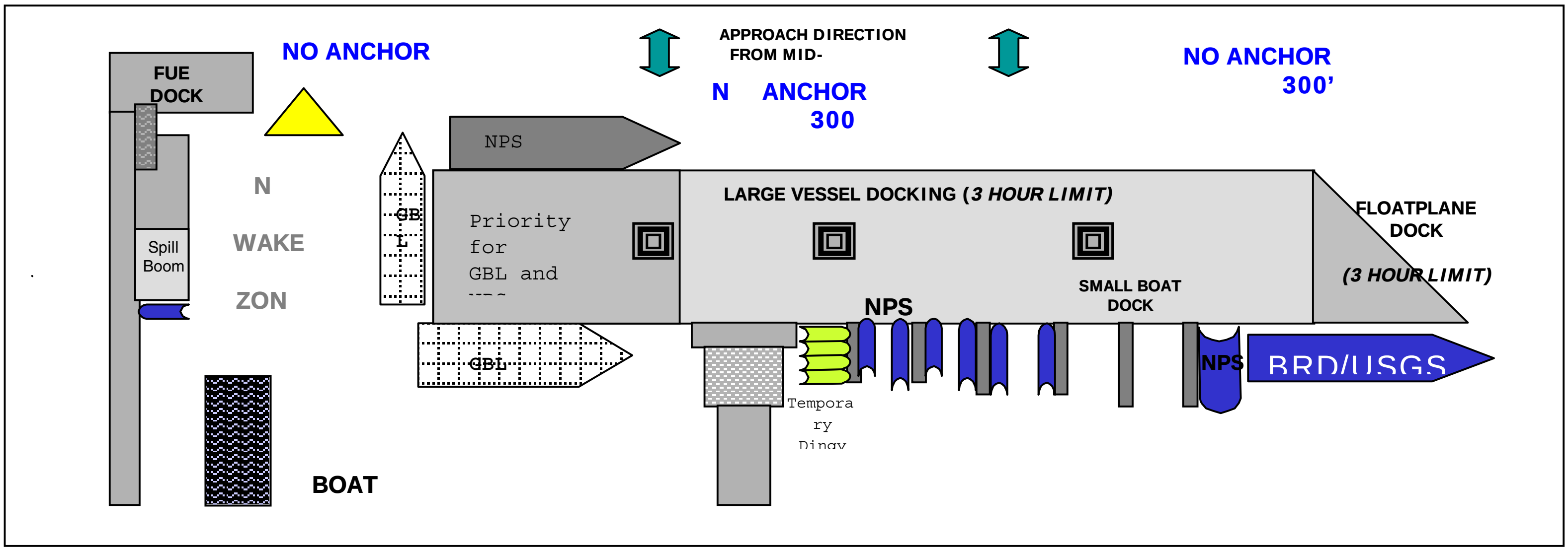
Superintendent — Date

Appendix A: Restrictions on the Use of Bartlett Cove Docks, 13.65 (b)(3)(ix)(C)

Rules for the safe and equitable use of Bartlett Cove waters and docks: Bartlett Cove Public Use Dock.

GUIDE TO DOCKING

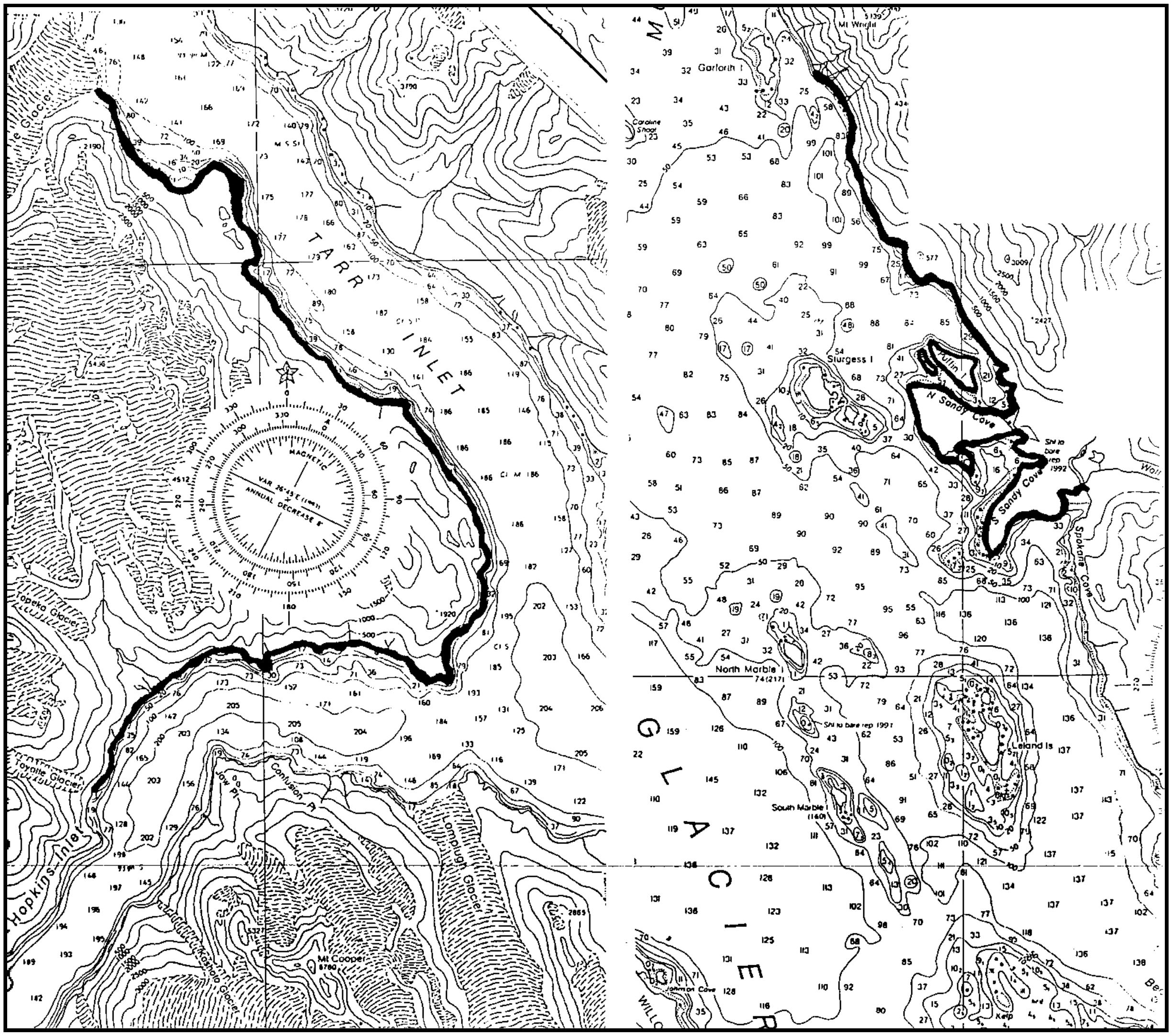
Bartlett Cove Public Use Dock



Appendix B, Areas Closed to Overnight Camping, 13.30(d)(2)

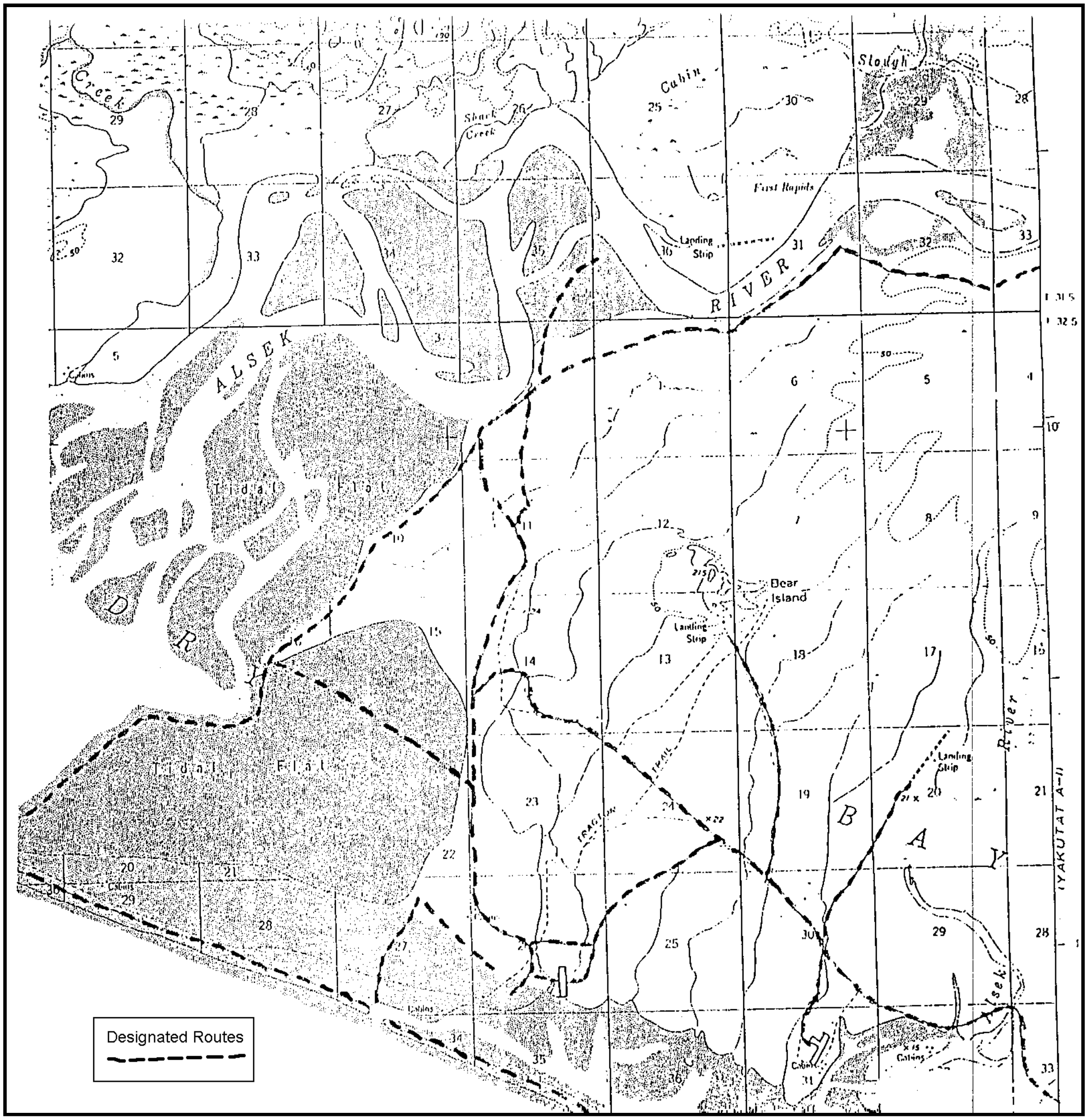
- The landmass from Wolf Creek to a point directly east of the southern tip of Garforth Island including Puffin Island and the two unnamed islands in North Sandy Cove, and the one unnamed island in South Sandy Cove, from sea level to any elevation is closed to overnight camping due to a high concentration of bears, May 1 - August 15.

- The landmass between Margerie Glacier and Toyatte Glacier from sea level to any elevation is closed to overnight camping unless otherwise authorized by the superintendent due to a history of bear/human incidents, May 1 - August 15. (See Appendix B)



Appendix C, Areas open to ATVs, 43 CFR 36.11(g)(1), 36 CFR 13.21(c)

36.11(g)(1) Use of off-road vehicles (ORV) on established trails (recreational use)
In Glacier Bay National Preserve, off-road vehicles are allowed with a permit only on the existing trails shown on the map above and on existing trails to and from gill net sites.
ANILCA § 205 Use of ATVs associated with commercial fishing
ATV use for commercial fishing purposes are allowed inside the boundary of the designated Temporary Fish Camp Zone identified on the map below.



Designated Routes
Bear
Island
Landing
Strip
First Rapids
Cabin
Slough
ALSEK
RIVER
Tidal Flat
Tidal Flat
(YAKUTAT A-1)

Appendix D: Maps and Charts of Glacier Bay Marine Waters Closed to Commercial Fishing
was not provided

APPENDIX C

Acoustics Memorandum

LGL Alaska Research Associates, Inc.
1101 E. 76th Avenue, Suite B
Anchorage, Alaska 99518 USA
Tel: (907) 562-3339 Fax: (907) 562-7223
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Memorandum

To: Louise Flynn, Assistant Project Manager

From: Michael T. Williams

Date: 31 October 2002

Re: Acoustic Appendix

Ms. Flynn, attached is an appendix that includes (1) Acoustic Concepts and Terminology, (2) Underwater Noise Propagation, (3) Zones of Influence, (4) Marine Mammal Hearing, and (5) Underwater Noise and Acoustics Environment. Please consider this text as supplemental to the other sections of the EIS to provide an in depth discussion of acoustics in order for the reader to gain a better understanding of the concepts discussed in the Soundscape, Threatened and Endangered Animals, and Marine Mammals sections.

1.0 ACOUSTIC CONCEPTS AND TERMINOLOGY

1.1 INTRODUCTION AND SCOPE

This section contains an introduction to acoustic concepts and terminology to aid non-acousticians in understanding the terms and techniques used in this report. It is based on a longer presentation given by Charles R. Greene, Jr. in Chapter 2 of *Marine Mammals and Noise* (Richardson et al. 1995). The scope of the material presented here is focused on acoustic principles and terminology used in this report. For a broader coverage of general acoustic concepts the reader should refer to *Marine Mammals and Noise* and to *Principles of Underwater Sound* (Urick 1983). Technical terms are identified by an underline when first described.

1.2 SOUND MEASUREMENT UNITS

1.2.1 Basic Units

Sound is produced when waves of vibrational energy travel through air or water as oscillations of the fluid particles to exert tiny push-pull pressures on our eardrums or transducers. Transducers (hydrophones or microphones) act as electronic ears, converting pressure waves to electronic signals. The frequency of the oscillation or vibration is measured in cycles per second or hertz.(Hz) The pitch of a sound as perceived by a human is directly related to frequency. Humans are often said to hear sounds ranging from 20 to 20,000 Hz. However, for most individuals the actual range of useful sensitivity is narrower. A tone, sometimes called a pure tone, involves a sinusoidal oscillation at a specific frequency. Frequency is the reciprocal of the oscillation period, which is the time required for one oscillation. The wavelength (•) of a periodic sound is the length of the fundamental oscillation in the propagation medium. To a physical acoustician, sound is a mechanical wave motion propagating in an elastic medium at a sound velocity (c) that depends on the relative compressibility of the medium. The wavelength of a single tone is related to its frequency by the equation:

$$• = c/f \tag{1.1}$$

Some fluctuations in fluid pressure are commonly called sounds even though they cannot be heard by humans. Ultrasonic frequencies are too high to be heard by humans (>20,000 Hz); infrasonic sounds are too low to be heard (<20 Hz). Many animals (e.g., dolphins, bats, and dogs) can detect certain ultrasounds. Some animals, including elephants, pigeons, and probably some baleen whales, can detect certain infrasounds.

A useful model of the acoustic process is the 'source-path-receiver'model. This model includes

a source of sound with specific frequency and temporal characteristics,
the sound transmission path(s) that changes sound characteristics as the sound propagates
and
a receiver with specific detection capabilities.

For example, consider a whale swimming near a ship: the ship is a source of underwater sound, the water (including surface and bottom) is the path from source to whale, and the whale is the receiver.

Source characteristics include variability over time (transient versus continuous), and sound intensity distribution in frequency (source level spectrum*)*. Transmission refers to the propagation of sound through the air, water, or bottom from a source to a receiver. The transmission path is the route from source to receiver, The path may include various combinations of air, water, or bottom materials. The path often is not a straight line. Multiple transmission paths (multipaths) occur when sound reflects from surfaces along the path, such as the surface and (in underwater sound transmission) the bottom. Rough surface or bottom features cause sound to be scattered, and some underwater sound impacting the bottom is absorbed. Refraction (ray bending) can be important in either under-water or airborne sound transmission. In this report the receivers of interest are marine mammals. Important receiver characteristics include an animal's hearing sensitivity to sounds at different frequencies and its responsiveness to different types and levels of sounds.

The energy or acoustic intensity transmitted by sound waves is rarely measured directly but is often discussed. It is important because it is a fundamental measure of propagating sound. It is defined as the acoustical power per unit area in the direction of propagation; the units are watts/m^2. The intensity, power, and energy of an acoustic wave are proportional to the average of the pressure squared (mean square pressure). Acoustics researchers often refer to intensities or powers, but they derive these from pressures squared. Measurement instruments (and ears) normally sense pressure, from which intensity or power is computed. This practice is legitimate for measurements in the same medium (i.e., in water or in air), where constants of proportionality between intensity or power and pressure are the same. For most sound receivers sound pressure is measured in micropascals (• Pa). A pascal is a standard unit of pressure in the SI system of units. One pascal is the pressure resulting from a force of one Newton exerted over an area of one square meter.

In presenting sound measurements, acousticians use ratios of pressures, or pressures squared, requiring adoption of a standard reference pressure for use in the denominator of the ratio. The reference pressure for underwater sounds is 1 • Pa (Table 1.1). For airborne sound it is conventional to use 20 • Pa as the reference pressure—the approximate threshold of human hearing at 1 kHz (Table 1.1).

The human ear is capable of responding to a very wide range of sound intensity levels – a factor of 10^{13}. It spans this range by means of a logarithmic response, therefore acousticians have adopted a logartithmic scale for sound intensity denoted in decibels. In decibels, the intensity level of a sound of intensity I is given by equation (1.2):

Intensity Level (dB) = $10 \log (I/I_0)$ (1.2)

where I_0 is the reference intensity, 10^{-12} W/m^2 . Because intensity is proportional to pressure squared, the sound pressure level (SPL) of a sound of pressure P is given by

Sound Pressure Level (dB) = $20 \log (P/P_0)$ (1.3)

where P is the reference pressure, e.g., 1 • Pa. The phrase "sound pressure level" implies a decibel measure and that a reference pressure has been used as the denominator of the ratio.

In summary, when studying underwater sound, we usually measure pressure, not intensity. The reference pressure for underwater sounds is one micropascal (• Pa).

Pulsed sounds usually should be measured in terms of their energy, not just their pressure or power. Energy is proportional to the time integral of the pressure squared. Thus, sound energy is proportional to and may be described in terms of • Pa^2–s (micropascal, squared, for one second). Airborne impulsive sounds are usually measured on an energy basis, integrating the squared instantaneous sound pressure over the pulse duration and adjusting the resulting level to a reference one sec duration to obtain the Sound Exposure Level (SEL). A frequency-dependent filter approximating the human hearing curve (A-weighting) is used unless otherwise stated (ANSI 1994). The energy measurement technique, without A-weights, is sometimes applied in underwater acoustics, but rarely in studies of underwater noise versus marine mammals. Better standardization and reporting of measurement methods for pulsed underwater sounds are urgently needed to permit meaningful comparisons among studies.

1.2.2 Sound Spectra

Sound spectra are important because we use them to describe the distribution of sound power as a function of frequency. An animal's sensitivity to sounds varies with frequency, and its response to a sound is expected to depend strongly on the presence and levels of sound in the frequency band (range of frequencies) to which it is sensitive.

A sound waveform represents the amplitude variations of the sound with time. Sound from some sources has power distributed over a wide range of frequencies. Some sound components may be periodic, consisting of a repeated waveform whose power is concentrated at specific frequencies. The waveform of a pure tone is a simple sinusoid. However, other components of sounds are continuously distributed across frequency. Such sound may have a hissing quality at high frequencies or a rumbling quality at low frequencies. The waveforms of these more complex sounds are erratic.

To describe continuously distributed sounds, acousticians use the concept of power density spectrum. This is a graph plotting power per unit frequency versus frequency. Because measurements are usually in terms of pressure rather than power, a more common graph is the sound pressure density spectrum—the mean square pressure per unit frequency, in • Pa^2/Hz (e.g., Fig. 1.1).

1.2.3 Levels of Tones

A tone is a sinusoidal waveform for which all power is at a particular frequency. Tones originate from rotating or oscillating objects. For example, something that rotates at 3000 rpm (50 times/s) likely will create a tone at 50 Hz. There may be additional tones (harmonics) at integer multiples of this fundamental frequency (100, 150 .Hz). For a multibladed propeller or turbine, the blade rate (rotation rate per second times number of blades) is often the fundamental frequency of a harmonic family of tones.. The pure tone has all its power at one frequency. As filter bandwidth decreases, the output from the filter containing the tone remains constant.

1.2.4 Octave and 1/3-Octave Levels

Sound pressure density spectrum levels, representing mean square sound pressure per unit of frequency, can be integrated over a range of frequencies (band) to obtain the mean square pressure expected in the band.

To facilitate comparison of sources with different ouput power and frequency content, two types of proportional bandwidth filters have been adopted as standards: octave band for noise-control engineering applications, and one-third octave band for hearing response related applications. In each case, filter bandwidth is proportional to filter center frequency. An octave is a factor of two in frequency. For example, middle C on the music scale is at 262 Hz; the next higher C on the scale, an octave higher, is at 524 Hz. The bandwidth of a 1-octave band is 70.7% of its center frequency and the bandwidth of a 1/3-octave band is 23% of its center frequency. Standard center frequencies (in Hz) for adjacent ½-octave bands include the following:

50 63 80 100 125 160 200 250 315 400 500 Hz

plus other frequencies lower or higher by factors of 10. Sound levels are often presented for 1/3 -octave bands because, in humans and some animals, the effective filter bandwidth of the hearing system is roughly 1/3 octave.

1.3 TERMS DESCRIBING SOUND SOURCES

1.3.1 Temporal Properties

A sound may be transient, of relatively short duration having an obvious start and end, or it may be continuous, seeming to go on and on. Transient underwater sounds include impulsive transient sounds from explosions, airguns, pile drivers, and sonars. An explosion produces a single transient sound, but airguns, pile drivers, and many sonars produce repeated transients. Sound from a fixed, ongoing source like an operating drillship is continuous. However, the distinction between transient and continuous sounds is not absolute. Sound emitted from an aircraft or a ship underway is continuous, but it is transient insofar as a stationary receiver is concerned. Also, many sounds are not purely transient or purely continuous even at the source. For example, on a drillship, generators and pumps operate essentially continuously, but there are occasional transient bangs and clanks from various impacts during operations.

In describing a transient sound it is useful to present the peak level as well as some description of how the sound varies with time— its waveform. The peak level may be described as being a particular pressure, or as a mean square pressure averaged over a relatively short interval. The latter approach allows more reasonable comparisons with mean square pressures of continuous sounds. When transient sounds are so short as to be impulsive, they are best described in terms of their energy levels (Section 1.2.1) and energy density spectra. Some transient sounds, like airgun impulses, occur periodically. For such sources it is also helpful to describe the duty cycle, or the fraction of time during which the transients are significant.

A continuous sound or slow transient may be described by its mean square pressure and its mean square pressure density spectrum, for some defined averaging time. The latter shows the distribution of sound power versus frequency (e.g., Fig. 1.1). It may also be useful to show the corresponding levels in various 1/3-octave and 1-octave bands (e.g., Fig. 1.2).

1.3.2 Amplitude Properties

Source level is defined as the pressure level that would be measured at a standard reference distance (e.g., 1 m) from an ideal point source radiating the same amount of sound as the actual source being measured. This concept is necessary because sound measurements near large, distributed sources, like ships, depend strongly on source size and measurement location, and are difficult to relate to levels measured far away. Such near-field measurements are generally lower than would be obtained at the same distance from a point source radiating the same amount of energy. The concept of source level introduces the dimension of distance into the description of sound. In general, sound level decreases with increasing distance from the source. To compare different sound sources, it is necessary to adopt a standardized reference distance at which source levels will be determined. Normally, field measurements are made at distances larger than the standard reference distance, beyond the near field. Source level is determined by taking into account the known or expected change in level (propagation loss) between the reference and actual distances. For underwater sounds, a reference distance of 1 m (or 1 yard in older reports) is usually cited (and is used in this report). However, in some reports on ship noise the reference distance may be 100 m or 100 yards. In any case, source level is estimated by adjusting the measured level to allow for transmission loss between a standard reference range and the range where the sound was measured. Only in this way can source levels of various sounds be compared.

1.4 TERMS DESCRIBING SOUND PROPAGATION

Discussions of sound propagation include two equivalent terms: transmission loss (TL) and propagation loss. Chapter 1 discusses this topic in greater detail, but some introductory material is necessary to understand parts of that and other chapters. Conceptually, a sound wave traveling from point A to point B diminishes in amplitude, or intensity, as it spreads out in space, is reflected, and is absorbed. If the source level (at 1 m) is 160 dB re 1 • Pa-m, the received level at range 1 km may be only 100 dB re 1 • Pa; in this case TL is 60 dB. TL is generally expressed in dB, representing a ratio of powers, intensities, or energies of a sound wave at two distances from the source. The distance at which the denominator measurement was taken is the reference distance for TL. Because dB scales are logarithmic, and log (ratio) equals log (numerator) minus log (denominator), TL can be expressed as the difference, in dB, between the levels at the two distances. Strictly speaking, TL is a positive quantity, but it is plotted downward, as in Fig. 1.3. A person viewing a TL graph can visualize the way in which a sound diminishes with increasing distance.

A major component of transmission loss is spreading loss. From a point source in a uniform medium (water or air), sound spreads outward as spherical waves. Spherical spreading implies that intensity, or the mean square pressure, varies inversely with the square of the distance from the source. Thus, TL due to spherical spreading is given in dB by 20 log (R/R_0) where R_0 is the reference range, normally 1 m. With spherical spreading, sound levels diminish by 6 dB when the distance is doubled, and by 20 dB when distance increases by a factor of 10 (Fig. 1.3).

Cylindrical spreading sometimes occurs when the medium is non homogeneous. In shallow water, sound reflects from the surface and bottom. At some distance from the source that is long compared to water depth, various reflected waves combine to form a cylindrical wave. Such a wave may be imagined by picturing a short tuna fish can. The top and bottom of the can correspond to the water surface and ocean bottom, and the curved outer surface is the cylindrical wavefront. In some situations (Chapter 1), a near-cylindrical wave can also form as a result of refraction or ray-bending. With cylindrical spreading, the sound intensity varies inversely with distance from the source. With cylindrical spreading, sound levels diminish by 3 dB when distance doubles, and by 10 dB when distance increases 10-fold. Thus, levels diminish much more slowly with increasing distance with cylindrical than with spherical spreading (Fig. 1.3).

Sound rays are refracted (bent) when sound speed changes along the ray path. *Refraction* is common in the atmosphere and the ocean when temperature varies with height above ground or depth in the ocean; temperature has a major influence on sound speed. Refraction of sound rays can result in convergence zones, which are regions of focused rays and higher sound levels; and shadow zones, which are regions of very low sound level.

As sound travels, some power is absorbed by the medium, giving rise to absorption losses. Such losses vary linearly with distance traveled, and absorption loss can be described as x dB/km. Absorption losses depend strongly on frequency, becoming greater with increasing frequencies. Scattering losses also vary linearly with distance, but result from different physical mechanisms. These losses are in addition to the spherical, cylindrical, or other spreading losses previously mentioned (e.g., Fig. 1.3B).

The terms phase, phase difference, relative phase, and phase angle can be used in comparing two periodic waveforms with the same period. For example, sound components from one source that arrive at a given point via two different propagation paths may differ in phase. Phase refers to the difference in time, or the offset, between two waveforms. If the difference equals the period, or any integer multiple of the period, the two waveforms look the same and the phase difference is zero. Thus, it is possible to describe phase as an angle in the range ± 180°. For example, if phase difference is 1/4 of the period, phase angle is ±90°. The sign depends on whether the waveform of interest is "ahead of' (leads +) or "behind" (lags -) the reference waveform. For continuous waveforms that are random or nonperiodic, the phase concept generalizes to one of time delay, describing the time offset of a waveform and its replica.

1.5 TERMS DESCRIBING AMBIENT NOISE

Ambient noise is the background noise. There is no single source, point or otherwise. In the ocean, ambient noise arises from wind, waves, surf, ice, organisms, earthquakes, distant shipping, volcanoes, fishing boats, and more. At any one place and time, several of these sources are likely to contribute significantly to ambient noise. In the source-path-receiver model, ambient noise is present in the medium (water or air) along the path, and it is present at any receiver location. Ambient noise varies with season, location, time of day, and frequency. It has the same attributes as other sounds, including transient and continuous components, tones, hisses, and rumbles. It is measured in the same units as other sounds. However, in measuring ambient noise, it makes no sense to use a reference distance from the "source", as there is no one source.

1.6 TERMS DESCRIBING SOUND RECEPTION

Sounds can be received by animals' ears and instruments such as hydrophones and microphones. Hydrophones and microphones are transducers that transform received acoustic pressures into electrical voltages or currents, which may be amplified and conditioned for application to meters, tape recorders, speakers, or earphones. These transducers are characterized by their sensitivities, which vary with frequency, by the electrical noise they add to received sound, and by their distortion properties. Hydrophone sensitivities generally are described in volts per micropascal or in dB re 1 V/• Pa.

Animals, including people, have complicated sound reception capabilities. We introduce a few key terms here. More terminology related to hearing is given in Chapter 8 of *Marine Mammals and Noise* (Richardson *et al*. 1995) and Section 4 of this memorandum. The absolute auditory threshold of an animal is the minimum received sound level at which a sound with particular frequency and other properties can be perceived in the absence of significant background noise. Threshold and auditory sensitivity are inversely related. In other words, an animal can hear a fainter sound if the threshold is low than if it is high, and vice versa.

Auditory thresholds vary with frequency. A graph of thresholds versus frequency, called an audiogram, typically is U-shaped. Thresholds generally are high (poor sensitivity) at low frequencies. From there, thresholds generally diminish (improved sensitivity) with increasing frequency, up to some frequency range of optimal sensitivity (best frequency). Above that range, thresholds increase (deteriorating sensitivity) with a further increase in frequency. The "best frequency" varies from one species to another. Section 8.2 in Richardson *et al*. (1995) includes underwater and in-air audiograms of all marine mammal species for which audiograms have been measured; the human in-air audiogram is also shown (Fig. 8.3).

The terms critical ratio and critical band deal with the audibility of a pure tone in the presence of background noise. People and animals have varying abilities in this regard. The critical ratio is the ratio of the level of a barely audible tone to the spectrum level of background noise at similar frequencies. Because of the logarithmic nature of dB scales, a critical ratio can be derived by subtracting the spectrum level of the background noise from the tone level. For example, if a tone must be 100 dB re 1 • Pa to be detected with background noise of 80 dB re 1 • Pa at similar frequencies, the critical ratio is 20 dB (i.e., 100 minus 80). Critical ratios tend to increase with increasing frequency.

Critical bands can be defined in different ways, but in general the critical band around a given frequency is the band within which background noise affects detection of a sound signal at that frequency. Background noise at frequencies outside the critical band has little effect on detection of a sound within that band unless the noise level is very high. Critical bands are often roughly 1/3 octave wide. Hence, it is often useful to summarize man-made noise and ambient noise on a 1/3 octave basis. The process by which background noise may prevent detection of sound signals at nearby frequencies is called masking.

2.0 Underwater Noise Propogation

2.1 Introduction

This section is included to provide an introduction to sound propagation for non-acousticians. It is based on a longer summary of sound propagation principles contained in Chapter 4 of *Marine Mammals and Noise* (Richardson et al. 1995). The scope of the material presented here is concerned primarily with the acoustics of the Glacier Bay environment and focuses on underwater sound propagation in shallow water with a brief discussion of airborne sound propagation and transmission of airborne sound into water. For a more complete discussion, including deep water sound transmission and theoretical aspects of sound propagation, the reader is referred to *Marine Mammals and Noise*, and to *Principles of Underwater Sound* (Urick 1983).

The audibility or apparent loudness of a noise source is determined by the radiated acoustic power (source level), the propagation efficiency, the ambient noise, and the hearing sensitivity of the subject species. Noise levels produced by human activities in underwater and terrestrial environments are determined not only by their acoustic power output but, equally important, by the local sound transmission conditions. A moderate-level source transmitting over an efficient path may produce the same received level at a given range as a higher-level source transmitting through an area where sound is attenuated rapidly, that is, over a “lossy” path. Likewise, a given noise source operating in different areas, or in the same area at different times, may be detectable for greatly varying distances, depending on regional and temporal changes in sound propagation conditions among other factors. In deep water, depth variations in water properties strongly affect sound propagation. In shallow water, interactions with the surface and bottom have strong effects.

As a result, the zone of acoustic influence for a given source of man-made noise can vary in radius 10-fold or more, depending on operating site and depth, and on seasonal changes in water properties. Hence, sound transmission measurements, analyses, and model predictions are necessary to estimate the potential radius of acoustic influence of noisy human activities.

Site-specific sound propagation data are often lacking when a potentially noisy activity is planned. It is often not feasible to obtain in situ sound transmission measurements to estimate how intrusive the new noise will be. However, predictions can often be made even without site-specific propagation data. Predictions are based on propagation models developed for both airborne and underwater sound. These models provide procedures for estimating the received noise level as a function of distance, assuming that the source level and characteristics are known. These propagation models may be purely theoretical, based on physical principles; or semi-empirical, using both physical principles plus field measurements.

Model predictions can be useful for planning and for preparing environmental impact statements, but it is advisable to obtain relevant empirical data as well. This is important because of the highly variable and site-specific nature of underwater sound transmission, especially in shallow water, and of airborne sound transmission near the ground.

This section describes some sound propagation concepts relevant to noise impact prediction. We provide a brief review of theoretical aspects; shallow water, and airborne sound transmission; and air-to-water transmission. Equations are included where useful for clarity, but the reader should refer to the references described previously for a more detailed theoretical treatment of the topics presented here.

2.2 Theoretical Aspects

In a uniform medium with no nearby boundaries and no absorption loss, sound from an omnidirectional source spreads uniformly outward with a spherical wavefront. Intensity decreases as the area of the wavefront expands. At distances that are large compared with the source dimensions (far field), sound intensity varies inversely as the square of range from the acoustic center of the source. Since sound intensity is proportional to sound pressure squared, sound pressure is inversely proportional to range. In logarithmic terms, this is called a 20 log R spreading loss or spherical spreading:

$Lr = L_s - 20 \log R$

where Lr is the received level in dB re 1 • Pa (underwater) or dB re 20 • Pa (in-air),

L_s is the source level at 1 m in the same units, and R is the range in m.

When sound becomes trapped in a sound duct between horizontal refracting or reflecting layers, it is constrained to spread outward cylindrically rather than spherically. Cylindrical spreading also occurs when sound is trapped between the surface and bottom in shallow water. In these cases, sound intensity decreases in proportion to the increase in area of the expanding cylindrical wavefront. As a result, sound intensity varies inversely as the range from the source (i.e., as 1/R), in contrast to the $1/R^2$ that applies with spherical spreading. Sound pressure varies inversely as the square root of range (i.e., as $1/R^{0.5}$), in contrast to the 1/R that applies with spherical spreading. This is the 10 log R spreading loss of cylindrical sound transmission:

$L_r = L_s - 10 \log H - 10 \log R$

where H is the effective channel depth. The "- 10 log H" term is related to the fact that cylindrical spreading does not begin at the source; spreading is usually more or less spherical from the source out to some distance (approximately equal to the water depth), and then may transition to cylindrical. Sound attenuates much more rapidly with increasing distance with spherical (20 log R) than with cylindrical (10 log R) spreading (Fig. 1.3). A given source can be heard farther away when there is cylindrical spreading along much of the path from source to receiver.

Simple spherical or cylindrical spreading are important theoretical concepts and apply at least approximately to many real-world situations. However, the ocean is not a uniform medium. Variations in temperature and salinity with water depth affect the rate of propagation loss. The speed of sound increases with increasing temperature, salinity, and pressure. This results in distortion of the wavefront as it propagates. This distortion is equivalent to bending (refraction) of the sound rays that trace the paths of points on the wavefront. Refraction causes rays to be bent toward the direction of slower sound speed, since the portion of the wavefront traveling in the region of higher sound speed advances faster than the remaining portion. Refraction is a dominant feature of sound transmission in both deep and shallow water. Variation of sound speed with depth controls the ray paths. As a result, the decrease of sound intensity with range is influenced not only by spreading loss but also by concentration or reduction in the ray density due to refraction. In the current application the gradients are those of the summer season in Glacier Bay so the effects of seasonal changes on transmission loss will not be discussed in detail.

In shallow water with an absorptive bottom the 10 Log R spreading loss of cylindrical reflection is not appropriate because energy is lost by bottom absorption and scattering. In regions where the bottom reflection loss for sound rays is proportional to the angle of incidence with the bottom a 15 Log R spreading loss is developed, but often there are variations in the transmission path properties that result in a multistage range-dependent spreading loss characteristic. This is discussed in more detail in the next subsection.

2.3 Shallow Water Sound Propagation

Sound transmission in shallow water is highly variable and site-specific because it is strongly influenced by the acoustic properties of the bottom and surface as well as by variations in sound speed within the water column. As in deep water, variations in temperature and salinity with depth cause sound rays to be refracted downward or upward. Refraction of sound in shallow water can result in either reduced or enhanced sound transmission. With upward refraction, bottom reflections and the resulting bottom losses are reduced; with downward refraction the opposite occurs. Thus, sound transmission conditions in continental shelf waters and bays can vary widely.

The many environmental factors that influence shallow water sound transmission make it difficult to develop adequate theoretical models. One must combine theory with site-specific empirical data to obtain reliable propagation predictions. Low frequency sounds do not propagate well in shallow waters due to the long wave lengths, whereas high frequency sounds propagate relatively well. In many cases, however, the bottom consists of water-saturated sediment and does not reflect all the sound energy. In these conditions, propagation of low-frequency energy extends downward into the bottom material. If the composition and layer structure of the bottom are known, or can be estimated, this information, when incorporated into the modal analysis procedure, permits calculation of shallow water sound transmission losses with good accuracy.

To accommodate the variability of real-world data, semi-empirical propagation models have been designed for application to shallow water. It is possible to make reasonable propagation predictions from simple formulas of these types if sound speed is nearly independent of water depth and if the bottom either is flat or slopes uniformly and gradually (Weston 1976). Weston's formulas divide the shallow water transmission path into four regions: a spherical spreading region near the source (20 Log R); a transitional, cylindrical-spreading region where bottom- and surface-reflected rays contribute more energy than the directly transmitted rays (10 log R); a grazing angle dependent, "mode-stripping", region (15 Log R); and a "lowest-mode" cylindrical spreading region (10 Log R). Weston's formulas have been modified by P.W. Smith, Jr. (Malme et al. 1986), and incorporated into a short computer program (Weston/Smith Model) that calculates transmission loss when given parameters of frequency, water depth at the source, bottom slope, and two parameters describing the bottom reflection loss.

2.4 Absorption and Factors Affecting Spreading Loss

Several additional factors can have important influences on sound propagation in both deep and shallow water. These include molecular absorption and interference effects associated with shallow sources or receivers. A sloping bottom or special types of subbottom layers can also affect propagation, especially in shallow water.

2.4.1 Absorption

When sound energy is transmitted through water, a small portion is absorbed by water molecules. Absorption of sound by seawater increases with increasing frequency; energy loss is approximately proportional to the square of frequency. Absorption is also weakly influenced by water temperature. Furthermore, there is a relatively strong pressure dependence, with absorption coefficients being reduced with increasing depth. At frequencies >5 kHz, absorption causes significant (>2 dB) transmission loss if range is >10 km. At frequencies <1 kHz, absorption is not significant at ranges <40 km.

2.4.2 Shallow Source and Receiver Effects

When the source or receiver are very close to the surface, the surface reflection of the sound interacts strongly with direct sound radiation. The reflected sound is out of phase with the direct sound. If the source has strong tonal or narrow-bandwidth components, this phenomenon produces an interference pattern. It may be observed as range-dependent fluctuations in sound level at receiving locations along a horizontal radial line from the source. This phenomenon, the Lloyd mirror effect, is strongest with low-frequency tones and in calm sea conditions.

This effect occurs when range from source to receiver is long enough such that the direct and reflected path lengths are comparable. An interference field develops with alternating maxima and minima in received level. Beyond the interference zone, propagation loss is higher than normal when either the source or the receiver is close to the surface, that is, when their depths are less than• /4 for the dominant frequencies. With a shallow source, the source and its reflected image become effectively a dipole source with a vertical directionality (Urick 1983). In deep water, with both a shallow source and a shallow receiver, spreading loss may be as much as 40 log R, versus the 20 log R expected from spherical spreading. In shallow water, the shallow source dipole effect introduces an additional 10 log R spreading loss, increasing the loss from - 15 log R to - 25 log R. A similar interference effect occurs when the receiving location is within 1/4 wavelength of the surface. Thus, propagation from a shallow source to a shallow receiver in shallow water will show - 35 log R spreading loss. These types of effects occur for low frequency ship noise. Low frequency propeller noise is typically several decibels weaker when received near the surface than when received at depth.

2.4.3 Bottom Slope Effects

The slope of the bottom has a strong influence on sound transmission in shallow water. For transmission from a shallow region into deeper water, the increasing depth permits sound energy to spread out into a

larger volume than would have been available if depth had remained constant. This tends to result in a reduced sound level. On the other hand, a downward-sloping bottom causes decreasing angles of incidence of sound rays with the bottom and surface. This results in fewer reflections per kilometer, and thus less energy loss. For most bottom types, the reduction in reflection loss with increasing depth has a stronger influence than the increased water volume.
Hence, the net effect of a downward slope along the propagation path often is lower transmission loss.

An upward slope causes more surface and bottom reflections, and a steeper incidence angle for each reflection. Consequently, there is a net increase in loss rate as sound enters shallower water unless bottom loss is very low. As propagation continues upslope, there is a transition from multimode to single-mode propagation and a shift from 15 log R to 10 log R spreading loss. Although spreading loss is reduced, attenuation from bottom loss may be high because of the many reflections in shallow water. Eventually, depth is reduced to the point where modal transmission is not supported and the remaining sound energy is attenuated very rapidly.

2.5 Airborne Sound Transmission

Airborne sound transmission needs to be considered for two reasons. First, sound from some sources, especially aircraft, travels through air before entering water, and is attenuated along the airborne portion of the propagation path. Second, some marine mammals—pinnipeds and sea otters—commonly occur on land or ice, where they hear airborne sounds and emit aerial calls.

Sound from an omnidirectional source in an unbounded uniform atmosphere is attenuated only by spherical spreading (20 log R) and by absorption of sound energy by air molecules. However, sound from a source near the ground is affected by additional factors. The ground is usually nonrigid and permeable, and propagation near this surface is influenced by reflections and wave transmission along the surface. Interference between the direct, reflected, and ground wave paths causes fluctuations in received level and in frequency composition for near-ground transmission. Also, refraction caused by wind and temperature gradients produces shadow zones with poor sound transmission in the upwind direction, and often produces enhanced transmission downwind. When sound is transmitted from an elevated source such as an aircraft, the influence of gradient refraction and ground effects are greatly reduced, so for most airborne noise sources of concern in Glacier Bay the received level may be estimated by a simplified transmission loss relationship.

$L_r = L_s$ - 20 Log R – • R/1000

Where • is the atmospheric absorption loss in dB/km.

2.5.1 Atmospheric Absorption

Atmospheric absorption of sound at frequencies below 30 kHz is produced by oxygen and nitrogen molecules. The dominant mechanism is similar to the process acting underwater. The amount of absorption depends on frequency, temperature, relative humidity, and to a small degree atmospheric pressure. The physical relationships between these parameters and absorption are not easily expressed mathematically, but an empirical algorithm has been developed to compute absorption coefficients from these four parameters. At middle frequencies, sound absorption has more influence on sound transmission in the atmosphere than in the ocean. For example, at 1 kHz the underwater sound absorption coefficient is - 0.06 dB/km, whereas a typical value for in-air attenuation is - 4 dB/km. The absorption coefficient increases rapidly with frequency to - 130 dB/km at 10 kHz, depending on temperature and humidity. Hence, only low-frequency sound is transmitted well in air

2.6 Air-to-Water Transmission

Sound traveling from a source in air to a receiver underwater propagates in four ways: (1) via a direct refracted path; (2) via direct refracted paths that are reflected by the bottom; (3) via a lateral (surface-traveling) wave; and (4) via scattering from a rough sea surface. The types of propagation vary in importance depending on local conditions, depth of receiver, and bottom depth. The direct refracted path is important when the receiver is nearly under the aircraft. Snell's law predicts a critical angle of 13° from the vertical for the transmission of sound from air to water. Under calm sea conditions, sound is totally reflected at larger angles and does not enter the water. However, some airborne sound may penetrate water at angles >13° from the vertical when rough seas provide water surfaces at suitable angles.

Sound traveling from air to water along the direct refracted path passes through three phases: through air; across the air-water surface; and from the surface to the underwater receiver. To a first approximation, propagation loss in air can be described by simple spherical spreading—a 6 dB decrease per distance doubled. At the surface, the great difference in acoustic properties of air and water results in most acoustic energy being reflected. However, the sound pressure transmitted to the water is actually enhanced because of a pressure-doubling effect at the interface. Hence, sound pressure at the surface directly beneath the source is twice that expected in air at the same distance if there were no water surface. From the surface to the underwater receiver, sound propagation includes both geometrical spreading and the effects of the divergence of sound energy as it passes through the surface. This results in a complicated distribution of underwater sound pressure that depends on height of source, location of receiver, water depth, and temperature-salinity profile of the water column. Air-to-water sound propagation has been documented using wave theory. To estimate underwater sound levels produced by an airborne source over shallow water, an air-to-water sound transmission model has been developed (Richardson et al. 1995).

Model results are consistent with empirical data. In deep water, there are high transmission losses between a source in air and an underwater receiver distant from the subsource point. Underwater received levels away from the subsource point are higher in shallow than in deep water. This difference occurs because, in shallow water, sound is transmitted horizontally away from the subsource point by multiple reflections from the bottom and surface. This process is more efficient for hard bottom conditions. Even with a hard bottom, however, underwater noise diminishes more rapidly with increasing horizontal distance than does airborne noise. Consistent with this, under typical ambient noise conditions, an approaching aircraft can be heard in the air well before it is audible underwater.

2.7 Summary

Sound propagation in the sea has been the subject of intensive research. The open literature is voluminous, and there is additional unpublished and classified information. For specific applications, the information provided in this chapter should be augmented by a detailed review of relevant references.

Sound propagation research has made considerable progress in recent years. Field measurements of sound levels in relation to distance, frequency, and environmental parameters have been obtained in many areas and situations. Based on these data and on theoretical considerations, efficient computer models have been developed. Some models provide sufficient detail to account for many of the propagation processes occurring in the real world. However, most models are designed for specialized applications (often classified) and are not easily generalized for use in predicting potential noise impact ranges for anthropogenic sources. Fortunately, simple and general relationships can be used to make estimates of transmission loss for many sources and locations, both underwater and in air (Richardson et al.1995).

3.0 Zones of Influence

One method to assess the effects of man-made noise on marine mammals is to estimate the radii within which effects are expected. This "Zone of Influence" model was described in detail in Richardson *et al.* (1995) and is summarized here. Readers are directed to the original source for a more detailed description of the factors affecting zones of influence, and the variability therein.

There are at least four zones identified in which man-made noise can affect marine mammals. Those zones are:

1. *zone of audibility* – the area within which a sound is barely audible above background noise,
2. *zone of responsiveness* – the region within which an animal reacts to the sound either behaviorally of physiologically. This zone may or may not be smaller than the zone of audibility,
3. *zone of masking* – the region within which a man-made sound is strong enough to interfere with the detection of other sounds, such as communication or echolocation sounds,
4. *zone of hearing loss, discomfort, or injury* – the area within which the level of sound is high enough to cause discomfort or tissue damage to auditory or other systems.

Many assumptions must be made to predict radii of acoustic influence on marine mammals, and in many cases the data are not adequate to allow precise predictions. Local variables, including time, season, and location, will also affect radii of influence. While many factors prevent zones of influence from being exact predictors of the effects of noise to marine mammals, the model may be the best way to predict and mitigate the effects of man-made noise to marine mammals.

3.1 Zone of Audibility

The zone of audibility is the maximum possible radius of influence of a man-made noise on marine mammals. The radius of the zone of audibility is affected by many variables, including the source level and frequency, propagation loss, ambient noise, hearing sensitivity of the animal and individual variation.

Ambient noise greatly affects the zone of audibility. If the Signal to Noise Ratio (SNR, the difference between the received signal level and background noise level) is• 0 dB, the man-made noise may not be detected, and may not affect the animal.

Many man-made sounds are dominated by low frequency components. For a single source, dominated by low frequency components, the zone of audibility will vary greatly depending on the animals' abilities to hear low frequency sounds. Pinnipeds and odontocetes (toothed whales and dolphins) generally are not highly sensitive to low frequency sounds, while baleen whales are believed to be highly sensitive to low frequency sounds. Therefore, for a single source, the zone of audibility will vary greatly from species to species. If the ambient level is lower than the absolute threshold (the lowest sound level that can be detected) for the frequency in question, the zone of audibility will be determined not by the man-made sound, but by the sensitivity of the animal. The radius of influence will also vary depending on the sensitivity of the individual.

3.2 Zone of Responsiveness

The zone of responsiveness is the area around of source of man-made noise within which marine mammals of a given species show observable behavioral responses (Richardson *et al.* 1995). Many studies (e.g. Baker and Herman 1989, Frankel and Clark 1998, 2000, Bogaard *et al.* 1999, Todd *et al.* 1996) have documented behavioral changes in response to sound from human activities. However, types of behavioral responses and the distance at which reactions became evident varied widely, even for a particular species with the same human activity. Furthermore, behavioral differences are generally only detectible with sophisticated statistical techniques. Therefore, while the zone of responsiveness is a real phenomenon for many species and human activities, the radius is a statistical phenomenon: a few animals may respond at great distances, the majority may react when the source is closer, and a few may not respond until the source is very close or may not respond at all. To define the zone of responsiveness, it is necessary to define the proportion of animals expected to react, and the type of reaction that is expected.

The most obvious behavioral response to noise is an avoidance reaction. However, avoidance responses can be strong or weak. Animals may swim rapidly, directly away from a noise source, or may vary speed and direction from the source. Animals may even swim *toward* a source, for instance pinnipeds may move toward the water, or cetaceans in shallow water may move toward deeper water, even if the sound source is offshore. Other behavioral responses also may indicate disturbance. Pinnipeds on a beach may lift their heads or otherwise become alert, and cetaceans may change general activity state, resting or socializing whales may begin to travel. Other indications may not be easily detected by observation, the mean duration of surfacings and dives, blow rate, and blow intervals may change in response to sound. However, these responses are often only detectible with statistical tests. Those changes may, nevertheless, be useful as indicators of stress without any obvious avoidance response.

Biological factors can influence the responsiveness of animals to sound disturbance. Resting whales may be more apt to respond than animals that are socializing, feeding or mating (Richardson *et al.* 1985). Age and sex classes can also vary in their responsiveness. Immature or pregnant Steller sea lions at a haul-out site were more likely to enter the water when an airplane flew over than were territorial males or females with pups (Calkins 1979). Habitat differences may also influence responsiveness: walruses were more responsive to approaching boats when they were hauled out on ice than in the water (Fay 1984), and whales in shallow water or surrounded by ice may react more strongly to noise.

It is often difficult to determine appropriate criteria to measure the zone of responsiveness. Several methods of estimating the radii of influence have been suggested. One method is based on received sound levels: animals may react when the received sound level reaches or exceeds a specific level, in a specific bandwidth. One complicating factor of this method is determining which frequency band is appropriate. Response thresholds for broad bands are likely to be higher than for narrower bands which contain the most intense noise. For example, Richardson *et al*. (1990) determined that the response threshold for bowhead whales in the Beaufort Sea exposed to drilling and dredging sounds was approximately 115 dB re 1 • Pa on a broadband (20-1000 Hz) basis and approximately 110 dB re 1 • Pain the 1/3 octave band where industrial noise was most prominent. Another possible criterion is the Signal-to-Noise Ratio. A sound of given level may be more disturbing when the ambient level is low than when the ambient level is high. A third criterion possibility is that of distance from a sound source. Distance criteria are easy to define, implement and monitor for compliance. However, received sound level and distance are not perfectly correlated, and received sound level a given distance from a source will vary with time and location. Sound sources also vary, so received levels at a given distance will vary depending on the sound source (e.g. cruise ship v. private skiff). A further complication is the sensitivity of species in question. Distance criteria will be larger for species more sensitive to the dominant frequencies from a man-made sound source than for species less sensitive.

3.3 Zone of Masking

If noise is strong enough relative to a target signal, the signal will be "masked" and undetectable. In theory, each man-made sound source is surrounded by a Zone of Masking within which useful sounds are undetectable to marine mammals of a given species. The area where masking will occur is highly variable, and dependent upon all factors that affect the received levels of background noise and the sound signal.

Any man-made noise introduced into the marine environment will add to the background noise. This increase will interfere with an animal's ability to detect very weak signals. Therefore, the Zone of Audibility is also the largest potential Zone of Masking. For an animal close to a source of man-made noise, the noise level will be high and the animal would only be able to hear sounds from nearby animals, calls from animals further away would be weaker and may be undetectable. Thus, for animals that use low level sounds for communication such as baleen whales that may use weak, low-frequency sounds for communication (Payne and Webb 1971) the Zone of Masking will be larger than for animals that do not regularly use weak, low-frequency sounds. Short-distance communications are unlikely to be masked by distant sources of man-made noise. Therefore, the Zone of Masking is influenced not only by the level of the target sound, but also by its function. For a single species in a single situation, there may be multiple Zones of Masking, depending on the frequency, level, and function of the target sound.

There is some evidence that animals may have strategies to compensate for masking of useful sounds. This would be expected since natural background noise (wave noise, non-useful biological noise, etc.) can also mask useful sounds. Serrano and Terhune (2001) report that harp seals (*Pagophilus groenlandicus*) in the Gulf of St. Lawrence, Canada increased the number of elements per call as ambient calling rates (noise) within a breeding colony increased. The increase in the number of elements per call may be a strategy to avoid masking in a noisy environment and to maximize call detection over long distances.

3.4 Zone of Hearing Loss, Discomfort , and Injury

Prolonged or repeated exposures to high levels of airborne sound accelerates the normal process of gradual hearing loss in humans (Kryter 1985). This deterioration is a *permanent threshold shift* (PTS) in that sensitivity at some frequencies is permanently lowered; a higher level is required before it is detected. Besides PTS, temporary exposure to high noise levels can cause a *temporary threshold shift* (TTS) that can last anywhere from a few minutes to days. PTS can also develop from a brief exposure to an extremely high sound level, such as that from a nearby explosion.

There is little direct evidence that marine mammals suffer TTS or PTS, although it is assumed that the hearing sensitivity of marine mammals can be reduced at least temporarily by exposure to strong noises. Kastak *et al*. (1999) reported TTS in three species of pinnipeds after underwater exposure to noise. A harbor seal exposed to white noise with frequencies ranging from 100 Hz to 2,000 Hz at source levels between 60-75 dB for 20 – 22 min. experienced a threshold shift of approximately 4.8 dB, recovery to near baseline levels was reported within 24 hours of noise exposure (Kastak *et al*. 1999). Threshold shifts were similar for two California sea lions (*Zalophus californianus*)and a juvenile elephant seal (*Mirounga angustirostris*).

In humans, a chronic exposure of approximately 80 dB above threshold is required for PTS to develop. If the same follows for marine mammals hearing underwater, a chronic exposure to noise levels of ~120 db re 1• Pa, approximately 80 dB above absolute threshold, would be required for induce PTS in belugas (one of a few cetaceans for which absolute thresholds have been measured). For pinnipeds the exposure would probably be higher (~ 140 dB re 1 • Pa) given their higher absolute thresholds. While some marine mammals tolerate noise at ~120 dB re 1 • Pa, it is doubtful that marine mammals would remain in an area ensonified at 120 – 140 dB re 1 • Pa long enough to suffer TTS or PTS. Many of the loudest sources of man-made noise (e.g. supertankers or icebreakers) are themselves mobile, and are unlikely to ensonify a given area for long enough to induce TTS or PTS in marine mammals. However, while chronic exposure is unlikely, intermittent or explosive noise may be strong enough in some circumstances to induce TTS or PTS in marine mammals. In addition to inducing TTS or PTS, very strong explosive noise has the potential to cause tissue damage to auditory or other tissues. Todd *et al*. (1996) examined two dead humpback whales found near industrial explosive activities in Trinity Bay, Newfoundland. Both whales showed evidence of tissue damage consistent with extremely high noise levels, and it is likely that the noise contributed to the deaths of the whales. Besides damage to auditory tissues, extremely strong noise sources can cause damage to internal organs: respiratory cavities can be induced to resonate in response to strong underwater noise with the appropriate wavelengths.

3.5 Summary

Radii of influence of man-made noise to marine mammals are dependent upon numerous factors. The source level and spectral characteristics of the noise, the rate of attenuation of the noise, and ambient noise will all affect radii of influence. Attenuation and ambient noise are themselves dependent upon environmental characteristics, including water depth, water qualities, bottom characteristics, sea state, and many others. When considering masking, characteristics of the target signal also add to the variability in predicting radii. Predictions of radii are also variable due to the sensitivity, individual variation, and motivation of the marine mammals themselves. Much caution must be taken in developing and interpreting zones of influence. However, while many factors prevent zones of influence from being exact predictors of the effects of noise to marine mammals, the model may be the best way to predict and mitigate the effects from man-made noise.

4.0 Marine Mammal Hearing

Sound, unlike light and other stimuli, is transmitted very efficiently through water. Sounds from natural and man-made sources can often be heard for many kilometers, far beyond the range at which the stimuli would be detected visually either underwater or in air. Marine mammals probably use the characteristics of sound transmission to obtain information about their surroundings, including the presence of conspecifics and other marine mammals, and the presence of prey or predators. Concern has been raised that the multitude of man-made sounds introduced into the ocean may have deleterious effects to marine mammals.

Factors affecting marine mammal hearing

The hearing abilities of marine mammals (and other animals) are functions of the following (after Richardson et al. 1995):

1. Absolute hearing threshold – the level of sound that is barely audible in the absence of significant ambient noise.

2. Frequency and intensity discrimination – the ability to discriminate among sounds of different frequencies and intensities.

3. Localization – the ability to localize sound direction at the frequencies under consideration

4. Masking – the ability or inability to distinguish target sounds from ambient noise

5. Motivation – the psychological state of the animal may influence whether the sound is detected, and whether the animal reacts.

6. Individual variation – the variation between individuals in hearing sensitivity.

4.1 Absolute Threshold

Audiograms show the sensitivity of marine mammals to sounds of different frequencies. Audiograms are normally obtained using captive animals specially trained to respond when sounds become audible. In this way, the absolute threshold for various frequencies can be measured. Audiograms typically produce a U-shaped chart, with the best sensitivity (bottom of the U) in the middle frequencies, and decreasing sensitivity (higher intensity required for detection) at low and high frequencies. It is not known how well baleen whales follow this trend, their use of low frequency sound, and the anatomy of their auditory organs suggest that they may have good low frequency hearing. Audiograms have been obtained for seven species of toothed whales and seven species of pinnipeds. No audiograms have been collected for baleen whales. Of the marine mammals inhabiting Glacier Bay National Park and Preserve, audiograms have been obtained for only the killer whale and the harbor porpoise.

4.1.1 Odontocete Threshold

Odontocetes generally have very acute hearing at the middle frequencies, with lower sensitivity at low and high frequencies. The best frequencies for the seven species of odontocetes for which audiograms have been obtained ranged from ~8 to 90 kHz (Richardson et al. 1995). Hearing extends at least as low as 40 – 75 Hz in the beluga and the bottlenose dolphin, but their sensitivity at low frequencies appears to be low. By contrast, the sensitivity at high frequencies appears to be very good for most odontocetes, extending up to 80 – 150 kHz. The good high-frequency hearing is likely related to the use of high frequency sounds for echolocation.

4.1.2 Pinniped Threshold

Underwater audiograms have been obtained for four species of phocid (hair or true seals) including one for the harbor seal, which inhabits Glacier Bay National Park and Preserve waters, and for three species of otariid (sea lions and fur seals).

Phocids generally have flat audiograms from 1 kHz to 30 – 50 kHz with thresholds between 60 and 85 dB re 1 • Pa (Richardson et al. 1995). Little is known about pinniped hearing below 1 kHz, but for a single harbor seal sensitivity was 96 dB re 1 • Pa at 100 Hz (Kastak and Schusterman 1995). Sensitivity for most phocids remains good until about 60 kHz, after which sensitivity is poor (Richardson et al. 1995).

Underwater sensitivity at the high and low frequency ends of otariids is generally lower than for phocids, but there is little difference in the middle frequencies (Richardson et al. 1995). The high-frequency limit for most otariids appears to be about 36 – 40 kHz (Schusterman 1981), and sensitivity in the 100 – 1 kHz range appears to be lower than for phocids, based on the slopes of the audiograms that have been performed. Otariids that have been tested appear to have best sensitivity between 2 and 17 kHz (Moore and Schusterman 1987; Schusterman et al. 1972). Kastak and Schusterman (2002) recently reported that the auditory sensitivity of a free-diving California sea lion changed at depth. Hearing sensitivity generally worsened with depth, with significant interaction between depth and frequency. However, sensitivity at 50 m increased above 35 kHz compared to sensitivity at 10 m. Similar studies have not been conducted with phocids, but would help elucidate mechanisms of pinnipeds' underwater hearing.

Pinnipeds are amphibious and thus must also respond to airborne sounds. In-air audiograms have been obtained for two otariids and two phocids, including the harbor seal. Otariids apparently are more sensitive to airborne sounds and appear to detect higher frequency airborne sounds than phocids. The high frequency limit for otariids is similar to the underwater limit of 36 – 40 kHz, whereas for phocids, the upper limit appears to be around 20 kHz, considerably lower than the 60 kHz limit underwater. Sensitivity for both otariids and phocids deteriorates as the frequency goes below 2 kHz.

4.2.2 Frequency and Intensity Discrimination

The ability to differentiate between two signals of different frequency and intensity is important in detecting sound signals amidst background noise. This ability is also important for detecting calls from conspecifics, prey and predators.

Odontocetes apparently have very good frequency discrimination. Bottlenose dolphins can discriminate frequencies differing by 0.21 – 0.81% between 2 and 130 kHz (Thompson and Herman 1975). Pinnipeds have less precise frequency discrimination than odontocetes. Harbor seals were able to detect differences as small as 1.0 – 1.8% between 1 and 57 kHz (Møhl 1967, 1968).

Intensity discrimination may be important in detecting signals in the presence of noise. Odontocetes may be able to detect differences as small as 0.35 – 2.0 dB (Johnson 1971). Few data exist on the ability of pinnipeds to detect differences in intensity. Moore and Schusterman (1976) report that the California sea lion may be able to detect differences as small as 3 dB at 16 kHz.

4.2.3 Directional Hearing

The ability to localize sounds may be important for interactions among social marine mammals, and is undoubtedly important in prey detection by echolocation or by passive signal detection. Humans' ability to localize sounds depends on the interaural delay of sounds. Sound travels five times faster in water than in air, greatly reducing the ability to detect interaural delay. Bone conduction may also reduce the ability of terrestrial animals to localize sound underwater. In whales, the auditory organs are isolated from the skull, enhancing the ability to localize sound. Pinnipeds auditory structures are fused to the skull, which suggests a reduced ability to localize underwater sounds, but pinnipeds have other adaptations for hearing both in-air and underwater.

Odontocetes have very good ability to localize sound, as would be expected based on their echolocation abilities. Bottlenose dolphins are able to differentiate tones 2-3° off midline, and may have been able to detect clicks 0.7 – 0.9° off midline (Renaud and Popper 1975). Clicks are used for echolocation and should be more easily located than pure tones. These results were measured with the dolphin's head restrained. Head movement may increase the localization abilities of echolocating dolphins.

Pinnipeds have less precise abilities to localize sounds than odontocetes. A harbor seal was able to localize underwater tones ~ 6º apart (Møhl 1968b), and a California sea lion was able to localize underwater tones ~ 4º apart (Moore and Au 1975). The ability to localize tones is better in air than underwater. A harbor seal was able to localize clicks in air ~ 3º apart (Terhune 1974).

There is some indirect evidence that baleen whales have the ability to localize sounds at frequencies of a few hundreds, to tens of hertz (Richardson et al. 1995). Baleen whales sometimes orient and swim towards distant calling conspecifics (Watkins 1981; Tyack and Whitehead 1983), or swim directly away from predator calls (Malme et al. 1983) or industrial noise (Richardson et al. 1995).

4.3 Auditory Masking

Normal background noise (natural and man-made) may interfere with the ability of an animal to detect a sound signal. The amount by which a pure tone must exceed the background level in order to be audible is called the Critical Ratio (CR). CRs are generally measured for specific frequencies, since ability to detect sounds is dependent upon frequency. In general, CRs increase with increasing frequency.

4.3.1 Adaptations to Reduce Masking

Since natural noise can interfere with the ability to detect sounds, it would be expected that animals have developed strategies to reduce masking. Marine mammals that localize sounds reduce the effect of masking as a result of directional noises, that is masking is not as severe for important sounds that come from directions different than those of the noise. Masking of high frequency sounds in the bottlenose dolphin is strongly dependent upon the directionality of the sound and noise signals (Au and Moore 1984). In general, the masking effect of background noise is reduced if the noise either comes from a direction other than that of the target, or is omnidirectional (Richardson et al. 1995).

In order to reduce masking marine mammals may also shift the frequency of their calls from a "noisy" frequency band to one with less ambient noise (Lesage et al. 1999), increase the length of calls (Miller et al. 2000), change the duration of elements in calls (Norris 1999), increase the number of specific calls (Lesage et al. 1999) or elements within calls (Serrano and Terhune 2001).

4.4 Individual Variation and Motivation

In addition to the physical factors that influence marine mammal hearing, individual variation in hearing abilities and differences in motivation will influence the effects of sound to marine mammals. Ketten et al. (1995) compared hearing abilities of a long-term captive dolphin, one juvenile, and two young adult dolphins. The older dolphin showed hearing loss consistent with age related hearing loss in humans. The older dolphin showed a shift in high frequency sensitivity from normal threshold levels up to 165 kHz to no functional hearing above 60 kHz at his death at age 28. The conclusion was that the hearing loss was attributable only to age-related changes in the ear.

Reactions of marine mammals to sounds vary considerably. Some humpbacks show little or no reaction to vessels within distances that other humpbacks have shown obvious reactions. Krieger and Wing (1984, 1986) determined that humpbacks are less likely to react to vessels when they are actively feeding than when resting or engaged in other activities. Humpback pods with calves, or small pods, were more likely to react to vessels than were larger pods or pods without calves present (Bauer et al. 1993). Thus, the motivation (behavioral state, whether sound is perceived as a threat) will affect how or whether marine mammals will react to sound.

4.5 Baleen Whale Hearing

There are no audiograms for baleen whales, so all information about hearing in baleen whales is based on behavioral observations, anatomical evidence, and extrapolations from other marine mammal hearing characteristics. Field observations of the responsiveness of baleen whales to sounds can set an upper bound for detection thresholds. However, it is not possible to determine if sounds at lower levels than those that elicited a response were detected but did not elicit an overt response or were undetected by the animal. Humpback whales reacted to calls from other humpbacks at levels as low as 102 dB re 1 • Pa,and bowhead whales fled from an approaching boat when the noise level was 90 dB re 1 • Pa(Frankel et al. 1995; Richardson and Greene 1993).

Baleen whales are probably able to hear low frequency sounds, including infrasounds (< 20 Hz). Baleen whales react to sounds from conspecifics that range from 20 Hz (fin whales) to 550 Hz (humpback whales) (Watkins 1981; Frankel et al. 1995). Humpback, gray and bowhead whales all react to airgun pulses and underwater playbacks of low frequency (50 – 500 Hz) man-made sounds (Richardson et al. 1995). Anatomical evidence also suggests that baleen whales are adapted to hear low frequency sounds (Ketten 1998). The upper bounds of baleen whale hearing are not as high as odontocetes. Humpback whales reacted to sonar signals at 3.1 – 3.6 kHz and broadband clinkers centered around 4 kHz (Lien et al. 1990, 1992; Maybaum 1993). Watkins (1986) reported that baleen whales react to sonar sounds up to 28 kHz, but not to sounds 36 kHz and above.

4.6 Marine Mammal Sounds

The frequencies of sounds produced by marine mammals identify at least some of the frequencies important to these species. Marine mammals probably use sounds they create to obtain much information about their environment, including information about the presence of danger, food, a conspecific or other animal, and to transmit information about their own position, identity, and territorial or reproductive status (Richardson et al. 1995). While the sounds created by marine mammals are a good indication of frequencies important to those species, it is likely that higher and lower frequencies are also important.

4.6.1 Mysticete Sounds

Since baleen whales have rarely been held in captivity, sounds created by baleen whales have generally been recorded in the wild. Most baleen whale sounds are dominated by low frequencies, generally below 1 kHz, although a few recordings of clicks with dominant frequencies from 16 to 25 kHz have been recorded near minke, fin and blue whales (Beamish and Mitchell 1973; Thompson et al. 1979; Beamish 1979). It is thought these high frequency sounds may have been from odontocetes in the area, or recording artifacts (Richardson et al. 1995).

Humpback whales produce stereotyped songs associated with reproduction on low-latitude wintering grounds (Tyack 1981). Songs have occasionally been recorded on the high-latitude summer feeding grounds (Mattila et al. 1987; McSweeney et al. 1989; Gabriele et al. 2001), in late summer or early fall. Gabriele et al. (2001) suggest that the increase in song frequency in fall may correspond with the beginning of hormonal activity in male humpbacks associated with the migration to the wintering grounds. Humpback whale song elements range from • 20 Hz to 4 or 8 kHz, estimated source levels range from 144 to 174 dB re 1• Pa (Thompson et al. 1979).

On the summer feeding grounds humpbacks produce sounds associated with feeding behavior (Jurasz and Jurasz 1979; Cerchio and Dahlheim 2001). These calls ranged from 236 – 1219 Hz (Cerchio and Dahlheim 2001). It is suggested that these calls may serve to manipulate prey distribution (scaring fish into tighter groups) and as assembly calls, but not to coordinate feeding (Baker 1985).

Humpbacks also produce sounds on the wintering grounds associated with agonistic behavior in social groups. The sounds extend from 50 Hz to • 10 kHz. These sounds may elicit response from humpbacks up to 9 km away (Tyack and Whitehead 1983).

4.6.2 Odontocete Sounds

Odontocetes produce three broad types of sounds, tonal whistles, short duration pulsed sounds, and less distinct pulsed sounds such as cries, grunts and barks. Odontocetes that produce whistles tend to be social, gathering in large groups of up to thousands of individuals, while non-whistling odontocetes tend to be non-social or gather in small groups of a few individuals (Tyack 1986; Herman and Tavolga 1980).

Most odontocete's whistles are narrow-band sounds. Whistles typically have most of their energy below 20 kHz and can vary greatly in frequency structure. Some odontocetes may use special, unique whistles as "signature calls" that may carry some information about the sender. Whistles may also serve to coordinate activity such as feeding in large, dispersed groups (Norris and Dohl 1980; Würsig and Würsig 1980).

Clicks and pulsed sounds are typically short (50 – 200 • s) bursts of sound that can range from 0.1 – 200 kHz (Watkins 1980; Santoro et al. 1989). Source levels of sperm whale clicks can be near 180 dB re 1 • Pa-m (Watkins 1980). Clicks have been demonstrated to be used for echolocation in several species of odontocetes, and numerous other species produce echolocation type sounds although they have not been proved to echolocate. Echolocating odontocetes produce forward directional pulsed sounds of high frequency (12 – 150 kHz), short duration (50 – 200 • s), high intensity (up to 220 – 230 dB re 1 • Pa-m) sounds.

4.6.3 Phocid Sounds

Phocid seals are diverse in their behavior and habitat use, some spend almost all their time in water or hauled out on ice. Others haul out regularly on land. Most phocid seal calls seem to be associated with mating, mother-pup associations or territoriality. Underwater calls may be less important for species that perform those activities on land. Some phocids produce sounds that propagate for long distances, and others produce faint sounds that probably do not propagate far. Phocids probably hear sounds up to approx. 60 kHz underwater, and most calls are made between 90 Hz and 16 kHz (Richardson et al. 1995).

Harbor seals spend considerable time hauled out on land, although much social behavior occurs underwater as well. Males produce repeated call trains of low frequency (<4 kHz) underwater pulses including roars, grunts, and creaks (Hanggi and Schusterman 1994). Calls from pups are individually distinct and broadcast simultaneously in-air and underwater when the pups head is in the air. Females use calls from their pups both in-air and underwater to recognize and maintain contact with their pups. Pup calls in-air are centered around 350 Hz, (Ralls et al. 1985) while underwater calls are shifted to higher frequencies (Richardson et al. 1995).

4.6.4 Otariid Sounds

Sea lions and fur seals spend a great deal of time hauled out on land. They defend territories, mate, and give birth on traditional terrestrial rookeries. In-air vocalizations are used to defend territories, attract females, and establish and maintain mother-pup bonds.

No information exists on the frequency composition or source levels of Steller sea lion calls. Only California sea lion calls have been recorded and analyzed, and are thought to be generally consistent with those of Steller sea lions. California sea lion males bark incessantly while defending territories on rookeries. Barks have most energy <1 kHz. Females bark at intruders into their territory, squeal, belch and growl. Females exchange calls with new pups for several hours after birth. Mothers and pups are then able to recognize one another by their calls (Trillmich 1981). Female belches and growls have most energy between 0.25 – 4 kHz, female – pup attraction calls are 1 – 2 kHz and the pup's bleat is at 0.25 – 6 kHz (Peterson and Bartholomew 1969). Male Steller sea lions roar and hiss to defend territories on rookeries, and females defend birthing territories with barks and growls. Females and pups exchange vocal signals soon after birth, the calls may function in mother – pup recognition.

Underwater sounds of California sea lions are generally associated with social situations (Schusterman et al. 1966). Most underwater sounds are barks that are produced while the head is above the surface. Most of the energy is at frequencies below 2 kHz, and is similar in water and air (Schevill et al. 1963). When submerged, California sea lions produce barks, whinny and buzzing sounds, and click trains (Schusterman et al. 1966). Steller sea lions are said to produce clicks, growls, snorts and bleats underwater (Poulter 1968).

4.6.5 Sea Otter Sounds

Sea otters spend much of their time in water, but underwater sounds have not been studied. Airborne sounds of adult sea otters include: whines, whistles, growls, cooing, chuckles, snarls, and screams (Kenyon 1981). Otters may also produce sounds by vigorously kicking and splashing while at the surface (Calkins and Lent 1975). Calls between mothers and pups appear to be important for maintaining contact (Sandegren et al. 1973). Most of the energy in mother and pup calls is between 3 – 5 kHz.

5.0 UNDERWATER NOISE ACOUSTICS ENVIRONMENT

The ambient underwater noise in Glacier Bay results from both natural and man-made sources. The natural sources are primarily splash noise from wind-generated waves, and turbulence noise from high tidal currents in restricted channels. Other sources of natural noise that are unique to Glacier Bay are found in Sitakaday Narrows and in upper-bay waters that are near the glaciers. The noise in Sitakaday Narrows is produced by current interaction with the bottom - that results in turbulence noise and impact noise caused by the movement of small rocks and boulders as they are tumbled down bay by the strong tidal flow. In the upper bay, and in particular, Queen Inlet, glaciers advancing intermittently down mountain slopes produce strong low frequency underwater rumbles resembling thunder. These sounds can be heard as they propagate out into the bay as far as the Marble Islands, and occasionally, in quiet background conditions, in Bartlett Cove.

Man-made components of ambient noise are primarily caused by water transportation activities. Cruise ships are the loudest sources but tour boats, charter boats, private skiffs, and even airplanes contribute to the underwater noise levels in areas near Bartlett Cove and other areas where park visitors may be concentrated. Vessel noise is considered part of the ambient noise if no nearby source can be recognized. The following discussion presents details concerning the natural and man-made components of Glacier Bay underwater noise collected in the 1980s. Readers are encouraged to read the previous sections “Acoustic Concepts and Terminology”, “Sound Propagation”, “Zones of Influence”, and “Marine Mammal Hearing” before reading this section. It must be noted that there are more current data for the underwater acoustics environment in Glacier Bay, however, those data are not widely available. Obtaining those data will allow a more complete description of the underwater environment in Glacier Bay and provide a better basis for comparisons of the effects of the alternatives presented within this EIS.

5.1 Ambient Noise Levels

Ambient noise has both long-term and transient properties. The long-term properties are described in terms of their average (mean rms) overall sound level, temporal statistics (transient level fluctuations in time) and frequency composition. Ambient noise data are generally measured at a single point for a long period (several hours or days). . The fluctuations in sound energy that normally occur over the sampling period are generally averaged to an <u>equivalent sound level</u> (L_{eq}), which is the constant rms sound level that would provide the same acoustic energy as the actual signal over the same period. The range in amplitude of the fluctuating sound level is described statistically by the percentage of time that the “instantaneous” rms level is above or below selected values, typically 5%, 50% and 95% of the total range observed during the measurement period. The frequency composition is usually measured as a 1/3 octave band using the same measurement period as used in determining the L_{eq}. When signals with strong tonal components are present, a narrow band analysis may be used to obtain better frequency definition since most of the energy is contained in a narrow band that includes the tonal frequency. The 1/3 octave band analysis is used for broadband signals because it provides a better correspondence to the hearing sensitivity of humans (and other mammals).

Acoustic measurements in Glacier Bay have provided data to compare the ambient sound levels in various parts of the bay with archival data obtained in open water areas to determine if Glacier Bay is more or less “noisy” than open water areas nearby. Data reported by Wenz (1982) and Urick (1983) are compared with data obtained by Miles and Malme (1983) in Bartlett Cove as shown in Fig. 1. The Bartlett Cove data were obtained for conditions with very light winds, so the variation in sound level over the two

8-hr measurement periods was due primarily to boat and ship traffic, rather than differing environmental conditions. The mean sound level from boat and ship traffic in Bartlett Cove corresponds to a Sea State 4 (wind speed of about 20 kts) in open water.

It is also necessary to consider the temporal characteristics of ambient noise. The long term averages discussed previously convey the impression that sound levels under water are nearly constant. This is not the case in Bartlett Cove as shown in Fig. 2, taken from a graphic level recording sequence obtained over two 10-minute periods in Bartlett Cove (Miles and Malme 1982). The record shows the fluctuations in overall sound levels due to humpback whale vocalizations, ship arrivals and departures, and fishing boat movements. The level of the whale vocalizations is much higher (at the measurement position) than the departure of the cruise ship Statendam as it begins to travel up bay.

There is a wide variation in ambient noise for other sites in the bay, as can be seen in Figs.3A and 3B. Station 17 near North Marble Island shows sound levels lower than Sea State 0 (calm winds, smooth seas) at frequencies above 250 Hz. The low frequency noise levels seen in Figs. 3A and 3B are from either distant ships or glacier motion. Intermediate levels of noise are seen in the spectrum obtained in Queen Inlet. The narrow band peaks in this spectrum are caused by glacier rumbles. The spectrum obtained near Muir Glacier is dominated by the noise of out-gassing from the glacial ice nearby. The high frequency sounds are higher than would be obtained by wind and wave noise at Sea State 6 (wind speed about 30 kts).

5.2 Description of Noise Range for Each Vessel Class

The man-made component of ambient noise is produced primarily by ship and boat movements. It is possible to categorize the classes of vessels using the bay by type or application. However, on analyzing the acoustic output of vessels of the same type, a wide variation is often found. As a result, only two general classifications, cruise ships, and other miscellaneous boats, have been used. This may be modified when acoustic data from additional vessels become available. Figure 4 shows the source level spectra for the range of sound levels produced by 6 representative cruise ships for which data are available. For comparison, the source levels of a range of smaller vessels, representative of the types that use the bay, are also shown. These spectra were obtained by estimating transmission loss (TL) for received levels reported by Malme et.al. (1982). The received energy levels for each 1/3 octave band were summed to obtain an overall source level (L_s) for each vessel. The average source level for the cruise ships is about 179 dB, with 9 dB variation between the maximum and minimum overall source levels. The average source level for the smaller vessels is 164 dB with variation of 10 dB. The difference in average source levels between the cruise ships and the smaller vessels is about 15 dB.

In order to estimate the assumed zone of responsiveness (Sec. 3.2.4.2), or the range at which the overall radiated sound level from these vessels approaches the 130 dB disturbance criterion, it is necessary to review the Glacier Bay TL data reported by Malme et al. (1982). The data are summarized for 200 Hz in Fig. 5. The TL measured for Station 41, at the bay entrance, was selected for a whale waters location. The estimated ranges are shown in Table 5-1.

TABLE 5-1: NOISE RANGES BY VESSEL

Vessel Class	L_s, dB re 1 µPa @ 1 m	Criterion, dB re 1 µPa	Required TL, dB	Minimum Range, m
Cruise Ships	179	130	49	600
Tour, fishing, sport, misc.	164	130	34	50

The TL data reported by Malme *et al*. (1982) at six sites in Glacier Bay included a range of 100 Hz - 16,000 Hz. In this case 200 Hz was selected as a representative frequency, as sounds from cruise ship are generally low frequency. Further TL analyses will be made to include TL values for all frequencies at selected sites reported by Malme *et al*. (1982) to provide a more optimum match with the spectra of the cruise ships. Additional analysis will also be made using an expanded ship database including all the vessels that visited the park during the 2001 season to provide a more detailed and relevant analysis for ships in Glacier Bay.

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APPENDIX D

Air Emissions Calculation Methodology

Memo

Date: 02/27/2003

To: Louise Flynn, Ecology and Environment, Inc., Assistant Project Manager

From: Laurie Kutina, Ecology and Environment, Inc., Air Quality Specialist

RE: Appendix D: Air Emissions Calculations Methodology

Existing and projected air emissions were estimated using 2001 operation data, vessel entry and use day quotas, NPS staff and vessel operator observations and the most recent emission factor data and emission calculation method for vessels. Projections of future air pollutant emission levels were derived based on proposed changes in vessel activity for each alternative. Emission calculations used hours of operation that were averaged from 2001 data and NPS staff and vessel operator observations to provide average vessel times at each speed classification (time-in-mode).

Vessel emission factor data and calculation methodology were obtained from documentation recently published by the USEPA Office of Mobile Sources (Energy and Environmental Analysis 2000). The estimation method, as described below, incorporates the latest information available from nine different emission studies and utilizes kilowatt-hour (kW-hr) emission factors to determine emissions based upon load factor (i.e. percent of engine capacity while the vessel is under power) and operational time. The load factors were estimated using this method, and projected time-in-mode for each power setting was estimated based upon observations of existing conditions and proposed speed restrictions within Glacier Bay.

The emissions factor algorithms derived are from the following equation:

$$\mathbf{E\ (g/kW\text{-}hr) = a\ (Fractional\ Load)^{-x} + b}$$

Where E is the emissions rate per unit of work. The data analysis showed no statistically significant differences in emissions rates by engine size or output range, or by two-stroke/four-stoke, subject to the caveats detailed above. Emissions rates for SO_2 are based on (fuel consumption *x* sulfur content of fuel) since all SO_2 emissions are fuel derived. The Sulfur content of fuel was assumed to be 27 lbs/1000 gal. The SO_2 regression equation used is:

$$\mathbf{Emissions\ Rate\ (g/kW\text{-}hr) = a\ (Fuel\ Sulfur\ Flow\ in\ g/kW\text{-}hr) + b}$$

The calculation of all factors is provided in Table D-1.

Computation of emissions from auxiliary engines used by cruise ships required the use of the same emission factors specified above, and are evaluated at a load factor equal to one (i.e., at full load). The equation for emission from auxiliary engines is

$$\text{Emissions} = (\text{EF})(\text{LF}=1) \times \text{Auxiliary Power (kW)} \times \text{Time}$$

The basic equations used for the calculation of emissions are:

$$\text{EMISSIONS}_{,\text{VCC,MODE}} = (\text{EF})(\text{LF}_{\text{MODE}}) \times (\text{HP}) \times \text{LF}_{\text{MODE}} \times \text{TIME}$$

where:

VCC - vessel class (Cruise ship, or tour, charter, or private vessel)

EF - emissions factor
LF -mode specific load factor
HP I- maximum Horsepower

Load Factor and Power calculations are provided in Table D-2, and the calculations of emissions rates in lbs/hr are provided in D-3.

For this evaluation, it was assumed that the cruise ships would operate in the park for 9 hours per use day, , and that tour vessels would operate in the park for 13 hours per use day (based upon 2001 average—See tables D-4 and D-5). Charter and Private vessels are assumed to operate for 9.5 hours per use day, based upon generic assumptions established by The Energy and Environmental Analysis 2000 Report because there was no specific operation time data available. Time-in-mode for assumptions are adjusted for Alternative 4 and 5, where speed restrictions will require cruise ships to maintain a slow cruise. It was assumed that the cruise ships would therefore take twice as long to enter and leave the bay, and therefore the total time for cruise ships under Alternatives 4 and 5 is 13 hours. Other vessels are not subject to the speed restrictions. NPS staff and vessel operator observations were used to determine average time at each speed classification (time-in-mode), assuming that the majority of time is spent at normal cruise, with some time spent at a slow cruise and manuevering. (see Table D-6) .

2001 use day data was collected for cruise ships, tour vessels, charter vessels, and private vessels, and it was used to determine baseline annual emissions. This data is summarized in Tables D-4, D-5, D-7, and D-8.

In the development of projected emissions, annual use-day quotas were used to determine number of in-season use-days for all vessels, and off season entries for cruise ships and tour vessels. Off season Vessel use days for charter and private vessels were assumed to be the same as the baseline. Daily emission and annual emissions were calculated differently in this evaluation. Daily emissions were calculated assuming that the vessel use of Glacier Bay is at the maximum quota of two cruise ships, three tour vessels, six charter vessels, and twenty-five private vessels, adjusted as required for each alternative. The total provides a worst-case evaluation of daily emissions in the park on a given day, and under these conditions. Annual emissions include all emissions emitted during the calendar year, January to December, and were determined using annual seasonal quotas and 2001 use data as described above.

Baseline emissions and 2001 operating data are provided in Tables D-7 and D-8 and Use-day quotas and calculations for Alternatives 1, 2, 3, 4, and 5 are provided in Tables, D-9, D-11, D-13, D-15 and D-17, respectively. Load factors are adjusted to account for speed reductions for alternatives 4 and 5. Estimated daily and annual emissions for Alternatives 1, 2, 3, 4, and 5 are summarized in Tables D-10, D-12, D-14, D-16, and D-18, respectively.

Summary of Estimated Cruise Ship Emissions Under Alternative 5
Table D-18

Alternative 5 Emissions lbs/day

	PM	NOX	SO2	CO	HC
Cruise Ships	147.28	1,432.00	142.21	521.04	95.57
Tour Boats	23.00	925.84	103.14	98.33	9.38
Charter Vessels	7.42	297.51	33.00	35.42	3.70
Private Vessels	70.53	2,836.98	315.80	307.51	29.93
Total	248.23	5,492.33	594.15	962.28	138.58

Alternative 5 Emissions TPY

	PM	NOX	SO2	CO	HC
Cruise Ships	8.51	82.70	8.21	30.09	5.52
Tour Boats	1.58	63.77	7.10	6.77	0.65
Charter Vessels	0.38	15.05	1.67	1.79	0.19
Private Vessels	3.83	154.16	17.16	16.71	1.63
Total	14.30	315.68	34.15	55.36	7.98
Change from Alt 1	-0.08	-192.36	-22.25	-2.01	1.89
Change from Baseline	2.58	-96.73	-11.63	8.76	3.02
Total average CO2 for a 4 person household TPY)					
Number of households equivalent:					

APPENDIX E

Vessel Use Data and Incident Reports

2001 GLACIER BAY NATIONAL PARK RECREATIONAL BOATER REPORT

DAYS AT MAXIMUM USE

Month	Days at Max Use
June, 2001	0
July, 2001	1
lAugust, 2001	0

PERMIT ENTRIES BY YEAR

Year	Total Entries	General Entries	Local Entries
1998	412	348	64
1999	418	331	87
2000	414	356	58
2001	385	323	62

PERMIT ENTRY TYPES BY MONTH FOR YEAR

Year	Permit Type	Total	June	July	August
1998	General	348	104	144	100
1998	Local	64	29	28	7
1999	General	331	114	145	72
1999	Local	87	33	29	25
2000	General	356	106	146	104
2000	Local	58	26	14	18
2001	General	323	96	139	88
2001	Local	62	29	19	14

GENERAL PERMIT STATUS

Year	Permit Type	Permit Status	Total	June	July	August
2001	General	Canceled	49	13	26	9
2001	General	Denied	11	1	1	
2001	General	Departed	323	96	139	88
2001	General	No Show	27	3	10	13

LOCAL PERMIT STATUS

Year	Permit Type	Permit Status	Total	June	July	August
2001	General	Canceled	3	1	2	
2001	General	Denied				
2001	General	Departed	62	29	19	14

LOCAL CATEGORIES

Year	Local Category	Count
2001	Elfin	1
2001	GBL	8
2001	Gustavus	22
2001	NPS	30
2001	Others	1

GENERAL PERMITS GIVEN TO LOCAL BOATERS

NOTE: 33 local boaters were given general permits in 2001

Year	General locals	Count	Single Use Day Entries	Multiple Use Day Entries
2001	Elfin Cove	2	18	14
2001	Hoonah	3		
2001	Gustavus	28		

DAY BOATERS (includes General and Local Permits)

Year	Category	Total	June	July	August
2001	Boat Use Days	239	94	65	80
2001	Visitors	678	250	192	236
2001	Fuel only entries	9	6	2	1

USE DAYS BY MONTH BY YEAR

Month	General Use	Local Use	Total Use
June, 2001	428	79	507
July, 2001	604	72	676
August, 2001	355	65	420

USE DAY ENTRIES BY YEAR

Year	General Use Days	Local Use Days	Total Use Days	General Entries	Local Entries	Total Entries
1998	1440	242	1682	348	64	412
1999	1375	358	1733	331	87	418
2000	1454	213	1667	356	58	414
2001	1387	216	1603	322	62	384

GENERAL PERMITS BY STATE/PROVINCE FOR MONTH FOR YEAR

Year	Permit Type	State/ Province	Total	June	July	August
2001	General	Alaska	122	37	42	43
2001	General	Washington	79	32	34	13
2001	General	California	22	2	15	5
2001	General	Oregon	22	6	11	5
2001	General	Delaware	5		3	2
2001	General	Nevada	5	3	2	
2001	General	Florida	4		3	1
2001	General	Texas	4		3	1
2001	General	Colorado	3		2	1
2001	General	Connecticut	3			3
2001	General	British Columbia	1		1	
2001	General	Hawaii	1		1	
2001	General	Montana	1	1		
2001	General	New Mexico	1			1

GENERAL PERMITS PORT- COUNTRY

Year	Permit Type	MV Port Country	Total	June	July	August
2001	General	Canada	27	10	12	5
2001	General	United Kingdom	5	2	1	2
2001	General	Cayman Islands	4	0	4	0
2001	General	Virgin Islands (British)	4	0	1	3
2001	General	Bermuda	3	1	1	1
2001	General	Belize	2	0	1	1
2001	General	Germany	1	0	1	0
2001	General	Ireland	1	1	0	0

MOTOR VESSELL USE TYPE

Year	Permit Type	MV Use Type	Total	June	July	August
2001	General	Bareboat	49	18	16	15
2001	General	Charter	9	0	3	6
2001	General	Commercial Fishing	4	0	3	1
2001	General	Corporate	32	6	17	9
2001	General	Government	2	0	0	2
2001	General	Private	226	72	100	54
2001	Local	Bareboat	1	1	0	0
2001	Local	Charter	8	5	2	1
2001	Local	Commercial Fishing	1	0	1	0
2001	Local	Corporate	7	2	1	4
2001	Local	Government	12	7	0	5
2001	Local	Private	33	14	15	4

GENERAL PERMIT VISITOR USE DAYS BY MONTH FOR YEAR

Month	Crew	Passengers	Visitors	Visitor Use Days	Days of Stay (Average)
June, 2001	130	149	279	1254	4.79
July, 2001	309	246	555	2152	4.29
August, 2001	182	133	315	1177	3.79

GENERAL PERMIT VISITOR USE DAYS BY YEAR

Year	Crew	Passengers	Visitors	Visitor Use Days	Days of Stay	Boat Use Days	Boat Entries
1998	727	888	1615	6268	4.14	1440	348
1999	661	682	1343	5189	4.15	1375	331
2000	703	533	1236	4950	4.07	1454	356
2001	621	528	1149	4583	4.31	1387	322

LOCAL PERMIT VISITOR USE DAYS BY MONTH FOR YEAR

Month	Boat Use Days	People Use Days
June, 2001	79	196
July, 2001	72	203
August, 2001	65	184

LOCAL PERMIT USE DAYS BY YEAR

Year	Boat Use Days	People Use Days
1998	242	721
1999	358	966
2000	213	628
2001	216	583

USE DAYS BY TYPE BY MONTH FOR YEAR

Year	Permit Type	Total	June	July	August
2001	General	1387	460	597	330
2001	Local	216	79	72	65

LOCAL PERMITS BY SIZE FOR MONTH FOR YEAR

Year	Permit Type	Vessel Size	Total	June	July	August
2001	Local	1 - 20	34	15	9	10
2001	Local	21 - 30	18	10	6	2
2001	Local	31 - 40	3	1	2	0
2001	Local	41 - 50	4	1	2	1
2001	Local	51 - 60	2	1	0	1
2001	Local	61 - 70	1	1	0	0

GENERAL VESSELLS BY SIZE FOR MONTH FOR YEAR

Year	Permit Type	Vessel Size	Total	June	July	August
2001	General	1 - 20	16	2	5	9
2001	General	21 - 30	47	14	18	15
2001	General	31 - 40	102	34	38	30
2001	General	41 - 50	86	30	37	19
2001	General	51 - 60	29	9	14	6
2001	General	61 - 70	15	2	12	1
2001	General	71 - 80	7	2	3	2
2001	General	81 - 90	4	1	2	1
2001	General	91 - 200	16	2	10	4

BOAT TYPES

Year	Permit Type	MV Type	Total	June	July	August
2001	General	P-Mega	22	2	17	3
2001	General	Power	230	75	91	64
2001	General	S-Mega	6	0	2	4
2001	General	Sailing	1	19	29	17
2001	Local	P-Mega	61	1	0	0
2001	Local	Power		28	19	14

Private Vessel Characteristics of Permitted Vessels In Glacier Bay

Hull Speeds of Vessels Entering Glacier Bay (1998-2002)

Motorized Vessel Type	Hull Speed Category (Knots)	Permits Issued (1998-2002)
Power	1 to 10	565
Sail	1 to 10	333
Power	11 to 20	967
Sail	11 to 20	25
Power	21 to 30	472
Power	31 to 40	205
Power	41 to 50	104
Power	51 to 60	1

Private Vessel Characteristics of Permitted Vessels In Glacier Bay

Lengths of Private Vessels Entering Glacier Bay

Motorize Vessel Type and Size	Permits Issued	Year
Power 18'	61	1998
Power 18'	93	1999
Power 18'	105	2000
Power 18'	121	2001
Power 18'	114	2002
	Total Permits: 494	
Power 40'	193	1998
Power 40'	342	1999
Power 40'	237	2000
Power 40'	199	2001
Power 40'	217	2002
	Total Permits: 1188	
Power 80'	139	1998
Power 80'	150	1999
Power 80'	134	2000
Power 80'	119	2001
Power 80'	106	2002
	Total Permits: 648	
Power 120'	23	1998
Power 120'	9	1999
Power 120'	7	2000
Power 120'	3	2001
Power 120'	7	2002
	Total Permits: 49	
Power 160'	6	1998
Power 160'	0	1999
Power 160'	2	2000
Power 160'	0	2001
Power 160'	2	2002
	Total Permits: 10	
Power 200'	1	1998
Power 200'	0	1999
Power 200'	2	2000
Power 200'	0	2001
Power 200'	0	2002
	Total Permits: 3	

Lengths of Private Vessels Entering Glacier Bay

Motorize Vessel Type and Size	Permits Issued	Year
P-Mega 40'	0	1998
P-Mega 40'	0	1999
P-Mega 40'	0	2000
P-Mega 40'	1	2001
P-Mega 40'	1	2002
	Total Permits: 2	
P-Mega 80'	0	1998
P-Mega 80'	4	1999
P-Mega 80'	5	2000
P-Mega 80'	9	2001
P-Mega 80'	8	2002
	Total Permits: 26	
P-Mega 120'	0	1998
P-Mega 120'	11	1999
P-Mega 120'	4	2000
P-Mega 120'	9	2001
P-Mega 120'	9	2002
	Total Permits: 33	
P-Mega 160'	0	1998
P-Mega 160'	6	1999
P-Mega 160'	0	2000
P-Mega 160'	4	2001
P-Mega 160'	4	2002
	Total Permits: 10	
P-Mega 200'	0	1998
P-Mega 200'	3	1999
P-Mega 200'	0	2000
P-Mega 200'	1	2001
P-Mega 200'	1	2002
	Total Permits: 5	
P-Mega 262'	0	1998
P-Mega 262'	0	1999
P-Mega 262'	1	2000
P-Mega 262'	0	2001
P-Mega 262'	0	2002
	Total Permits: 1	

Lengths of Private Vessels Entering Glacier Bay

Motorize Vessel Type and Size	Permits Issued	Year
Sailing 40'	41	1998
Sailing 40'	45	1999
Sailing 40'	38	2000
Sailing 40'	35	2001
Sailing 40'	30	2002
	Total Permits: 189	
Sailing 80'	44	1998
Sailing 80'	26	1999
Sailing 80'	31	2000
Sailing 80'	30	2001
Sailing 80'	31	2002
	Total Permits: 162	
Sailing 120'	7	1998
Sailing 120'	0	1999
Sailing 120'	4	2000
Sailing 120'	1	2001
Sailing 120'	0	2002
	Total Permits: 12	
Sailing 160'	1	1998
Sailing 160'	0	1999
Sailing 160'	0	2000
Sailing 160'	0	2001
Sailing 160'	0	2002
	Total Permits: 1	
S-Mega 80'	0	1998
S-Mega 80'	0	1999
S-Mega 80'	1	2000
S-Mega 80'	4	2001
S-Mega 80'	2	2002
	Total Permits: 7	
S-Mega 120'	0	1998
S-Mega 120'	0	1999
S-Mega 120'	1	2000
S-Mega 120'	1	2001
S-Mega 120'	0	2002
	Total Permits: 2	
S-Mega 160'	0	1998
S-Mega 160'	1	1999
S-Mega 160'	0	2000
S-Mega 160'	1	2001
S-Mega 160'	2	2002
	Total Permits: 4	

Matrix to Identify Glacier Bay Administrative Use

Unless specified in writing all park regulations apply to administrative vessel use.

Draft

RECOMMENDATION FOR ADMINISTRATIVE VESSEL USE	**Yes**	**No**
Category		
Project Description		
Dates Requested		
Level I (Park Goals) If Yes, go to next level. If No, consider denying use.	**Yes**	**No**
Does the requested activity meet one of the park's Government Performance and Results Act (GPRA) goals?		
Level II (Reasonable Accommodation) If Yes in any of the categories, go to next level. If No in all categories, consider denying use.	**Yes**	**No**
Is there an alternative available for conducting the activity that would not require use of an		
Are there extenuating circumstances specific to this activity that justify an Administrative		
Activity is critical to a park mission or goal.		
Alternative(s) would be cost prohibitive.		
Activity is the activity a result of an emergency or safety related issue		
Alternative(s) would be un-reasonable.		
Activity addresses visitor accessibility.		
Activity fosters Agency to Agency or State to State relations		
Activity requires specific expertise that cannot be found in the public sector?		
Level III (Impacts) If Yes in any category, go to next level. If No in all categories, consider authorizing the use.	**Yes**	**No**
Would the activity result in adverse effects on public health or safety?		
Would the activity result in significant adverse effects on historic or cultural resources, park lands, wilderness areas, sole or principal driking water, wetlands, floodplains, or ecologically significant critical areas, including those listed on the National Register of Natural Landmarks?		
Would the activity have highly controversial or significant environmental effects?		
Would the activity involve unique or unknown environmental risks?		
Establish a precedent for future action or represent a decision about future actions that would involve potentially significant environmental effects?		
Have adverse effects on species listed or proposed for listing on the list of Endangered or Threatened Species, or have adverse effects on designated Critical Habitat for these		
Threaten to violate a federal, state, local, or tribal law or requirement imposed for the protection of the environment?		
Require compliance with Executive Order 11988 (Floodplain Management), Executive Order 11990 (Protection of Wetlands), or the Fish and Wildlife Coordination Act?		

Matrix to Identify Glacier Bay Administrative Use

Unless specified in writing all park regulations apply to administrative vessel use.

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RECOMMENDATION FOR ADMINISTRATIVE VESSEL USE	**Yes**	**No**
Restrict access to and ceremonial use of Indian sacred sites by Indian religious practitioners or adversely affect the physical integrity of such sacred sites?		
Contribute to the introduction, continued existence, or spread of federally listed noxious weeds?		
Have adverse effects on properties listed or eligible for listing on the National Register of Historic Places?		
Have the potential to violate the NPS Organic Act by impairing park resources or values?		
Be directly related to other activities with individually insignificant but cumulatively significant environmental effects?		
Level IV (Consequences) If Yes in any category, consider authorizing the use. If No, consider denying the request.	**Yes**	**No**
Would the consequences of not allowing the activity to take place result in the following…		
Greater damage to park resources?		
Loss of available information for making management decisions that would protect the park's resources or provide for visitor enjoyment?		
Detriment to public education?		
Detriment to agency-to-agency or state-to-state relations?		
Others???		
Recommendation for Administrative Vessel Use	**Yes**	**No**
Activities that are recommended for administrative use, but also require an exception to a park regulation must also be evaluated under the Waiver to Park Regulations Decision Document.		

Dundas Bay Vessel Traffic Documented during Outer Waters Vessel Activity Survey (OWVAS) Project Aerial Surveys

Vessel Use in Dundas Bay - Summer 2001

		Tourboat	Private[1]	Charter	Commercial fishing[2]	NPS	Other[3]	Total Vessels
Week 01	**June 1 - June 7**				No Data			
Week 02	**June 8 - June 14**	0	1	1	0	0	0	2
Week 03	**June 15 - June 21**	0	1	0	0	0	0	1
Week 04	**June 22 - June 28**	0	0	0	0	0	0	0
Week 05	**June 29 - July 5**	0	6	2	0	0	1	9
Week 06	**July 6 - July 12**	0	6	3	0	0	1	10
Week 07	**July 13 - July 19**	0	2	0	0	0	1	3
Week 08	**July 20 - July 26**	0	2	2	0	0	1	5
Week 09	**July 27 - Aug. 2**	0	4	0	1	0	0	5
Week 10	**Aug. 3 - Aug. 9**	0	9	0	0	0	1	10
Week 11	**Aug. 10 - Aug. 16**	0	3	1	1	0	0	5
Week 12	**Aug. 17 - Aug. 23**				No Data			
Week 13	**Aug. 24 - Aug. 30**	0	0	0	2	0	0	2
Week 14	**Aug. 31 - Sept. 6**	0	2	1	6	0	0	9
Week 15	**Sept. 7 - Sept. 13**	0	0	0	3	0	0	3
Week 16	**Sept. 14 - Sept. 20**				No Data			
Week 17	**Sept. - Sept. 27**	0	0	0	0	0	0	0
Week 18	**Sept. 28 - Oct. 4**	0	0	0	0	0	0	0
	Total	0	36	10	13	0	5	64

Vessel Use in Dundas Bay - Summer 2002

		Tourboat	Private[1]	Charter	Commercial fishing[2]	NPS	Other[3]	Total Vessels
Week 01	**June 1 - June 7**				No Data			
Week 02	**June 8 - June 14**				No Data			
Week 03	**June 15 - June 21**	2	1	0	1	0	1	5
Week 04	**June 22 - June 28**	0	6	4	0	0	2	12
Week 05	**June 29 - July 5**	0	4	2	0	0	0	6
Week 06	**July 6 - July 12**	1	6	2	0	1	16	26
Week 07	**July 13 - July 19**	0	5	0	0	1	0	6
Week 08	**July 20 - July 26**				No Data			
Week 09	**July 27 - Aug. 2**	3	6	0	0	1	3	13
Week 10	**Aug. 3 - Aug. 9**	0	1	0	0	0	0	1
Week 11	**Aug. 10 - Aug. 16**	0	0	2	2	0	0	4
Week 12	**Aug. 17 - Aug. 23**	0	1	2	3	0	0	6
Week 13	**Aug. 24 - Aug. 30**	0	0	0	0	0	0	0
Week 14	**Aug. 31 - Sept. 6**	0	0	2	1	2	0	5
Week 15	**Sept. 7 - Sept. 13**	0	0	0	5	2	0	7
Week 16	**Sept. 14 - Sept. 20**	0	0	1	5	2	0	8
Week 17	**Sept. - Sept. 27**	0	0	0	0	2	0	2
Week 18	**Sept. 28 - Oct. 4**	0	0	0	0	0	0	0
	Total	6	30	15	17	11	22	101

[1]Vessel class includes cabin cruiser style vessels and sailboats.

[2]Vessel class includes primarily trollers, one crabber and one tender.

[3]Vessel class includes kayaks, skiffs or other vessels (Pilot) that may be associated with either private or commercial vessels.

APPENDIX F

Fuel Spill and Spill Response Information

TABLE 1: GUIDING PROPERTIES OF EFFECTS OF FUEL OIL			
	Fuel Oil Type		
Properties	**Marine Diesel (No. 2)**[a]	**IFO 380 (No. 6)** [a]	**Gas/Oil Mixture** [b]
General description	light, refined product	blend of heavy residual oil with diesel (3:1 usually)	Blended light refined product with llubricating oil (25-50:1 usually)
Classification (33 CFR 155)	Group I, non-persistent oil	Group III, persistent oil	Group I, non-persistent oil
Probability of mousse formation	low (viscosity too low)	low (viscosity too high)	low (viscosity too low)
Percent evaporated and Dispersed after 12 hours	24%	1%	86%
Percent evaporated and Dispersed after 24 hours	42%	4%	98%
Percent evaporated and Dispersed after 48 hours	67%	10%	100%
Percent evaporated and Dispersed after 5 days	87%	20%	100%
Behavior on shoreline	penetrates porous sediments, dispersed/degraded by tide, wave and microbial action	remains on surface, bath tub ring at high tide, degradation takes months to years	Dispersed/degraded by tide, wave and microbial action, readily volaitlizes with wind and warm temperatures
Environmental toxicity	acutely toxic to water column organisms, shellfish tainting, fish kills in confined shallow water, minor impacts on seabirds due to quick dissipation	primarily from physical coating of marine mammals, seabirds, intertidal organisms	acutely toxic to water column organisms, shellfish tainting, fish kills in confined shallow water, minor impacts on seabirds due to quick dissipation
Effectiveness of mechanical recovery and shoreline countermeasures	usually of limited effectiveness due to rapid dissipation, exclusion/deflection booming can be effective	open water recovery should be attempted, shoreline countermeasures can be very effective	Usually of limited effectiveness due to rapid dissipation, dispersion instead of containment is suggested because of the combustible nature of gasoline

A: Source Ely 2000
Assumes 2,500 barrel spill (100,000 gallons) in 9 degrees Celsius seawater under calm conditions with winds at 10 miles per hour.
B: Source NOAA ADIOS Software 2000
Assumes 100 gallon spill in 9 degrees Celsius seawater under calm conditions with winds at 10 miles per hour.

TABLE 2: SPILL RESPONSE EQUIPMENT AT BARTLETT OR BLUE MOUSE COVES, MARCH 1999

Location	Item Description	Amount	Time	Operations Status
Boat Dock	Deflection boom, 34-inch yellow with slide and pin connectors	400 feet (enough to encircle dock)	<1 hour	Ready
Fuel Storage Building by Tank Farm	Mini boom, SS-500, 4 booms/bale, 5 inches diameter by 10 feet	3 bales (120 feet)	<1 hour	Ready
	Sorbent mat, SS-150	2 bales	<1 hour	Ready
	Sorbent pads, 17-by-19-inch sheets, 3M, 100 sheets/bale	14 bales	<1 hour	Ready
	Type 270 boom	4 booms 10 feet by 8 inches (40 feet)	<1 hour	Ready
Fuel Barge *Petrel* at Bartlett Cove,	Deflection boom, 34-inch yellow with slide and pin connectors	3 segments	1 hour	Ready
October to May	Mini boom, SS-500, 5-inch diameter by 10 feet	4 booms (40 feet)	1 hour	Ready
At Blue Mouse Cove, May to October	Sorbent pads, 17-by-19 inches, 100 sheets/ bale	½ bale	1 hour	Ready
At Blue Mouse Cove, May to October	Diesel America 3-inch trash pump	1 each	1 hour	Ready
At Blue Mouse Cove May to October	Floating Hale pump with hose for fire	1 each	1 hour	Ready
Containment pad adjacent to fuel tank farm	2,000 gallon tanker truck	1 each	15 minutes	Ready
Boat Dock, April to May	15.5-foot Boston Whaler boat	1 each	30 minutes	Ready
Park Maintenance Shop	Front-end loader Caterpillar IT-18	1 each	30 minutes	Ready

Source: Baker 2000.
Additional equipment is readily available at the Power Plant and Park Landfill.

TABLE 3: PROBABLE SPILL SCENARIOS – BARTLETT COVE FUEL STORAGE AND TRANSFER FACILITY

Most likely discharge	Occurs during dispensing of fuel to the boats. The average most probable spill is 1 pint of gasoline or diesel fuel waterborne in any single incident, however, if the pumping operation continues without observation, a spill of around 150 gallons may occur.
Maximum most probable discharge	Failure of piping, hoses, or coupling during transfer. This can occur from a split hose, coupling, pipe fitting, or pipe while fuel is being transferred from the barge to shore. This would likely spill several hundred gallons of product before flow could be stopped.
Worst case discharge	The worst case discharge at this facility would come from a rupture of one of four 3,000 gallon fuel oil tanks. Three of these tanks are used for fuel storage at the Glacier Bay Lodge, and one is used for fuel storage at the Utility Service Building.

Source: Baker 2000.

APPENDIX G

Vessel Wakes Technical Memorandum

Peratrovich, Nottingham, & Drage, Inc.
engineering consultants

DRAFT Technical Memorandum

Vessel Wakes

Glacier Bay Environmental Impact Statement
Glacier Bay National Park And Preserve, Alaska

November 2002

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PN&D Project No. 02056

Table of Contents

Tables

Figures

Plates

Attachments

1 INTRODUCTION

The purpose of this technical memorandum is to describe the nature of vessel generated waves, referred to as wakes, in Glacier Bay National Park and Preserve, Gustavus, Alaska. The analysis compares the effects of vessel generated surface waves to the effect of natural wind generated surface waves. This analysis was applied to selected sites on the Glacier Bay proper shoreline. The reason for the analysis is to identify where vessel wakes could cause adverse effects to the resources and/or users of the park. This information will be used as one element in determining the appropriate number of vessels and vessel operating requirements in the park. The technical memorandum presents a method to evaluate the different physical effects caused by wakes for each respective alternative in the Environmental Impact Statement on Vessel Quotas and Operating Requirements (EIS). Other effects of vessel generated waves on park users and animal inhabitants of Glacier Bay proper are discussed in other sections of the Environmental Impact Statement. Many terms used in this memorandum have specific meaning in coastal engineering. Please see section 6 for definitions.

2 EXECUTIVE SUMMARY

An extensive literature search was conducted to identify any existing evaluation models that were directly applicable to this project. None were found so the theory behind several existing models was utilized in developing the models used for this study. The process used to determine the sites was to identify where vessels travel within 2,000 feet of the shoreline. This distance was based on research and the accuracy of the vessel traffic data. The next step was to conduct a wind analysis and derive the wave climatology for each site. The wave climatology provides the energy imparted to the site over a one-year period due to natural wind waves. An energy index was calculated for each site by comparing the energy imparted by vessel wakes to natural wind waves. This index makes it possible to discern the effect due to natural wind wave energy from the effect due to vessel wakes despite differences in wind energy at all sites. The potential erodability of the site was evaluated by examining existing data on substrate size and beach slope. The site was assigned an overall erosion potential based on the site erosion potential due to substrate and the vessel wake energy index.

3 BACKGROUND

This section provides the theoretical basis for the analysis of waves. It is intended to provide the reader with an understanding of the various wave models available, which model(s) were used, and how those models were used in the evaluation of waves and wakes on the shoreline of Glacier Bay proper.

3.1 BASIC ASSUMPTIONS AND INFORMATION

There are many causes of waves across a water body. These include tides, wind, tsunamis, and vessels. The technical memorandum evaluates two generators of waves, wind and vessels.

Wave energy is a quantifiable parameter and is equal to the ability of the wave to do work on the shoreline. The energy that a wave contains determines if and how much effect the wave can have on a shoreline. The energy contained in a wave that can act on a shoreline can be measured many ways. For this memorandum, the wave height is the measure for the energy contained within a wave.

A site visit to Glacier Bay revealed no observable signs of erosion or effects of vessel wakes on the shoreline. However, wave energy from vessels could have an impact over time which is not readily observable.

3.2 WIND WAVE CLIMATOLOGY

The wind wave climate is a description of the waves that are a result of the wind and is similar to describing the general weather pattern for an area. It provides wave heights and periods of typical waves. Identifying the wind wave climate at each site provides a way to analyze the effects of waves on that site. Wind induced waves are natural, or background, levels of energy that interact with the shoreline and the energy contained in a wave may act to change the shoreline.

There are several pieces of information necessary to analyze the natural wind wave climate in the park or any other location. The most important is the wind conditions. The wind speed, duration, and direction need to be measured over a period of time, preferable many years. After evaluating the wind speed, duration, and direction, the size of the natural waves can be determined. The orientation of the open water body plus its size, fetch, and depth determines the size of waves that can be generated by the wind. The typical period of a wind-generated wave in Glacier Bay proper is 1-3 seconds.

3.3 VESSEL WAKE CLIMATOLOGY

Vessels can generate two types of waves, surface and internal waves. Large vessels generate waves that generally affect the top 40 feet of the water column for the largest vessels in Glacier Bay proper. Smaller vessels' effect will be shallower. The first type of wave is surface waves. Surface waves are visible on the surface of the water body. These surface waves have the potential to affect other boaters and the shoreline environment. Surface waves would not be expected to cause mixing of nutrients in the water column. The second type of wave, internal waves, is created by vessels under specific conditions and is capable of causing mixing in the water column. Internal waves are density dependent, which means that there must be stratification in the water column that the vessel directly affects. Internal waves do not act on the shoreline and will not be discussed further in this technical memorandum.

The vessel wake climate is the effect of vessel operation on the waterway. The vessel wake climate is compared to the wind wave climate to analyze how vessel wakes affect the shoreline in excess of natural processes. Various parameters including the vessel's hull shape and displacement, and the distance to where the wave energy is no longer capable of changing the coastline were looked at to determine the size and number of vessel wakes to strike each site. The vessel wake climate pictured in Figure 1 is not capable of affecting the coastline because it is too far away from the shoreline.

FIGURE 1 PASSING BOAT'S WAKE.

3.3.1 Literature Review and Discussion of Models

The literature on vessel wave generation describes models with widely varying inputs and even more widely varying outputs. Models presented by Sorenson(1989), Blaauw et al (1983) and PIANC (1987) were analyzed to determine their applicability to Glacier Bay proper conditions. Examples of their outputs are in Attachment "Wave generation model calculations". No models were found to be directly applicable to this evaluation but the models do provide the basis for the assumptions made in analyzing the available information. A discussion of the models for wave generation and how a shoreline is affected by waves is presented here.

Generation of Surface Waves by Vessels

Vessels displace water in their passage and generate waves on the surface. This phenomenon is directly related to the water resistance encountered by the vessel due to its speed. Vessels generate surface waves in two waveforms: diverging wakes and transverse wakes (Figure 2). The crests of these waves converge at a "cusp line" where their superposition causes maximum amplitude. This means that the wake will be highest at the cusp line due to the addition of the transverse and diverging wakes. Theory and experiments indicate that the angle of the cusp line range from 19 to 22 degrees off the ship track line. The ship track is the route that a particular vessel takes on a specific trip. The energy imparted by the vessel to the water spreads laterally along the lengthening crest lines with correspondingly reduced wave height (Sorenson 1973).

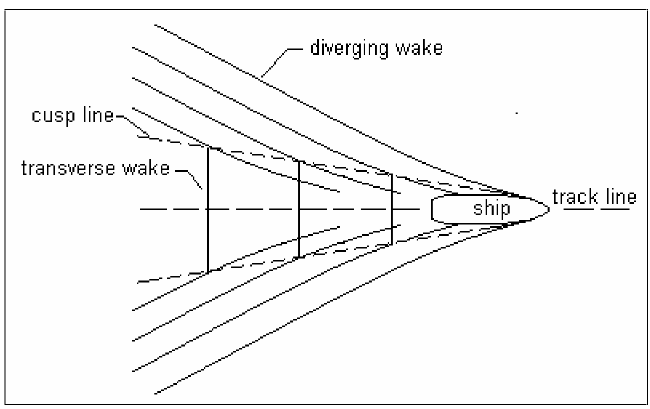

FIGURE 2 PATTERN OF VESSEL-GENERATED WAVES.

The relationship of the vessel speed to the water depth determines the behavior of the wake. A vessel traveling at the same speed through areas with different water depths will produce different wakes. The Froude Number, F, is an accepted measure to define this relationship, defined as

$$F = \frac{V}{\sqrt{gd}}$$ **, where** **Equation 1**

V = the vessel speed through the water,
g = acceleration of gravity (32.2 ft/sec2 or 9.81 m/sec2), and
d = water depth.

The transverse wake is longer than the diverging wake, in terms of the horizontal distance between adjacent wave crests, and therefore is first affected by shallow water. When F exceeds 0.6 to 0.7, the transverse wake is transformed through interaction with the bottom and its propagation speed is constrained. This means that transverse wakes are more quickly dissipated and less likely to reach a shore or any great distance from the vessel when the water body is shallow. Waves cannot exceed a propagation speed of $\sqrt{gd}$, so no transverse waves are possible when F is greater than one. Only diverging wakes are generated when vessels, like planing small powerboats or larger high-speed catamaran excursion boats, are at higher speeds. Diverging waves have shorter wavelengths than transverse wakes and are less prone to water depth effects. Their propagation speed, C, is predicted by:

$C = V\cos\theta$, where **Equation 2**

$\cos\theta$ = the trigonometric cosine of the angle of wave propagation to the ship's track line.

V = the vessel speed through the water

The pattern of a group of diverging waves from a single ship passage experienced at some point away from the track line is typically 15 waves with increasing wave heights to a central maximum height, as illustrated in Figure **3** (Sorensen 1973 and 1989, Weggel and Sorensen 1986, and Maynard 2001). The maximum height of the wake, initially a function of ship speed, displacement, and underwater shape, decreases with distance from the track line.

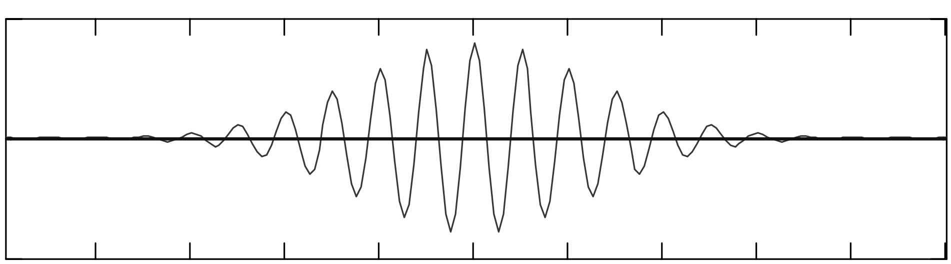

FIGURE 3 GROUP PATTERN OF 15-20 WAVES. THE WAVES ARE GENERATED BY A SINGLE VESSEL PASSAGE, EXPERIENCED AT A POINT ON THE WATER OFFSET FROM THE TRACK LINE.

Predictions of maximum wave height at a given distance from the track line are based on empirical findings. Weggel and Sorensen (1986) predict maximum wave height, H_m, at track offset distance, x, on the basis of F, water depth, d, and the cube root of ship displacement, $\forall^{1/3}$. See pages 4, 5 and 6 of Attachment "Wave generation model calculations" for details of the formulation. Figure 4 illustrates an example application for a cruise ship. Note that the predicted maximum wave height decreases as the wake travels farther from the vessel that produced the wake. This equation is conservative in comparison to other similar formulations and measurements (Blaauw et al 1984, PIANC 1987, Sorensen 1989, Hüsig et al 2000, and Veri-Tech 2002).

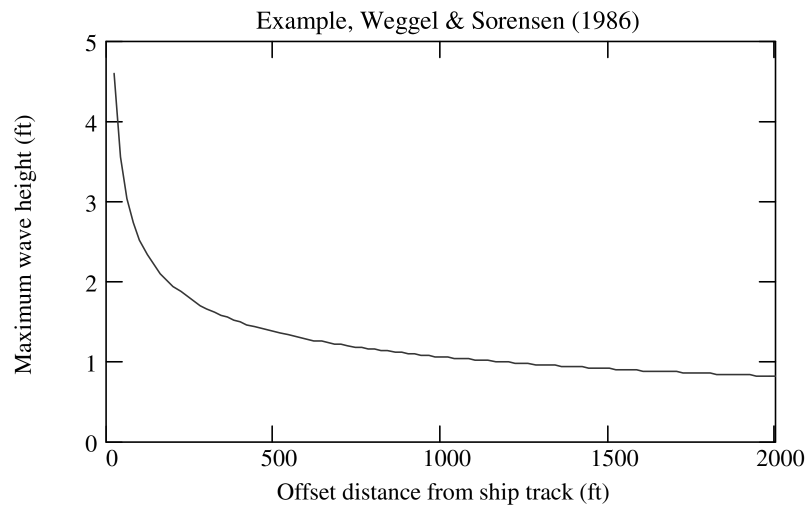

FIGURE 4 EXAMPLE APPLICATION OF WEGGEL AND SORENSEN (1986). GIVEN A SHIP OF 1000 TONS DISPLACEMENT WITH A SPEED OF 15 KNOTS THROUGH THE WATER IN 100 FATHOMS DEPTH. THE WAKE IS PREDICTED TO PROPAGATE AT C = 12.2 KNOTS WITH AN ANGLE θ = 35.3 DEGREES TO THE SHIP TRACK AND TO HAVE A PERIOD T = 4.0 SECONDS AND WAVELENGTH L = 83.4 FT. WAVE HEIGHTS BEFORE AND AFTER THE MAXIMUM WILL BE DIMINISHED AS SHOWN IN FIGURE 3.

Table 1 provides the maximum wave height generated by a series of vessels at a speed of 10 knots, as presented in Sorensen (1973). Sorensen's measurements demonstrate that vessels of varying sizes all had wakes with maximum wave heights of less than 1-foot at a distance of 500 feet from the sailing line. Similar findings were reported in a study which measured vessel wakes on the Kenai River and Johnson Lake (Maynord 2001). In this study Maynord looked at the vessel wakes of 16 to 20-foot long boats of various hull shapes and beams. He found that these vessels generated maximum waves at speeds of approximately 8-knots. The waves were less than one foot measured between 30 and 50 feet from the track line. Although the wave height dropped off rapidly with distance from the track line, the wave's periods remained constant.

Table 1 Maximum Wave Amplitudes Generated By A Series of Vessels At A Speed of 10 Knots as Presented by Sorensen (1973).

Vessel	Length ft	Beam ft	Draft ft	Displacement tons	Distance from sailing line 100 ft Height ft	500 ft Height ft
Cabin Cruiser	23	8.25	1.7	3	1.1	0.8
Coast Guard Cutter	40	10	3.5	10	1.6	1
Tugboat	45	13	6	29	1.6	0.9
Fishing boat	64	12.8	3	35	1.8	0.7
Fireboat	100	28	10.5	343	1.6	1

3.4 DESIGN WAKE ASSUMPTIONS

- Design Wake height is 1 foot. This is the maximum wave height expected for any of the vessels permitted in Glacier Bay proper and therefore is protective of the coastline.
- All vessels within 2,000 feet of the shoreline will have a design wake of 1-foot. (See "Vessel Track Analysis Methodology" for information on the selection of 2,000 feet from the shoreline for analysis purposes).
- Vessels generate 15 wake waves. This is the maximum number of waves that will intercept the shoreline at any one point from a passing vessel.
- All wake energy is assumed to be directed perpendicular to the shore.

4 GLACIER BAY PROPER ANALYSIS METHODOLOGY

4.1 METHODOLOGY FOR CONDUCTING WAKE ANALYSIS OF GLACIER BAY PROPER

PN&D analyzed the collected data and chose specific sites that will require detailed evaluation. This was done by:

- evaluating vessel track data for proximity to shoreline to determine the number of vessels that come within 2,000 feet of the shoreline for the energy index calculation

- evaluating Gustavus, Alaska wind data to determine the natural wind patterns including strength (windspeed) and direction
- examination of the physical features of Glacier Bay proper to determine the physical restrictions and limitations in wave development,
- evaluating the fetch geometries of the chosen sites to determine the amount of wind wave energy that will assault the site and compare that to the vessel wake energy at the same site, and
- evaluation of material size at beaches to determine risk of erosion.

4.2 GLACIER BAY PROPERPHYSICAL FEATURES

The mouth of Glacier Bay proper is located near Gustavus, Alaska, which is 50 miles due west of Juneau, Alaska. Glacier Bay proper (Plate 1) is approximately 60 miles long and consists of a 4-mile wide entrance narrows, Sitakaday Narrows, which opens up into an approximately 12-mile wide main body. North of the main body, the East Arm creates a north-south fetch of approximately 55miles. The West Arm also creates a maximum fetch of 55 miles, oriented at 140 degrees. Fetches are distances over which waves are generated when sustained winds blow. These long fetches, over deep waters of Glacier Bay proper, create a wave climate similar to the open sea. Water depths in mid-channel range from 200 feet in Sitakaday Narrows to 1,400 feet in the upper West Arm. Glacier Bay proper also contains many protected waterways in various orientations and the wave climate will differ substantially from the open areas. Analysis with restricted fetches (narrow channels) applies to the waves generated in these protected waterways.

Tidal currents and waves are major influences over the shape of beaches. This is a relatively new method of influence in Glacier Bay proper due to the long period of glacial ice coverage. Glacier Bay proper is an example of a secondary coast, in that terrestrial forces, in this case, glacial activity, formed it. The tidal range in Glacier Bay proper is large at approximately 24 feet. Tidal currents act on the shoreline primarily as long shore transport. In addition, wave action acts both perpendicular to the shore and parallel to the shore; something that was absent until recently due to glacial ice covering the bay.

4.3 SITE VISIT

PN&D conducted a site visit to Glacier Bay proper on June 12, 2002. One of the purposes of the site visit was to observe maximum tides and currents. The site reconnaissance consisted of taking photographs and recording the vessels path using a global positioning system (GPS) unit during an eight hour Spirit of

Adventure Tour Vessel Cruise from Bartlett Cove to Grand Pacific Glacier at the head of the West Arm. The GPS record for the cruise is shown in Plate 1. The vessel positions and speed between waypoints is provided in Attachment “Spirit of Adventure positions and speeds”. During the trip around the bay, a negative 2.7-foot (extreme low) tide was observed at approximately 9:30 am. A brown bear was observed foraging at the waterline on the exposed food supply at the extreme low water mark (see concentration of waypoints just north of Tidal Inlet, Plate 1).

The data collected by the GPS during the site visit included vessel track (route) and speed. Vessel track information is necessary to estimate the number of vessels that are close enough to the shore to effect the shoreline. GPS provides a speed relative to the ground; much like a speedometer provides the speed of a car. This does not provide the speed of the vessel in relation to the water when there are currents. To identify the speed of Spirit of Adventure in relation to the water, PN&D used coastal prediction tables available at NOAA/OPS online. The maximum ebb current was 5.2 knots west of Beardslee Island and the maximum flood current was 6.1 knots for the day of the site visit. These values corresponded with the 4-knot flood current observed by the ship captain at 2:15 pm, which should have been the time of maximum flood current adjusted to that location. By using the GPS record made during the cruise, Spirit of Adventure speed relative to the water at any time can be inferred using its GPS speed log (speed relative to the ground) and tidal currents predictions for each location. The GPS record also provides the distance from the shore that the vessel traveled. This is necessary information to determine which sites to investigate further.

FIGURE 5 DAWN PRINCESS, CRUISE SHIP CLASS

The investigators observed that the cruise ship Dawn Princess (Figure 5) appeared to be traveling at top speed up Glacier Bay proper at 1pm on June 12, and appeared to have generated a wake of less than 1 foot height at a distance of 2,000 feet, when Spirit of Adventure crossed its wake. The period of the wake was between 1 and 2 seconds. The period and distance were estimated by timing the sound and motion induced in the video recording of the wake crossing.

4.3.1 Ship Captains Interview

One of the purposes of the trip was to observe the wake produced by catamaran tour vessels, such as Spirit of Adventure. This vessel has very desirable characteristics for a tour vessel because it accelerates rapidly and produces minimum wake and noise. The maximum wake, according to Spirit of Adventure Captain Kanoi Taylor, occurs when the boat is at the speed of 12 to13 knots relative to the water. The maximum water height generated by Spirit of Adventure is not in the form of a wave. The frothy convergence centered behind the stern quickly dissipates energy without contributing energy to formation of waves. See Figure 6, Spirit of Adventure wake. This type of wake is advantageous for a vessel which makes frequent stops along beaches, as waves from the departure wake are minimized.

FIGURE 6 SPIRIT OF ADVENTURE WAKE

4.4 WIND WAVE ANALYSIS METHODOLOGY

The wind wave analysis calculates the natural wind wave heights and periods for sites in Glacier Bay proper. Site-specific wind measurements are unavailable for Glacier Bay; however it is available for Gustavus Airport, Alaska. Several coastal cities in southeast Alaska have first order stations, including Juneau (1987-1999), Sitka (March-December 1999), Ketchikan (March-December 1999), and Cordova (December 1999). Wind summaries and wind roses for Juneau, Ketchikan, Sitka and Cordova are presented in Attachment "Wind summaries for Sitka, Ketchikan, Juneau, and Cordova (1987-1999)". Weather data collection stations have different ratings based on collection methods and accuracy standards with first order stations having the most reliable data. Plate 2 compares Gustavus to its nearest first order station and demonstrates that the wind patterns in Gustavus are similar to Juneau and sufficient for this evaluation. Therefore, data from the Gustavus Airport from 1987 to 2002 was used as the baseline data for the Glacier Bay wind analysis. The airport anemometer in Gustavus is on a flat, sparsely treed delta and is likely to share its wind climate with Glacier Bay proper. National Climate Data Center provided raw wind data for Gustavus.

As in all of southeast Alaska, wind directions induced by large-scale weather patterns prevail along the main channels of the bay. The dominant NW-SE winds at Gustavus (Plate 2), for example, have a similar speed distribution to N-S prevailing winds in the main channel of the lower bay (Plate 1). Similarly, the distributions of wind speeds in the prevailing directions at Glacier Bay proper and Gustavus are expected to be similar to the speed distribution in the prevailing directions at Juneau, 50 miles east, as seen in Plate 5. A pattern of wind speeds and directions in selected parts of Glacier Bay proper was constructed following this above logic.

For the wave analysis, below, PN&D used the Gustavus wind rose to combine related sectors of winds. This is done to determine the directions to use for the wave analysis. Five categories appear to be most significant and winds from combining related sectors are shown in Plate 3. The related groups were assigned the values of 50^o, 130^o, 200^o, 260^o and 340^o.

4.4.1 Fetch Restrictions and Wind Duration Analysis Methodology

Wave analysis requires predicting the height and period of the waves. The length of the fetch, duration and intensity of wind determine the height and period of the waves. Glacier Bay proper has both open fetch areas and restricted fetch areas. In open areas, like the midsection of the main body of water, the fetch is less important than the duration of a particular wind event in generating waves. When this condition exists, the wave growth is said to be duration limited. In a narrow area, like protected inlets and near protecting islands, wave growth will be fetch limited. There is not sufficient fetch length (depending on the direction of the particular wind) in some parts of Glacier Bay proper to generate large waves even if the wind blows strongly for a long time.

In the wave analysis, fetch restrictions were modeled using CEDAS (Veritech, Inc) wind generated wave growth model. Deep water wave growth was used since d/L>0.7 for wind waves in Glacier Bay proper. Glacier Bay proper has deep water waves, which means the wave energy does not interact with the bottom. This is similar to the ocean. For a diagram showing application in restricted fetches see Attachment "Technical References", Aces Technical Reference, pages 8 and 9.

A wind duration of one hour was used for the wave growth modeling. This assumption will predict smaller waves than would actually exist during wind events as a typical storm event lasts longer than one hour. A wind event is a period of sustained wind in both speed and direction. This is a conservative assumption from this discussion because the analysis will be biased towards the vessel wakes causing an effect.

4.4.2 Wave Analysis Methodology

The wave analysis includes information from the weather stations and the vessel track information. The information from the weather stations is used to create the natural wind wave climate at each site. The vessel track information is used with the vessel wave design height to create the vessel wave climate at each site. The energy, or ability to do work, of the two climates is compared against each other in the energy index. The number of waves that strike the shore, whether it is a storm or vessel passing, is one measure of the amount of energy in a single event.

According to the Airy (linear wave) theory, if all waves are propagated in the same direction, the total energy for each wave is:

$$E := \frac{1}{8}\cdot\rho\cdot g\cdot H^2$$

where ρ is the density of water, g is the acceleration due to gravity and H the wave height.

To get the total energy, we multiply the energy per wave by the number of waves. In this report, it is convenient for comparison purposes to define the energy index, N, for a particular coastal site. N is the cumulative energy of the design height (one foot) vessel waves to strike the shore in a year divided by the cumulative energy of wind-generated waves to strike the same shore in a year.

Assumed Wave Height

The approach used for this technical memorandum is to select a conservative wave height based on the vessels which are permitted in the bay and use this height for all calculations. This will provide an increased safety factor in calculating the energy contained within a vessel wake. The conservative wave height value provides a worst-case scenario as this is the maximum wave height expected to be produced by any of the vessels permitted to enter Glacier Bay proper. Further justification of this approach is given at II-7-61, Coastal Engineering Manual (30 Sep 96), see Attachment “Technical References”.

Vessel Track Analysis Methodology

Vessel traffic information is required to determine the number of vessel waves at any site. PN&D used the track logged during the site visit on June 12, 2002 and the vessel tracks provided by NPS in order to determine the number of vessel waves. During the site visit on the Spirit of Adventure, this vessel appeared to be traveling closer to shore than any other vessel observed during the trip. According to the GPS record, the Spirit of Adventure maintained an average distance of approximately 1,000 feet when it was closest to shore.

Vessel track data provided by NPS contains shape file data for cruise vessels, tour vessels and charter vessels. There was no information for private vessels. The vessel track data set was used to predict the number of vessels that passed within 2,000 feet of the shore. The tracks within 2,000 feet of the coastline were counted. The analysis uses 2,000 feet because the literature indicates that wakes from vessels are found to have attenuated to approximately 1-foot at a distance of 1,000 feet from the vessels track. The 2,000-foot distance provides an acceptable margin of error and is protective of the coastline against erosion. It is important to note that the NPS stated that their track data is only accurate to ±3,000 feet. NPS track data provides the only information available with which to make a prediction on vessel traffic patterns. Plate 4 Glacier Bay vessel traffic is an example of one of the vessel track datasets from NPS.

Wave and Wake Energy Analysis Methodology

To complete the shoreline effect analysis for Glacier Bay proper, the energy levels for wind-induced waves and vessel wakes are divided to give a comparison index. The following assumptions were made:

- A design vessel wake represented all vessel wakes at each shore site.
- This design vessel wake is conservative as most vessel wakes will have less energy than the design wake.
- The design boat wake maximum height is 1-foot.

- 100% of the vessel wake energy is directed at the shore.
- Wind duration for a storm event is set at 1 hour.

A design boat wake was chosen to represent every vessel wake because reliable statistical information about each particular class of vessels wakes is not available and the vessel wake attenuation through the water has a significant effect on its energy at the shore site. The 1-foot design wake is conservative and biased towards showing an affect on the shoreline. The wind duration for wind-induced waves is conservative as storms typically last longer than 1-hour.

4.4.3 Site Selection for Analysis

Energy levels were generated at 22 study areas (see Figure 9). Details of the selected sites are shown in Attachment "Areas identified for detailed study". These areas were selected by analyzing vessel track information as provided above.

An energy index value (N value) was generated for each of the 22 sites, and the sites were divided into the following categories to compare the ability of vessel-generated waves against natural conditions. This does not consider the substrate material so it is not the effects analysis.

- High – if the energy of the vessel waves is of the same order of magnitude as the wind waves (1/1). This means that all the vessel wake energy over the year has the same amount or more energy as natural background conditions and is highly likely to change (erode) the coastline.
- Moderate – if the energy of the vessel waves is one-tenth of the energy of the wind waves. This means that all the vessel wake energy over the year has one-tenth (1/10) the amount of energy as a natural background conditions and is moderately likely to change (erode) the coastline.
- Minor – if the energy of the vessel waves is one-hundredth of the energy of the wind waves. This means that all the vessel wake energy over the year has one-hundredth (1/100) the amount of energy as a natural background conditions and has a low likelihood of changing (eroding) the coastline.
- Negligible – if the energy of the vessel waves in one-thousandth of the energy of the wind waves. This means that all the vessel wake energy over the year has one-thousandth (1/1000) the amount of energy as a natural background conditions and is highly unlikely to change (erode) the coastline.

The period chosen for the evaluation is one year. This allows for the use of a full year of wind data. Any shorter period would not correctly interpret cumulative effects of wind waves. A longer period would be necessary to correctly predict the effect of climate cycles, for example El Nino. The vessel analysis evaluates a single permit-required season, which generally runs from June through October.

4.4.4 Wind Wave and Vessel Wake Comparison

This section discusses the probability that a design vessel's wake height will exceed a typical summer storm's wave height. This probability is important to discuss because it provides a summary of how strong a wake is compared to a wave. The probability varies from site to site and from beach to beach due to different angles to the wind and the fetch length. Wind direction is an important factor in evaluating the natural wind waves because there must be sufficient fetch to create a wave and the wave needs to be nearly perpendicular to the shore for the wave to act on the beach.

Site 11, see plate 4, provides an example of calculating probabilities. Site 11 has two beaches as it includes the shoreline on each side of Tidal Inlet. Beach A is to the northwest of Tidal Inlet and Beach B is to the southeast of Tidal Inlet. For the same wind intensity and direction, the wind waves along Beach B will be higher because the fetches are longer. As discussed above, wind direction was grouped into five related sectors. For Site 11, the only two sectors of concern are 260° and 340°. Table 2 shows the number of observations when a summer (June through August) wind event created a wave of 1-foot or higher. **Error! Reference source not found.** Table 3 shows the probability of a wind event creating a wave that exceeds the 1-foot design height for selected wind speeds and durations. For example, at Beach A, a 14-knot wind blowing for an hour from 340 degrees can be expected to occur one time in 5 summers and will produce waves of the same height as the design vessel wake. As a comparison, a 10-knot wind from the same direction (340 degrees) for two hours would produce the same wind waves. These two scenarios exert the same amount of energy on the beach. The differing fetches account for the differing probabilities between Beach A and Beach B.

TABLE 2 NUMBER OF OBSERVATIONS WHEN WIND WAVES EXCEEDED 1-FOOT FOR SITE 11. LIMITED TO SUMMER OBSERVATIONS (JUNE, JULY AND AUGUST), GUSTAVUS, AK.[1]

Wind Speed In Knots	Number of Observations with Wind Direction 260°	Number of Observations with Wind Direction 340°
16	1	0
15	1	1
14	2	1
13	9	3
12	12	16
11	27	30
10	59	56
9	105	111
8	158	215
7	276	383

TABLE 3 PROBABILITY OF SELECTED WIND SPEEDS AND DURATIONS PRODUCING 1-FOOT WAVES AT SITE 11.[2]

Wind		Beach A			Beach B		
Duration (Hours)	Direction (Degrees)	Wind Speed (Knots)	Probability of exceeding 1-Foot wave (%)	Average Number of times exceeding 1-foot wave	Wind speed* (Knots)	Probability of exceeding 1-Foot wave (%)	Average Number of times exceeding 1-foot wave
1	340	14	0.0087	0.2	13	0.0260	0.6
2	340	10	0.4858	nc[3]	9	0.9630	nc
3	340	8	1.8652	nc	7	3.3226	nc
1	260	16	0.0087	0.2	14	0.0174	0.4
2	260	12	0.1041	nc	11	0.2342	nc
3	260	11	0.2342	nc	9	0.9109	nc

4.4.5 Wind/Wave Model Assumptions

- Design wake assumptions stated above. The design wake represents all vessels, regardless of size and speed, that come within 2,000 feet of the shoreline.
- Wind wave growth event is 1 hour.
- Glacier Bay is a deep-water environment in terms of wind wave growth and characteristics.
- Analysis period is one-year.

[1] Total Observations equal 11,527.
[2] The wind speed and duration shown are required to produce at least 1-foot waves.
[3] NC = Not calculated (duration analysis not performed)

4.5 PHYSICAL ATTRIBUTE DEFINITIONS

The substrate is the size of material present in the tidal zone. Table 4 provides the definition of the various material types and their potential for erosion.

TABLE 4 SUBSTRATE SIZE CHART

Substrate	Material Size	Comparison Size	Erosion Potential
Bedrock	Continuous rock	Continuous rock	Negligible
Boulder	>256 mm	≥ human head size	Minor
Cobble	64-256 mm	Billiard ball to human head	Minor
Pebble	4-64 mm	Pea to billiard ball	Minor
Granule	2-4 mm	BB to pea	Moderate
Coarse sand	1-2 mm	Pinhead to BB	Moderate
Fine sand	0.0625-1 mm	Gritty (sugar/salt) to pinhead	High
Silt	>0.0625 mm	Smooth; forms clumps/balls	High
Shell	4-256 mm shells/fragments	Shells/fragments	Minor

The CoastWalkers database defines the substrate in terms of primary and secondary substrate. The primary substrate is the material size most commonly found at the site. The secondary substrate is the second most common material size and it has at least 10% coverage.

The slope that a beach can maintain is a function of the material size. Generally, large material also has a steep slope and small material has a gentler slope. The slope of beach is important for analysis because this defines how widely the energy is distributed across the beach (see Figure 8).

The erosion potential of a site is a function of the size of material and the amount of energy it receives. Bedrock has negligible erosion potential. Boulders, cobbles, and pebbles have minor erosion potential and require high energy levels to erode. Granules and coarse sand have moderate erosion potential and fine sand and silt have a high erosion potential. The amount of erosion visible for smaller materials depends on recruitment of new materials. A beach could have a very high erosion potential, yet not erode with a storm because it has a strong source (recruitment point) of new materials.

4.6 OVERALL ANALYSIS METHODOLOGY

Each site is assigned an erosion potential based on the site's potential for erosion. Each site is also assigned a rating for the energy index, which indicates the amount of energy imparted on the site by vessel wakes in comparison to the natural wind wave energy. How these two ratings are obtained and calculated is described above.

Reaching an overall potential effect at a site requires evaluation of the erosion potential rating and the energy index (vessel wake potential) rating. The highest, or more severe, rating common to both categories is the overall rating. For example, Site 1 has a high to moderate rating for erosion potential and a vessel wake potential of negligible. This means that the overall potential effect is negligible. What is instructive by showing both the erosion potential and vessel wake potential ratings is that it is clear how a change in vessel usage near a site could change the overall potential effect. Site 1 is susceptible to an increase in erosion should there be an increase in vessel traffic due to the small substrate. Under the current conditions, vessel traffic is limited and therefore does not significantly affect the shoreline at Site 1. In contrast, Site 4 has an overall rating of minor because both the erosion potential and vessel wake potential ratings are minor. An increase in vessel traffic will not affect the overall rating at this site because the substrate is resistant to erosion.

4.6.1 Assumptions

- No compound wakes occur due to two vessels traveling so closely that their wakes become additive.
- The beach material is assumed to be consistent throughout the tidal zone so tide height is not factored into the analysis. The height of the tide is important for other considerations include near shore and intertidal users.

5 GLACIER BAY PROPER ANALYSIS

5.1 INTRODUCTION

As stated above, there is a two-prong approach to analyzing a site for potential affect due to vessel wakes. The first evaluation is the comparison between the natural wind wave climate and the vessel wake climate. This analysis provides an index of how much energy above the natural wind environment that vessel wakes impart on the coastline. The second evaluation is of the substrate present at the site. The amount of energy necessary to affect a shoreline depends on the type and size of material. The analysis is complete when the energy potential from the vessel wakes is considered with the substrate material.

5.2 ANALYSIS EXAMPLE SITES

Two sites were selected to show the analysis process. The first site, Site 20, is in upper Muir Inlet near Stump Cove (Figure 7) and the second site, Site 11, is in the Lower West Arm (see Plate 4).

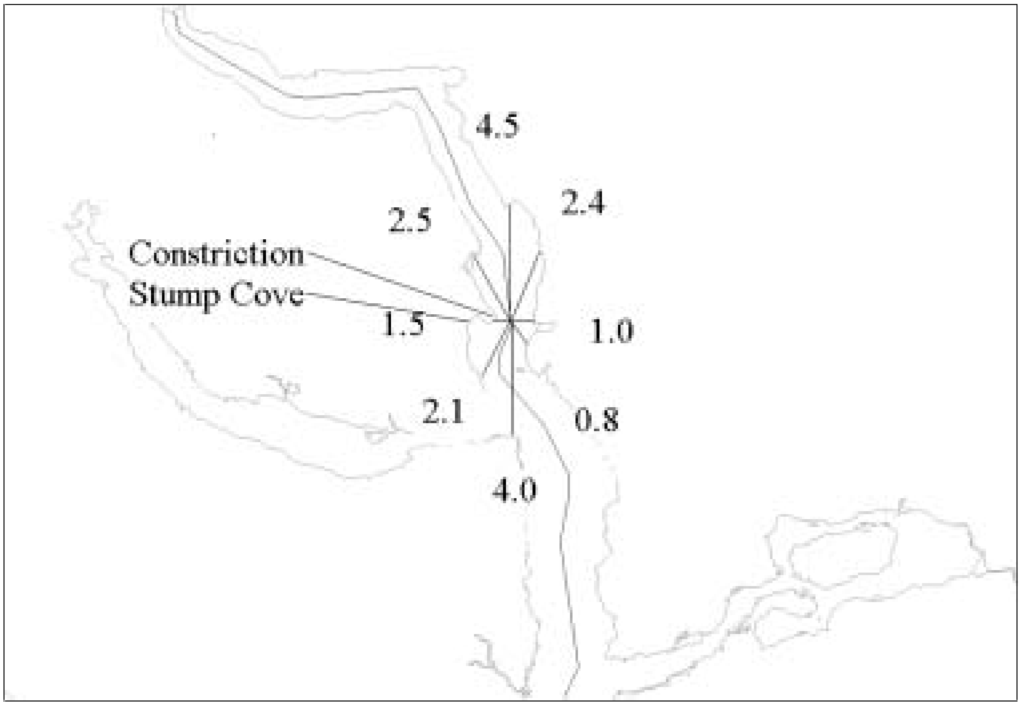

FIGURE 7 FETCH LENGTHS IN MILES IN UPPER MUIR INLET NEAR STUMP COVE, SITE 20.

Site Descriptions

Stump Cove has a narrow and curving channel that is likely to force traffic closer to shore. The Lower West Arm site is moderately well sheltered. The fetch lengths, in miles, near Stump Cove are shown in Figure 7. Site 11 and 20 are representative of the types of areas most likely to be adversely affected by vessel wakes and thus requiring the most attention when evaluating vessel quotas and operating requirements. Due to the size of the vessels and safe vessel traffic management standards, it is assumed that vessels would not travel in the same track at the same time to produce compounded wakes. Additionally, this analysis does not distinguish between time of day or tidal cycle. The energies calculated are for a square foot of shoreline perpendicular to the shore. The energies due to tide and the part of wave energy which is directed parallel to shore are pictured with the second arrow in Figure 8. Energy parallel to shore is responsible for long shore sediment transport and was not considered in computing the energy index, N.

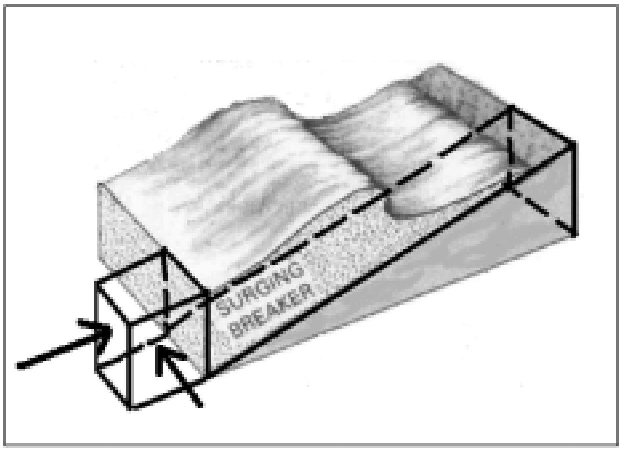

FIGURE 8 WAVE ENERGIES RELATED TO THE SHORE

Wind and Wake Example Analysis

Attachment "Example calculations" provides the calculation of the energy index for the Stump Cove site (Site 20). The example follows all the assumptions listed previously. The Stump Cove site is one of the more sheltered areas in Glacier Bay proper where motorized vessels are permitted. This site experiences little to no vessel traffic according to the NPS vessel track data. With the current vessel traffic, this site has an energy index of N=0.008, which is below the negligible significance level. In other words, vessel wakes impart less than one thousandth (1/1000) the amount of energy on this site than natural wind waves.

The second example analysis in a moderately well sheltered site in the lower West Arm (Site 11). With the current vessel traffic, this site has an energy index of N=0.02, which is minor significance level. In other words, vessel wakes impart less than one tenth (1/10) but more than one hundredth (1/100) the amount of energy on this site than natural wind waves. See Table 5 for a comparison of the two sites.

TABLE 5 VESSEL WAKE AND WIND WAVE ENERGY COMPARISON AT 2 SITES

Site	Vessels		Wind	Energy Index (N)[4]	Significance Level
	# of vessel wakes	Energy	Energy		
Stump Cove (site 20), Beach A	362	112	148,000	0.008	Negligible
Lower West Arm (site 11), Beach A	6,515	2,014	108,000	0.02	Minor

Wave energy at a site is expressed in units of square feet perpendicular to the shore. However, the actual energy transfer takes place on the face of the shore, which is the long rectangular area under the breaker in Figure 8. A steep beach will have a much larger concentration of energy upon its face than a gentler sloping beach as shown in Figure 8. The range of beach slopes in Glacier Bay proper is approximately 1/10 of one degree to 75 degrees. For the range of beach slopes here, there is a range of between 1 and 600 square feet of beach area influenced by the waves. Thus the concentration of energy on the steepest beaches is 600 times the concentration of energy on the gentlest beaches for one given wave climate.

TABLE 6 POTENTIAL AFFECT ON 22 SITES BY VESSEL WAKES WITH CURRENT QUOTAS.

Site	Beach potential[5]	Assigned Site Total potential[6]
1	Negligible	Negligible
2	Minor	Minor
3	Negligible	Negligible
4	Minor	Minor
5	Minor	Minor
	Minor	
6	Negligible	Negligible
7	Negligible	Negligible
	Negligible	
	Negligible	
8	Negligible	Negligible
	Negligible	
9	Negligible	Minor
	Negligible	
	Minor	
10	Negligible	Negligible
11	Minor	Minor

[4] Energy Index (N) is equal to the vessel wake energy divided by the wind wave energy.
[5] Each site is divided into one or more beaches. This is due to the different fetches and variations in the shoreline, which affect the waves that can strike the shore.
[6] To be conservative, the highest potential level for a beach is also the total potential.

Site	Beach potential[5]	Assigned Site Total potential[6]
	Negligible	
12	Minor	Minor
	Minor	
	Negligible	
13	Negligible	Negligible
	Negligible	
14	Negligible	Minor
	Minor	
	Negligible	
15	Minor	Minor
	Minor	
16	Negligible	Moderate
	Moderate	
	Moderate	
17	Minor	Minor
18	Minor	Minor
	Negligible	
	Minor	
19	Negligible	Negligible
	Negligible	
20	Negligible	Negligible
	Negligible	
	Negligible	
21	Negligible	Negligible
22	Minor	Minor

5.3 PHYSICAL ATTRIBUTES OF THE 22 SITES BEING ANALYZED

The vessel wake analyses identified 22 sites where vessels travel close enough to the shoreline to potentially cause change on that shoreline (see Figure 9). This section provides a summary of the physical attributes of the 22 sites identified as presented in the CoastWalkers database. The physical attributes summarized below include the primary substrate, secondary substrate, and the slope. These attributes are important in evaluating the potential for erosion.

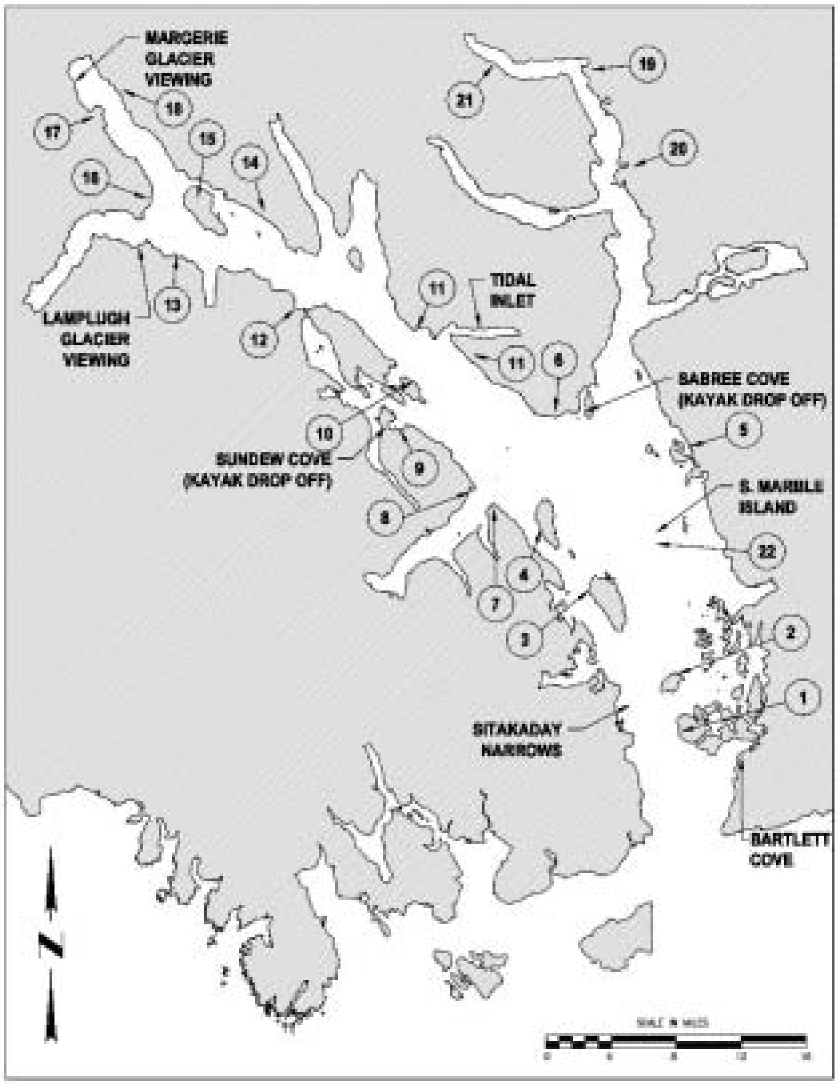

FIGURE 9 SITES SELECTED FOR VESSEL WAKE ANALYSIS.

5.3.1 Physical Attributes of the 22 Sites

The NPS CoastWalker database provides substrate and slope information for each polygon mapped. The polygons are based on changes in substrate material size and the slope. Table 7 provides site information based on the CoastWalker database by summarizing the substrate information for all polygons in the site. See Attachment "CoastWalkers Polygon Table" for a list of the polygons included in each site. The sites have anywhere from eight polygons to 119 polygons representing a single beach in this technical memorandum. The average number of polygons for a single site is approximately 40.

TABLE 7 SUBSTRATE TYPES AND SLOPE FOR EACH SITE.

Site	Primary Substrate	Secondary Substrate	Slope (degrees)	Erosion Potential
1	coarse sand	granule	2.9	High
2	pebble	pebble	5.2	Moderate
3	cobble	cobble	16.4	Minor
4	cobble	boulder	11.8	Minor
5	pebble	pebble	8.8	Moderate
6	pebble	cobble	8.2	Moderate to Minor
7	boulder	cobble	18.0	Minor
8	cobble	cobble	11.5	Minor
9	granule	pebble	7.8	High to Moderate
10	boulder	cobble	13.1	Minor
11	cobble	cobble	16.5	Minor
12	cobble	cobble	13.9	Minor
13	cobble	cobble	16.2	Minor
14	granule	pebble	6.7	High to Moderate
15	cobble	boulder	15.4	Minor
16	boulder	boulder	31.9	Minor
17	boulder	boulder	27.0	Minor
18	pebble	pebble	11.7	Moderate to Minor
19	Not mapped			N/A
20	Granule	granule	8.1	High
21	Not mapped			N/A
22	Not mapped			N/A

Site 1

The average material size for site 1 is coarse sand. The minimum size material is silt and the largest is cobble. The median and mode material size is fine sand. The average secondary substrate size is granule. The minimum size material for secondary substrate is silt and the largest is cobble. The median and mode material size for secondary substrate is pebble. The average slope is 2.9 degrees. The minimum slope is 1 degree and the maximum slope is 5 degrees. The median slope is 2.75 degrees and the mode is 2.5 degrees.

Site 2

The average material size for site 2 is pebble. The minimum size material is granule and the largest is cobble. The median and mode material size is cobble. The average secondary substrate size is pebble. The minimum size material for secondary substrate is pebble and the largest is boulder. The median and mode material size for secondary substrate is pebble. The average slope is 5.2 degrees. The minimum slope is 0 degrees and the maximum slope is 8 degrees. The median slope is 5.75 degrees and the mode is 7 degrees.

Site 3

The average material size for site 3 is cobble. The minimum size material is coarse sand and the largest is bedrock. The median material size is boulder and mode material size is bedrock. The average secondary substrate size is cobble. The minimum size material for secondary substrate is coarse sand and the largest is bedrock. The median and mode material size for secondary substrate is cobble. The average slope is 16.4 degrees. The minimum slope is 4 degrees and the maximum slope is 66 degrees. The median slope is 12 degrees and the mode is 7 degrees.

Site 4

The average material size for site 4 is cobble. The minimum size material is granule and the largest is bedrock. The median and mode material size is pebble. The average secondary substrate size is boulder. The minimum size material for secondary substrate is granule and the largest is bedrock. The median and mode material size for secondary substrate is cobble. The average slope is 11.8 degrees. The minimum slope is 2.5 degrees and the maximum slope is 26 degrees. The median slope is 10 degrees and the mode is 8 degrees.

Site 5

The average material size for site 5 is pebble. The minimum size material is fine sand and the largest is bedrock. The median and mode material size is pebble. The average secondary substrate size is pebble. The minimum size material for secondary substrate is silt and the largest is boulder. The median material size for secondary substrate is pebble and mode material size is cobble. The average slope is 8.8 degrees. The minimum slope is 2.5 degrees and the maximum slope is 21.5 degrees. The median slope is 7.5 degrees and the mode is 12 degrees.

Site 6

The average material size for site 6 is pebble. The minimum size material is silt and the largest is bedrock. The median and mode material size is pebble. The average secondary substrate size is cobble. The minimum size material for secondary substrate is fine sand and the largest is bedrock. The median and mode material size for secondary substrate is cobble. The average slope is 8.2 degrees. The minimum slope is 1 degree and the maximum slope is 33 degrees. The median slope is 7.5 degrees and the mode is 6 degrees.

Site 7
The average material size for site 7 is boulder. The minimum size material is pebble and the largest is bedrock. The median material size is boulder and mode material size is bedrock. The average secondary substrate size is cobble. The minimum size material for secondary substrate is granule and the largest is boulder. The median and mode material size for secondary substrate is cobble. The average slope is 18 degrees. The minimum slope is 3 degrees and the maximum slope is 75 degrees. The median slope is 12 degrees and the mode is 6 degrees.

Site 8
The average material size for site 8 is cobble. The minimum size material is silt and the largest is bedrock. The median and mode material size is pebble. The average secondary substrate size is cobble. The minimum size material for secondary substrate is fine sand and the largest is bedrock. The median and mode material size for secondary substrate is cobble. The average slope is 11.5 degrees. The minimum slope is 1.5 degrees and the maximum slope is 70 degrees. The median slope is 9 degrees and the mode is 8 degrees.

Site 9
The average material size for site 9 is granule. The minimum size material is silt and the largest is bedrock. The median and mode material size is pebble. The average secondary substrate size is pebble. The minimum size material for secondary substrate is fine sand and the largest is bedrock. The median and mode material size for secondary substrate is pebble. The average slope is 7.5 degrees. The minimum slope is 2.5 degrees and the maximum slope is 22 degrees. The median slope is 7.8 degrees and the mode is 9 degrees.

Site 10
The average material size for site 10 is boulder. The minimum size material is pebble and the largest is bedrock. The median and mode material size is boulder. The average secondary substrate size is cobble. The minimum size material for secondary substrate is pebble and the largest is bedrock. The median and mode material size for secondary substrate is cobble. The average slope is 13.1 degrees. The minimum slope is 5 degrees and the maximum slope is 44.5 degrees. The median slope is 8.3 degrees and the mode is 6.5 degrees.

Site 11
The average material size for site 11 is cobble. The minimum size material is fine sand and the largest is bedrock. The median and mode material size is pebble. The average secondary substrate size is cobble.

The minimum size material for secondary substrate is fine sand and the largest is bedrock. The median and mode material size for secondary substrate is cobble. The average slope is 16.5 degrees. The minimum slope is 3 degrees and the maximum slope is 90 degrees. The median slope is 9 degrees and the mode is 8 degrees.

Site 12

The average material size for site 12 is cobble. The minimum size material is silt and the largest is bedrock. The median material size is cobble and mode material size is pebble. The average secondary substrate size is cobble. The minimum size material for secondary substrate is silt and the largest is bedrock. The median and mode material size for secondary substrate is cobble. The average slope is 13.9 degrees. The minimum slope is 2 degrees and the maximum slope is 65 degrees. The median slope is 8 degrees and the mode is 5 degrees.

Site 13

The average material size for site 13 is cobble. The minimum size material is fine sand and the largest is bedrock. The median material size is cobble and mode material size is bedrock. The average secondary substrate size is cobble. The minimum size material for secondary substrate is coarse sand and the largest is bedrock. The median material size for secondary substrate is cobble and mode material size is bedrock. The average slope is 16.2 degrees. The minimum slope is 2 degrees and the maximum slope is 45 degrees. The median slope is 8.8 degrees and the mode is 7 degrees.

Site 14

The average material size for site 14 is granule. The minimum size material is silt and the largest is cobble. The median and mode material size is pebble. The average secondary substrate size is pebble. The minimum size material for secondary substrate is silt and the largest is boulder. The median and mode material size for secondary substrate is cobble. The average slope is 6.7 degrees. The minimum slope is 1.5 degrees and the maximum slope is 15.5 degrees. The median slope is 6.5 degrees and the mode is 7.5 degrees.

Site 15

The average material size for site 15 is cobble. The minimum size material is silt and the largest is bedrock. The median and mode material size is cobble. The average secondary substrate size is boulder. The minimum size material for secondary substrate is silt and the largest is bedrock. The median material size for secondary substrate is boulder and mode material size is bedrock. The average slope is 15.4

degrees. The minimum slope is 4 degrees and the maximum slope is 55 degrees. The median slope is 10 degrees and the mode is 8 degrees.

Site 16

The average material size for site 16 is boulder. The minimum size material is granule and the largest is bedrock. The median material size is boulder and mode material size is bedrock. The average secondary substrate size is boulder. The minimum size material for secondary substrate is granule and the largest is bedrock. The median material size for secondary substrate is boulder and mode material size is bedrock. The average slope is 31.9 degrees. The minimum slope is 4 degrees and the maximum slope is 89 degrees. The median slope is 26 degrees and the mode is 35 degrees.

Site 17

The average material size for site 17 is boulder. The minimum size material is pebble and the largest is bedrock. The median material size is bedrock and mode material size is bedrock. The average secondary substrate size is boulder. The minimum size material for secondary substrate is pebble and the largest is bedrock. The median material size for secondary substrate is boulder and mode material size is bedrock. The average slope is 27 degrees. The minimum slope is 4 degrees and the maximum slope is 50 degrees. The median slope is 26 degrees and the mode is 50 degrees.

Site 18

The average material size for site 18 is pebble. The minimum size material is silt and the largest is bedrock. The median and mode material size is pebble. The average secondary substrate size is pebble. The minimum size material for secondary substrate is silt and the largest is bedrock. The median and mode material size for secondary substrate is cobble. The average slope is 11.7 degrees. The minimum slope is 1.5 degrees and the maximum slope is 70 degrees. The median slope is 9 degrees and the mode is 6 degrees.

Site 19

This site was not mapped as part of the CoastWalkers program.

Site 20

The average material size for site 20 is granule. The minimum size material is silt and the largest is bedrock. The median and mode material size is pebble. The average secondary substrate size is granule. The minimum size material for secondary substrate is silt and the largest is bedrock. The median material size for secondary substrate is pebble and mode material size is cobble. The average slope is 8.1 degrees.

The minimum slope is 0.5 degrees and the maximum slope is 55 degrees. The median slope is 7.5 degrees and the mode is 10 degrees.

Site 21

This site was not mapped as part of the CoastWalkers program.

Site 22

This site was not mapped as part of the CoastWalkers program.

5.4 SUMMARY OF POTENTIAL EFFECTS ON THE 22 SITES

This section summarizes the information provided above for each site. It is intended to provide the reader with an understanding of the vessel wake effects on the specific beaches. This evaluation is for the current quota and vessel restrictions so the evaluation of a site could change if the number of vessels permitted to enter Glacier Bay proper increases or decreases. See Table 8 for a summary of the overall potential affect to Glacier Bay National Park and Preserve due to vessels.

Site 1

Site 1 is generally a sandy beach with some larger material. This means that the beach has a high to moderate potential for erosion. However, the potential for vessel wakes to adversely affect the site at the current quota is negligible. Therefore, this site has a negligible potential for adverse affects at the current quota.

Site 2

Site 2 is generally a pebbled beach with cobbles. This means that the beach has a moderate potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is minor. Therefore, this site has a minor potential for adverse affects at the current quota.

Site 3

Site 3 is generally a cobbled to sandy beach that also has a significant amount of boulders and bedrock. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is negligible. Therefore, this site has a negligible potential for adverse affects at the current quota.

Site 4
Site 4 is generally a cobbled beach with larger material including boulders. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is minor. Therefore, this site has a minor potential for adverse affects at the current quota.

Site 5
Site 5 is generally a pebbled beach. This means that the beach has a moderate potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is minor. Therefore, this site has a minor potential for adverse affects at the current quota.

Site 6
Site 6 is generally a pebbled beach with larger material including cobbles. This means that the beach has a moderate to minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is negligible. Therefore, this site has a negligible potential for adverse affects at the current quota.

Site 7
Site 7 is generally a boulder beach. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is negligible. Therefore, this site has a negligible potential for adverse affects at the current quota.

Site 8
Site 8 is generally a cobbled beach with both larger material including bedrock and some smaller material including silt. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is negligible. Therefore, this site has a negligible potential for adverse affects at the current quota.

Site 9
Site 9 is generally a granular beach with pebbles. This means that the beach has a high to moderate potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is negligible to minor. Therefore, this site has a minor potential for adverse affects at the current quota.

Site 10
Site 10 is generally a boulder beach with cobbles. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is negligible. Therefore, this site has a negligible potential for adverse affects at the current quota.

Site 11
Site 11 is generally a cobbled beach. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is minor to negligible. Therefore, this site has a minor potential for adverse affects at the current quota.

Site 12
Site 12 is generally a cobbled beach. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is minor to negligible. Therefore, this site has a minor potential for adverse affects at the current quota.

Site 13
Site 13 is generally a cobbled beach with exposed bedrock. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is negligible. Therefore, this site has a negligible potential for adverse affects at the current quota.

Site 14
Site 14 is generally a granular beach with pebbles and cobbles. This means that the beach has a high to moderate potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is negligible to minor. Therefore, this site has a minor potential for adverse affects at the current quota.

Site 15
Site 15 is generally a cobble beach with larger material including boulders and bedrock. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is minor. Therefore, this site has a minor potential for adverse affects at the current quota.

Site 16
Site 16 is generally a boulder beach with bedrock. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is moderate to

negligible. Therefore, this site has a minor potential for adverse affects at the current quota due to the larger material size of the substrate.

Site 17

Site 17 is generally a boulder beach with bedrock. This means that the beach has a minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is minor. Therefore, this site has a minor potential for adverse affects at the current quota.

Site 18

Site 18 is generally a pebbled beach with some cobbles. This means that the beach has a moderate to minor potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is minor to negligible. Therefore, this site has a minor potential for adverse affects at the current quota.

Site 19

Physical attribute information is not available for Site 19. This site is in Muir Inlet and outside the area mapped for the NPS during the CoastWalkers project. A glacier covered the site as recently as 40 years ago. The potential for vessel wakes to adversely affect the site at the current quota is negligible. More information on the shoreline material is necessary to determine the overall potential affect.

Site 20

Site 20 is generally a granular beach with some pebbles. This means that the beach has a high potential for erosion. The potential for vessel wakes to adversely affect the site at the current quota is negligible. Therefore, this site has a negligible potential for adverse affects at the current quota.

Site 21

Physical attribute information is not available for Site 21. This site is in the upper reaches of Muir Inlet and outside the area mapped for the NPS. A glacier covered the site as recently as 30 years ago. The potential for vessel wakes to adversely affect the site at the current quota is negligible. More information on the shoreline material is necessary to determine the overall potential affect.

Site 22

Physical attribute information is not available for Site 22. This site is on South Marble Island and outside the area mapped for the NPS. Seabird activity on the island was noted during the cruise tour and maps indicate that this site is a seabird nesting area. The potential for vessel wakes to adversely affect the site at the current quota is minor. More information on the shoreline material is necessary to determine the overall potential affect.

TABLE 8 POTENTIAL FOR ADVERSE AFFECTS AT 22 SITES IN GLACIER BAY NATIONAL PARK AND PRESERVE WITH THE 1996 VESSEL "USE DAYS".

Site	Erosion Potential at the Site	Vessel Wake Potential Effect[7]	Overall Potential Effect[8]
1	High to moderate	Negligible	Negligible
2	Moderate	Minor	Minor
3	Minor	Negligible	Negligible
4	Minor	Minor	Minor
5	Moderate	Minor	Minor
6	Moderate to minor	Negligible	Negligible
7	Minor	Negligible	Negligible
8	Minor	Negligible	Negligible
9	High to moderate	Negligible to minor	Minor
10	Minor	Negligible	Negligible
11	Minor	Minor to negligible	Minor
12	Minor	Minor to negligible	Minor
13	Minor	Negligible	Negligible
14	High to moderate	Negligible to minor	Minor
15	Minor	Minor	Minor
16	Minor	Moderate to negligible	Minor
17	Minor	Minor	Minor
18	Moderate to minor	Minor to negligible	Minor
19	Not mapped	Negligible	*Need additional information*
20	High	Negligible	Negligible
21	Not mapped	Negligible	*Need additional information*
22	Not mapped	Minor	*Need additional information*

5.5 WAKE EFFECTS ON WATERWAY USERS

The tide range in Glacier Bay proper is approximately 24 feet. With mixed tides the bay daily experiences two different high tide levels and two different low tide levels (see Figure 12). A high tide is followed by a higher low, which is followed by a higher high, which is followed by a lower low. Twice a month, due to alignment of the sun and moon, spring tides occur. For approximately two days, both higher highs and lower lows are exaggerated. Although spring tides occur twice a month, the most exaggerated spring tides occur in the spring season when large vessel traffic is absent in Glacier Bay proper.

[7] 1996 vessel quotas.
[8] 1996 vessel quotas.

There are many waterway users that may be in the vicinity of the shoreline. These users can include nesting birds, kayakers, and campers. For this section, shore nesting birds will be used as an example of potentially affected users. Most shore nesting birds establish their nests to minimize swamping due to waves and with consideration of the tides and typical storms during the nesting season. Some birds may be forced into the marginal areas and be at higher risk for swamping during natural conditions and when vessels are not present. Swamping of shore nesting birds is most likely to occur when boat wakes occur simultaneously with higher high spring tides. The probability that a vessel wake will wash over a nest is equal to the probability of a spring tide occurring times the probability that the nests are placed low on the beach and "too close to the high water level."

The probability of a higher high spring tide is equal to the number of hours of higher high spring tides a season divided by the number of hours in the season. This probability is 0.56%, calculated as follows:

$$\frac{1\text{hr}}{(\text{higher}-\text{high})\text{tide}}\cdot\frac{1\,(\text{higher}-\text{high})\text{tide}}{\text{day}}\cdot\frac{4\text{day}}{\text{month}}\cdot\frac{3\text{month}}{\text{season}} \div \frac{24\text{hr}}{\text{day}}\cdot\frac{30\text{day}}{\text{month}}\cdot\frac{3\text{month}}{\text{season}}$$

The analysis of whether a nest will be swamped due to vessel wakes can be carried over to any shoreline user. For example, if a kayaker pulls their kayak above the higher high tide line, the probability that the kayak will be swamped and possible pulled out into the bay is the same as the example above, 0.56%. However, if the kayak is not pulled up to this point on the beach, then the probability of the kayak being swamped will increase depending on the location of the kayak and the tide range during that time.

5.6 WAVE PARAMETERS CONSIDERED BUT NOT SELECTED FOR THE DETAILED ANALYSIS

Another parameter besides energy was calculated and compared to wave energy at selected sites to provide an alternative method of evaluating vessel waves impact to the Glacier Bay proper ecosystem. This wave parameter is water particle velocity and it relates to long shore transport.

Maximum water particle velocities were considered. Water particle velocities stir up the sediments by exerting drag on the sediment particles. The motion of the water under surface waves (for which gravity is the restoring force) is circular near the surface. As the depth increases, the motion becomes elliptical. Very near the bottom, the water can be imagined as moving back and forth.

Example calculations of water particle velocities showed that for the wave heights and periods typical of the wave climate in Glacier Bay proper, the velocities would be more difficult to compare in the various sites of interest because additional input parameters are required. These include the wave speed, C, and the period of the vessel waves. The calculations performed show that the typical particle velocities were smaller than the design velocity of 10 feet per second (fps), which is used in aquariums to prevent marine fouling. Velocities of less than 10 fps are inferred to be required to allow marine growth. Velocities in the range of 10 fps do routinely occur in the shallow surf zone during wind wave events. Even in the shallowest water, as predicted by Airy theory, the maximum horizontal water particle velocity caused by the design boat wake is approximately 3 fps.

Water particle velocity was not as suitable a parameter for analysis of vessel wake effects in Glacier Bay proper. The additional input information required is not readily available and would require making additional assumptions.

6 CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

The purpose of this technical memorandum is to provide a method to evaluate existing and proposed vessel quotas and operating requirements in Glacier Bay National Park and Preserve. The method detailed in this technical memorandum will be used to classify all sites selected for full evaluation in the EIS. Some conclusions can be drawn based on our work so far and on the information contained within this technical memorandum. These include:

- For most of Glacier Bay proper, vessel wakes pose little threat to the coastline.
- There are specific locations where operating requirements may be necessary to prevent adverse effect to the shoreline. This may include creating a no-wake zone near the shoreline. See the Environmental Impact Statement for specific sites and evaluations.
- The potential effect of vessel generated internal waves to all aspects of the environment is not known. Research indicates that internal waves have the potential to mix stratified layers of water. This could affect stratification of pelagic organisms like algae. Further scientific study is required to determine if they exist and their affects on the environment. It is likely that naturally occurring internal waves occur in Glacier Bay proper and would not be affected by vessels due to the shallow extent of influence by the vessel.
- Vessel wake disturbance occurs close to the vessel producing the wake. Wakes are essentially dissipated within 2,000 feet of the vessel.

- Requiring vessels to stay farther from shore during the hour of higher-high spring tides will guard against the possibility of wakes washing over nesting sites.
- Wave climates (both natural and vessel induced) affect near shore and tidal users. The height of the tide is an important factor in whether the vessel-induced wake would affect the user.
- Erosion due to beaching vessels is more likely to cause erosion at a specific site than vessel wakes.

Data is needed in the following areas:

- Wind data in several key locations throughout the park. Wind data used in this memorandum is not specific for Glacier Bay and thus only extrapolated.
- Accurate vessel track data is needed. This is the weakest element in the analysis.
- Waves should be measured in the bay to provide validation of the energy indices, N values.
- Effects of ship induced internal waves on the water column.

7 DEFINITIONS

Average – This is the typical quantity, also known as the mean.

Beach – In coastal engineering a beach or shore encompasses the extents shown in Figure 10. Rocky beaches (for instance) will not have all the features, but will have the same zones that are defined by the water levels shown in the figure.

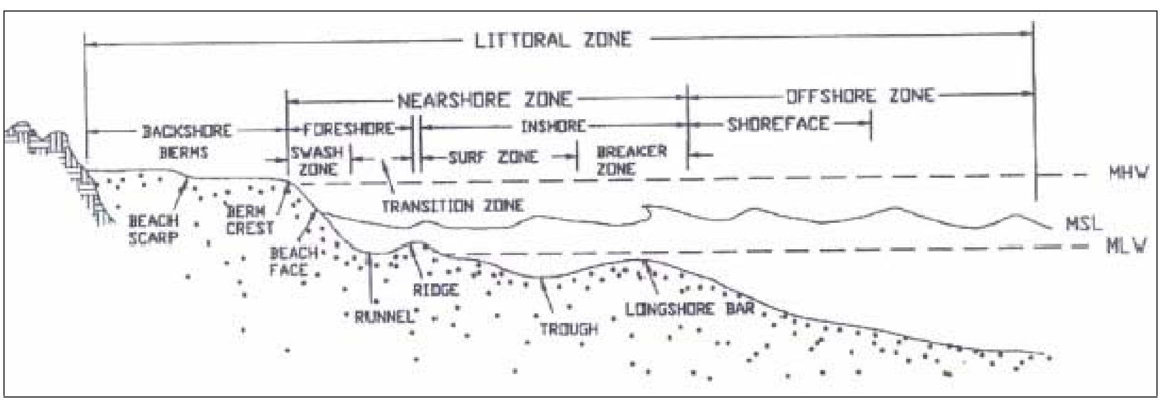

FIGURE 10 BEACH TERMINOLOGY AND EXTENTS.

Beam – vessel maximum width normal to flow, see Figure 11 (B on the drawing).

Blockage Ratio – cross sectional area of waterway divided by the maximum submerged cross section of the vessel. A maximum blockage ratio of 60 in Glacier Bay proper would occur if a cruise ship traversed the 0.25 mile wide channel north of Russell Island.

Constricted waterway – a navigated waterway with blockage ratio less than 20.

Deep water – related to a wave's position in the water, where d satisfies $0.5 < \frac{d}{L} <$ infinity, see Figure 13.

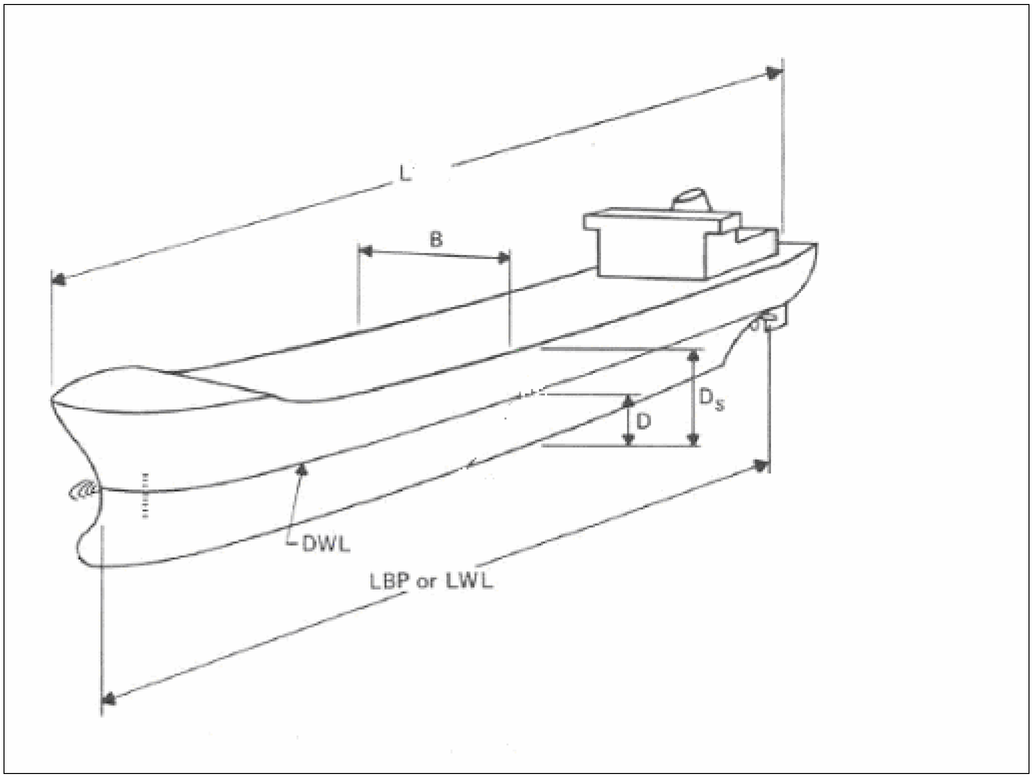

FIGURE 11 VESSEL DIMENSIONS

Diverging Wake – the wave which spreads outward from the boats bow and is always present

Fetch – the unobstructed area in which waves are generated by a wind having a rather constant direction and speed

Mean Lower Low Water (MLLW) is the 0 water level in Figure 12, and is the datum referenced in coastal engineering. Glacier Bay has what is called mixed tides, with one small and one large tide a day. Referenced water levels are averaged over a period of years to establish the datum.

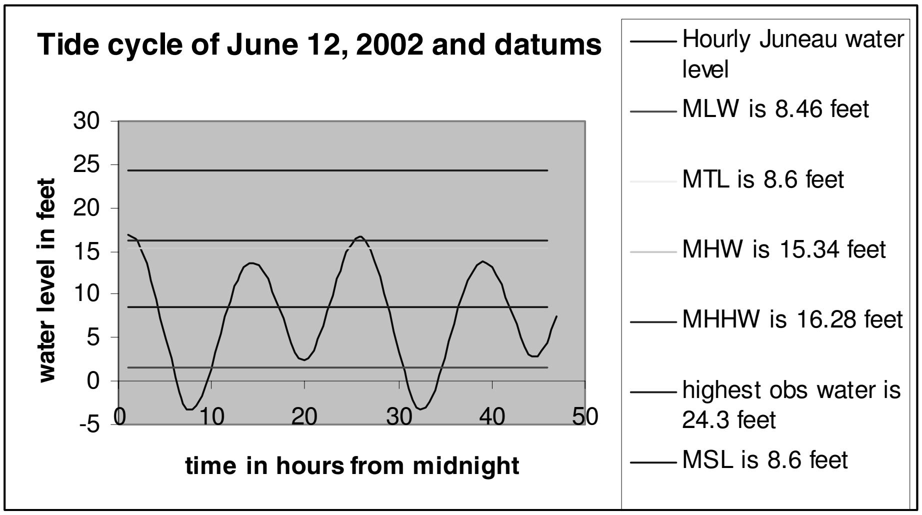

FIGURE 12 TIDES IN JUNEAU.

Median – The middle number of a given sequence of numbers, as used in statistical analysis.

Mode – The number that occurs most frequently in a given sequence of numbers, as used in statistical analysis.

Negative tide - when the water is below the usual low water mark (0 MLLW), as on the day of June 12 in Gustavus, see Figure 12. This occurs twice monthly.

Orographic effects - effects attributed to mountains.

Propagation Speed – the same as wave speed, or celerity.

Ship (Vessel) Track Line – the path over the water.

Spring Tide – Tides which occur twice monthly and have both higher highs and lower lows. The most extreme spring tides do occur during the spring before boats begin to enter Glacier Bay, but the term is used throughout the seasons.

Transverse Wake – the wave which is directed opposite the boats motion, is caused by the boats stern and is sometimes present.

Wave height or amplitude – Shown as H in Figure 13.

Wave period – the length of time which a stationary observer on the surface of the water observes between two successive crests.

Wave length – L in Figure 13

Wave speed – the speed at which the wave propagates or advances, usually referred to as C, or wave celerity. See Figure 13.

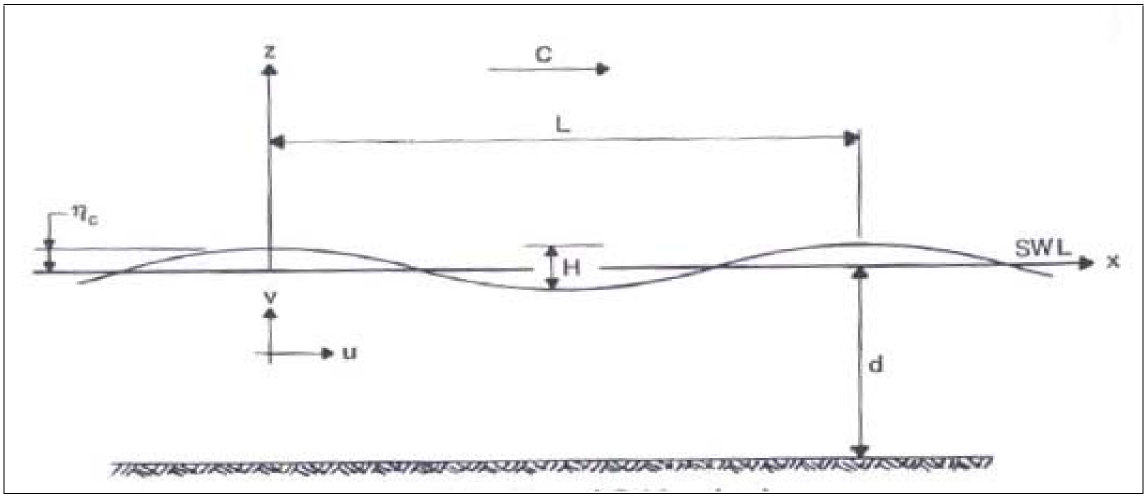

FIGURE 13 WAVE PARAMETER DEFINITIONS

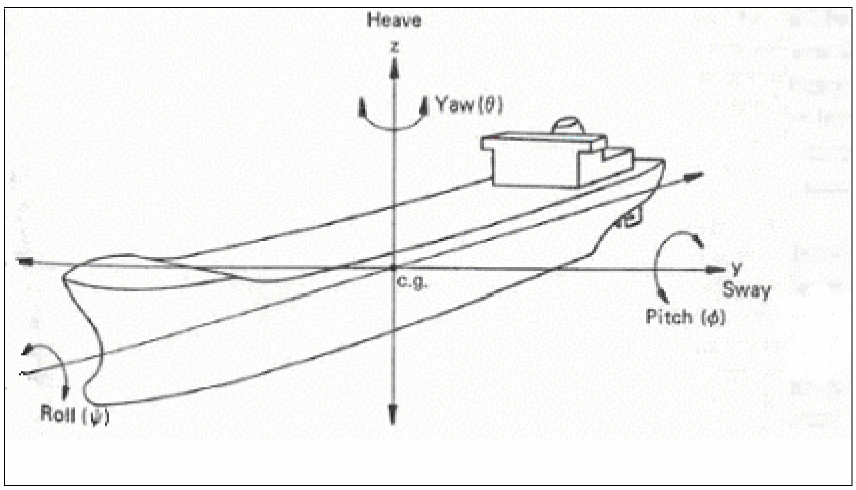

FIGURE 14 VESSEL MOTION DEFINITIONS

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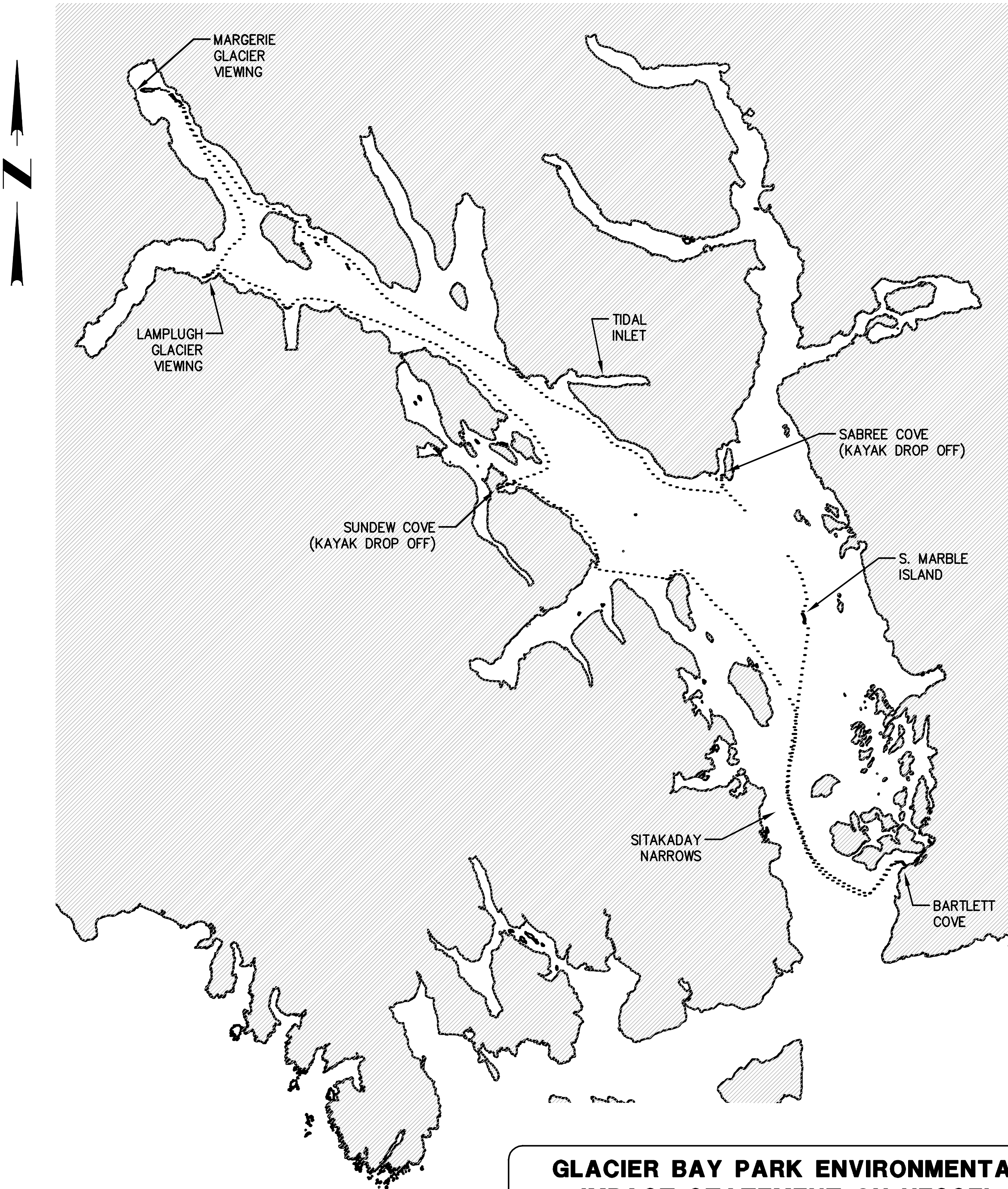


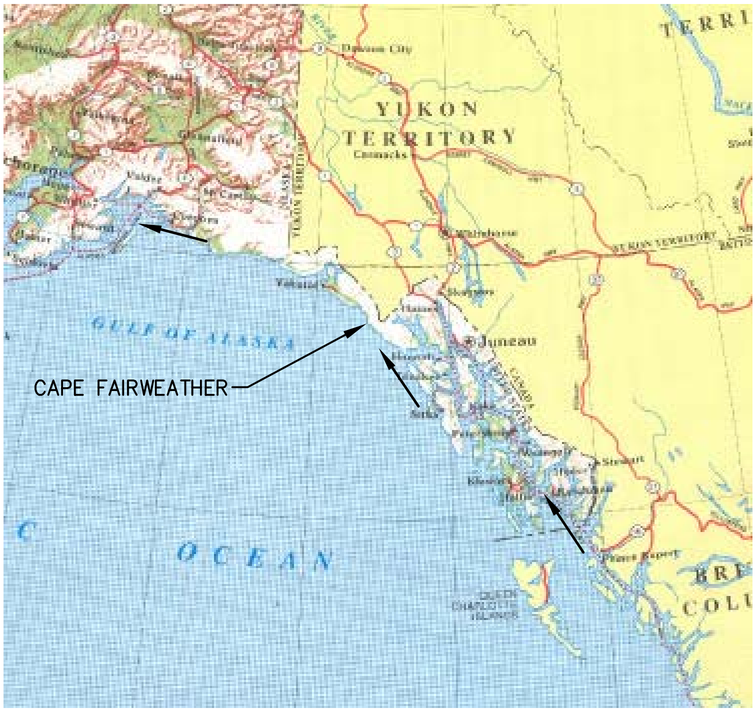
GLACIER BAY PARK ENVIRONMENTAL IMPACT STATEMENT ON VESSEL QUOTAS AND OPERATING REQUIREMENTS

Peratrovich, Nottingham & Drage, Inc.
Engineering Consultants

1506 West 36th Avenue,
Anchorage, Alaska 99503 (907) 561-1011 FAX (907) 563-4220

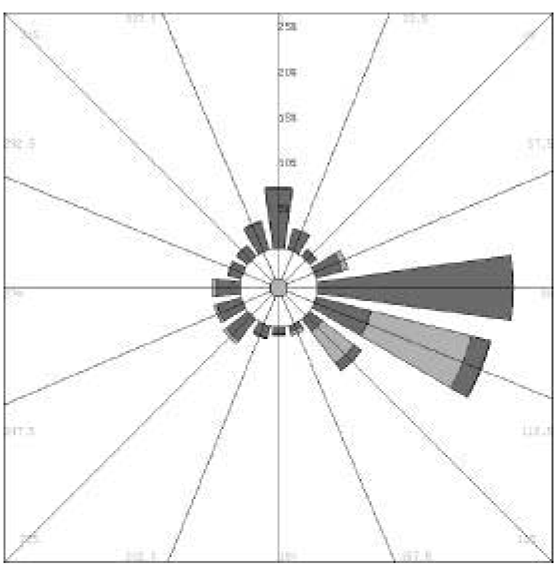
SPIRIT OF ADVENTURE CRUISE WAY POINTS - JUNE 12, 2002

PLATE 1



VICINITY MAP

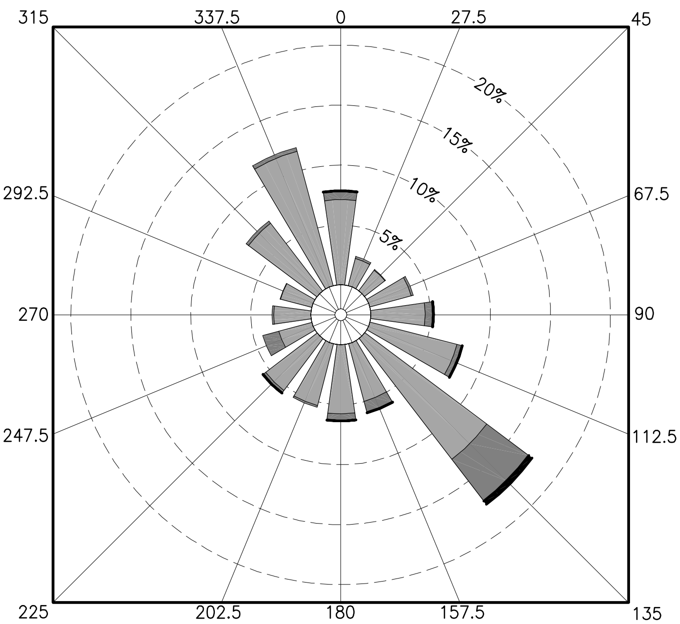
STATION: JUNEAU, AK
YEARS: 1987 – 1999
MONTHS: ALL
DAYS: ALL
HOURS: ALL
SOURCE: AK SEA ATLAS WEBSITE, TDF14, TD3280 – HOURLY



JUNEAU, ALASKA

STATION: GUSTAVUS, AK
YEARS: 1987 – 2001
MONTHS: ALL
DAYS: ALL
HOURS: ALL
SOURCE: NATIONAL CLIMATE DATA CENTER – HOURLY

NOTE:
RADIAL BANDS INDICATE 10 KNOT INCREMENTS OF WIND ACTING TOWARD THE CENTER OF THE WIND ROSE.



GUSTAVUS, ALASKA

GLACIER BAY PARK ENVIRONMENTAL IMPACT STATEMENT ON VESSEL QUOTAS AND OPERATING REQUIREMENTS

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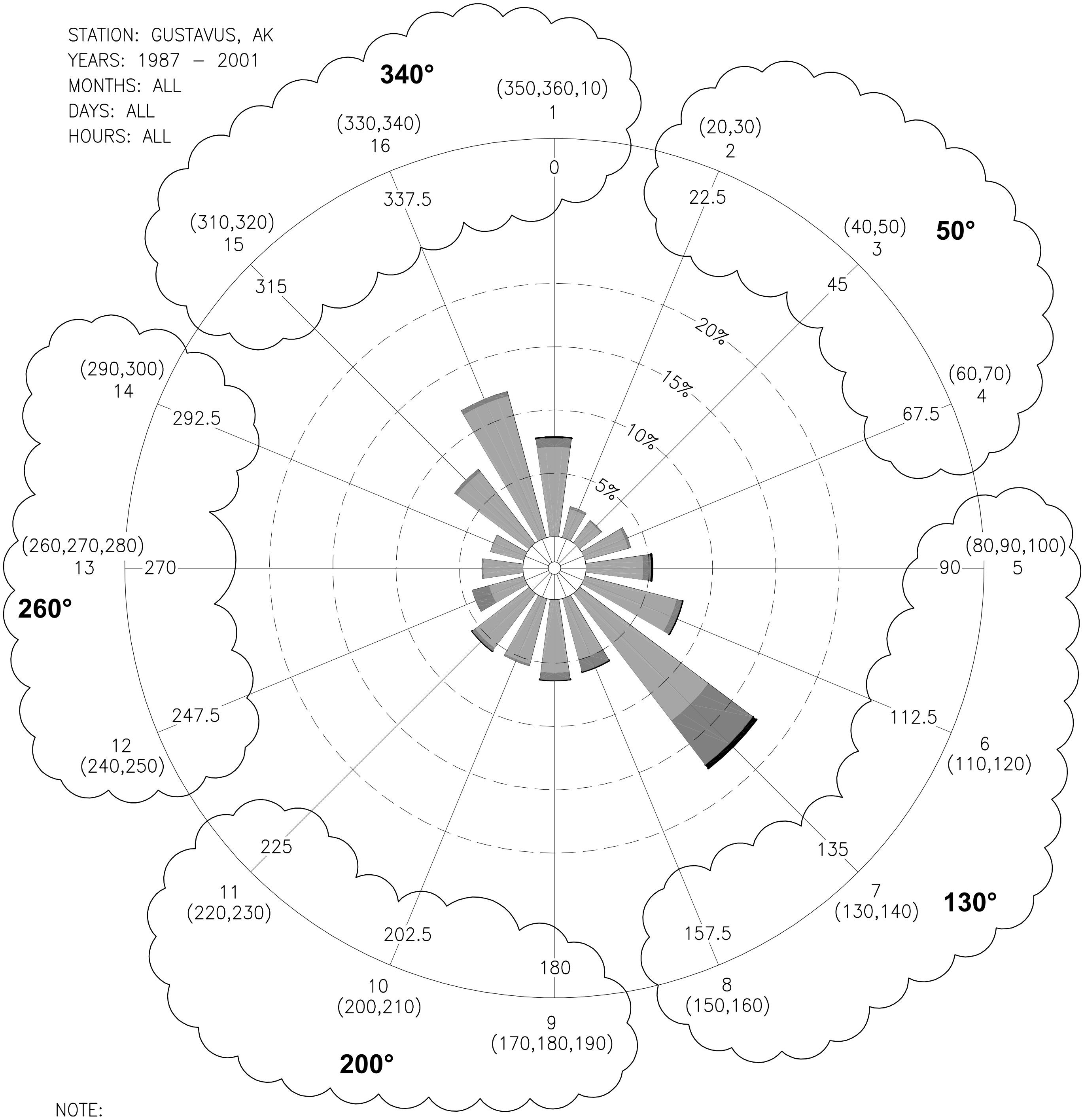
1506 West 36th Avenue,
Anchorage, Alaska 99503 (907) 561-1011 FAX (907) 563-4220

WIND ROSE COMPARSION

PLATE
2



NOTE:
1. RADIAL BANDS INDICATE 10 KNOT INCREMENTS OF WIND ACTING TOWARD THE CENTER OF THE WIND ROSE.
2. NUMBERS 1 TO 16 REPRESENT SECTOR BINS.
3. NUMBERS IN PARENTHESIS REPRESENT THE WIND DIRECTIONS REPORTED BY NCDC WHICH WERE ASSIGNED TO EACH SECTOR BIN.
4. BOLD NUMBERS IN OUTER CLOUDS REPRESENT THE WIND ASSIGNED TO THE CLOUDED SECTORS FOR WAVE GROWTH ANALYSIS.

GLACIER BAY PARK ENVIRONMENTAL IMPACT STATEMENT ON VESSEL QUOTAS AND OPERATING REQUIREMENTS

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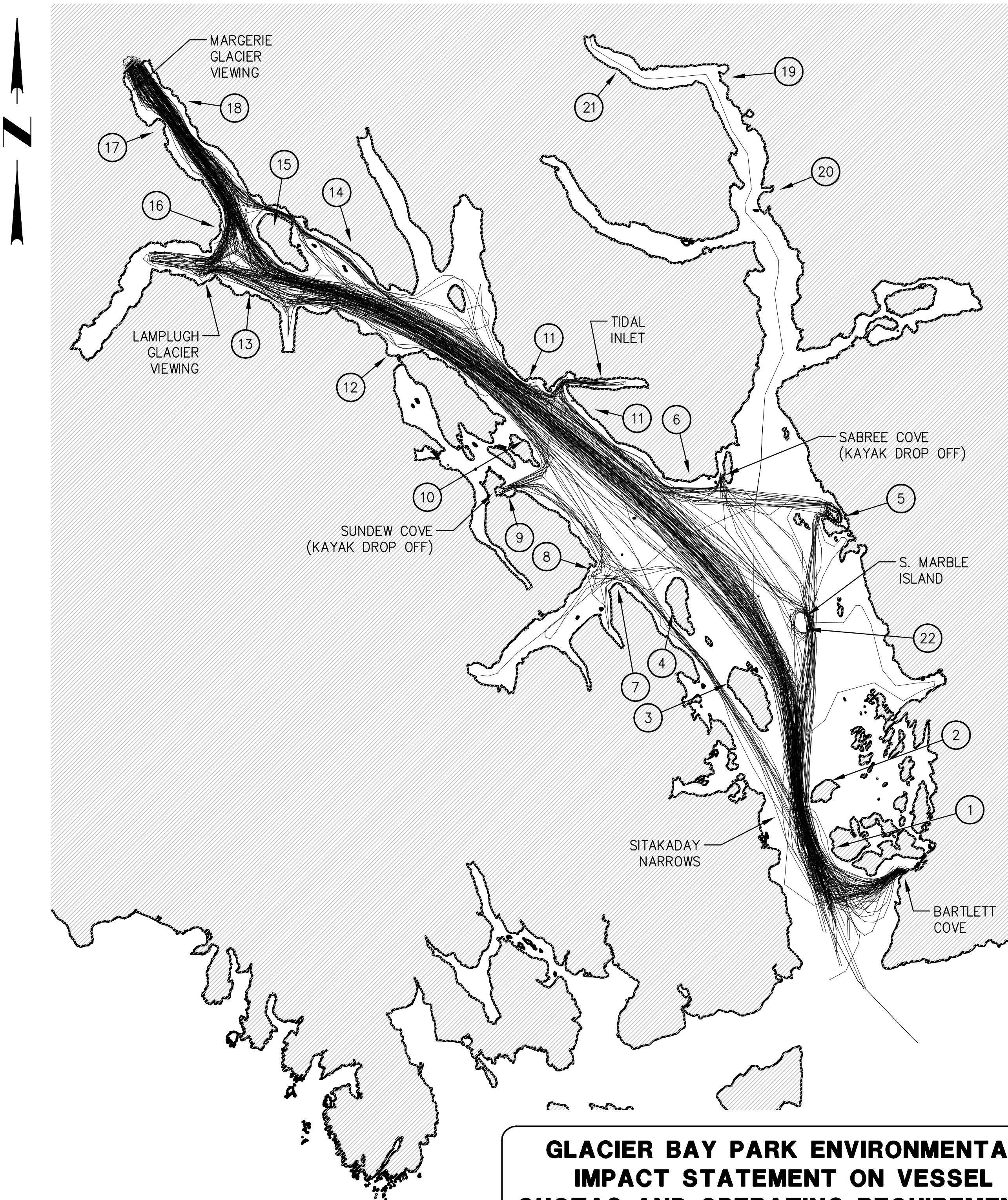
Anchorage, Alaska 99503 (907) 561-1011 FAX (907) 563-4220

BIN ARRANGEMENT FOR WIND ANALYSIS

PLATE
3



NOTES:
NUMBERS INDICATE SHORELINE IDENTIFIED
FOR DETAILED STUDY.

GLACIER BAY PARK ENVIRONMENTAL IMPACT STATEMENT ON VESSEL QUOTAS AND OPERATING REQUIREMENTS

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GLACIER BAY VESSEL TRAFFIC

PLATE
4

assigned angle	sector		calm	1-9kn	10-19kn	20-29kn	30-39kn	40-49kn	50-max
				Gustavus probabilities summarized as described in technical memo					
	1*	0	0.30	4.9707	0.5096	0.0056	0.0000	0.0000	0.0000
	2	22.5		1.6352	0.1333	0.0011	0.0000	0.0000	0.0000
	3	45		1.4919	0.0605	0.0011	0.0000	0.0000	0.0000
	4	67.5		2.4966	0.1434	0.0011	0.0000	0.0000	0.0000
50				**5.6237**	**0.3371**	**0.0034**	**0.0000**	**0.0000**	**0.0000**
	5	90		3.1708	0.4839	0.0056	0.0000	0.0000	0.0000
	6	112.5		5.2451	0.3125	0.0123	0.0000	0.0000	0.0000
	7	135		8.8976	3.0633	0.2464	0.0011	0.0011	0.0000
	8	157.5		3.4878	0.6843	0.0202	0.0000	0.0000	0.0000
135				**20.8013**	**4.5440**	**0.2845**	**0.0011**	**0.0011**	**0.0000**
	9	180		4.0467	0.4077	0.0090	0.0000	0.0000	0.0000
	10	202.5		3.7208	0.0997	0.0022	0.0000	0.0000	0.0011
	11	225		3.7824	0.1904	0.0056	0.0000	0.0022	0.0000
200				**11.5498**	**0.6978**	**0.0168**	**0.0000**	**0.0022**	**0.0011**
	12	247.5		2.0037	0.9554	0.0022	0.0000	0.0022	0.0022
	13	270		2.1684	0.0918	0.0011	0.0000	0.0000	0.0000
	14	292.5		1.8805	0.0202	0.0000	0.0011	0.0011	0.0011
260				**6.0527**	**1.0674**	**0.0034**	**0.0011**	**0.0034**	**0.0034**
	15	315		4.9741	0.1736	0.0000	0.0000	0.0000	0.0000
	16	337.5		8.1247	0.2363	0.0034	0.0000	0.0000	0.0000
340				**18.0695**	**0.9195**	**0.0090**	**0.0000**	**0.0000**	**0.0000**
		% totals	30.34	62.0969	7.5658	0.3170	0.0022	0.0067	0.0045

assigned angle	sector		calm	1-9kn	10-19kn	20-29kn	30-39kn	40-49kn	50-max
				Juneau summaried as Gustavus					
	1*	0	0.22	6.6959	0.0827	0.0018	0.0000	0.0000	0.0000
	2	22.5		2.4436	0.0361	0.0018	0.0000	0.0000	0.0000
	3	45		0.9329	0.0774	0.0026	0.0000	0.0000	0.0000
	4	67.5		2.9448	0.7131	0.0149	0.0000	0.0000	0.0000
50				**6.3213**	**0.8265**	**0.0193**	**0.0000**	**0.0000**	**0.0000**
	5	90		10.4469	6.7407	0.2814	0.0009	0.0009	0.0000
	6	112.5		6.2193	11.4397	2.0681	0.0985	0.0009	0.0000
	7	135		1.7498	4.4018	1.0446	0.0440	0.0000	0.0000
	8	157.5		0.7131	0.4282	0.0457	0.0000	0.0000	0.0000
135				**19.1291**	**23.0104**	**3.4398**	**0.1433**	**0.0018**	**0.0000**
	9	180		0.8942	0.1196	0.0070	0.0000	0.0000	0.0000
	10	202.5		1.4095	0.1337	0.0035	0.0000	0.0000	0.0000
	11	225		3.0855	0.3816	0.0009	0.0000	0.0000	0.0000
200				**5.3892**	**0.6349**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	12	247.5		2.7795	0.3878	0.0000	0.0000	0.0000	0.0000
	13	270		2.7258	0.4185	0.0000	0.0000	0.0000	0.0000
	14	292.5		1.4420	0.1196	0.0000	0.0000	0.0000	0.0000
260				**6.9473**	**0.9259**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
	15	315		1.5414	0.0404	0.0000	0.0000	0.0000	0.0000
	16	337.5		3.2745	0.0431	0.0000	0.0000	0.0000	0.0000
340				**11.5118**	**0.1662**	**0.0018**	**0.0000**	**0.0000**	**0.0000**
		% totals	21.52	49.2987	25.5639	3.4609	0.1433	0.0018	0.0000

* sector 1 added to direction assigned 340 degrees

records total Gustavus 1987-2001

calm	1-9kn	10-19kn	20-29kn	30-39kn	40-49kn	50-max	
27091	4438	455	5	0	0	0	4898
	1460	119	1	0	0	0	1580
	1332	54	1	0	0	0	1387
	2229	128	1	0	0	0	2358
50	**5021**	**301**	**3**	**0**	**0**	**0**	**5325**
	2831	432	5	0	0	0	3268
	4683	279	11	0	0	0	4973
	7944	2735	220	1	1	0	10901
	3114	611	18	0	0	0	3743
135	**18572**	**4057**	**254**	**1**	**1**	**0**	**22885**
	3613	364	8	0	0	0	3985
	3322	89	2	0	0	1	3414
	3377	170	5	0	2	0	3554
200	**10312**	**623**	**15**	**0**	**2**	**1**	**10953**
	1789	853	2	0	2	2	2648
	1936	82	1	0	0	0	2019
	1679	18	0	1	1	1	1700
260	**5404**	**953**	**3**	**1**	**3**	**3**	**6367**
	4441	155	0	0	0	0	4596
	7254	211	3	0	0	0	7468
340	**16133**	**821**	**8**	**0**	**0**	**0**	**16962**
	55442	6755	283	2	6	4	62492
						grand tot	89583

records total Juneau 1987-1999 (first order station)

calm	1-9kn	10-19kn	20-29kn	30-39kn	40-49kn	50-max	
24474	7615	94	2	0	0	0	7711
	2779	41	2	0	0	0	2822
	1061	88	3	0	0	0	1152
	3349	811	17	0	0	0	4177
50	**7189**	**940**	**22**	**0**	**0**	**0**	**8151**
	11881	7666	320	1	1	0	19869
	7073	13010	2352	112	1	0	22548
	1990	5006	1188	50	0	0	8234
	811	487	52	0	0	0	1350
135	**21755**	**26169**	**3912**	**163**	**2**	**0**	**52001**
	1017	136	8	0	0	0	1161
	1603	152	4	0	0	0	1759
	3509	434	1	0	0	0	3944
200	**6129**	**722**	**13**	**0**	**0**	**0**	**6864**
	3163	441	0	0	0	0	3604
	3100	476	0	0	0	0	3576
	1640	136	0	0	0	0	1776
260	**7903**	**1053**	**0**	**0**	**0**	**0**	**8956**
	1753	46	0	0	0	0	1799
	3724	49	0	0	0	0	3773
340	**13092**	**189**	**2**	**0**	**0**	**0**	**13283**
	56068	29073	3949	163	2	0	89255
						grand tot	113729

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Memorandum

To: File — Project No.: 02056.02

From: Jennifer Wilson — Date: October 3, 2002

Re: *Wave Generation Model Calculations*

Project: Glacier Bay National Park and Preserve Vessel Quotas and Operating Requirements Environmental Impact Statement, Appendix F Technical Memorandum

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The attached document, *Wave Generation Model Calculations*, provides the wave generation models used to calculate wave energy. The models calculate wave heights in restricted and unrestricted channels, deep versus shallow water, and the type of wave considering the shape of the vessel hull. Document created July 2002.

Ref. Sorensen, R. M., 1973. "Ship-Generated Waves," Advances in Hydroscience," v. 9, pp. 49-83.

(deep water)

$$C = V \cdot \cos(\theta)$$

C = ship wave propagation speed
V = ship velocity relative to the water
θ = angle between ship track and wave direction of propagation (wave ray)

$$\lambda = \frac{2 \cdot \pi \cdot V^2 \cdot \cos^2(\theta)}{g} \qquad T = \frac{2 \cdot \pi \cdot V \cdot \cos(\theta)}{g}$$

λ = wavelength (horizontal distance between crests along wave propagation direction)
g = acceleration of gravity

$$x = \left(\frac{n \cdot \pi \cdot V^2}{2 \cdot g}\right) \cdot (\sin(\alpha) + \sin(3 \cdot \alpha)) \qquad y = \left(\frac{-n \cdot \pi \cdot V^2}{2 \cdot g}\right) \cdot (5 \cdot \cos(\alpha) - \cos(3 \cdot \alpha))$$

x and y = coordinates of wave crest
α = angle between ship track and a line to the point (x,y)

$$F = \frac{V}{\sqrt{g \cdot d}} = \frac{\sqrt{\frac{g \cdot \lambda}{2 \cdot \pi}}}{\sqrt{g \cdot d}} = 0.56$$

F = Froude number limit for deep water transverse waves ($d/\lambda = 0.5$)

d = still water depth

at F > 0.6 - 0.7, ship waves respond to bottom (no longer deep water)

(shallow water)

$$\cos^2(\alpha) = \frac{8\cdot\left[1 - \left(\frac{2\cdot k\cdot d}{\sinh(2\cdot k\cdot d)}\right)\right]}{\left(3 - \frac{2\cdot k\cdot d}{\sinh(2\cdot k\cdot d)}\right)^2}$$ α = cusp locus angle

$$k = \frac{2\cdot\pi}{\lambda}$$ wave number

at F = 1, $V = C = C_g = \sqrt{g\cdot d}$ and $\alpha = 90\cdot deg$

at F > 1, only diverging waves exist and transverse waves are no longer generated

$$\alpha = \operatorname{asin}\left(\frac{\sqrt{g\cdot d}}{V}\right)$$

$$V\cdot\cos(\theta) = \left(\frac{g\cdot T}{2\cdot\pi}\right)\tanh\left(\frac{2\cdot\pi\cdot d}{V\cdot T\cdot\cos(\theta)}\right)$$ general relation, V, θ, d, and T

ref. Sorensen, R.M., 1989. "Port and Channel Bank Protection from Ship Waves," Proc., Ports '89, ASCE, pp. 393-401

$\theta = 35.3 \cdot \left[1 - e^{12 \cdot (F-1)}\right]$ θ = wave propogation direction

$C = \sqrt{\frac{g \cdot C \cdot T}{2 \cdot \pi} \cdot \tanh\left(\frac{2 \cdot \pi \cdot d}{C \cdot T}\right)} = V \cdot \cos(\theta)$ (requires trial and error solution for T)

Unconstricted channels, deep water:
(from Gates and Herbich 1977)

$$H_{max} = 1.11 \cdot \left(\frac{K_w \cdot B}{L_e}\right) \cdot \frac{V^2}{2 \cdot g} \cdot \left(2 \cdot N + \frac{3}{2}\right)^{\frac{-1}{3}}$$

distance from the sailing line to channel bank

$$x = \frac{2 \cdot V^2}{g} \cdot \frac{\left(2 \cdot N + \frac{3}{2}\right) \cdot \pi}{\sqrt{3}} \cdot \sin(19.467 \cdot deg)$$

B = ship beam
L_e = the distance from the ship bow back to midship = LWL/2
N = the cusp number = 1, 2, 3...
K_w = coefficient (function of ship waterline length, LWL, and ship speed V)
= $-6.2(V/(LWL)^{1/2}) + 72$ for $V/L^{1/2} < 0.95$
= 1.13 for $V/(LWL)^{1/2} > 1.0$

Canal (from Blaauw et al 1984):

$$H_{max} = A \cdot d \cdot \left(\frac{S}{d}\right)^{-0.33} \left(\frac{V}{\sqrt{g \cdot d}}\right)^{2.67}$$

S = distance from the ship's side to the channel bank
A = a coefficient for ship type and loading
= 0.8 (pushing type)
= 0.35 (empty pushing type and tugboat)
= 0.25 (conventional European inland vessel)

from PIANC 1987 (**navigation channel bank** design): $H_{max} = d \cdot \left(\frac{S}{d}\right)^{-0.33} \cdot \left(\frac{V}{\sqrt{g \cdot d}}\right)^4$

ref. Weggel, J., and Sorensen, R., 1986, "Ship Wave Prediction for Port and Channel Design," Proc., Ports '86, American Society of Civil Engineers, NY, pp. 797-814.

dimensionless parameters: $F = \frac{V}{\sqrt{g \cdot d}}$ — $F < 0.7$ deep water condition

F = 1, θ = 0

wave height $H_x = \frac{H}{Displ^{\frac{1}{3}}}$ — H = max. ship wave height; Displ = ship displacement volume

offset distance (from track) $x_x = \frac{x}{Displ^{\frac{1}{3}}}$

depth $d_x = \frac{d}{Displ^{\frac{1}{3}}}$

block coefficient $c_x = \frac{Displ}{L \cdot B \cdot D}$ — L = ship length; B = beam; D = draft

length $L_x = \frac{L}{Displ^{\frac{1}{3}}}$

beam $B_x = \frac{B}{\mathrm{Displ}^{\frac{1}{3}}}$ draft $D_x = \frac{D}{\mathrm{Displ}^{\frac{1}{3}}}$

model: $H_x = \alpha \cdot x_x^{\,n}$ $n = \beta \cdot d_x^{\,\delta}$

$\log(\alpha) = a + b \cdot \log(d_x) + c \cdot \log(d_x)$ $\alpha = 10^{(a + b \cdot \log(d_x) + c \cdot \log(d_x))}$

$a = \frac{-0.6}{F}$ $b = 0.75 \cdot F^{-1.126}$ $c = 2.6531 \cdot F - 1.95$ $\alpha = 10^{\left[a + 0.43429 \cdot b \cdot \log(d_x) + .1886 \cdot c \cdot \left(\log(d_x)^2\right)\right]}$

$\beta = -0.225 \cdot F^{-0.699}$ $\delta = -0.118 \cdot F^{-0.366}$ for $0.20 < F < 0.55$

$\beta = -0.342$ $\delta = -0.146$ for $0.55 < F < 0.8$

$C_{div} = V \cdot \cos(\theta)$ phase speed of diverging ship waves

$\theta = 35.267 \cdot \left(1 - e^{-12 + 12 \cdot F}\right)$ angle θ in degrees

$C_{div} = \frac{g \cdot T_{div}}{2 \cdot \pi}$ for $F \le 0.7$

$C_{div} = \sqrt{\frac{g \cdot L_{div}}{2 \cdot \pi} \cdot \tanh\left(\frac{2 \cdot \pi \cdot d}{L_{div}}\right)}$ for $F > 0.7$

$T_{div} = \frac{L_{div}}{C_{div}}$

$\mathrm{knots} \equiv 6076 \cdot \frac{ft}{hr}$ $\mathrm{tons} \equiv 2240 \cdot lbf$ $\mathrm{fathoms} \equiv 6 \cdot ft$

Example execution: use characteristics of cruise ship $L := 700 \cdot ft \quad B := 80 \cdot ft \quad D := 24 \cdot ft$

$DWT := 1000 \cdot tons$

$$Displ := \frac{DWT}{100 \cdot \frac{lbf}{ft^3}} \qquad Displ = 2.24 \times 10^4\, ft^3 \qquad Displ^{\frac{1}{3}} = 28.189\, ft$$

$$d := 100 \cdot fathoms \qquad d_x := \frac{d}{Displ^{\frac{1}{3}}} \qquad d_x = 21.285$$

$$V := 15 \cdot knots \qquad F := \frac{V}{\sqrt{g \cdot d}} \qquad F = 0.182$$

$$a := \frac{-0.6}{F} \qquad a = -3.293$$

$$b := 0.75 \cdot F^{-1.125} \qquad b = 5.092$$

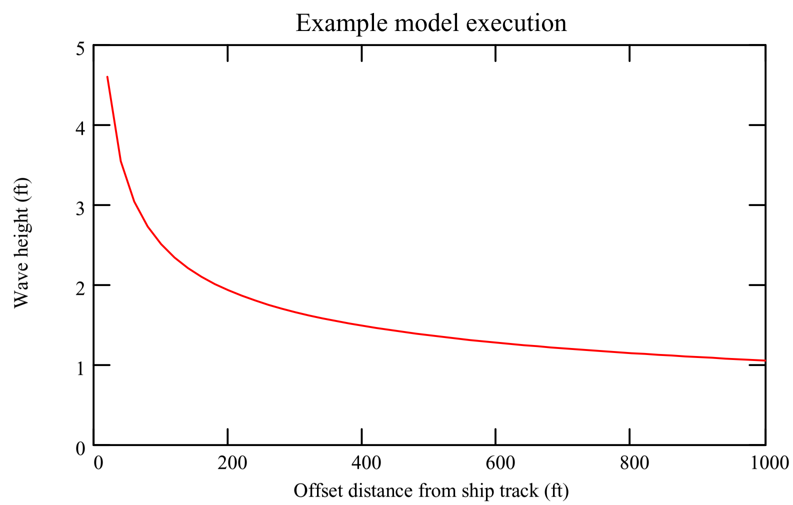
$$c := 2.6531 \cdot F - 1.95 \qquad c = -1.467$$

$$\alpha := 10^{\left[a + 0.43429 \cdot b \cdot \log(d_x) + .1886 \cdot c \cdot \left(\log(d_x)^2\right)\right]} \qquad \alpha = 0.143$$

$\beta := -0.225 \cdot F^{-0.699} \qquad \delta := -0.118 \cdot F^{-0.366}$ for $0.20 < F < 0.55$

$$n := \beta \cdot d_x^{\delta} \qquad n = -0.377 \qquad i := 1, 2 .. 100 \qquad x_i := 20 \cdot i \cdot ft$$

$$x_{x_i} := \frac{x_i}{Displ^{\frac{1}{3}}} \qquad H_{x_i} := \alpha \cdot \left(x_{x_i}\right)^n \qquad H_i := H_{x_i} \cdot Displ^{\frac{1}{3}}$$



$x_i =$ (ft)	$x_{x_i} =$	$H_{x_i} =$	$H_i =$ (ft)
20	0.709	0.163	4.599
40	1.419	0.126	3.541
60	2.128	0.108	3.038
80	2.838	0.097	2.726
100	3.547	0.089	2.505
120	4.257	0.083	2.339
140	4.966	0.078	2.207
160	5.676	0.074	2.098
180	6.385	0.071	2.007
200	7.095	0.068	1.929
220	7.804	0.066	1.861
240	8.514	0.064	1.8
260	9.223	0.062	1.747
280	9.933	0.06	1.699
300	10.642	0.059	1.655
320	11.352	0.057	1.615

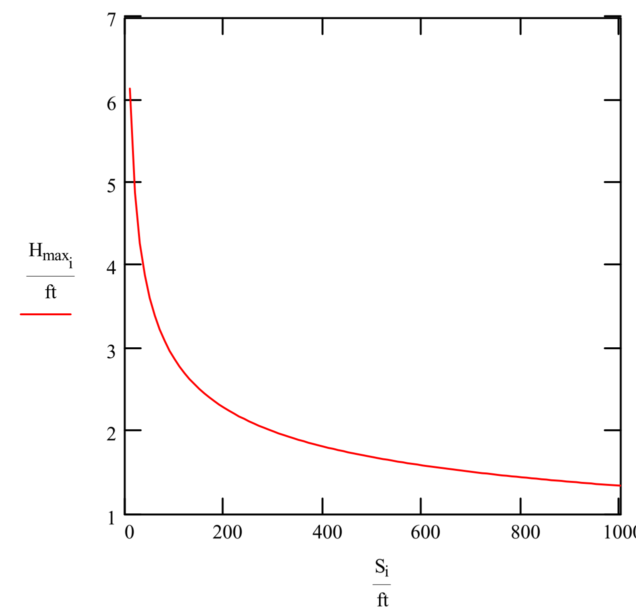
Canal (from Blaauw et al 1984):

S = distance from the ship's side to the channel bank
A = a coefficient for ship type and loading
= 0.8 (pushing type)
= 0.35 (empty pushing type and tugboat)
= 0.25 (conventional European inland vessel)

$A := 0.25 \qquad S_i := 10 \cdot i \cdot ft$

$$H_{max_i} := A \cdot d \cdot \left(\frac{S_i}{d}\right)^{-0.33} \left(\frac{V}{\sqrt{g \cdot d}}\right)^{2.67}$$

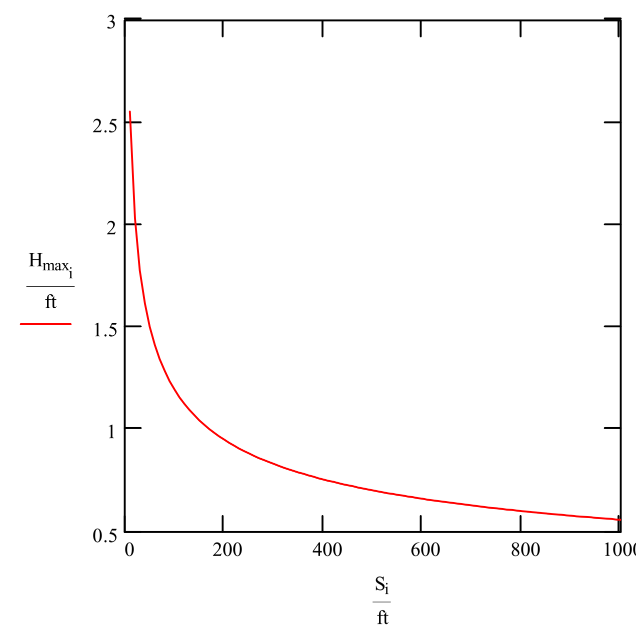
$S_i =$ (ft)	$H_{max_i} =$ (ft)
10	6.146
20	4.89
30	4.277
40	3.89
50	3.614
60	3.403
70	3.234
80	3.095
90	2.977
100	2.875
110	2.786
120	2.707
130	2.636
140	2.573
150	2.515
160	2.462



from PIANC 1987 (**navigation channel bank** design):

$$H_{max_i} := d\cdot\left(\frac{S_i}{d}\right)^{-0.33}\cdot\left(\frac{V}{\sqrt{g\cdot d}}\right)^4$$

$S_i =$ (ft)	$H_{max_i} =$ (ft)
10	2.554
20	2.032
30	1.777
40	1.616
50	1.502
60	1.414
70	1.344
80	1.286
90	1.237
100	1.195
110	1.158
120	1.125
130	1.096
140	1.069
150	1.045
160	1.023



Unconstricted channels, deep water:
(from Gates and Herbich 1977)

$$H_{max} = 1.11\cdot\left(\frac{K_w\cdot B}{L_e}\right)\cdot\frac{V^2}{2\cdot g}\cdot\left(2\cdot N+\frac{3}{2}\right)^{\frac{-1}{3}}$$

distance from the sailing line to channel bank

$$x = \frac{2\cdot V^2}{g}\cdot\frac{\left(2\cdot N+\frac{3}{2}\right)\cdot\pi}{\sqrt{3}}\cdot\sin(19.467\cdot deg)$$

B = ship beam
L_e = the distance from the ship bow back to midship = LWL/2
N = the cusp number = 1, 2, 3...
K_w = coefficient (function of ship waterline length, LWL, and ship speed V)
= -6.2(V/(g*LWL)$^{1/2}$) + 72 for V/L$^{1/2}$ < 0.95
= 1.13 for V/(g*LWL)$^{1/2}$ > 1.0

$B = 80\,ft \qquad L = 700\,ft \qquad LWL := L \qquad L_e := \frac{LWL}{2}$

$V = 15\,knots \qquad \frac{V}{\sqrt{g\cdot LWL}} = 0.169 \qquad K_w := -6.2\cdot\frac{V}{\sqrt{g\cdot LWL}} + 72$

$N := 1, 2 .. 20$

$K_w = 70.954$

$$x_N := \frac{2\cdot V^2}{g}\cdot\frac{\left(2\cdot N+\frac{3}{2}\right)\cdot\pi}{\sqrt{3}}\cdot\sin(19.467\cdot deg) \qquad H_{max_N} := 1.11\cdot\left(\frac{K_w\cdot B}{L_e}\right)\cdot\frac{V^2}{2\cdot g}\cdot\left(2\cdot N+\frac{3}{2}\right)^{\frac{-1}{3}}$$

N =	x_N = (ft)	H_{max_N} = (ft)
1	84.291	118.098
2	132.458	101.581
3	180.624	91.604
4	228.791	84.663
5	276.957	79.439
6	325.124	75.305

NOTE: apparent errors in transcription of formulae!

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Memorandum

To: File
Project No.: 02056.02

From: Jennifer Wilson
Date: October 3, 2002

Re: *Spirit of Adventure Positions and Speeds* document

Project: Glacier Bay National Park and Preserve Vessel Quotas and Operating Requirements Environmental Impact Statement, Appendix F Technical Memorandum Concerning Vessel Wakes

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The attached document, *Spirit of Adventure Positions and Speeds*, maps the GPS route taken during the site visit to Glacier Bay proper on June 12, 2002. This site visit included a cruise by Sandra Donohue (PN&D Engineers) and Orson Smith, PE. The purpose of the visit was to collect information on the shoreline structure and vessel tracks. The cruise also provided information on different vessel wakes including height, period, and differences due to type of vessel hull.

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	**LONGITUDE**	**GMT**	**DEC TIME** local	**DISTANCE** feet	**SPEED *** knots
N5827.30554	W13553.24518	15:33:32	7.56	80.3	1.0
N5827.30876	W13553.26965	15:34:18	7.57	146.6	1.9
N5827.33129	W13553.28606	15:35:03	7.58	11.9	0.2
N5827.33193	W13553.28960	15:35:49	7.60	371.2	4.8
N5827.37925	W13553.36331	15:36:35	7.61	487.7	6.3
N5827.43139	W13553.47982	15:37:21	7.62	486.6	6.3
N5827.46165	W13553.62144	15:38:07	7.64	515.7	6.8
N5827.47323	W13553.78206	15:38:52	7.65	750.7	9.9
N5827.47001	W13554.01798	15:39:37	7.66	1474.9	19.0
N5827.32324	W13554.38716	15:40:23	7.67	1698.6	21.9
N5827.07605	W13554.63596	15:41:09	7.69	1659.5	21.8
N5826.83562	W13554.88283	15:41:54	7.70	1689.8	21.8
N5826.60709	W13555.18507	15:42:40	7.71	1684.3	21.7
N5826.40271	W13555.54234	15:43:26	7.72	1689.0	21.8
N5826.20347	W13555.91216	15:44:12	7.74	1671.8	22.0
N5826.00006	W13556.26557	15:44:57	7.75	1657.4	21.3
N5825.86230	W13556.71489	15:45:43	7.76	1647.8	21.7
N5825.92184	W13557.21990	15:46:28	7.77	1681.1	22.1
N5826.02387	W13557.71074	15:47:13	7.79	1707.9	22.0
N5826.14071	W13558.19869	15:47:59	7.80	1714.5	22.1
N5826.27203	W13558.67537	15:48:45	7.81	1685.1	21.7
N5826.41365	W13559.13049	15:49:31	7.83	1651.8	21.7
N5826.54176	W13559.58818	15:50:16	7.84	1639.8	21.1
N5826.66664	W13600.04491	15:51:02	7.85	1540.7	19.8
N5826.82339	W13600.42535	15:51:48	7.86	1454.2	19.1
N5826.99977	W13600.73402	15:52:33	7.88	1438.2	18.5
N5827.17036	W13601.04719	15:53:19	7.89	1375.3	18.1
N5827.35028	W13601.30919	15:54:04	7.90	1372.2	17.7
N5827.55885	W13601.47399	15:54:50	7.91	1313.6	17.3
N5827.75873	W13601.63074	15:55:35	7.93	1322.5	17.4
N5827.95474	W13601.81098	15:56:20	7.94	1317.5	17.3
N5828.14207	W13602.01923	15:57:05	7.95	1343.9	17.3
N5828.34871	W13602.16922	15:57:51	7.96	1393.5	17.9
N5828.57176	W13602.26996	15:58:37	7.98	1416.8	18.7
N5828.79449	W13602.40096	15:59:22	7.99	1420.8	18.3
N5829.00434	W13602.59762	16:00:08	8.00	1440.1	18.5
N5829.21452	W13602.80651	16:00:54	8.02	1428.0	18.8
N5829.42148	W13603.01894	16:01:39	8.03	1444.9	19.0
N5829.63230	W13603.22880	16:02:24	8.04	1486.5	19.1
N5829.85632	W13603.41612	16:03:10	8.05	1470.0	19.4
N5830.08839	W13603.54583	16:03:55	8.07	1527.3	19.7
N5830.33333	W13603.65237	16:04:41	8.08	1533.1	19.7
N5830.58148	W13603.73799	16:05:27	8.09	1513.1	19.9
N5830.82964	W13603.77339	16:06:12	8.10	1536.5	19.8
N5831.08231	W13603.76599	16:06:58	8.12	1517.4	20.0
N5831.33079	W13603.72157	16:07:43	8.13	1518.9	20.0
N5831.57959	W13603.67844	16:08:28	8.14	1567.4	20.2

* speed measured relative to the ground

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5831.83611	W13603.62952	16:09:14	8.15	1603.3	21.1
N5832.09908	W13603.59218	16:09:59	8.17	1850.2	23.8
N5832.40131	W13603.52427	16:10:45	8.18	1831.1	24.1
N5832.69807	W13603.42610	16:11:30	8.19	1870.8	24.1
N5833.00320	W13603.35014	16:12:16	8.20	1880.0	24.2
N5833.31026	W13603.28062	16:13:02	8.22	1882.9	24.3
N5833.61603	W13603.18663	16:13:48	8.23	1836.3	24.2
N5833.91536	W13603.10971	16:14:33	8.24	1855.4	24.4
N5834.21695	W13603.02055	16:15:18	8.26	1886.0	24.3
N5834.52497	W13602.95038	16:16:04	8.27	1891.2	24.4
N5834.83461	W13602.89373	16:16:50	8.28	1872.4	24.1
N5835.14135	W13602.84127	16:17:36	8.29	1835.1	24.2
N5835.44068	W13602.76724	16:18:21	8.31	1853.2	24.4
N5835.74323	W13602.69643	16:19:06	8.32	1895.9	24.4
N5836.05287	W13602.62594	16:19:52	8.33	1861.5	24.5
N5836.35735	W13602.56447	16:20:37	8.34	1912.7	24.6
N5836.66827	W13602.47273	16:21:23	8.36	1867.6	24.6
N5836.96954	W13602.35783	16:22:08	8.37	1906.9	24.6
N5837.28143	W13602.29474	16:22:54	8.38	1873.0	24.7
N5837.58720	W13602.22297	16:23:39	8.39	1902.4	24.5
N5837.89812	W13602.15570	16:24:25	8.41	1888.5	24.3
N5838.20776	W13602.10903	16:25:11	8.42	1633.5	21.0
N5838.42920	W13602.40128	16:25:57	8.43	282.6	3.7
N5838.46106	W13602.46630	16:26:42	8.45	107.4	1.4
N5838.47748	W13602.47885	16:27:28	8.46	162.4	2.1
N5838.50419	W13602.47949	16:28:14	8.47	67.3	0.9
N5838.51514	W13602.47628	16:28:59	8.48	38.8	0.5
N5838.52093	W13602.47113	16:29:45	8.50	22.1	0.3
N5838.52318	W13602.46565	16:30:31	8.51	14.5	0.2
N5838.52415	W13602.46147	16:31:17	8.52	15.4	0.2
N5838.52318	W13602.45696	16:32:02	8.53	219.7	2.9
N5838.55537	W13602.42542	16:32:47	8.55	319.2	4.1
N5838.60783	W13602.42156	16:33:33	8.56	313.1	4.1
N5838.65837	W13602.44055	16:34:18	8.57	293.4	3.8
N5838.70343	W13602.47370	16:35:04	8.58	254.8	3.3
N5838.74366	W13602.49623	16:35:50	8.60	232.0	3.0
N5838.77778	W13602.52906	16:36:36	8.61	185.7	2.4
N5838.80385	W13602.55964	16:37:21	8.62	117.7	1.5
N5838.81962	W13602.58120	16:38:07	8.64	124.2	1.6
N5838.83668	W13602.60277	16:38:52	8.65	89.7	1.2
N5838.84794	W13602.62111	16:39:37	8.66	239.5	3.1
N5838.88689	W13602.63238	16:40:23	8.67	637.9	8.4
N5838.98796	W13602.57831	16:41:08	8.69	1675.2	22.1
N5839.24867	W13602.40707	16:41:53	8.70	1931.0	24.9
N5839.55830	W13602.27125	16:42:39	8.71	1941.8	25.0
N5839.87180	W13602.38841	16:43:25	8.72	1941.3	25.0
N5840.18014	W13602.54773	16:44:11	8.74	1904.1	25.1
N5840.48205	W13602.70770	16:44:56	8.75	1906.2	25.1
N5840.77366	W13602.92914	16:45:41	8.76	1925.4	25.4

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5841.04821	W13603.23266	16:46:26	8.77	1907.8	25.1
N5841.29251	W13603.61149	16:47:11	8.79	1924.8	25.3
N5841.53906	W13603.99355	16:47:56	8.80	17685.0	25.0
N5843.61541	W13607.91322	16:54:55	8.92	1944.3	25.0
N5843.85359	W13608.32424	16:55:41	8.93	1945.1	25.1
N5844.07536	W13608.76842	16:56:27	8.94	1913.5	25.2
N5844.29487	W13609.20293	16:57:12	8.95	1906.6	25.1
N5844.52822	W13609.60655	16:57:57	8.97	1880.3	24.8
N5844.79215	W13609.91715	16:58:42	8.98	1919.6	24.7
N5845.10339	W13610.01918	16:59:28	8.99	704.6	9.1
N5845.21926	W13610.02305	17:00:14	9.00	55.0	0.7
N5845.21057	W13610.01822	17:01:00	9.02	258.5	3.3
N5845.23729	W13609.95449	17:01:46	9.03	164.6	2.1
N5845.24051	W13609.90267	17:02:32	9.04	20.3	0.3
N5845.24051	W13609.89623	17:03:18	9.06	10.3	0.1
N5845.23890	W13609.89720	17:04:03	9.07	4.1	0.1
N5845.23825	W13609.89687	17:04:49	9.08	2.2	0.0
N5845.23793	W13609.89720	17:05:34	9.09	9.3	0.1
N5845.23890	W13609.89494	17:06:19	9.11	7.8	0.1
N5845.23793	W13609.89655	17:07:05	9.12	7.8	0.1
N5845.23890	W13609.89816	17:07:51	9.13	192.9	2.5
N5845.23954	W13609.95932	17:08:36	9.14	64.3	0.8
N5845.22956	W13609.96608	17:09:22	9.16	1427.5	18.8
N5844.99686	W13610.02626	17:10:07	9.17	1981.3	25.5
N5844.67113	W13610.00888	17:10:53	9.18	1796.8	23.7
N5844.43488	W13610.35103	17:11:38	9.19	1866.7	24.6
N5844.45548	W13610.94133	17:12:23	9.21	1940.0	25.0
N5844.50408	W13611.54901	17:13:09	9.22	1906.1	25.1
N5844.51406	W13612.15283	17:13:54	9.23	1923.3	25.3
N5844.53176	W13612.76147	17:14:39	9.24	1967.1	25.3
N5844.57457	W13613.37945	17:15:25	9.26	1964.1	25.3
N5844.63411	W13613.99132	17:16:11	9.27	1969.8	25.4
N5844.72939	W13614.58806	17:16:57	9.28	1950.6	25.1
N5844.84236	W13615.16677	17:17:43	9.30	1935.0	24.9
N5845.01552	W13615.68143	17:18:29	9.31	1908.0	25.1
N5845.21991	W13616.14041	17:19:14	9.32	1938.6	25.0
N5845.45905	W13616.54693	17:20:00	9.33	1894.4	24.9
N5845.72170	W13616.87008	17:20:45	9.35	1902.5	25.1
N5845.98466	W13617.19710	17:21:30	9.36	1926.0	24.8
N5846.18003	W13617.67796	17:22:16	9.37	1879.4	24.7
N5846.31779	W13618.21162	17:23:01	9.38	1911.0	24.6
N5846.41242	W13618.78969	17:23:47	9.40	1903.4	24.5
N5846.48902	W13619.37516	17:24:33	9.41	1905.5	24.5
N5846.64674	W13619.89754	17:25:19	9.42	1843.5	24.3
N5846.88298	W13620.26415	17:26:04	9.43	1920.8	24.7
N5847.14498	W13620.60468	17:26:50	9.45	1878.7	24.7
N5847.37254	W13621.00798	17:27:35	9.46	1878.9	24.7
N5847.54731	W13621.49979	17:28:20	9.47	1911.2	24.6
N5847.73110	W13621.99192	17:29:06	9.49	1883.9	24.8

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5847.91553	W13622.47247	17:29:51	9.50	1931.8	24.9
N5848.05329	W13623.02511	17:30:37	9.51	1895.6	25.0
N5848.16787	W13623.58483	17:31:22	9.52	1926.5	24.8
N5848.28278	W13624.15485	17:32:08	9.54	1878.3	24.7
N5848.40605	W13624.70170	17:32:53	9.55	1874.2	24.7
N5848.53801	W13625.23954	17:33:38	9.56	1899.6	24.5
N5848.68833	W13625.76836	17:34:24	9.57	1855.8	24.4
N5848.87855	W13626.22927	17:35:09	9.59	1905.1	24.5
N5849.06201	W13626.71980	17:35:55	9.60	1850.1	24.4
N5849.23357	W13627.20517	17:36:40	9.61	1770.4	22.8
N5849.40254	W13627.66318	17:37:26	9.62	1441.6	19.0
N5849.56219	W13628.00179	17:38:11	9.64	392.8	5.1
N5849.59663	W13628.10736	17:38:57	9.65	97.4	1.3
N5849.60307	W13628.13568	17:39:42	9.66	31.5	0.4
N5849.60339	W13628.14566	17:40:28	9.67	12.7	0.2
N5849.60178	W13628.14823	17:41:13	9.69	21.9	0.3
N5849.59824	W13628.14695	17:41:58	9.70	74.0	1.0
N5849.59792	W13628.17044	17:42:44	9.71	777.6	10.0
N5849.68643	W13628.34876	17:43:30	9.73	886.4	11.4
N5849.81196	W13628.49199	17:44:16	9.74	777.1	10.0
N5849.91978	W13628.62459	17:45:02	9.75	275.6	3.6
N5849.94778	W13628.69347	17:45:48	9.76	91.3	1.2
N5849.94457	W13628.72180	17:46:33	9.78	59.3	0.8
N5849.93620	W13628.73145	17:47:18	9.79	248.4	3.2
N5849.93427	W13628.81031	17:48:04	9.80	965.9	12.7
N5849.97482	W13629.10707	17:48:49	9.81	1863.1	24.0
N5850.11902	W13629.62946	17:49:35	9.83	1864.0	24.5
N5850.26546	W13630.14991	17:50:20	9.84	1906.4	24.6
N5850.41996	W13630.67713	17:51:06	9.85	1917.6	24.7
N5850.56866	W13631.21464	17:51:52	9.86	1867.2	24.6
N5850.70610	W13631.74540	17:52:37	9.88	1907.5	24.6
N5850.84740	W13632.28678	17:53:23	9.89	1867.8	24.6
N5850.98580	W13632.81689	17:54:08	9.90	1905.4	24.5
N5851.13160	W13633.35311	17:54:54	9.92	1913.3	24.6
N5851.28449	W13633.88484	17:55:40	9.93	1916.4	24.7
N5851.43577	W13634.41945	17:56:26	9.94	1909.6	24.6
N5851.57803	W13634.96083	17:57:12	9.95	1880.1	24.8
N5851.71482	W13635.49706	17:57:57	9.97	1928.3	24.8
N5851.86352	W13636.03876	17:58:43	9.98	1875.9	24.7
N5852.01351	W13636.56018	17:59:28	9.99	1916.0	24.7
N5852.17219	W13637.08675	18:00:14	10.00	1878.0	24.7
N5852.32733	W13637.60334	18:00:59	10.02	1884.9	24.8
N5852.47957	W13638.12573	18:01:44	10.03	1913.4	24.6
N5852.62731	W13638.66324	18:02:30	10.04	1885.5	24.8
N5852.76571	W13639.20012	18:03:15	10.05	1923.8	24.8
N5852.90251	W13639.75211	18:04:01	10.07	1876.7	24.7
N5853.08372	W13640.23556	18:04:46	10.08	1916.0	24.7
N5853.29100	W13640.69486	18:05:32	10.09	1882.8	24.8
N5853.50214	W13641.13324	18:06:17	10.10	1926.0	24.8

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5853.73581	W13641.54716	18:07:03	10.12	1908.3	25.1
N5853.96048	W13641.97137	18:07:48	10.13	1919.5	25.3
N5854.18546	W13642.40010	18:08:33	10.14	1963.5	25.3
N5854.42300	W13642.82367	18:09:19	10.16	1927.8	25.4
N5854.65313	W13643.24596	18:10:04	10.17	1857.2	23.9
N5854.84271	W13643.70977	18:10:50	10.18	1756.1	22.6
N5854.98272	W13644.19900	18:11:36	10.19	1749.0	22.5
N5855.11501	W13644.69371	18:12:22	10.21	1712.5	22.5
N5855.26113	W13645.16009	18:13:07	10.22	1638.7	21.6
N5855.43526	W13645.55856	18:13:52	10.23	1432.4	18.4
N5855.61905	W13645.84405	18:14:38	10.24	593.5	7.6
N5855.71561	W13645.87173	18:15:24	10.26	297.5	3.8
N5855.76453	W13645.86948	18:16:10	10.27	292.7	3.9
N5855.81249	W13645.86144	18:16:55	10.28	140.5	1.9
N5855.83534	W13645.85468	18:17:40	10.29	75.7	1.0
N5855.84757	W13645.85017	18:18:26	10.31	54.9	0.7
N5855.85658	W13645.84888	18:19:12	10.32	31.9	0.4
N5855.86173	W13645.85081	18:19:57	10.33	13.7	0.2
N5855.86366	W13645.85307	18:20:43	10.35	5.6	0.1
N5855.86431	W13645.85435	18:21:28	10.36	19.8	0.3
N5855.86688	W13645.85822	18:22:14	10.37	21.8	0.3
N5855.86946	W13645.86304	18:23:00	10.38	16.2	0.2
N5855.87075	W13645.86755	18:23:45	10.40	3.9	0.1
N5855.87139	W13645.86755	18:24:30	10.41	11.9	0.2
N5855.86946	W13645.86691	18:25:16	10.42	109.3	1.4
N5855.85497	W13645.84631	18:26:02	10.43	126.3	1.6
N5855.83534	W13645.83311	18:26:48	10.45	201.9	2.7
N5855.81249	W13645.87978	18:27:33	10.46	1312.6	16.9
N5855.74425	W13646.27664	18:28:19	10.47	1786.4	23.0
N5855.82118	W13646.82606	18:29:05	10.48	1798.7	23.2
N5855.91838	W13647.36744	18:29:51	10.50	1778.4	22.9
N5856.05839	W13647.86505	18:30:37	10.51	1743.1	22.5
N5856.29014	W13648.19206	18:31:23	10.52	1672.2	22.0
N5856.53121	W13648.44859	18:32:08	10.54	1727.4	22.7
N5856.68120	W13648.91626	18:32:53	10.55	1890.5	24.9
N5856.82218	W13649.45345	18:33:38	10.56	1897.5	25.0
N5856.96541	W13649.99096	18:34:23	10.57	1943.2	25.0
N5857.08546	W13650.56517	18:35:09	10.59	1897.9	25.0
N5857.19168	W13651.13423	18:35:54	10.60	1912.0	25.2
N5857.29017	W13651.71326	18:36:39	10.61	1963.3	25.3
N5857.40057	W13652.30163	18:37:25	10.62	1890.1	24.9
N5857.53382	W13652.84623	18:38:10	10.64	1906.8	25.1
N5857.76782	W13653.25114	18:38:55	10.65	1944.0	25.0
N5858.01404	W13653.64671	18:39:41	10.66	1945.3	25.1
N5858.26446	W13654.03295	18:40:27	10.67	1901.5	25.0
N5858.51004	W13654.40856	18:41:12	10.69	1898.6	25.0
N5858.76270	W13654.76455	18:41:57	10.70	1948.8	25.1
N5859.02052	W13655.13405	18:42:43	10.71	1890.6	24.9
N5859.24679	W13655.54796	18:43:28	10.72	1935.8	24.9

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5859.46051	W13656.00598	18:44:14	10.74	1942.3	25.0
N5859.66521	W13656.48202	18:45:00	10.75	1893.9	24.9
N5859.86895	W13656.93939	18:45:45	10.76	1932.1	24.9
N5900.11293	W13657.33464	18:46:31	10.78	1925.7	24.8
N5900.36623	W13657.70382	18:47:17	10.79	1878.1	24.7
N5900.61761	W13658.05240	18:48:02	10.80	1931.9	24.9
N5900.90150	W13658.32952	18:48:48	10.81	1861.9	24.5
N5901.17476	W13658.59796	18:49:33	10.83	1928.2	24.8
N5901.45221	W13658.89633	18:50:19	10.84	1905.5	24.5
N5901.70906	W13659.24523	18:51:05	10.85	1750.7	22.5
N5901.92728	W13659.61022	18:51:51	10.86	730.6	9.4
N5902.03607	W13659.70936	18:52:37	10.88	441.4	5.7
N5902.09626	W13659.78822	18:53:23	10.89	334.0	4.3
N5902.14229	W13659.84647	18:54:09	10.90	271.7	3.6
N5902.17351	W13659.90859	18:54:54	10.92	337.8	4.4
N5902.21953	W13659.96910	18:55:39	10.93	335.4	4.3
N5902.26942	W13700.01481	18:56:25	10.94	1195.4	15.7
N5902.37821	W13700.33313	18:57:10	10.95	1904.3	25.1
N5902.44935	W13700.92601	18:57:55	10.97	1363.1	17.6
N5902.48861	W13701.35505	18:58:41	10.98	488.6	6.3
N5902.48572	W13701.51116	18:59:27	10.99	538.8	7.1
N5902.47606	W13701.68239	19:00:12	11.00	656.4	8.5
N5902.48636	W13701.89128	19:00:58	11.02	370.7	4.8
N5902.49312	W13702.00908	19:01:44	11.03	414.1	5.3
N5902.47413	W13702.13622	19:02:30	11.04	540.7	7.0
N5902.47316	W13702.30906	19:03:16	11.05	296.1	3.8
N5902.48024	W13702.40273	19:04:02	11.07	197.8	2.5
N5902.48636	W13702.46485	19:04:48	11.08	328.8	4.3
N5902.46351	W13702.56012	19:05:33	11.09	202.0	2.6
N5902.45932	W13702.62417	19:06:19	11.11	169.1	2.2
N5902.44420	W13702.66955	19:07:05	11.12	204.3	2.7
N5902.42070	W13702.71622	19:07:50	11.13	134.7	1.7
N5902.39978	W13702.73038	19:08:36	11.14	38.0	0.5
N5902.39559	W13702.72137	19:09:21	11.16	52.7	0.7
N5902.39302	W13702.70528	19:10:06	11.17	41.5	0.5
N5902.39141	W13702.69240	19:10:52	11.18	37.2	0.5
N5902.39141	W13702.68050	19:11:38	11.19	34.3	0.5
N5902.39109	W13702.66955	19:12:23	11.21	38.1	0.5
N5902.38980	W13702.65764	19:13:08	11.22	39.3	0.5
N5902.38980	W13702.64509	19:13:54	11.23	4.4	0.1
N5902.38916	W13702.64445	19:14:39	11.24	9.3	0.1
N5902.38883	W13702.64734	19:15:25	11.26	13.3	0.2
N5902.38723	W13702.64445	19:16:11	11.27	42.7	0.5
N5902.38304	W13702.63350	19:16:57	11.28	35.6	0.5
N5902.38143	W13702.62256	19:17:42	11.30	76.7	1.0
N5902.37435	W13702.60228	19:18:28	11.31	41.6	0.5
N5902.36791	W13702.59778	19:19:13	11.32	26.0	0.3
N5902.36405	W13702.59424	19:19:59	11.33	18.2	0.2
N5902.36373	W13702.58844	19:20:45	11.35	19.7	0.3

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5902.36630	W13702.58458	19:21:30	11.36	30.0	0.4
N5902.37113	W13702.58265	19:22:16	11.37	6.3	0.1
N5902.37145	W13702.58072	19:23:02	11.38	4.4	0.1
N5902.37210	W13702.58136	19:23:48	11.40	19.8	0.3
N5902.36952	W13702.57750	19:24:34	11.41	17.0	0.2
N5902.36824	W13702.57267	19:25:19	11.42	21.7	0.3
N5902.36470	W13702.57170	19:26:05	11.43	15.6	0.2
N5902.36309	W13702.57557	19:26:50	11.45	18.6	0.2
N5902.36598	W13702.57750	19:27:36	11.46	37.6	0.5
N5902.36437	W13702.56591	19:28:21	11.47	40.7	0.5
N5902.36341	W13702.55304	19:29:07	11.49	42.9	0.6
N5902.36148	W13702.53984	19:29:52	11.50	49.3	0.6
N5902.35987	W13702.52439	19:30:38	11.51	61.9	0.8
N5902.35568	W13702.50637	19:31:23	11.52	42.1	0.5
N5902.36051	W13702.51602	19:32:09	11.54	11.7	0.2
N5902.36148	W13702.51280	19:32:55	11.55	15.2	0.2
N5902.36019	W13702.50862	19:33:40	11.56	22.0	0.3
N5902.35922	W13702.50186	19:34:26	11.57	29.5	0.4
N5902.35568	W13702.49542	19:35:11	11.59	36.8	0.5
N5902.35246	W13702.48544	19:35:56	11.60	23.1	0.3
N5902.35246	W13702.47804	19:36:42	11.61	41.4	0.5
N5902.35085	W13702.46517	19:37:27	11.62	66.7	0.9
N5902.34281	W13702.45068	19:38:13	11.64	28.8	0.4
N5902.34538	W13702.44296	19:38:58	11.65	31.8	0.4
N5902.34377	W13702.43330	19:39:44	11.66	25.2	0.5
N5902.34345	W13702.42526	19:40:12	11.67	23.3	0.3
N5902.34152	W13702.41882	19:40:57	11.68	24.5	0.3
N5902.34216	W13702.41109	19:41:42	11.70	27.3	0.4
N5902.34184	W13702.40240	19:42:28	11.71	16.2	0.2
N5902.34216	W13702.39725	19:43:13	11.72	12.7	0.2
N5902.34281	W13702.39339	19:43:59	11.73	28.0	0.4
N5902.34023	W13702.38599	19:44:45	11.75	23.2	0.3
N5902.33991	W13702.37859	19:45:30	11.76	31.8	0.4
N5902.33895	W13702.36861	19:46:16	11.77	27.5	0.4
N5902.33830	W13702.35992	19:47:01	11.78	74.3	1.0
N5902.34377	W13702.33867	19:47:47	11.80	351.1	4.5
N5902.36244	W13702.23246	19:48:33	11.81	468.3	6.0
N5902.36405	W13702.08279	19:49:19	11.82	624.1	8.0
N5902.35118	W13701.88484	19:50:05	11.83	677.8	8.7
N5902.40074	W13701.69076	19:50:51	11.85	911.6	11.7
N5902.49441	W13701.46320	19:51:37	11.86	967.2	12.7
N5902.53367	W13701.16354	19:52:22	11.87	1850.5	24.4
N5902.42810	W13700.60865	19:53:07	11.89	1831.1	23.6
N5902.22983	W13700.16802	19:53:53	11.90	627.2	8.1
N5902.16449	W13700.01288	19:54:39	11.91	623.8	8.0
N5902.10237	W13659.85420	19:55:25	11.92	397.3	5.2
N5902.05410	W13659.76858	19:56:10	11.94	350.9	4.6
N5902.01740	W13659.68200	19:56:55	11.95	355.5	4.7
N5901.99101	W13659.58061	19:57:40	11.96	267.7	3.4

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5901.98264	W13659.49661	19:58:26	11.97	357.4	4.7
N5901.96526	W13659.38749	19:59:11	11.99	369.9	4.9
N5901.93629	W13659.28353	19:59:56	12.00	460.6	5.9
N5901.87771	W13659.19019	20:00:42	12.01	676.5	8.7
N5901.78920	W13659.05919	20:01:28	12.02	1019.7	13.1
N5901.64661	W13658.88764	20:02:14	12.04	1131.5	14.9
N5901.46862	W13658.78207	20:02:59	12.05	1418.6	18.3
N5901.24782	W13658.63562	20:03:45	12.06	1894.2	24.9
N5900.94205	W13658.51975	20:04:30	12.08	1939.6	25.5
N5900.66621	W13658.20850	20:05:15	12.09	1996.0	25.7
N5900.38651	W13657.87473	20:06:01	12.10	2001.7	25.8
N5900.10842	W13657.53258	20:06:47	12.11	1955.7	25.8
N5859.82936	W13657.22199	20:07:32	12.13	2006.7	25.8
N5859.55159	W13656.87598	20:08:18	12.14	1987.4	25.6
N5859.28284	W13656.51485	20:09:04	12.15	1955.5	25.7
N5859.01054	W13656.18268	20:09:49	12.16	2010.3	25.9
N5858.71732	W13655.88625	20:10:35	12.18	1990.2	25.6
N5858.46433	W13655.48327	20:11:21	12.19	1930.8	25.4
N5858.21199	W13655.10926	20:12:06	12.20	1992.9	25.7
N5857.93583	W13654.76680	20:12:52	12.21	1968.4	25.4
N5857.66192	W13654.43206	20:13:38	12.23	1983.6	25.5
N5857.40508	W13654.04196	20:14:24	12.24	1992.0	25.7
N5857.11540	W13653.74520	20:15:10	12.25	1975.7	25.4
N5856.81767	W13653.49286	20:15:56	12.27	1922.5	25.3
N5856.52252	W13653.27302	20:16:41	12.28	1950.2	25.1
N5856.20516	W13653.18290	20:17:27	12.29	1908.6	25.1
N5855.89134	W13653.19706	20:18:12	12.30	1873.1	24.7
N5855.64319	W13653.55079	20:18:57	12.32	1938.3	25.0
N5855.42464	W13654.00044	20:19:43	12.33	1922.3	24.8
N5855.19644	W13654.42433	20:20:29	12.34	1920.0	24.7
N5854.92060	W13654.72206	20:21:15	12.35	1907.1	25.1
N5854.66053	W13655.06163	20:22:00	12.37	1940.0	25.0
N5854.40175	W13655.42308	20:22:46	12.38	1899.3	25.0
N5854.16261	W13655.81222	20:23:31	12.39	1914.4	25.2
N5853.97432	W13656.30081	20:24:16	12.40	1390.4	17.9
N5853.84042	W13656.65969	20:25:02	12.42	78.6	1.0
N5853.83334	W13656.68061	20:25:47	12.43	33.4	0.4
N5853.82787	W13656.68157	20:26:32	12.44	295.8	3.8
N5853.83817	W13656.58952	20:27:18	12.46	470.2	6.1
N5853.86553	W13656.44951	20:28:04	12.47	476.2	6.1
N5853.89997	W13656.31336	20:28:50	12.48	366.2	4.7
N5853.93086	W13656.21326	20:29:36	12.49	415.7	5.4
N5853.97689	W13656.11541	20:30:22	12.51	859.4	11.1
N5854.06347	W13655.89912	20:31:08	12.52	1845.5	23.8
N5854.25112	W13655.43724	20:31:54	12.53	1918.1	24.7
N5854.20252	W13654.83375	20:32:40	12.54	1979.5	25.5
N5854.05704	W13654.26984	20:33:26	12.56	1977.7	25.5
N5853.91670	W13653.70175	20:34:12	12.57	1985.3	25.6
N5853.77186	W13653.13526	20:34:58	12.58	2000.3	25.8

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5853.61962	W13652.57071	20:35:44	12.60	1949.0	25.7
N5853.51212	W13651.98621	20:36:29	12.61	1987.4	25.6
N5853.42715	W13651.37531	20:37:15	12.62	1950.3	25.7
N5853.33928	W13650.77825	20:38:00	12.63	1934.6	25.5
N5853.16483	W13650.26326	20:38:45	12.65	2001.6	25.8
N5852.91345	W13649.85192	20:39:31	12.66	1875.5	24.7
N5852.66787	W13649.49079	20:40:16	12.67	815.4	10.5
N5852.56165	W13649.33243	20:41:02	12.68	310.5	4.1
N5852.52335	W13649.26709	20:41:47	12.70	387.1	5.0
N5852.49760	W13649.15444	20:42:33	12.71	366.2	4.8
N5852.50758	W13649.03953	20:43:18	12.72	360.4	4.6
N5852.53848	W13648.94168	20:44:04	12.73	507.8	6.7
N5852.58804	W13648.81165	20:44:49	12.75	961.2	12.4
N5852.71647	W13648.63334	20:45:35	12.76	1795.0	23.1
N5852.91635	W13648.21298	20:46:21	12.77	1981.1	25.5
N5852.98555	W13647.59693	20:47:07	12.79	1980.3	25.5
N5852.98780	W13646.96672	20:47:53	12.80	1952.2	25.7
N5852.96205	W13646.34745	20:48:38	12.81	1988.3	25.6
N5852.91570	W13645.72110	20:49:24	12.82	1994.1	25.7
N5852.86002	W13645.09572	20:50:10	12.84	1992.8	25.7
N5852.73288	W13644.51121	20:50:56	12.85	2001.5	25.8
N5852.55553	W13643.97466	20:51:42	12.86	1995.9	25.7
N5852.41359	W13643.40206	20:52:28	12.87	1918.1	25.3
N5852.29965	W13642.83301	20:53:13	12.89	1977.6	25.5
N5852.20277	W13642.23241	20:53:59	12.90	1991.7	25.7
N5852.09945	W13641.63116	20:54:45	12.91	1954.0	25.7
N5851.99678	W13641.04215	20:55:30	12.93	2001.1	25.8
N5851.88541	W13640.44316	20:56:16	12.94	1951.6	25.7
N5851.78113	W13639.85608	20:57:01	12.95	2000.2	25.8
N5851.67266	W13639.25548	20:57:47	12.96	1964.9	25.9
N5851.56516	W13638.66614	20:58:32	12.98	1965.6	25.9
N5851.45186	W13638.08067	20:59:17	12.99	2007.2	25.9
N5851.33824	W13637.48136	21:00:03	13.00	1959.4	25.8
N5851.23363	W13636.89202	21:00:48	13.01	2001.0	25.8
N5851.12839	W13636.28917	21:01:34	13.03	1941.4	25.6
N5851.01251	W13635.71399	21:02:19	13.04	1995.0	25.7
N5850.83259	W13635.18356	21:03:05	13.05	1961.0	25.8
N5850.64913	W13634.67083	21:03:50	13.06	1960.1	25.8
N5850.46406	W13634.16067	21:04:35	13.08	2008.2	25.9
N5850.27737	W13633.63410	21:05:21	13.09	1959.6	25.8
N5850.07814	W13633.14455	21:06:06	13.10	2006.7	25.8
N5849.85412	W13632.67623	21:06:52	13.11	1977.2	26.0
N5849.64169	W13632.20052	21:07:37	13.13	2012.4	25.9
N5849.42411	W13631.71868	21:08:23	13.14	1959.8	25.8
N5849.18142	W13631.30895	21:09:08	13.15	1979.7	26.1
N5848.94228	W13630.88216	21:09:53	13.16	2031.5	26.2
N5848.71601	W13630.40741	21:10:39	13.18	1976.7	26.0
N5848.49875	W13629.94038	21:11:24	13.19	2031.6	26.2
N5848.27730	W13629.45726	21:12:10	13.20	2040.8	26.3

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5848.05103	W13628.97865	21:12:56	13.22	2048.9	26.4
N5847.82895	W13628.48941	21:13:42	13.23	2015.1	26.5
N5847.62006	W13627.99277	21:14:27	13.24	2013.6	26.5
N5847.40795	W13627.50193	21:15:12	13.25	2045.7	26.3
N5847.14627	W13627.09380	21:15:58	13.27	2065.6	26.6
N5846.85659	W13626.75134	21:16:44	13.28	2055.1	26.5
N5846.57914	W13626.37894	21:17:30	13.29	2011.3	26.5
N5846.31457	W13625.99592	21:18:15	13.30	2071.0	26.7
N5846.01009	W13625.70142	21:19:01	13.32	2009.4	26.5
N5845.69916	W13625.48544	21:19:46	13.33	1940.3	25.0
N5845.38696	W13625.61290	21:20:32	13.34	1940.5	25.5
N5845.21283	W13626.12853	21:21:17	13.35	2016.6	26.0
N5845.09116	W13626.72334	21:22:03	13.37	1960.2	25.8
N5844.97980	W13627.30656	21:22:48	13.38	2003.4	25.8
N5844.88452	W13627.91456	21:23:34	13.39	2012.9	25.9
N5844.78668	W13628.52417	21:24:20	13.41	1974.3	26.0
N5844.65375	W13629.09516	21:25:05	13.42	1950.6	25.1
N5844.48670	W13629.62302	21:25:51	13.43	700.6	9.2
N5844.44325	W13629.82869	21:26:36	13.44	299.2	3.9
N5844.42651	W13629.91785	21:27:22	13.46	254.6	3.3
N5844.41106	W13629.99284	21:28:08	13.47	78.1	1.0
N5844.40655	W13630.01602	21:28:53	13.48	18.3	0.2
N5844.40655	W13630.02181	21:29:39	13.49	2.8	0.0
N5844.40688	W13630.02117	21:30:24	13.51	2.2	0.0
N5844.40655	W13630.02085	21:31:10	13.52	9.0	0.1
N5844.40720	W13630.02342	21:31:55	13.53	7.1	0.1
N5844.40816	W13630.02213	21:32:41	13.54	26.6	0.3
N5844.40945	W13630.01409	21:33:26	13.56	245.4	3.2
N5844.42329	W13629.94102	21:34:12	13.57	105.0	1.4
N5844.43263	W13629.91302	21:34:57	13.58	120.7	1.6
N5844.42007	W13629.88341	21:35:42	13.60	421.3	5.4
N5844.43166	W13629.75177	21:36:28	13.61	1020.6	13.4
N5844.51180	W13629.46756	21:37:13	13.62	1867.2	24.1
N5844.62800	W13628.91974	21:37:59	13.63	1608.5	21.2
N5844.70074	W13628.42954	21:38:44	13.65	120.6	1.6
N5844.70685	W13628.39317	21:39:29	13.66	326.4	4.3
N5844.68336	W13628.48619	21:40:14	13.67	1666.7	21.5
N5844.62220	W13629.00118	21:41:00	13.68	453.1	5.8
N5844.60289	W13629.13990	21:41:46	13.70	166.0	2.2
N5844.57650	W13629.12638	21:42:31	13.71	1596.7	20.6
N5844.61190	W13628.62492	21:43:17	13.72	1896.4	24.4
N5844.61931	W13628.02399	21:44:03	13.73	1853.7	23.9
N5844.53144	W13627.46137	21:44:49	13.75	1859.6	24.5
N5844.39271	W13626.93609	21:45:34	13.76	1919.7	24.7
N5844.23114	W13626.41338	21:46:20	13.77	1946.4	25.1
N5844.04381	W13625.91320	21:47:06	13.79	1905.4	25.1
N5843.86132	W13625.42236	21:47:51	13.80	1949.9	25.1
N5843.70650	W13624.88130	21:48:37	13.81	1955.6	25.2
N5843.57325	W13624.31740	21:49:23	13.82	1970.6	25.4

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5843.44257	W13623.74609	21:50:09	13.84	1928.6	25.4
N5843.25621	W13623.25170	21:50:54	13.85	2001.9	25.8
N5843.01030	W13622.83006	21:51:40	13.86	1999.9	25.8
N5842.75571	W13622.42901	21:52:26	13.87	2008.7	25.9
N5842.49725	W13622.03280	21:53:12	13.89	2015.2	26.0
N5842.24137	W13621.62725	21:53:58	13.90	1978.7	26.1
N5841.97808	W13621.25903	21:54:43	13.91	2002.4	25.8
N5841.65815	W13621.10872	21:55:29	13.92	1250.0	16.5
N5841.45666	W13621.03019	21:56:14	13.94	501.8	6.5
N5841.37459	W13621.01345	21:57:00	13.95	227.1	3.0
N5841.33725	W13621.01442	21:57:45	13.96	30.0	0.4
N5841.33242	W13621.01249	21:58:31	13.98	27.5	0.4
N5841.32920	W13621.00637	21:59:17	13.99	50.2	0.6
N5841.32373	W13620.99446	22:00:03	14.00	64.6	0.9
N5841.31697	W13620.97869	22:00:48	14.01	192.6	2.5
N5841.28768	W13620.95552	22:01:33	14.03	210.1	2.7
N5841.25582	W13620.92977	22:02:19	14.04	860.2	11.1
N5841.11677	W13620.87956	22:03:05	14.05	937.6	12.3
N5840.97612	W13621.00122	22:03:50	14.06	769.5	9.9
N5840.85703	W13621.08362	22:04:36	14.08	1297.5	17.1
N5840.75403	W13620.72409	22:05:21	14.09	1962.6	25.3
N5840.70414	W13620.11062	22:06:07	14.10	1978.4	25.5
N5840.67356	W13619.48749	22:06:53	14.11	1982.9	25.5
N5840.64588	W13618.86243	22:07:39	14.13	1994.4	25.7
N5840.60372	W13618.23672	22:08:25	14.14	2002.2	25.8
N5840.56188	W13617.60844	22:09:11	14.15	1956.4	25.8
N5840.52325	W13616.99400	22:09:56	14.17	2021.0	26.0
N5840.49107	W13616.35767	22:10:42	14.18	2008.2	25.9
N5840.46178	W13615.72489	22:11:28	14.19	1934.7	25.5
N5840.41414	W13615.11978	22:12:13	14.20	1204.5	15.9
N5840.37069	W13614.74803	22:12:58	14.22	430.5	5.5
N5840.36554	W13614.61220	22:13:44	14.23	376.5	4.8
N5840.39451	W13614.50695	22:14:30	14.24	389.7	5.0
N5840.44697	W13614.43614	22:15:16	14.25	650.4	8.4
N5840.54771	W13614.36694	22:16:02	14.27	1546.5	20.4
N5840.74824	W13614.06599	22:16:47	14.28	1963.2	25.3
N5840.80746	W13613.45542	22:17:33	14.29	2014.4	25.9
N5840.66198	W13612.88282	22:18:19	14.31	1999.2	26.3
N5840.43699	W13612.42158	22:19:04	14.32	2037.2	26.2
N5840.18433	W13611.99833	22:19:50	14.33	1988.3	26.2
N5839.93134	W13611.59986	22:20:35	14.34	2019.9	26.0
N5839.68222	W13611.17725	22:21:21	14.36	1951.4	25.7
N5839.43631	W13610.78072	22:22:06	14.37	1968.3	25.9
N5839.20007	W13610.35521	22:22:51	14.38	1922.8	25.3
N5839.00662	W13609.87434	22:23:36	14.39	1963.6	25.3
N5838.81447	W13609.37545	22:24:22	14.41	1979.1	25.5
N5838.59045	W13608.92162	22:25:08	14.42	1985.1	25.6
N5838.34584	W13608.50610	22:25:54	14.43	1941.3	25.6
N5838.10926	W13608.09411	22:26:39	14.44	1922.9	25.3

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5837.87302	W13607.69017	22:27:24	14.46	1988.8	25.6
N5837.61971	W13607.29266	22:28:10	14.47	1989.3	25.6
N5837.36189	W13606.90578	22:28:56	14.48	1964.4	25.9
N5837.10601	W13606.52695	22:29:41	14.49	2025.6	26.1
N5836.83918	W13606.14393	22:30:27	14.51	2015.8	26.0
N5836.57139	W13605.76863	22:31:13	14.52	2001.7	26.4
N5836.30167	W13605.40621	22:31:58	14.53	2020.2	26.0
N5836.02519	W13605.05248	22:32:44	14.55	2046.6	26.4
N5835.73905	W13604.71227	22:33:30	14.56	1078.7	26.6
N5835.58649	W13604.53846	22:33:54	14.57	4898.9	24.8
N5834.92505	W13603.65559	22:35:51	14.60	1809.1	23.8
N5834.66917	W13603.36430	22:36:36	14.61	1796.5	23.7
N5834.39398	W13603.15799	22:37:21	14.62	1860.7	24.0
N5834.09271	W13603.05499	22:38:07	14.64	1884.6	24.3
N5833.78275	W13603.05692	22:38:53	14.65	1775.7	23.4
N5833.49147	W13603.09747	22:39:38	14.66	1144.9	15.1
N5833.30317	W13603.09780	22:40:23	14.67	1104.8	14.5
N5833.12164	W13603.11325	22:41:08	14.69	1112.1	14.3
N5832.93947	W13603.14447	22:41:54	14.70	1074.4	14.1
N5832.76534	W13603.20208	22:42:39	14.71	1095.6	14.1
N5832.59057	W13603.28609	22:43:25	14.72	1043.5	13.7
N5832.42320	W13603.35883	22:44:10	14.74	1029.6	13.3
N5832.25615	W13603.41194	22:44:56	14.75	1156.0	14.9
N5832.06979	W13603.48403	22:45:42	14.76	1479.7	19.1
N5831.82968	W13603.55999	22:46:28	14.77	1459.8	18.8
N5831.59278	W13603.63467	22:47:14	14.79	1435.0	18.9
N5831.35686	W13603.64690	22:47:59	14.80	1450.4	18.7
N5831.11835	W13603.63885	22:48:45	14.81	1361.9	17.9
N5830.89595	W13603.68971	22:49:30	14.83	1351.2	17.8
N5830.67386	W13603.70451	22:50:15	14.84	1327.4	17.5
N5830.45885	W13603.63209	22:51:00	14.85	1371.9	17.7
N5830.24256	W13603.50914	22:51:46	14.86	1388.8	17.9
N5830.02240	W13603.39263	22:52:32	14.88	1409.7	18.2
N5829.79806	W13603.28062	22:53:18	14.89	1433.3	18.5
N5829.57533	W13603.13288	22:54:04	14.90	1429.4	18.8
N5829.35679	W13602.96712	22:54:49	14.91	1422.8	18.7
N5829.14178	W13602.79042	22:55:34	14.93	1451.8	18.7
N5828.91229	W13602.66424	22:56:20	14.94	1405.5	18.5
N5828.70083	W13602.48561	22:57:05	14.95	1438.1	18.5
N5828.47359	W13602.36008	22:57:51	14.96	1439.6	19.0
N5828.25054	W13602.20816	22:58:36	14.98	1480.2	19.1
N5828.02330	W13602.04111	22:59:22	14.99	1443.3	19.0
N5827.80347	W13601.86988	23:00:07	15.00	1459.3	19.2
N5827.62837	W13601.55606	23:00:52	15.01	1469.7	19.4
N5827.46969	W13601.20748	23:01:37	15.03	1493.8	19.2
N5827.29685	W13600.87371	23:02:23	15.04	1513.4	19.5
N5827.11403	W13600.55088	23:03:09	15.05	1491.6	19.6
N5826.94666	W13600.20809	23:03:54	15.07	1522.7	19.6
N5826.79764	W13559.82346	23:04:40	15.08	1492.9	19.7

GPS Way Point Log
Cruise of Spirit of Adventure - 6-12-02

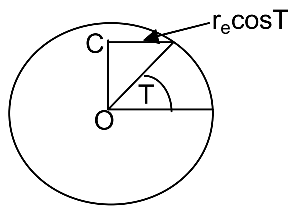
LATITUDE	LONGITUDE	GMT	DEC TIME local	DISTANCE feet	SPEED * knots
N5826.67018	W13559.42242	23:05:25	15.09	1516.3	19.5
N5826.55463	W13559.00013	23:06:11	15.10	1510.6	19.9
N5826.42975	W13558.58975	23:06:56	15.12	1556.4	20.0
N5826.31227	W13558.15524	23:07:42	15.13	1544.7	20.3
N5826.20573	W13557.71460	23:08:27	15.14	1618.0	20.8
N5826.11013	W13557.24017	23:09:13	15.15	1604.9	20.7
N5825.99973	W13556.78216	23:09:59	15.17	1519.6	20.0
N5825.97495	W13556.30709	23:10:44	15.18	1699.2	21.9
N5826.17419	W13555.93276	23:11:30	15.19	1693.4	22.3
N5826.40432	W13555.63310	23:12:15	15.20	1684.6	21.7
N5826.63156	W13555.33023	23:13:01	15.22	1613.8	21.2
N5826.85429	W13555.05439	23:13:46	15.23	1635.2	21.5
N5827.08989	W13554.80655	23:14:31	15.24	1567.0	20.2
N5827.27593	W13554.46570	23:15:17	15.25	1053.6	13.9
N5827.34449	W13554.16153	23:16:02	15.27	957.5	12.3
N5827.40596	W13553.88441	23:16:48	15.28	647.3	8.5
N5827.44716	W13553.69676	23:17:33	15.29	455.2	5.9
N5827.47613	W13553.56480	23:18:19	15.31	295.3	3.9
N5827.46519	W13553.47435	23:19:04	15.32	363.1	4.7
N5827.41465	W13553.41352	23:19:50	15.33	322.4	4.2
N5827.36991	W13553.35912	23:20:36	15.34	284.8	3.7
N5827.33258	W13553.30505	23:21:21	15.36	134.9	1.8
N5827.31874	W13553.27190	23:22:06	15.37	45.1	0.6
N5827.31842	W13553.25774	23:22:52	15.38	41.1	0.5
N5827.32002	W13553.24518	23:23:38	15.39	2.8	0.0
N5827.31970	W13553.24454	23:24:24	15.41	3.1	0.0
N5827.31970	W13553.24358	23:25:09	15.42	15.5	0.2
N5827.32002	W13553.24840	23:25:51	15.43	26865009.7	-286.5

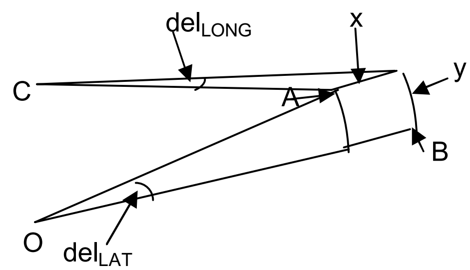
Approximate Distance given Latitude, Longitude - example calculation

Point A   Nome Municipl Airport
Point B   NOAA buoy in Norton sound

decimal latitude of A =	64.517			
decimal longitude of A =	165.45	$x=(Pi/180)del_{LONG}*CosT*r_e$	654.41	miles
		$y=(Pi/180)del_{LAT}*r_e$	513.59	miles
decimal latitude of B =	57.083	distance= $(x^2 + y^2)^{0.5}$	831.88	miles
decimal longitude of B =	177.73			

r_{e} =	3958.76	miles
T =	59	deg





Peratrovich, Nottingham & Drage, Inc.
Engineering Consultants
1506 West 36th Avenue Anchorage, Alaska 99503 (907) 561-1011 Fax (907) 563-4220

Memorandum

To: File — Project No.: 02056.02

From: Jennifer Wilson — Date: October 3, 2002

Re: *Wind Summaries for Sitka, Ketchikan, Juneau, and Cordova (1987-1999)*

Project: Glacier Bay National Park and Preserve Vessel Quotas and Operating Requirements Environmental Impact Statement, Appendix F Technical Memorandum

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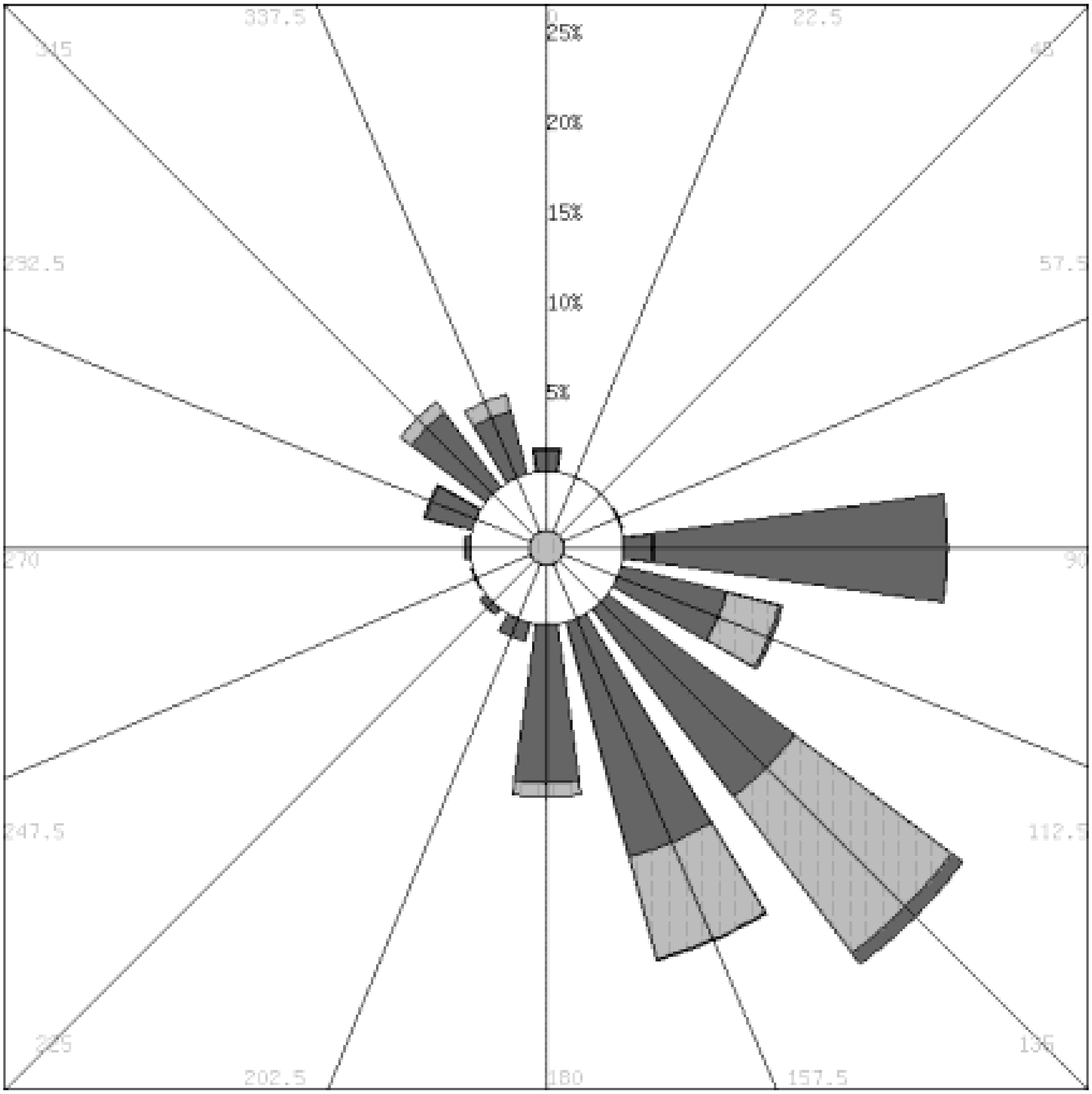
The attached document, *Wind Summaries for Sitka, Ketchikan, Juneau, and Cordova (1987-1999)*, provides the data used to calculate the wind climatology in Glacier Bay proper. The document includes wind roses showing the speed and direction of wind events from 1987 through 1999.



Ketchikan (radial bands indicate 10 knot increments of wind speed acting toward center of the wind rose)

Database: TDF14, TD3280 - Hourly Observations
Stations: Kethcikan Ap
Years: 1987-1999
Months: January-December
Days: 1-31
Hours: 12 am-11 pm

Note: Radial Bands indicate 10 knot increments of wind speed acting toward the center of the wind rose

Speed	0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°	180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°	Calm
0-9 knots	1.27% (93)	0.04% (3)	0.05% (4)	0.10% (7)	1.65% (121)	6.06% (444)	13.10% (960)	13.56% (994)	8.87% (650)	1.10% (81)	0.46% (34)	0.10% (7)	0.38% (28)	2.70% (198)	5.25% (385)	3.67% (269)	18.09% (1326)
10-19 knots	0.11% (8)				0.10% (7)	3.04% (223)	10.93% (801)	5.85% (429)	0.74% (54)	0.01% (1)				0.11% (8)	0.75% (55)	0.91% (67)	
20-29 knots						0.14% (10)	0.74% (54)	0.14% (10)									
Unknown	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	

* Values in the table report the percentage and quantity for a given speed and direction.
* 'Calm' values are not graphed on the wind rose, but percentages and quantities are reported in the table.
* Unknown values are not included in percentages, only quantity is reported.

Please Read
Invalid Values are **NOT** included in the above calculations. The following information is presented to show the completeness of the database for your query. Please use this information to determine the validity and accuracy of the query results.

Your query returned 306 records.

A complete query should have returned at least 4748 records (1 for each hour (1945-83), 1 for each day (1984-99)).
7331 valid data cells were analyzed for your query.
A complete query should have analyzed 113952 data cells.
13 data cells were found to be invalid.
Possible reasons for an incomplete dataset are:

- One or more stations are not valid for the dates selected.
- Data is missing for a portion of the dates selected.

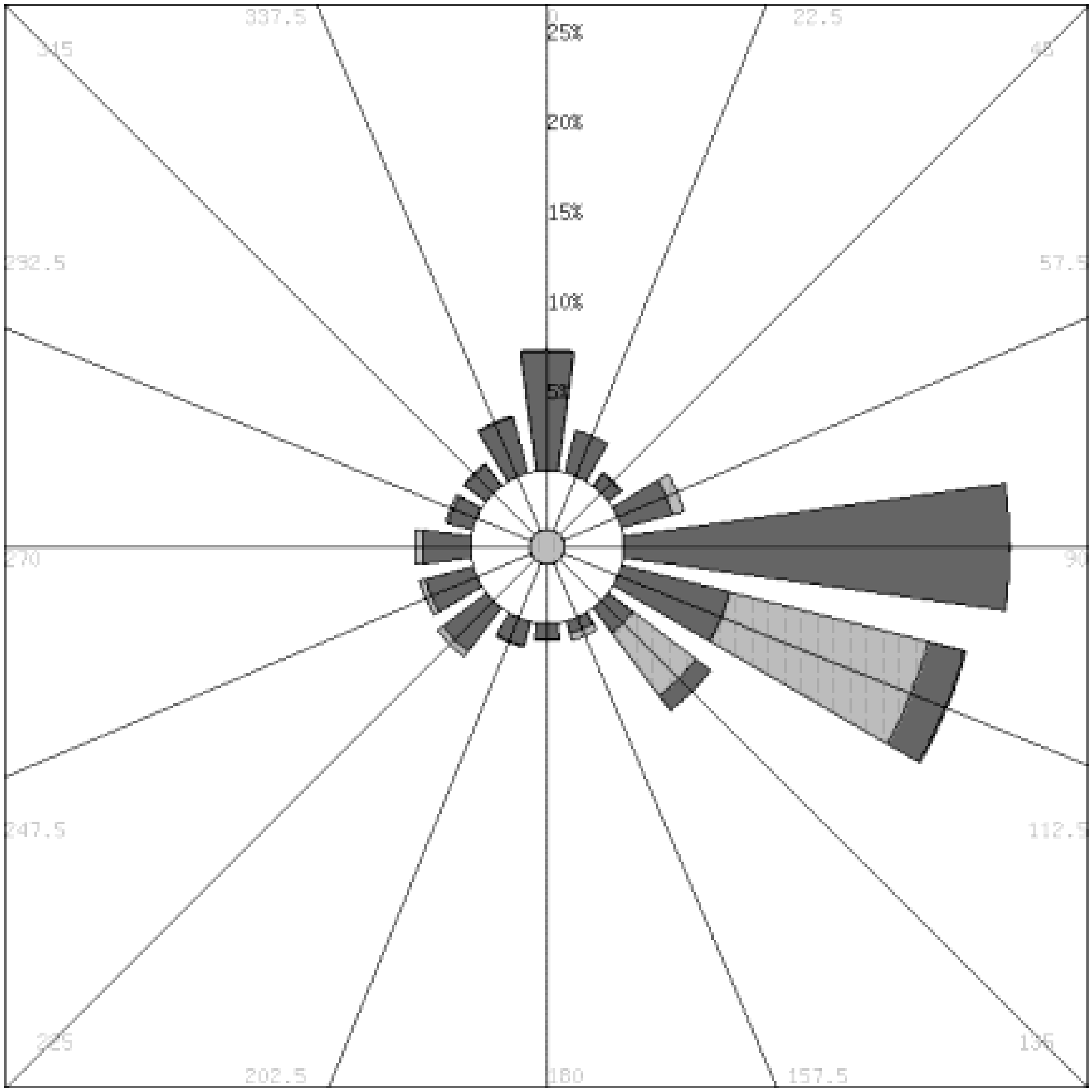
The dates found in the query are indicated below.

Station - KETHCIKAN AP (25325)												
Year	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
1999			1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31

The dates where invalid values were found are indicated below.

Station - KETHCIKAN AP (25325)												
Year	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
1999			1, 8-9, 29								28	

Change your search criteria by clicking here or by pressing the 'BACK' button on your browser.



Juneau (radial bands indicate 10 knot increments of wind speed acting
toward the center of the wind rose

Database: TDF14, TD3280 - Hourly Observations
Stations: Juneau Ap
Years: 1987-1999
Months: January-December
Days: 1-31
Hours: 12 am-11 pm

Note: Radial Bands indicate 10 knot increments of wind speed acting toward the center of the wind rose

Speed	0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°	180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°	Calm	Unknown
0-9 knots	6.70% (7615)	2.44% (2779)	0.93% (1061)	2.94% (3349)	10.45% (11881)	6.22% (7073)	1.75% (1990)	0.71% (811)	0.89% (1017)	1.41% (1603)	3.09% (3509)	2.78% (3163)	2.73% (3100)	1.44% (1640)	1.54% (1753)	3.27% (3724)	21.52% (24474)	(3)
10-19 knots	0.08% (94)	0.04% (41)	0.08% (88)	0.71% (811)	6.74% (7666)	11.44% (13010)	4.40% (5006)	0.43% (487)	0.12% (136)	0.13% (152)	0.38% (434)	0.39% (441)	0.42% (476)	0.12% (136)	0.04% (46)	0.04% (49)		(0)
20-29 knots	0.00% (2)	0.00% (2)	0.00% (3)	0.01% (17)	0.28% (320)	2.07% (2352)	1.04% (1188)	0.05% (52)	0.01% (8)	0.00% (4)	0.00% (1)							(0)
30-39 knots					0.00% (1)	0.10% (112)	0.04% (50)											(0)
40-49 knots					0.00% (1)	0.00% (1)												(0)
Unknown	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)		(0)

* Values in the table report the percentage and quantity for a given speed and direction.
* 'Calm' values are not graphed on the wind rose, but percentages and quantities are reported in the table.
* Unknown values are not included in percentages, only quantity is reported.

Please Read
Invalid Values are **NOT** included in the above calculations. The following information is presented to show the completeness of the database for your query. Please use this information to determine the validity and accuracy of the query results.

Your query returned 4748 records.
A complete query should have returned at least 4748 records (1 for each hour (1945-83), 1 for each day (1984-99)).
113732 valid data cells were analyzed for your query.
A complete query should have analyzed 113952 data cells.
220 data cells were found to be invalid.
Possible reasons for an incomplete dataset are:

- One or more stations are not valid for the dates selected.
- Data is missing for a portion of the dates selected.

The dates found in the query are indicated below.

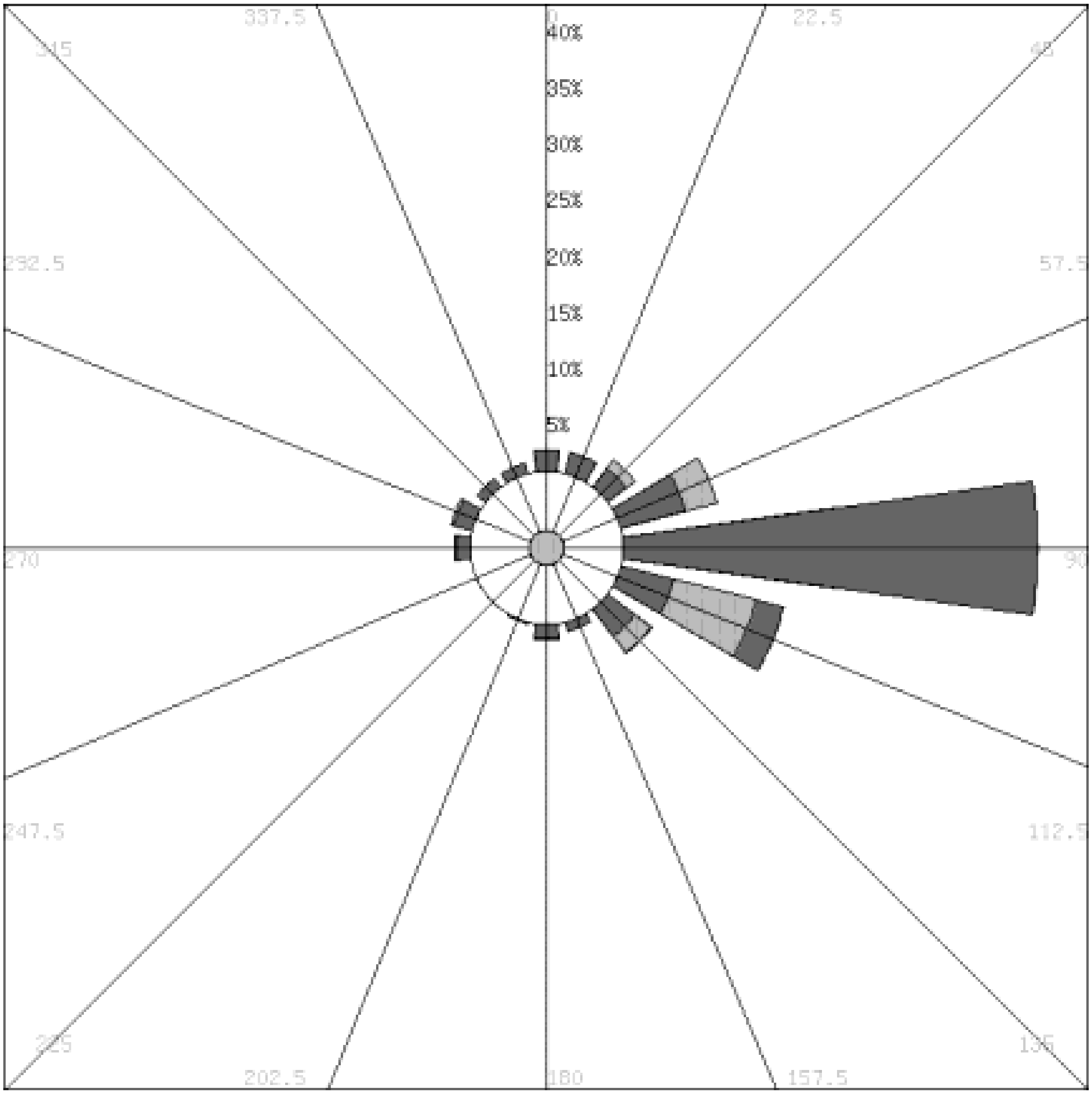
Station - JUNEAU AP (25309)												
Year	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
1987	1-31	1-28	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31
1988	1-31	1-29	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31
1989	1-31	1-28	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31
1990	1-31	1-28	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-18, 20-31
1991	1-31	1-28	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31
1992	1-31	1-29	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31
1993	1-31	1-28	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31
1994	1-31	1-28	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31
1995	1-31	1-28	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31
1996	1-31	1-29	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31
1997	1-31	1-28	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31
1998	1-31	1-28	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31

1999	1-31	1-28	1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31

The dates where invalid values were found are indicated below.

Station - JUNEAU AP (25309)												
Year	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
1987			1									
1988								19, 22-23	14			
1989											25-26, 29	6, 28
1990						28		2, 4-5, 7	18			12, 18, 20
1991			3					27				
1992									7			
1993					13-14	20					7, 15, 30	
1994		7			8				20-21, 24			
1995			6, 14, 18, 28, 30	3, 24			3, 9			2		20
1996	2, 11, 24, 29			2, 7, 9		15, 25	12, 20, 26	12, 18, 22-23, 27, 31	1, 13, 15, 17, 20, 25	2, 16-18, 31	1-2, 7, 19	1, 16
1997	16, 31	10, 21, 27	15	8, 14	4, 9	13, 26-27		6	6	11, 27		
1998	4, 29	2							18	5, 22		17
1999	3, 8, 10		28	18	3, 13							24-25

Change your search criteria by clicking here or by pressing the 'BACK' button on your browser.



Cordova (radial bands indicate 10 knot increments of wind speed acting
toward the center of the wind rose

Database: TDF14, TD3280 - Hourly Observations
Stations: Cordova Ap
Years: 1987-1999
Months: January-December
Days: 1-31
Hours: 12 am-11 pm

Note: Radial Bands indicate 10 knot increments of wind speed acting toward the center of the wind rose

Speed	0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°	180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°	Calm	Unknown
0-9 knots	2.03% (14)	2.03% (14)	2.17% (15)	5.93% (41)	10.71% (74)	4.92% (34)	3.04% (21)	0.87% (6)	1.30% (9)	0.14% (1)			1.30% (9)	1.74% (12)	1.01% (7)	1.01% (7)	36.90% (255)	(0)
10-19 knots			0.87% (6)	2.89% (20)	7.38% (51)	7.53% (52)	1.88% (13)		0.14% (1)				0.14% (1)	0.29% (2)				(0)
20-29 knots					1.16% (8)	2.46% (17)												(0)
30-39 knots							0.14% (1)											(0)
Unknown	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)		(0)

* Values in the table report the percentage and quantity for a given speed and direction.
* 'Calm' values are not graphed on the wind rose, but percentages and quantities are reported in the table.
* Unknown values are not included in percentages, only quantity is reported.

Please Read
Invalid Values are **NOT** included in the above calculations.

The following information is presented to show the completeness of the database for your query.

Please use this information to determine the validity and accuracy of the query results.

Your query returned 30 records.
A complete query should have returned at least 4748 records (1 for each hour (1945-83), 1 for each day (1984-99)).
691 valid data cells were analyzed for your query.
A complete query should have analyzed 113952 data cells.
29 data cells were found to be invalid.
Possible reasons for an incomplete dataset are:

- One or more stations are not valid for the dates selected.
- Data is missing for a portion of the dates selected.

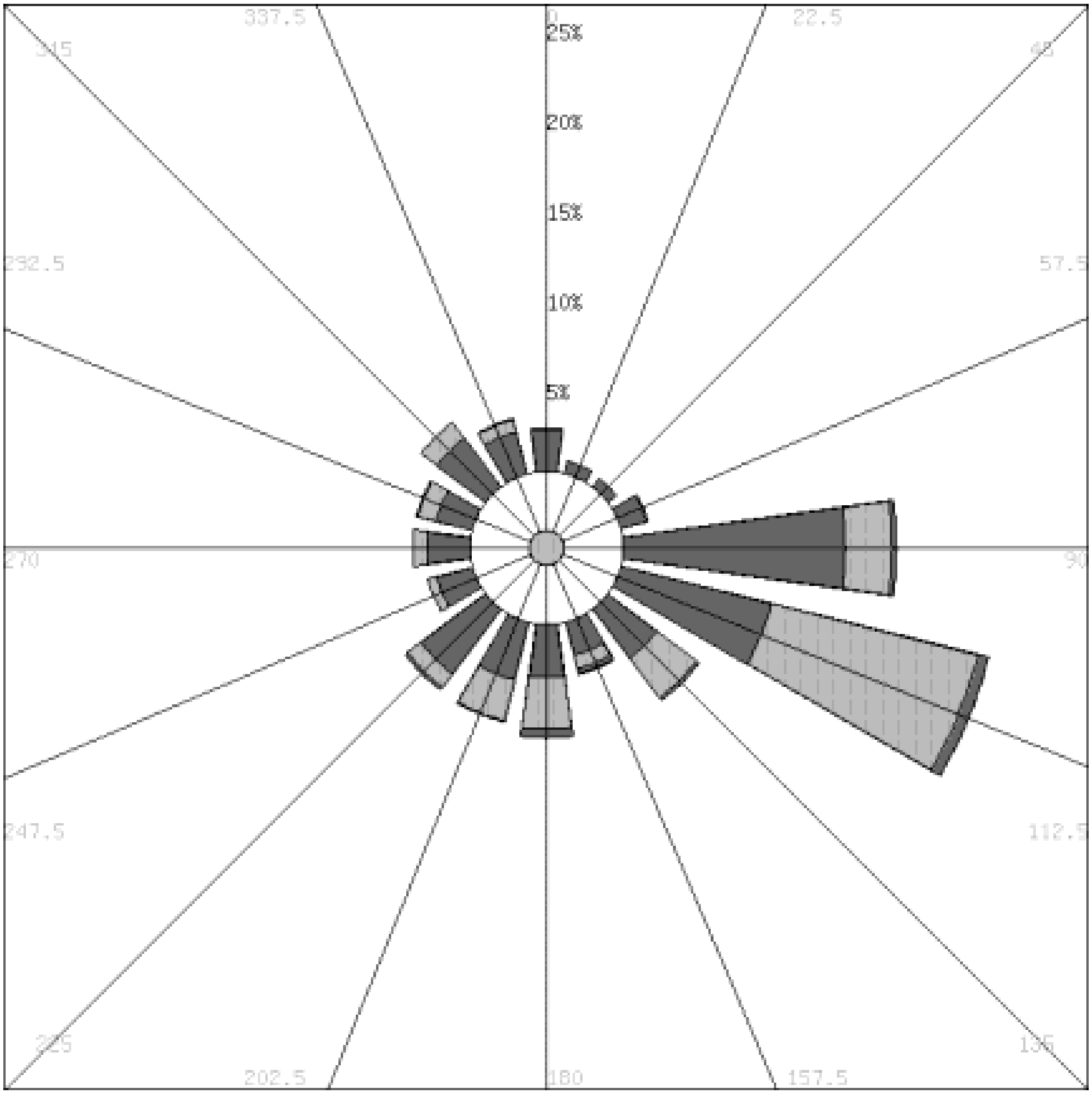
The dates found in the query are indicated below.

Station - CORDOVA AP (26410)												
Year	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
1999												1-30

The dates where invalid values were found are indicated below.

Station - CORDOVA AP (26410)												
Year	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
1999												1, 8, 13, 18, 30

Change your search criteria by clicking here or by pressing the 'BACK' button on your browser.



Sitka (radial bands indicate 10 knot increments of wind speed acting
toward the center of the wind rose

Database: TDF14, TD3280 - Hourly Observations
Stations: Sitka Ap
Years: 1987-1999
Months: January-December
Days: 1-31
Hours: 12 am-11 pm

Note: Radial Bands indicate 10 knot increments of wind speed acting toward the center of the wind rose

Speed	0°	22.5°	45°	67.5°	90°	112.5°	135°	157.5°	180°	202.5°	225°	247.5°	270°	292.5°	315°	337.5°	Calm	Unknown
0-9 knots	2.35% (172)	0.70% (51)	0.61% (45)	1.54% (113)	12.38% (907)	8.69% (637)	3.49% (256)	1.92% (141)	2.95% (216)	3.30% (242)	4.50% (330)	2.10% (154)	2.48% (182)	2.09% (153)	3.37% (247)	2.43% (178)	14.32% (1049)	(0)
10-19 knots	0.10% (7)			0.04% (3)	2.61% (191)	11.79% (864)	2.76% (202)	0.82% (60)	2.89% (212)	2.36% (173)	1.01% (74)	0.53% (39)	0.74% (54)	1.09% (80)	1.15% (84)	0.75% (55)		(0)
20-29 knots					0.25% (18)	0.59% (43)	0.19% (14)	0.26% (19)	0.52% (38)	0.08% (6)	0.11% (8)		0.05% (4)	0.03% (2)		0.01% (1)		(0)
30-39 knots								0.03% (2)	0.01% (1)									(0)
Unknown	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)		(0)

* Values in the table report the percentage and quantity for a given speed and direction.
* 'Calm' values are not graphed on the wind rose, but percentages and quantities are reported in the table.
* Unknown values are not included in percentages, only quantity is reported.

Please Read
Invalid Values are **NOT** included in the above calculations.

The following information is presented to show the completeness of the database for your query.

Please use this information to determine the validity and accuracy of the query results.

Your query returned 306 records.
A complete query should have returned at least 4748 records (1 for each hour (1945-83), 1 for each day (1984-99)).
7327 valid data cells were analyzed for your query.
A complete query should have analyzed 113952 data cells.
17 data cells were found to be invalid.
Possible reasons for an incomplete dataset are:

- One or more stations are not valid for the dates selected.
- Data is missing for a portion of the dates selected.

The dates found in the query are indicated below.

Station - SITKA AP (25333)												
Year	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
1999			1-31	1-30	1-31	1-30	1-31	1-31	1-30	1-31	1-30	1-31

The dates where invalid values were found are indicated below.

Station - SITKA AP (25333)												
Year	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
1999			1, 3-5, 7, 30								23	

Change your search criteria by clicking here or by pressing the 'BACK' button on your browser.

Peratrovich, Nottingham & Drage, Inc.
Engineering Consultants
1506 West 36th Avenue Anchorage, Alaska 99503 (907) 561-1011 Fax (907) 563-4220

Memorandum

To: File　　Project No.: 02056.02

From: Jennifer Wilson　　Date: October 3, 2002

Re: *Technical References*

Project: Glacier Bay National Park and Preserve Vessel Quotas and Operating Requirements Environmental Impact Statement, Appendix F Technical Memorandum

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The attached document, *Technical References*, provides several technical documents used as the basis for the model at Glacier Bay proper. The theory behind these references was critical for deriving a model for identifying locations in Glacier Bay proper for site specific study and to conduct the study.

The technical references include:

Windspeed adjustment and wave growth, ACES Technical Reference
Coastal Engineering Manual III-1-8, II-1-74, and II-7-57 through -61
Chance of exceedance chart
Juneau extreme prediction chart

Windspeed Adjustment and Wave Growth

Description

The methodologies represented in this ACES application provide quick and simple estimates for wave growth over open-water and restricted fetches in deep and shallow water. Also, improved methods (over those given in the *Shore Protection Manual* (SPM), 1984) are included for adjusting the observed winds to those required by wave growth formulas.

Introduction

Wind-generated wave growth is a complex process of considerable practical interest. Although the process is only partially understood, substantial demand remains for quick estimates required for design and analysis procedures. The most accurate estimates available are those provided by sophisticated numerical models such as those presented in Cardone et al. (1976), Hasselmann et al. (1976), Resio (1981), and Resio (1987). Yet many studies, especially at the preliminary level, attempt to describe wind-generated wave growth without the benefit of intensive large-scale modeling efforts. The prediction methods that follow present a first-order estimate for the process, but their simplification of the more complex physics should always be considered.

Methods are included for adjusting observed winds of varying character and location to the conditions required by wave growth formulas. A model depicting an idealized atmospheric boundary layer over the water surface is employed to estimate the low-level winds above the water surface. Stability effects (air-sea temperature gradient) are included, but barotropic effects (horizontal temperature gradient) are ignored. The numerical descriptions of the planetary boundary layer model are based upon similitude theory. Additional corrections are provided for the observed bias of ship-based wind observations as well as short fetches. Formulas for estimating winds of alternate durations are also included. The methodology for this portion of the application is largely taken from Resio, Vincent, and Corson (1982).

The simplified wave growth formulas predict deepwater wave growth according to fetch- and duration-limited criteria and are bounded (at the upper limit) by the estimates for a fully developed spectrum. The shallow-water formulations are based partly upon the fetch-limited deepwater forms and do not encompass duration effects. The methods described are essentially those in Vincent (1984), the SPM (1984), and Smith (1991).

Unless otherwise annotated, metric units are assumed for the following discussion.

General Assumptions and Limitations

The deep- and shallow-water wave growth curves are based on limited field data that have been generalized and extended on the basis of dimensionless analysis. The wind estimation procedures are based on a combination of boundary layer theory and limited field data largely from the Great Lakes. Wind transformation from land to water tends to be highly site and condition specific. The derivation of an individual site from these generalized conditions can create significant errors. Collection of site-specific field data to calibrate the techniques is suggested.

WIND ADJUSTMENT

The methodology for preparing wind observations for use in the wave growth formulas is based upon an idealized model of the planetary boundary layer depicted in Figure 1-1-1. For typical mid-latitude conditions, this planetary boundary layer exists in the lowest kilometer of the atmosphere and contains about 10 percent of the atmospheric mass (Holton, 1979).

Low-level winds directly over the water surface are considered to exist in a region characterized as having relatively constant stress at the air-sea interface. This surface layer will be designated the constant stress region for the remainder of this discussion.

Above the constant stress region is the Ekman layer, where the additional forces of Coriolis force, pressure gradient force, viscous stress, and convectively driven mixing are considered important.

Finally, above the Ekman region, geostrophic winds are considered to exist which result from considering the balance between pressure gradient forces and Coriolis force for synoptic scale systems.

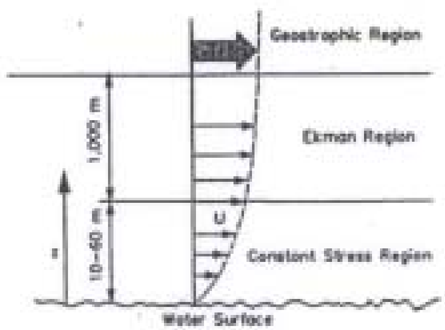

Figure 1-1-1. Idealized Atmospheric Boundary Layer over Water

Observed winds for use in the wave growth equations are considered to be characterized by six categories summarized in Table 1-1-1.

Table 1-1-1
Character and Action for Wind Observations

Observation type	Initial Action	Solution Domain
Over water (non-ship obs)	-------	Constant stress layer
Over water (ship obs)	Adjusted	Constant stress layer
At shoreline (onshore winds)	-------	Constant stress layer
At shoreline (offshore winds)	Geostrophic wind estimated	Full PBL* model
Over land	Geostrophic wind estimated	Full PBL model
Geostrophic wind	-------	Full PBL model

* PBL = Planetary Boundary Layer

Although the above six wind observation categories are presented for user convenience, only two separate cases are ultimately considered by the methodology: low-level winds observed within the constant stress region and known or estimated geostrophic winds. In the ACES application, adjustments for ship-based observations are made before proceeding with a solution in the constant stress region, and geostrophic winds are estimated for cases where low-level observed winds are predominantly over land masses. The case of observed winds blowing onshore and measured at the shoreline is considered to be effectively identical to the case of winds observed over water. Similarly, winds observed at the shoreline but blowing from the land mass in an offshore direction are considered effectively equivalent to winds observed at a more inland location. Complex wind patterns caused by local frictional characteristics or topography are obviously not considered by these simplifications.

Initial Adjustments and Estimates

Wind observations over water are typically the most desirable choice of available data sources for wave prediction. Observers on ships at sea frequently record such data and make qualitative estimates. Cardone (1969) reviewed the bias of ship-based observations and suggested the following adjustment:

$$U = 1.864\, U_{obs}^{\frac{7}{9}} \qquad (mps) \tag{1}$$

where

U = adjusted ship-based wind speed

U_{obs} = ship-based observations

For cases where the observed winds are predominantly over land surfaces, similar models of the boundary layer are sometimes employed for other prediction purposes. However, in this application, the following simple estimate for geostrophic winds is made from low-level wind observations (cgs units):

$$V_g = \frac{U_*}{\sqrt{C_{D\,land}}} \tag{2}$$

where

U_* = friction velocity

$$= \frac{k U_{obs}}{\ln\left(\frac{z_{obs}}{z_0}\right)} \tag{3}$$

k = von Karman constant (k=0.4)

z_{obs} = elevation of wind observation

z_0 = surface roughness length (assumed = 30 cm)

$C_{D\,land}$ = drag coefficient over land

$$C_{D\,land} = 0.00255\, z_0^{0.1639} \tag{4}$$

Constant Stress Region

The major features of the constant stress region can be summarized as follows:

- The constant stress region is confined to the lowest few meters of the boundary layer.
- Wind flow is assumed parallel to the water surface.
- The wind velocity is adjusted so that the horizontal frictional stress is nearly independent of height.
- The stress remains constant within the layer and is characterized by the friction velocity U_* .

Stability (air-sea temperature gradient) has an important effect on wave growth. The wind profile within this region is described by the following modified logarithmic form:

$$U_z = \frac{U_*}{k}\left[\ln\left(\frac{z}{z_0}\right) - \Psi\left(\frac{z}{L'}\right)\right] \tag{5}$$

where

U_z = wind velocity at elevation z

z_0 = surface roughness length

$$= \frac{C_1}{U_*} + C_2 U_*^2 + C_3 \tag{6}$$

$$\left(C_1 = 0.1525 \ , \ C_2 = \frac{0.019}{980} \ , \ C_3 = -0.00371\right) \tag{7}$$

Ψ = universal similarity function
KEYPS formula (Lumley and Panofsky, 1964)

L' = Obukov stability length

$$= 1.79\frac{U_*^2}{\Delta T}\left[\ln\left(\frac{z}{z_0}\right) - \Psi\left(\frac{z}{L'}\right)\right] \tag{8}$$

ΔT = air-sea temperature gradient

$$\left.\begin{array}{ll} \Psi = 0 & \mid \Delta T = 0 \\ \Psi = C\dfrac{z}{L'} & \mid \dfrac{z}{L'} > 0 \\ \Psi = 1 - \phi_s - 3\ln\phi_s + 2\ln\left(\dfrac{1+\phi_s}{2}\right) + 2\tan^{-1}\phi_s - \dfrac{\pi}{2} + \ln\left(\dfrac{1+\phi_s^2}{2}\right) & \mid \dfrac{z}{L'} \le 0 \end{array}\right\} \tag{9}$$

$$\phi_s = \frac{1}{1 - 18R_i^{1/4}} \tag{10}$$

$$R_i = \frac{z}{L'}(1 - 18R_i)^{1/4} \tag{11}$$

The solution of the above equations is an iterative process that converges very rapidly. The convergence criterion (ϵ) for U_* and L' are given below:

$$\epsilon_{U_*} \rightarrow 0.1(cm/sec) \qquad \text{and} \qquad \epsilon_{L'} \rightarrow 1(cm) \tag{12}$$

The wave growth equations discussed later require the equivalent wind speed at a 10-m elevation under conditions of neutral stability ($\Delta T = 0$). Having solved the equations in the constant stress region for U_*, the required equivalent neutral wind speed U_e may be easily obtained from Equation 5 using (U_*, $z = 10\,m$, $\Delta T = 0$):

$$U_{e_{1000}} = \frac{U_*}{k}\left[\ln\left(\frac{1000}{z_0}\right) - 0\right] \tag{13}$$

Full Boundary Layer

For cases where the geostrophic winds are known or have been estimated, the similitude equations describing the entire planetary boundary layer are solved. In addition to the relations described above for the constant stress region, the following relationships describe the model from water surface level to the geostrophic level:

$$\ln\frac{|\overline{V}_g|}{f z_0} = A - \ln\frac{U_*}{|\overline{V}_g|} + \sqrt{\frac{k^2|\overline{V}_g|^2}{U_*^2} - B^2} \tag{14}$$

$$\sin\theta = \frac{BU_*}{k|\overline{V}_g|} \tag{15}$$

where

$\overline{V}_g$ = geostrophic wind

f = Coriolis acceleration

A, B = nondimensional functions of stability

$$\left.\begin{aligned} A &= A_0[1 - e^{(0.015\mu)}] \\ B &= B_0 - B_1[1 - e^{(0.03\mu)}] \end{aligned}\right| \quad \mu \le 0 \tag{16}$$

$$\left.\begin{aligned} A &= A_0 - 0.96\sqrt{\mu} + \ln(\mu + 1) \\ B &= B_0 + 0.7\sqrt{\mu} \end{aligned}\right| \quad \mu > 0 \tag{17}$$

μ = dimensionless stability parameter

$$= \frac{kU_*}{fL'} \tag{18}$$

A_0, B_0, B_1 = constants

Θ = angle between $\overline{V}_g$ and the surface stress

Equations *14-18* are solved simultaneously together with Equations *5-11* until the convergence of U_*, L', and Λ is obtained. A slightly different value of $(C_2 = 0.0144/980)$ in Equation *7* is used (Dr. C. Linwood Vincent, CERC, personal communication, September 1989). The convergence criteria for the iterative solution to the equations are as follows:

$$\epsilon_{U_*} \rightarrow 0.1(cm/\sec) \quad \text{and} \quad \epsilon_{L'} \rightarrow 1(cm) \quad \text{and} \quad \epsilon_{\Lambda} \rightarrow 0.1 \tag{19}$$

The solution procedure converges very rapidly. As before, Equation *13* is then used to determine the equivalent neutral wind speed at the 10-m elevation using $(U_*,\ z = 10\ m,\ \Delta t = 0)$.

Final Adjustments

An additional adjustment is made for situations having relatively short fetch lengths before application of the wave growth equations. For fetch lengths shorter than 16 km, the following reduction is applied:

$$U_* = 0.9U_* \tag{20}$$

Finally, it is necessary to evaluate the effects of winds of varying duration, t_i, on the wave growth equations. The following expressions are used to adjust the wind speed to a duration of interest:

$$\frac{U_t}{U_{3600}} = 1.277 + 0.296\tanh\left(0.9\log\frac{45}{t_t}\right) \qquad \left|\ (1 < t_t < 3600\sec)\right. \tag{21}$$

$$\frac{U_t}{U_{3600}} = -0.15\log t_t + 1.5334 \qquad \left|\ (3600 < t_t < 36000\sec)\right. \tag{22}$$

The 1-hr wind speed U_{3600} is first determined (using $t_t = t_{obs}$). The wind speed U_t at the desired duration of interest is then determined by selecting the desired t_t and using the appropriate equation.

Wave Growth

Having estimated the winds above the water surface at a duration of interest, the objective is to provide an estimate of the wave growth caused by the winds. The simple wave growth formulas that follow provide quick estimates for wind-wave growth in deep and shallow water. The open-water expressions correspond to those listed in the SPM (1984) and Vincent (1984). The restricted fetch deepwater expressions can be found in Smith (1991). It should be noted that the drag law (Garratt, 1977) employed differs from that in the SPM. The major assumptions regarding the use of the simplified wave growth expressions include:

- Energy from the presence of other existing wave trains is neglected.
- Relatively short fetch geometries ($F \le 75\,\mathrm{mi}$).
- Relatively constant wind speed ($\Delta U \le 5\,\mathrm{kts}$) and direction ($\Delta\alpha \le 15°$).
- Winds prescribed at the *10-m* elevation ($z = 10\,\mathrm{m}$).
- Neutral stability conditions.
- Fixed value of drag coefficient ($C_D = 0.001$).

The wind adjustment methodology described earlier in this report adjusts the observed wind, U_{obs}, to the 10-m elevation under neutrally stable conditions U_e. Vincent (1984) maintains the wind speed should be adjusted to consider the nonlinear effect on the wind stress creating the waves. The drag law reported by Garratt (1977) is used:

$$\tau = \rho_a C_D U^2 \tag{23}$$

where

ρ = air density

$$C_D = 0.001\,(0.75 + 0.067\,U) \tag{24}$$

The equivalent neutral wind speed, then, is adjusted (or linearized) to a constant drag coefficient ($C_D = 0.001$) before application in the wave growth formulas:

$$U_a = U_e \sqrt{\frac{C_D}{0.001}} \tag{25}$$

Fetch Considerations

The wave growth formulations which follow are segregated into four categories: deep and shallow-water forms for both simple open-water fetches and for more complex, limiting geometries (designated "restricted fetch"). A brief discussion of fetch delineation is useful.

Open-Water Fetches

In open water, wave generation is limited by the dimensions of the subject meteorological event, and fetch widths are of the same order of magnitude as the fetch length. The simplified estimates for wave growth in open water attribute significance to the fetch length (but not width or shape). The wave growth is assumed to occur along the fetch in the direction of the wind.

Restricted Fetches

The more limiting or complex geometries of water bodies such as lakes, rivers, bays, and reservoirs have an impact on wind-wave generation. This restricted fetch methodology applies the concept of wave development in off-wind directions and considers the shape of the basin. The details of the method are reported by Smith (1991), and are based upon a concept reported by Donelan (1980) whereby the wave period (as a function of fetch lengths at off-wind directions) is maximized. For this approach, the radial fetch lengths (as measured from various points along the shoreline of the basin to the point of interest) are used to describe the geometry of the basin. In addition, the wind direction must be specified. Figure 1-1-2 illustrates the relevant geometric data required for the restricted fetch approach.

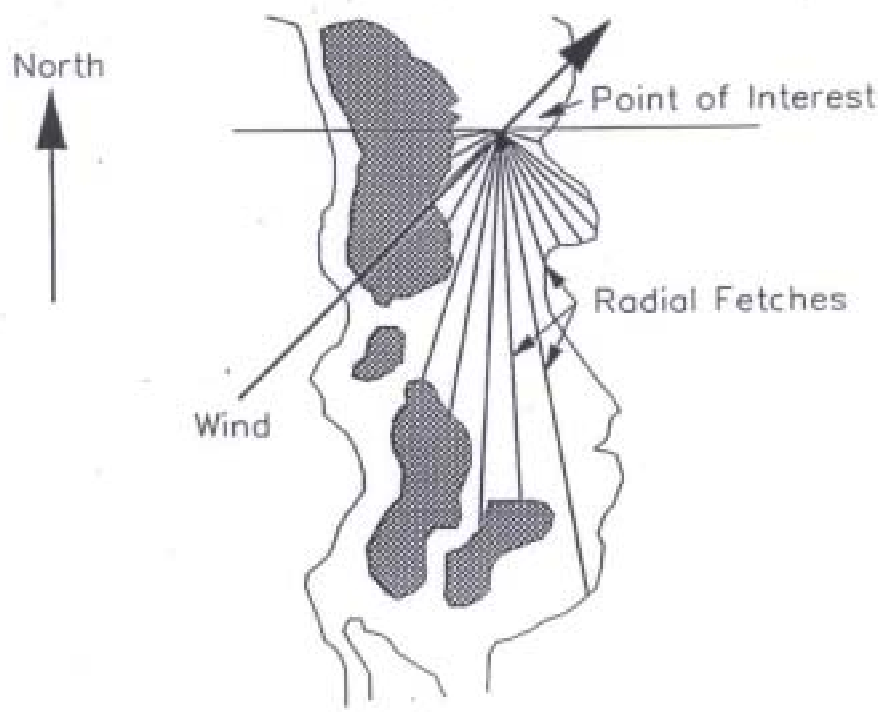

Figure 1-1-2. Restricted Fetch Geometry Data

The conventions used for specifying wind direction and fetch geometry are illustrated in Figure 1-1-3. The approach wind direction (α) as well as the radial fetch angles (β_1), and ($\Delta\beta$) should be specified in a clockwise direction from north from the point of interest where wave growth prediction is required.

From the specified radial fetch data, intermediate values are interpolated at 1-deg increments around the entire 360-deg compass. These interpolated fetches are subsequently averaged over 15-deg arcs centered at each whole 1-deg value.

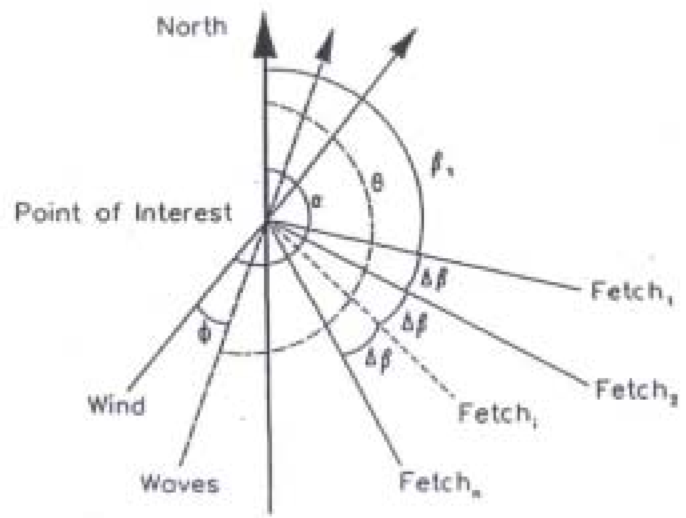

Figure 1-1-3. Restricted Fetch Conventions

The direction of wave development (θ) is solved by maximizing the product

$$F_*^{0.28} \cdot (\cos\phi)^{0.44} \tag{26}$$

This procedure maximizes the relevant terms in the expression for wave period (T_p) (Equation *36*). The angle (ϕ) is defined as the off-wind direction angle associated with the interpolated averaged fetch length value (F_*). Product results (Equation *26*) are evaluated from ($\phi = 0 \pm 90°$) at 1-deg increments. When the product (Equation *26*) is maximized, (ϕ) represents the angle between the wind and waves, and (θ) represents the compass direction from which wave development occurs along (F_*). For a specified wind direction, there will be a corresponding wave development direction where (T_p) is maximized by Equation *26*.

Deepwater Wave Growth

The formulas for wave growth in deep water encompass the effects of fetch and duration. The open-water formulas for fetch- and duration-limited wave growth are taken from Vincent (1984) and are based upon the spectrally based results given in Hasselmann et al. (1973, 1976). The fetch-limited and fully developed forms are also tabulated in the SPM (1984). The expressions for restricted fetch wave growth in deep water are from Smith (1991). In all cases, the wave growth estimates are bounded by the expressions for a fully developed equilibrium spectrum. The procedure is outlined as follows:

- Determine the minimum duration, t_{fetch}, required for a wave field to become fetch-limited:

Open Water		Restricted Fetch	
$t_{fetch} = 68.8\dfrac{F^{2/3}}{g^{1/3}U_a^{1/3}}$	(27)	$t_{fetch} = 51.09\dfrac{F^{0.72}}{g^{0.28}\bar{U}_a^{0.44}}$	(28)

- Determine the character of the wave growth (duration-limited or fetch-limited):

Open Water			Restricted Fetch	
$H = 0.0000851\left(\dfrac{U_a^2}{g}\right)\left(\dfrac{gt_l}{U_a}\right)^{5/7}$	(29)	Duration Limited	$H = 0.000103\left(\dfrac{\bar{U}_a^2}{g}\right)\left(\dfrac{gt_l}{\bar{U}_a}\right)^{0.69}$	(30)
$T = 0.0702\left(\dfrac{U_a}{g}\right)\left(\dfrac{gt_l}{U_a}\right)^{0.411}$	(31)	$(t_l < t_{fetch})$	$T = 0.082\left(\dfrac{\bar{U}_a}{g}\right)\left(\dfrac{gt_l}{\bar{U}_a}\right)^{0.39}$	(32)

--- or ---

$H = 0.0016\left(\dfrac{U_a^2}{g}\right)\left(\dfrac{gF}{U_a^2}\right)^{1/2}$	(33)	Fetch Limited	$H = 0.0015\left(\dfrac{\bar{U}_a^2}{g}\right)\left(\dfrac{gF}{\bar{U}_a^2}\right)^{1/2}$	(34)
$T = 0.2857\left(\dfrac{U_a}{g}\right)\left(\dfrac{gF}{U_a^2}\right)^{1/3}$	(35)	$(t_l \geq t_{fetch})$	$T = 0.3704\left(\dfrac{\bar{U}_a}{g}\right)\left(\dfrac{gF}{\bar{U}_a^2}\right)^{0.28}$	(36)

- Determine the "fully developed" condition:

Open Water			Restricted Fetch	
$H_{fd} = 0.2433\left(\dfrac{U_a^2}{g}\right)$	(37)	Fully Developed	$H_{fd} = 0.2433\left(\dfrac{\bar{U}_a^2}{g}\right)$	(38)
$T_{fd} = 8.134\left(\dfrac{U_a}{g}\right)$	(39)		$T_{fd} = 8.134\left(\dfrac{\bar{U}_a}{g}\right)$	(40)

- Ensure that the "fully developed" condition is not exceeded:

$$H_{m0} = \min(H, H_{fd}) \tag{41}$$

$$T_p = \min(T, T_{fd}) \tag{42}$$

where

g = acceleration due to gravity

t_t = wind duration used in duration-limited expressions

F = fetch length used in fetch-limited expressions

$\hat{U}_a = U_a \cos(\phi)$ = fetch-parallel component of U_a for restricted fetch approach

$\hat{U}_* = U_* \cos(\phi)$ = fetch-parallel component of U_* for restricted fetch approach

H = wave height determined by duration-limited or fetch-limited expressions

T = wave period determined by duration-limited or fetch-limited expressions

H_{fd} = wave height limited by fully developed spectrum criteria

T_{fd} = wave period limited by fully developed spectrum criteria

H_{m0} = final wave height determined from spectrally based methods

T_p = final wave period determined from spectrally based methods

Shallow-Water Wave Growth

Estimates for wave growth in shallow water are based upon the fetch-limited deepwater formulas, but modified to include the effects of bottom friction and percolation (Bretschneider and Reid, 1954). Water depth is assumed to be constant over the fetch. Duration-limited effects are not embodied by these formulas. The relationships have not been verified and may (or may not) be appropriate for the conditions and assumptions of the original Bretschneider-Reid work. **The expressions represent an interim method pending results of further research.** The open-water forms are also presented in the SPM (1984).

Open-Water Forms:

$$H_{m0} = \frac{U_a^2}{g} 0.283 \tanh\left[0.530\left(\frac{gd}{U_a^2}\right)^{0.75}\right] \tanh\left\{\frac{\frac{0.0016}{0.283}\left(\frac{gF}{U_a^2}\right)^{0.5}}{\tanh\left[0.530\left(\frac{gd}{U_a^2}\right)^{0.75}\right]}\right\} \tag{43}$$

$$T_p = \frac{U_a}{g} 7.54 \tanh\left[0.833\left(\frac{gd}{\hat{U}_a^2}\right)^{0.375}\right] \tanh\left\{\frac{\frac{0.2857}{7.54}\left(\frac{gF}{\hat{U}_a^2}\right)^{0.333}}{\tanh\left[0.833\left(\frac{gd}{\hat{U}_a^2}\right)^{0.375}\right]}\right\} \tag{44}$$

Restricted Fetch Forms:

$$H_{m0} = \frac{U_a^2}{g} 0.283 \tanh\left[0.530\left(\frac{gd}{U_a^2}\right)^{0.75}\right] \tanh\left\{\frac{\frac{0.0015}{0.283}\left(\frac{gF}{U_a^2}\right)^{0.5}}{\tanh\left[0.530\left(\frac{gd}{U_a^2}\right)^{0.75}\right]}\right\} \quad (45)$$

$$T_p = \frac{U_a}{g} 7.54 \tanh\left[0.833\left(\frac{gd}{U_a^2}\right)^{0.375}\right] \tanh\left\{\frac{\frac{0.3704}{7.54}\left(\frac{gF}{U_a^2}\right)^{0.28}}{\tanh\left[0.833\left(\frac{gd}{U_a^2}\right)^{0.375}\right]}\right\} \quad (46)$$

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Table III-1-2
Sediment Particle Sizes

ASTM (Unified) Classification[1]	U.S. Std. Sieve[2]	Size in mm	Phi Size	Wentworth Classification[3]
Boulder		4096.	-12.0	
		1024.	-10.0	Boulder
	12 in. (300 mm)	256.	-8.0	Large Cobble
Cobble		128.	-7.0	
		107.64	-6.75	
		90.51	-6.5	Small Cobble
	3 in. (75 mm)	76.11	-6.25	
		64.00	-6.0	
		53.82	-5.75	
		45.26	-5.5	Very Large Pebble
Coarse Gravel		38.05	-5.25	
		32.00	-5.0	
		26.91	-4.75	
		22.63	-4.5	Large Pebble
	3/4 in. (19 mm)	19.03	-4.25	
		16.00	-4.0	
		13.45	-3.75	
		11.31	-3.5	Medium Pebble
		9.51	-3.25	
Fine Gravel	2.5	8.00	-3.0	
	3	6.73	-2.75	
	3.5	5.66	-2.5	Small Pebble
	4 (4.75 mm)	4.76	-2.25	
	5	4.00	-2.0	
	6	3.36	-1.75	
Coarse Sand	7	2.83	-1.5	Granule
	8	2.38	-1.25	
	10 (2.0 mm)	2.00	-1.0	
	12	1.68	-0.75	
	14	1.41	-0.5	Very Coarse Sand
	16	1.19	-0.25	
	18	1.00	0.0	
Medium Sand	20	0.84	0.25	
	25	0.71	0.5	Coarse Sand
	30	0.59	0.75	
	35	0.50	1.0	
	40 (0.425 mm)	0.420	1.25	
	45	0.354	1.5	Medium Sand
	50	0.297	1.75	
	60	0.250	2.0	
	70	0.210	2.25	
Fine Sand	80	0.177	2.5	Fine Sand
	100	0.149	2.75	
	120	0.125	3.0	
	140	0.105	3.25	
	170	0.088	3.5	Very Fine Sand
	200 (0.075 mm)	0.074	3.75	
Fine-grained Soil:	230	0.0625	4.0	
	270	0.0526	4.25	
Clay if PI ≥ 4 and plot of PI vs. LL is on or above "A" line and the presence of organic matter does not influence LL.	325	0.0442	4.5	Coarse Silt
	400	0.0372	4.75	
		0.0312	5.0	Medium Silt
		0.0156	6.0	Fine Silt
		0.0078	7.0	Very Fine Silt
Silt if PI < 4 and plot of PI vs. LL is below "A" line and the presence of organic matter does not influence LL.		0.0039	8.0	Coarse Clay
		0.00195	9.0	Medium Clay
		0.00098	10.0	Fine Clay
		0.00049	11.0	
(PI = plasticity limit; LL = liquid limit)		0.00024	12.0	
		0.00012	13.0	
		0.000061	14.0	

[1] ASTM Standard D 2487-92. This is the ASTM version of the Unified Soil Classification System. Both systems are similar (from ASTM (1994)).
[2] Note that British Standard, French, and German DIN mesh sizes and classifications are different.
[3] Wentworth sizes (in inches) cited in Krumbein and Sloss (1963).

(7) Wave height distribution.

(a) The heights of individual waves may be regarded as a stochastic variable represented by a probability distribution function. From an observed wave record, such a function can be obtained from a histogram of wave heights normalized with the mean heights in several wave records measured at a point (Figure II-1-30). Thompson (1977) indicated how well coastal wave records follow the Rayleigh distribution. If wave energy is concentrated in a very narrow range of wave period, the maxima of the wave profile will coincide with the wave crests and the minima with the troughs. This is termed a *narrow-band condition*. Under the narrow-band condition, wave heights are represented by the following Rayleigh distribution (Longuet-Higgins 1952, 1975b, 1983)

$$p(H) = \frac{2H}{H_{rms}^2} \exp\left[-\frac{H^2}{H_{rms}^2}\right]$$
$$P(H) = 1 - \exp\left[-\frac{H^2}{H_{rms}^2}\right] \qquad \text{(II-1-130)}$$

(b) The significant wave height $H_{1/3}$ is the centroid of the area for $H > H_*$ under the density function where $H > H_*$ corresponds to waves in the highest one-third range as shown in Figure II-1-29, that is

$$P(H_*) = 1 - \frac{1}{3} = 1 - e^{\left(-\frac{H_*^2}{H_{rms}^2}\right)} \qquad \text{(II-1-131)}$$

from which we find $H_* = 1.05 H_{rms}$. Various estimates of wave heights may then be obtained upon integration of the above equation using certain mathematical properties of the Error function (Abramowitz and Stegun 1965). We find

$$\begin{aligned} H_{1/3} &= 4.00 \sqrt{m_0} = 1.416\ H_{rms} \\ H_{1/10} &= 1.27\ H_{1/3} = 1.80\ H_{rms} = 5.091 \sqrt{m_0} \\ H_{1/100} &= 1.67\ H_{1/3} = 2.36\ H_{rms} = 6.672 \sqrt{m_0} \\ H_{max} &= 1.86\ H_{1/3} \quad \textit{(for 1000 wave cycles in the record)} \end{aligned} \qquad \text{(II-1-132)}$$

(c) The *most probable maximum wave height* in a record containing N waves is related to the rms wave height (Longuet-Higgins 1952) by

$$H_{max} = \left[\sqrt{\log N} + \frac{0.2886}{\sqrt{\log N}} - \frac{0.247}{(\log N)^{3/2}}\right] H_{rms} \qquad \text{(II-1-133)}$$

To: [illegible]
From: Orison Smith, 7/18/02

remedial efforts that may be necessary. Or the model may then be run to evaluate proposed modifications of the harbor.

An alternative is to run more extensive field studies as the sole effort to evaluate conditions at a harbor. This would generally be more costly than the hybrid field-model approach, but it may provide some detail that can not be achieved from model studies alone.

Also, field studies have been done to support the general development of physical and numerical modelling techniques for the study of harbor flushing and circulation.

Field measurements include those that define the hydrodynamics of a harbor and supplementary measurements to quantify harbor flushing. The former include measurements of tide levels inside and outside of the harbor, current velocity measurements at the entrance to quantify flow rates into and out of the harbor, and flow velocity measurements throughout the harbor and/or drogue studies to define circulation patterns in the harbor. If tidal flushing is the primary concern, these measurements would be conducted on days when the wind velocity is low. Otherwise, a directional anemometer would also be used to measure the wind speed and direction.

To determine exchange coefficients throughout the harbor and the harbor's flushing efficiency, the harbor would be uniformly seeded with a harmless detectable solute such as a fluorescent dye and then sampled periodically at several points in the harbor for a period of several tidal cycles. The initial and subsequent dye concentrations (see Eq. II-7-20) can be measured in situ by a standard fluorometer. The dye Rhodamine WT has been used in a number of harbor flushing studies. (see Callaway 1981; Schwartz and Imberger 1988).

II-7-7. Vessel Interactions

a. Vessel-Generated Waves. As a vessel travels across the water surface a variable pressure distribution develops along the vessel hull. The pressure rises at the bow and stern and drops along the midsection. These pressure gradients, in turn, generate a set of waves that propagate out from the vessel bow and another generally lower set of waves that propagate out from the vessel stern. The heights of the resulting waves depend on the vessel speed, the bow and stern geometry, and the amount of clearance between the vessel hull and channel bottom and sides. The period and direction of the resulting waves depend only on the vessel speed and the water depth. For a detailed discussion of the vessel wave generating process and the resulting wave characteristics see Robb (1952), Sorensen (1973a, 1973b), and Newman (1978).

The pattern of wave crests generated at the bow of a vessel that is moving at a constant speed over deep water is depicted in Figure II-7-40. There are symmetrical sets of *diverging* waves that move obliquely out from the vessel's sailing line and a set of *transverse* waves that propagate along the sailing line. The *transverse* and *diverging* waves meet along the cusp locus lines that form an angle of 19°28' with the sailing line. The largest wave heights are found where the *transverse* and *diverging* waves meet. If the speed of the vessel is increased, this wave crest pattern retains the same geometric form but expands in size as the individual wave lengths (and periods) increase.

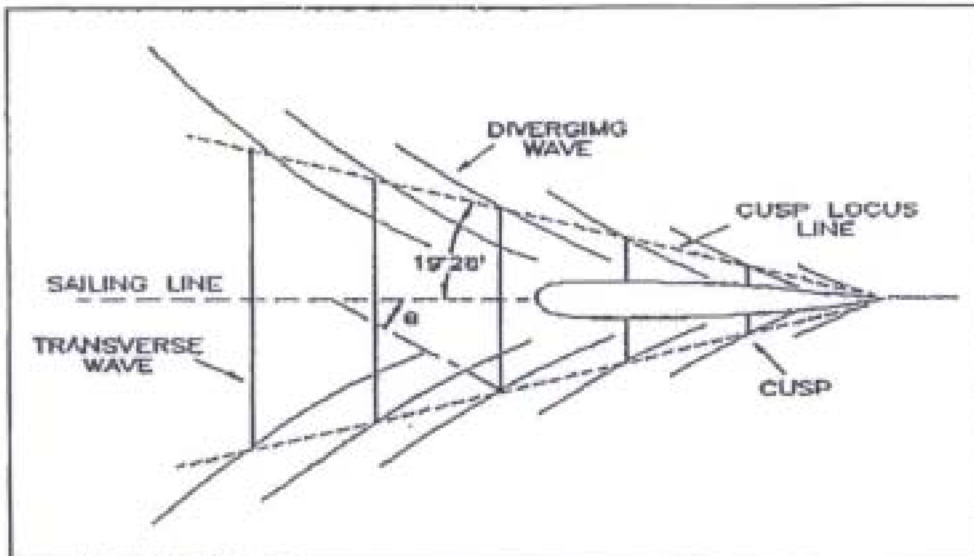


Figure II-7-40. Wave crest pattern generated at a vessel bow moving over deep water

The fixed pattern of wave crests requires that the individual wave celerities C be related to the vessel speed V_s by

$$C = V_s \cos\theta \qquad \text{(II-7-21)}$$

where θ is the angle between the sailing line and the direction of wave propagation (Figure II-7-40). Thus, the *transverse* waves travel at the same speed as the vessel and, in deep water, θ has a value of 35°16' for the *diverging* waves.

The increasing distances from the vessel, diffraction causes the wave crest lengths to continually increase and the resulting wave heights to continually decrease. It can be shown (Havelock 1908) that the wave heights at the cusp points decrease at a rate that is inversely proportional to the cube root of the distance from the vessel's bow (or stern). The *transverse* wave heights at the sailing line decrease at a rate proportional to the square root of the distance aft of the bow (or stern). Consequently, the *diverging* waves become more pronounced with distance from the vessel.

The above discussion applies to deep water, i.e. water depths where the particle motion in the vessel-generated waves does not reach to the bottom. This condition holds for a Froude number less than approximately 0.7, where the Froude number F is defined by

$$F = \frac{V_s}{\sqrt{gd}} \qquad \text{(II-7-22)}$$

As the Froude number increases from 0.7 to 1.0, wave motion is affected by the water depth and the wave crest pattern changes. The cusp locus line angle increases from 19°28' to 90° at a Froude number of one. The *diverging* wave heights increase more slowly than do the *transverse* wave heights, so the latter become more prominent as the Froude number approaches unity. At a Froude number of one, the *transverse* and *diverging* waves have coalesced and are oriented with their crest perpendicular to the sailing line. Most of the wave energy is concentrated in a single large wave at the bow. Owing to propulsion limits (Schofield 1974) most self-propelled vessels can only operate at maximum Froude numbers of about 0.9. Also, as a vessel's speed increases, if the vessel is sufficiently light (i.e. has a shallow draft), hydrodynamic lift may cause the vessel to plane so that there is no significant increase in the height of generated waves for vessel speeds in excess of the speed when planing commences.

For harbor design purposes, one would like to know the direction, period and height of the waves generated by a design vessel moving at the design speed. For Froude numbers up to unity, Weggel and Sorensen (1986) show that the direction of wave propagation θ(in degrees) is given by

$$\theta = 35.27\ (1 - e^{12(F-1)}) \tag{II-7-23}$$

Then, from Eq. II-7-21 the *diverging* wave celerity can be calculated, and the wave period can be determined from the linear wave theory dispersion equation.

EXAMPLE PROBLEM II-7-6

FIND:

The period of the *diverging* waves generated by the vessel.

GIVEN:

A vessel is moving at a speed of 10 knots (5.157 meters/second) over water 5 meters deep.

SOLUTION:

The vessel Froude number is

$$F = \frac{5.157}{\sqrt{9.81\ (5)}} = 0.73$$

so Eq. II-7-23 gives a direction of propagation

$$\theta = 35.27\ [1 - e^{12(0.73-1)}] = 33.88°$$

and Eq. II-7-21 gives a wave celerity

$$C = 5.157\ \cos(33.88°) = 4.28\ m/s$$

The linear wave dispersion equation can be written

$$C = \frac{gT}{2\pi} \tanh \frac{2\pi d}{CT}$$

Inserting known values for C,g and d into the dispersion equation leads to a trial solution for T which is found to be 2.8 seconds. This is a typical period for vessel-generated waves and demonstrates why floating breakwaters are usually effective in protecting against vessel waves.

The typical wave record produced by a moving vessel is shown in Figure II-7-41. Most field and laboratory investigations of vessel-generated waves (Sorensen and Weggel 1984; Weggel and Sorensen 1986) report the maximum wave height (H_m see Figure II-7-41) as a function of vessel speed and type, water depth, and distance from the sailing line to where the wave measurement was made. Table II-7-5 (from Sorensen 1973b) provides a tabulation of selected H_m values for a range of vessel characteristics and speeds at different distances from the sailing line. These data are given to indicate the range of typical wave heights that might occur for common vessels and that vessel speed is more important than vessel dimensions in determining the height of the wave generated.

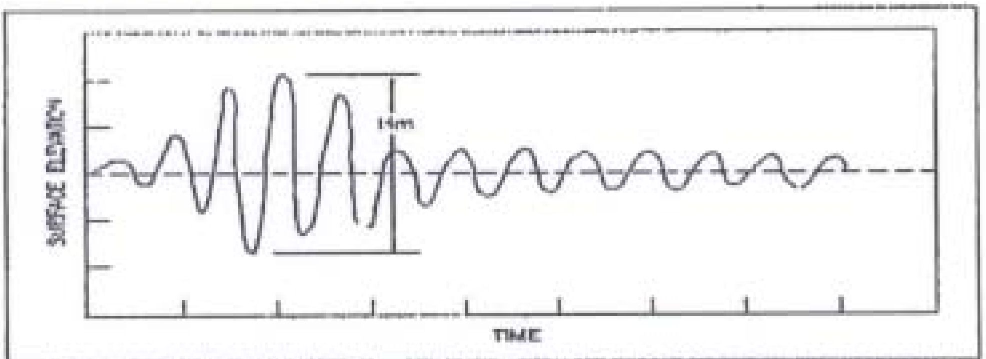


Figure II-7-41. Typical vessel-generated wave record

Table II-7-5
Selected Vessel-Generated Wave Heights (Sorensen 1973b)

Vessel	Speed (m/s)	H_m(m) @30m	H_m(m) @150m
Cabin Cruiser length-7.0m beam-2.5m draft-0.5m	3.1 5.1	0.3 0.4	0.1 0.2
Coast Guard Cutter length-12.2m beam-3.0m draft-1.1m	3.1 5.1 7.2*	0.2 0.5 0.7	0.3
Tugboat length-13.7m beam-4.0m draft-1.8m	3.1 5.1	0.3 0.5	0.1 0.3
Air-Sea Rescue Vessel length-19.5m beam-3.9m draft-0.9m	3.1 5.1 7.2*	0.1 0.4 0.6	0.2 0.3
Fireboat length-30.5m beam-8.5m draft-3.4m	3.1 5.1 7.2	0.1 0.5 0.9	0.1 0.3 0.6
Tanker length-153.6m beam-20.1m draft-8.5m	7.2 9.3		0.5 1.6

Note: The above data are from tests conducted at water depths ranging from 11.9 to 12.8 meters.
* denotes that the vessel was starting to plane.

A number of quasi-empirical procedures for predicting vessel-generated wave heights have been published (Sorensen 1986; Sorensen 1989 for a summary). Most procedures are restricted to a certain class or classes of vessels and specific channel conditions. A comparison (Sorensen 1989) of predicted H_m values for selected vessel speeds and water depths showed a significant variation among the results predicted by the various procedures. The best approach for design analyses appears to be to review the published vessel wave measurement data to compare with the vessel, vessel speed and channel conditions that most closely approach the design condition and select a conservative value of H_m from these data. If this is not possible, then the values in Table II-7-5 can be used as a rough estimate for the different types of vessels.

b. Vessel motions.

(1) Response to waves. Wave action will excite a floating vessel to oscillate in one or more of six components of motion or degrees of freedom. These are translation in the three coordinate directions (surge, sway and heave) and rotation around the three principal axes (roll, pitch and yaw). Which of these motion components is excited and to what extent depends primarily on the direction of wave incidence relative to the primary vessel axes and on the incident wave frequency spectrum compared to the resonant frequencies of the six motion components (Wehausen 1971). If the vessel is moored, the arrangement of the mooring lines and their taughtness will influence the resonant periods and the response amplitudes of the vessel motions. If the vessel is moving, the effective or encounter period of wave agitation is the wave period relative to the ship rather than to a fixed observation point. Wave mass transport will also cause a slow drift of the vessel in the direction of wave propagation.

Small vessels, such as the recreational vessels found in marinas, will commonly respond to shorter wind-wave periods. An analytical study coupled with some field measurements for seven small boats (Raichlen 1968) indicated that the periods of free oscillation were less than ten seconds. Larger sea-going deep-draft vessels, depending on the oscillation mode being excited, will respond to the entire range of wind-wave periods. Field measurements by van Wyk (1982) on ships having lengths around 250 to 300 m and beams around 40 m found maximum roll and pitch responses at encounter periods between 10 and 12 seconds. By proper design of the mooring system, the periods and amplitudes of vessel motion can be significantly modified.

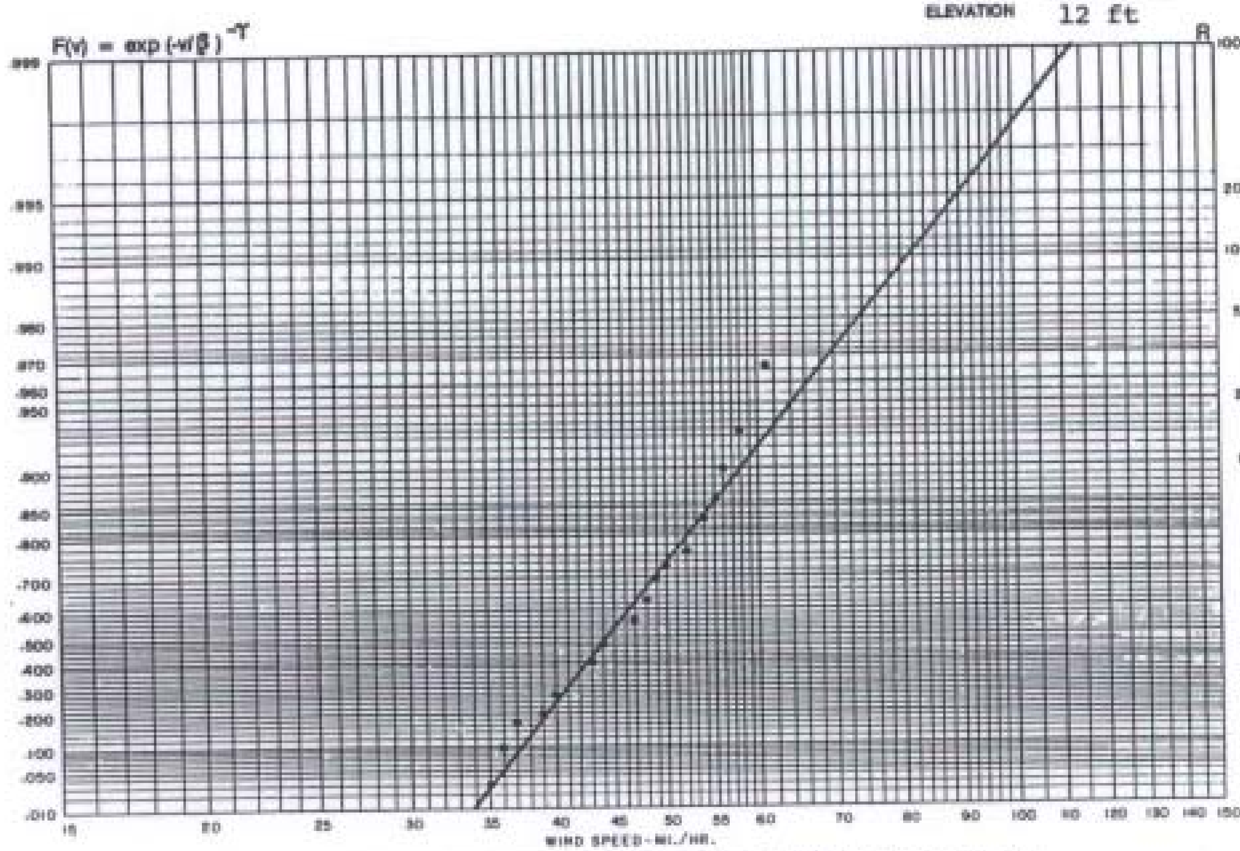
The wave-induced lateral and vertical motions of the design vessel will affect the required channel horizontal and depth dimensions respectively. The problem of wave-induced vessel oscillations has been addressed by analytical/numerical means (Anderson 1979; Madsen, et al. 1980, and Isaacson and Mercer 1982). These efforts usually employ small amplitude monochromatic waves and some limitations on vessel geometry and the incident wave directions relative to the vessel.

Some field measurement programs have been made that yield valuable design information. Wang and Noble (1982) describe an investigation of vessels entering the Columbia River

FIGURE 9

JUNEAU

LATITUDE	58 22'N
LONGITUDE	134 35'W
ELEVATION	12 ft



MAXIMUM-VALUE PROBABILITY PAPER, FISHER-TIPPET TYPE II DISTRIBUTION

$\bar{v}$ = 46.4 σ^2 = 63.2 σ = 8.0

μ = 36 β = 42 γ = 6.9

PERIOD OF RECORD: 1949-1978

EXTREME VALUE PREDICTIONS IN MILES PER HOUR

	RETURN PERIOD IN YEARS					
	25	50	100	250	500	1000
WIND ESTIMATE	66.8	73.9	81.8	93.5	103.4	114.3

"Extreme Wind Prediction for First Order Weather stations in AK"
Arctic Environment Information and Data Center, UAF,
Alaska Climate Center Technical Note #1 1984

Chance of exceedance

Return Period	Probability	Chance of happening during a given number of years									
		1	2	5	10	20	25	50	100	200	500
2	50%	50%	75%	97%	100%	100%	100%	100%	100%	100%	100%
3	33%	33%	56%	87%	98%	100%	100%	100%	100%	100%	100%
4	25%	25%	44%	76%	94%	100%	100%	100%	100%	100%	100%
5	20%	20%	36%	67%	89%	99%	100%	100%	100%	100%	100%
6	17%	17%	31%	60%	84%	97%	99%	100%	100%	100%	100%
7	14%	14%	27%	54%	79%	95%	98%	100%	100%	100%	100%
8	13%	13%	23%	49%	74%	93%	96%	100%	100%	100%	100%
9	11%	11%	21%	45%	69%	91%	95%	100%	100%	100%	100%
10	10%	10%	19%	41%	65%	88%	93%	99%	100%	100%	100%
20	5%	5%	10%	23%	40%	64%	72%	92%	99%	100%	100%
25	4%	4%	8%	18%	34%	56%	64%	87%	98%	100%	100%
50	2.0%	2.0%	4.0%	10%	18%	33%	40%	64%	87%	98%	100%
100	1.0%	1.0%	2.0%	4.9%	10%	18%	22%	39%	63%	87%	99%
200	0.5%	0.5%	1.0%	2.5%	4.9%	10%	12%	22%	39%	63%	92%
500	0.2%	0.2%	0.4%	1.0%	2.0%	3.9%	4.9%	10%	18%	33%	63%
1,000	0.1%	0.1%	0.2%	0.5%	1.0%	2.0%	2.5%	4.9%	10%	18%	39%
10,000	0.01%	0.01%	0.02%	0.05%	0.1%	0.2%	0.2%	0.5%	1.0%	2.0%	4.9%
100,000	0.001%	0.001%	0.002%	0.005%	0.01%	0.02%	0.02%	0.05%	0.1%	0.2%	0.5%
1,000,000	0.0001%	0.0001%	0.0002%	0.0005%	0.001%	0.002%	0.002%	0.005%	0.01%	0.02%	0.05%

$J = 1 - (1-p)^n$

where J = probability of occurence in period
P = probability of occurence in a given year
N = Number of years in a period

Peratrovich, Nottingham & Drage, Inc.
Engineering Consultants
1506 West 36th Avenue Anchorage, Alaska 99503 (907) 561-1011 Fax (907) 563-4220

Memorandum

To: File Project No.: 02056.02

From: Jennifer Wilson Date: October 3, 2002

Re: *Areas Identified for Detailed Study*

Project: Glacier Bay National Park and Preserve Vessel Quotas and Operating Requirements Environmental Impact Statement, Appendix F Technical Memorandum

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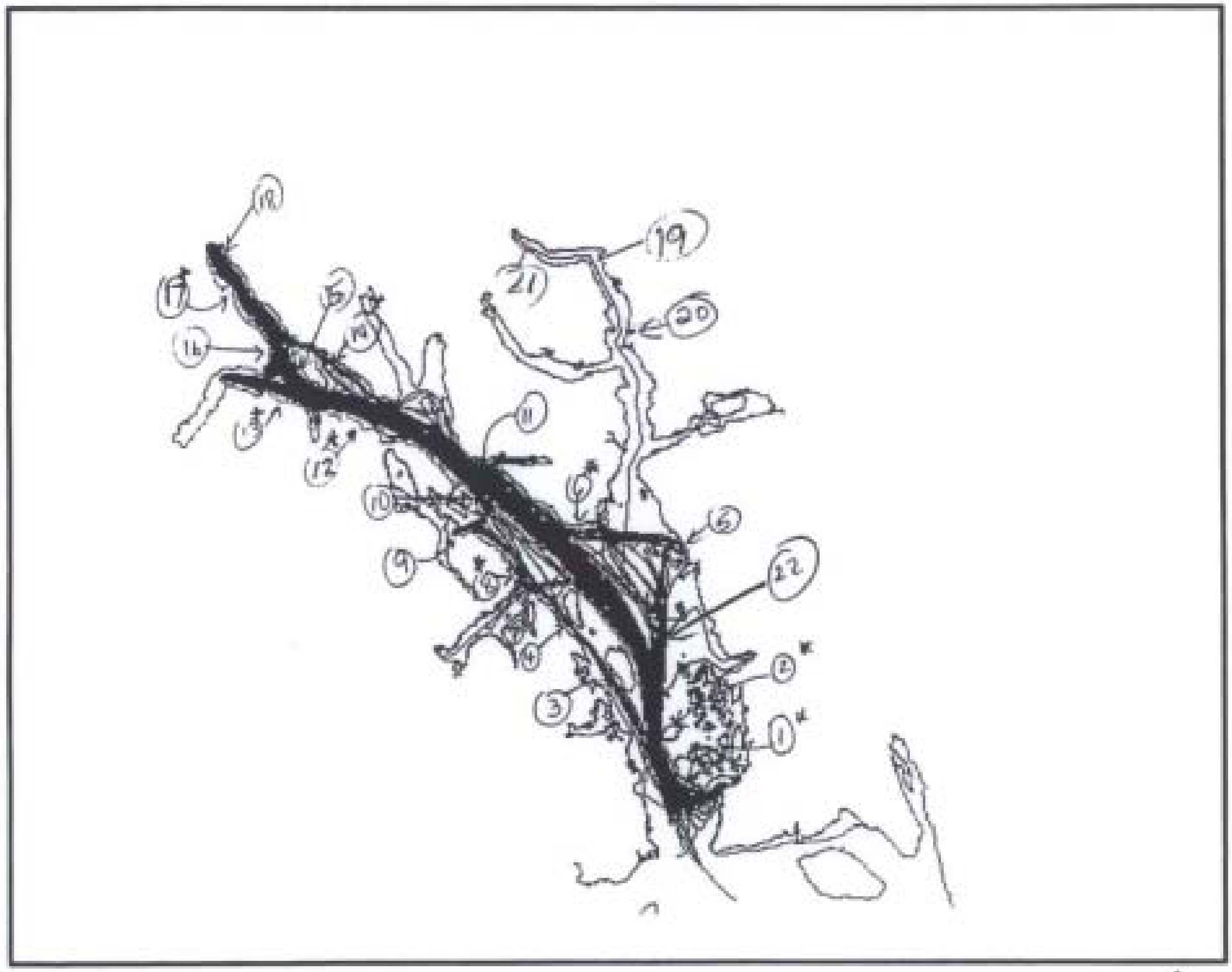
The attached document, *Areas Identified for Detailed Study*, provides the maps and data used to determine the sites where vessel traffic was within 2,000 feet of shore. This may be due to channel constriction or operation decisions. The attachment includes several maps with vessel track information.

ESRI ArcExplorer 2.0

Vessel Traffic



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Friday, Jul 12 2002

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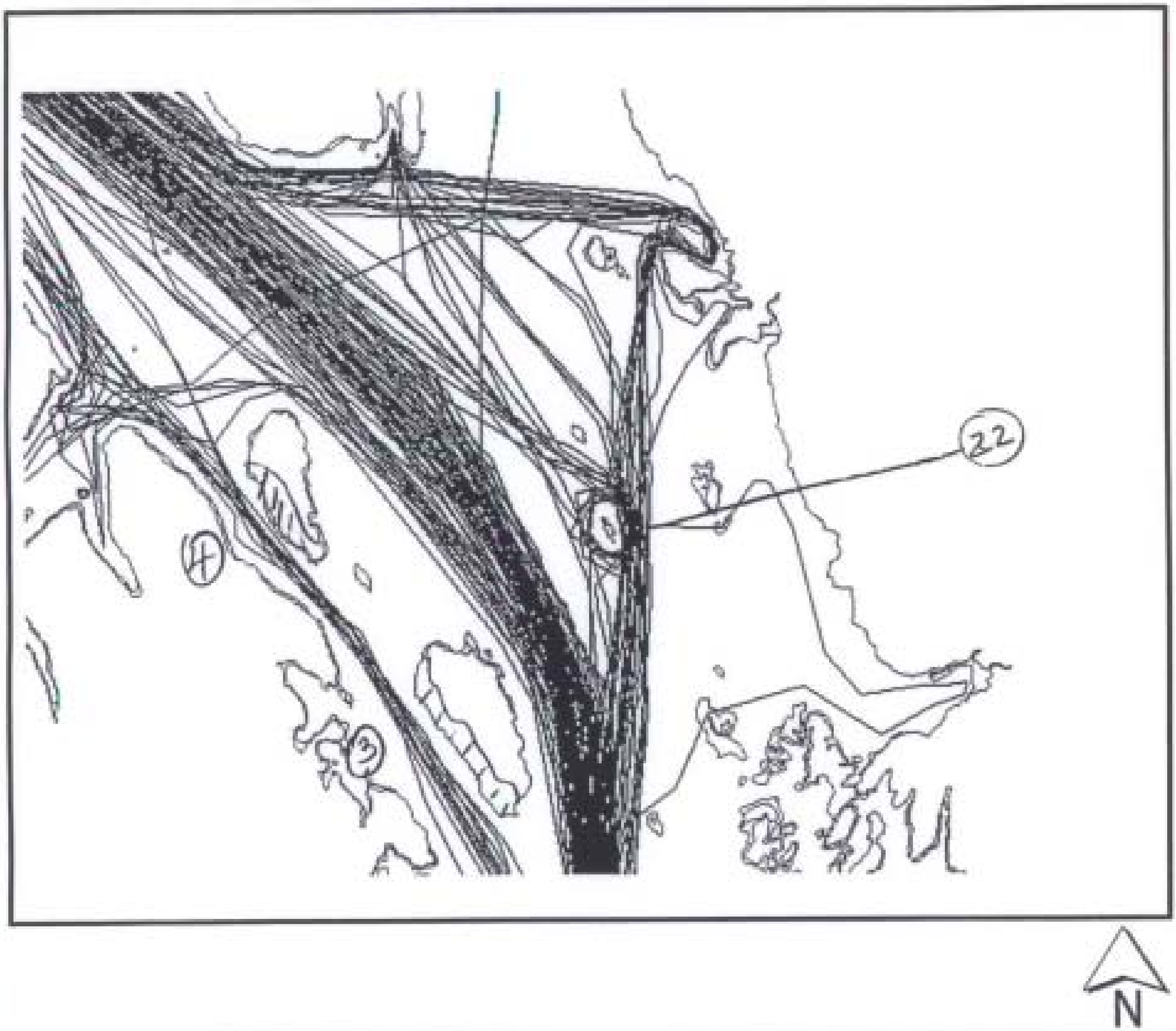
Sitadaday Narrows

Friday, Jul 12 2002

ESRI ArcExplorer 2.0

Whidbey Passage



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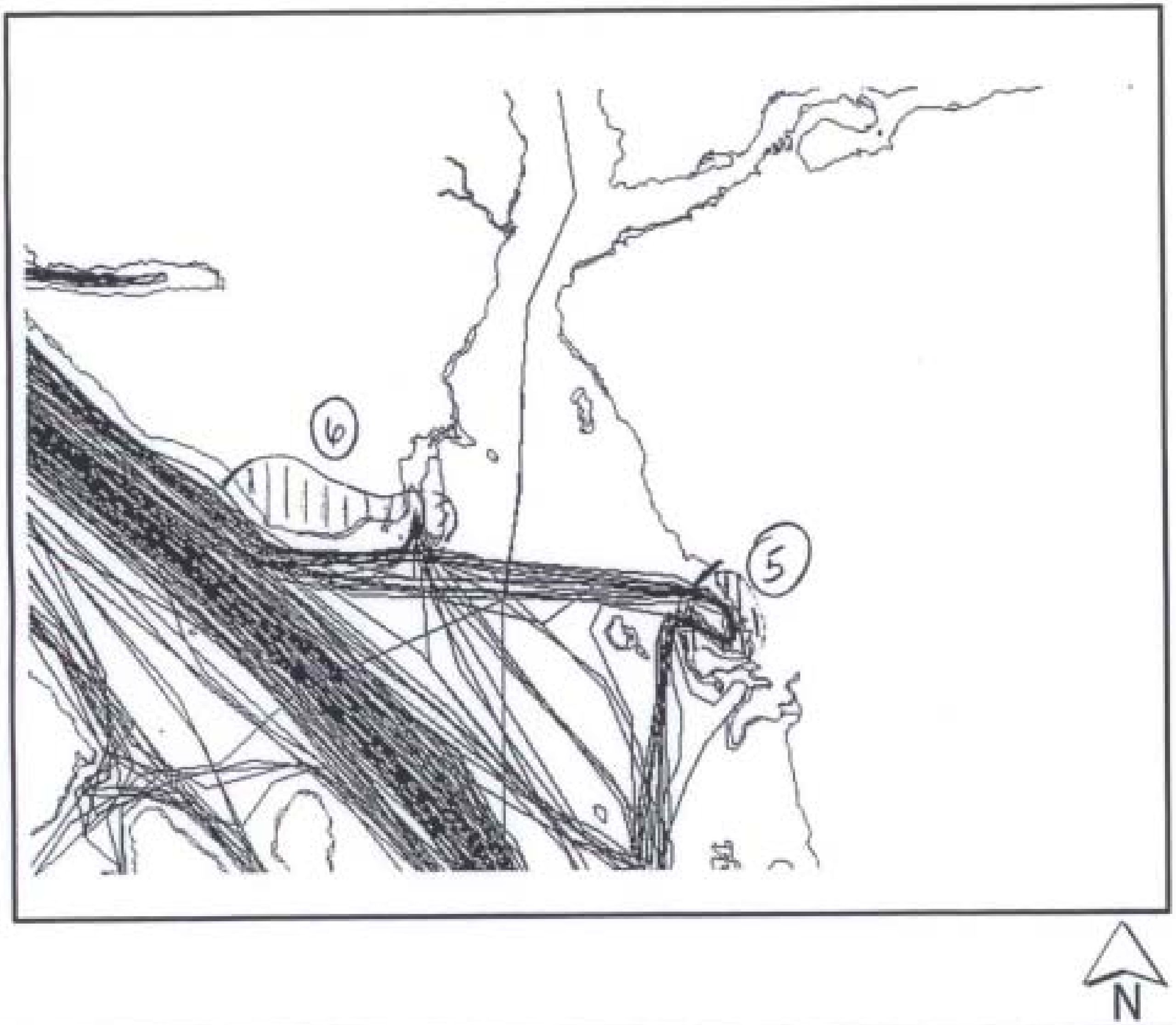
Lower Muir Inlet



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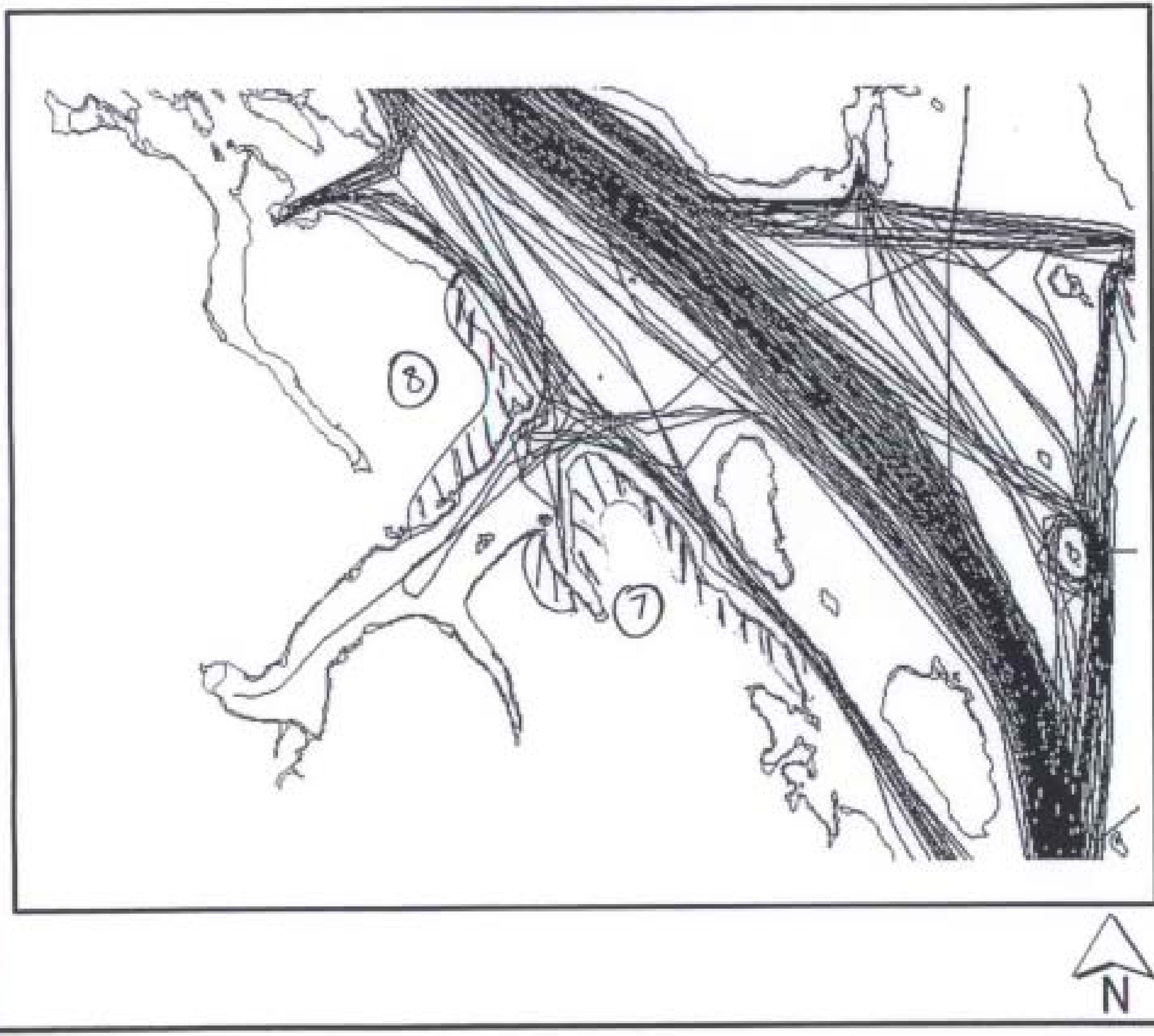
Geikie Inlet



Friday, Jul 12 2002

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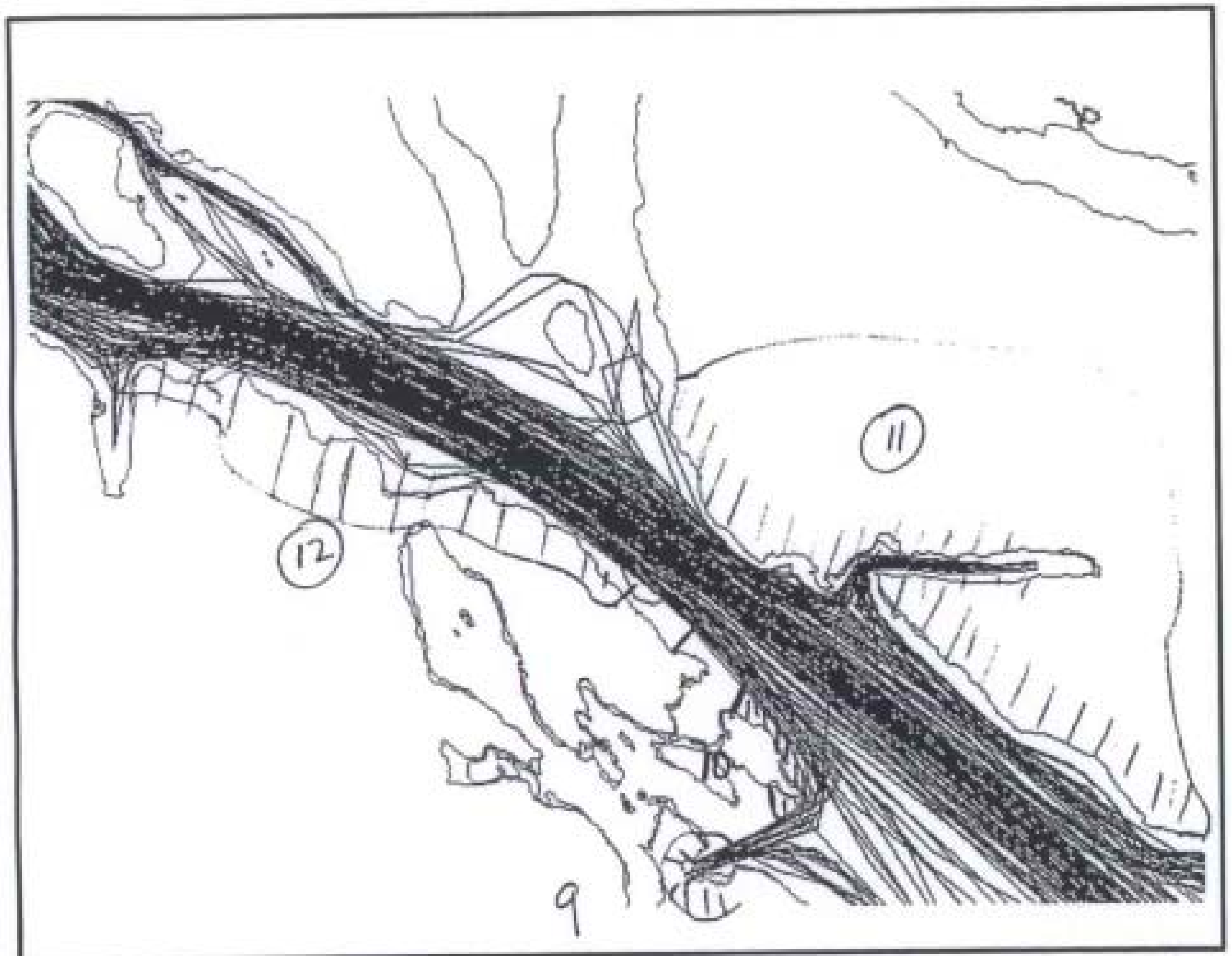
Tidal Inlet



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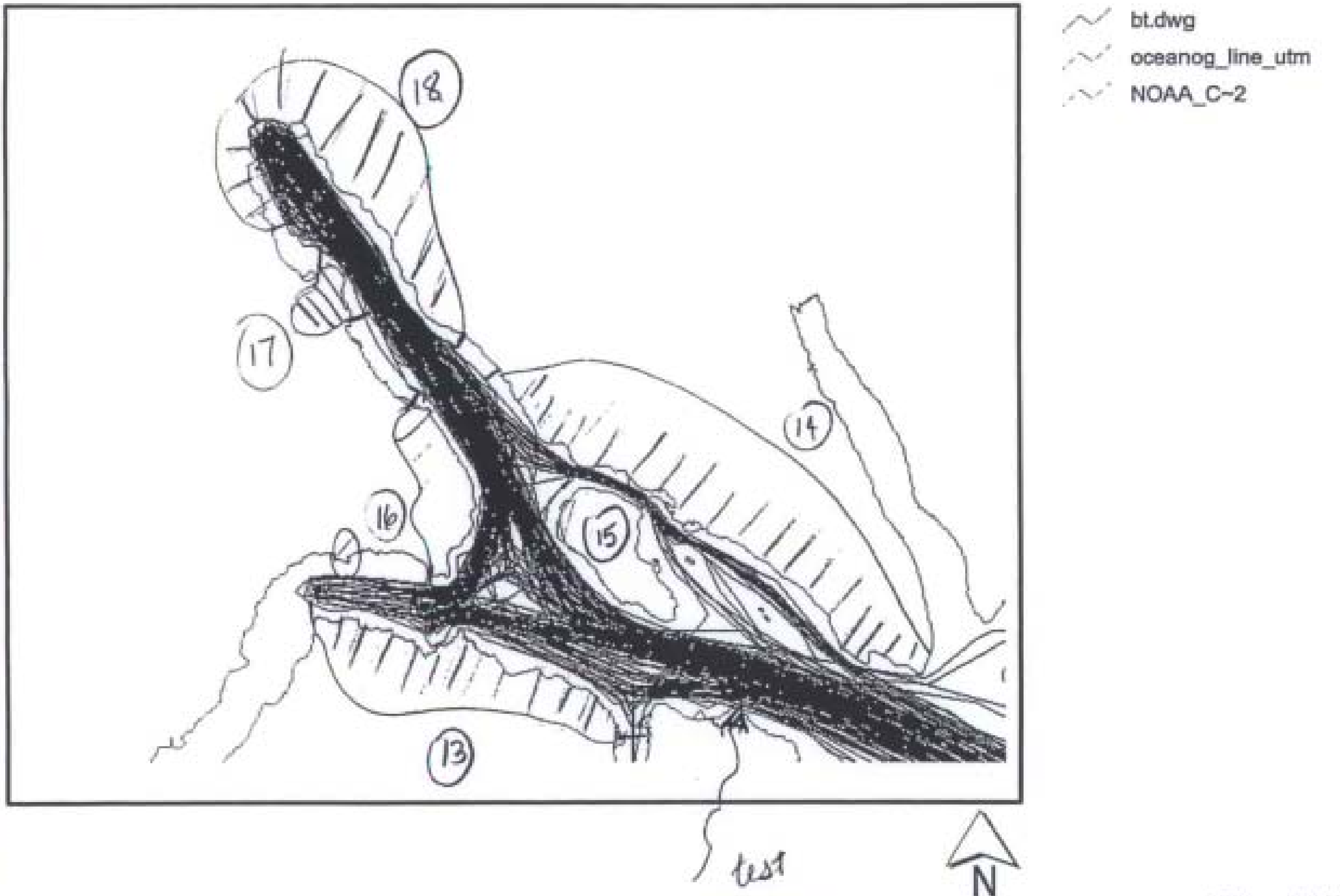
Friday, Jul 12 2002

ESRI ArcExplorer 2.0

Tarr Inlet



Friday, Jul 12 2002

Peratrovich, Nottingham & Drage, Inc.
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1506 West 36th Avenue Anchorage, Alaska 99503 (907) 561-1011 Fax (907) 563-4220

Memorandum

To: File Project No.: 02056.02

From: Jennifer Wilson Date: October 3, 2002

Re: *Example Calculations*

Project: Glacier Bay National Park and Preserve Vessel Quotas and Operating Requirements Environmental Impact Statement, Appendix F Technical Memorandum

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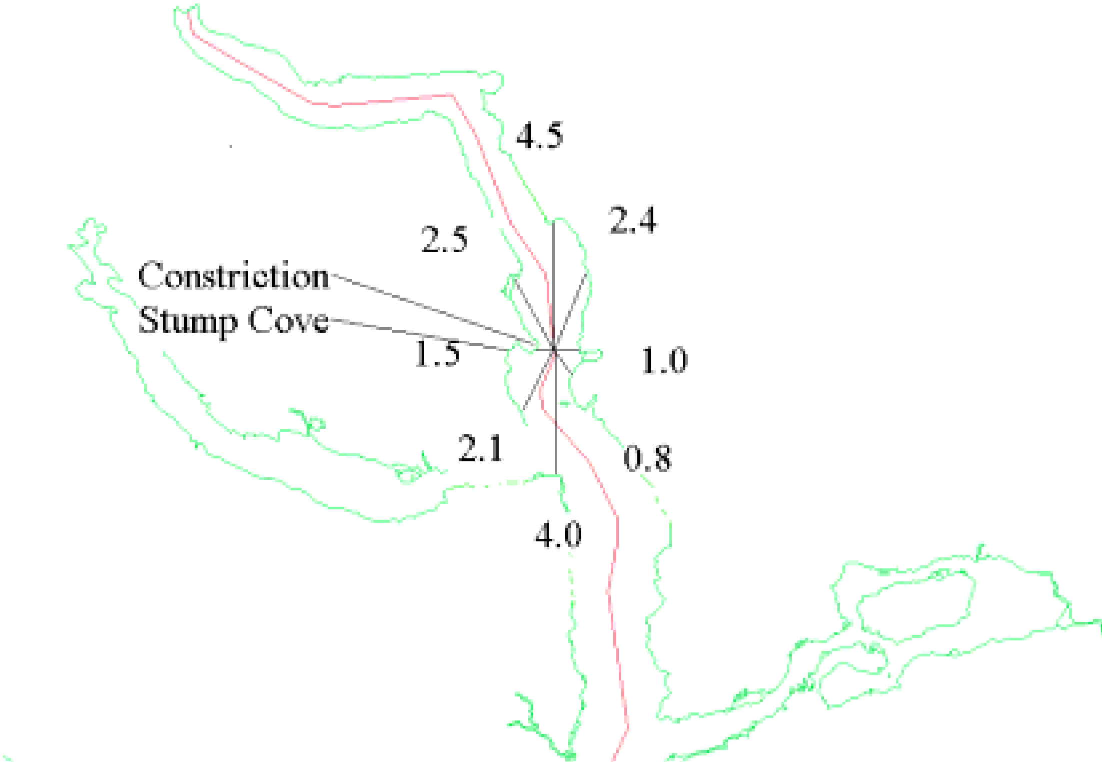
The attached document, *Example Calculations*, provides example calculations on vessel wake energy for Site 11 and Site 20 in Glacier Bay proper. These calculations use the 1996 vessel use-days under Alternative 1 (No Action Alternative).

Example Calculation 1. Upper Muir Inlet

Winds from 50 degrees



Site 20. Stump Cove near Muir Inlet, fetch distances in miles.

From the wind analysis, there are three categories of wind with values for direction 50 degrees, and the following probablilities of occurence in each category.

Category 1: 1 to 9.999 knots with probability of occurence of 5.6%
Category 2: 10 to 19.999 knots with probability of occurence of 0.34%
Category 3: 20 to 29.999 knots with probability of occurence of 0.0034%

$P_1 := 0.056237$

$P_2 := 0.003371$

$P_3 := 0.000034$

For the fetch shown in the drawing above, using CEDAS for restricted open water fetches, the wind direction of 50 degrees, a duration of 1 hour, the average wind velocity of 5 knots, we find that a significant wave of height 0.13 foot will be generated with a significant period of 0.8 sec.

With the average wind velocity of 15 knots, we find that a significant wave height of 0.68 feet with the significant wave period of 1.7 sec will be generated.

With the average wind velocity of 25 knots, we find that a significant wave height of 1.33 feet with the significant wave period of 2.27 sec will be generated.

The general direction of the waves are 52 degrees in both instances and the shorelines affected will be oriented perpendicular to this direction.

$H_{MO1} := 0.13 \qquad T_{P1} := 0.8s$

$H_{MO2} := 0.68 \qquad T_{P2} := 1.7s$

$H_{MO3} := 1.33 \qquad T_{P3} := 2.27s$

The expected number of waves in an hourly wind event:

$$E_1 := \frac{1}{T_{P1}} \cdot 60 \frac{sec}{min} \cdot 60 \frac{min}{hr} \qquad E_1 = 4.5 \times 10^3\, hr^{-1}$$

$$E_2 := \frac{1}{T_{P2}} \cdot 60 \frac{sec}{min} \cdot 60 \frac{min}{hr} \qquad E_2 = 2.118 \times 10^3\, hr^{-1}$$

$$E_3 := \frac{1}{T_{P3}} \cdot 60 \frac{sec}{min} \cdot 60 \frac{min}{hr} \qquad E_3 = 1.586 \times 10^3\, hr^{-1}$$

Two shores most directly affected by the wind from 50 degrees are labeled as Beach A and Beach B in the figure below.

If Beach A were directly perpendicular to the direction of the waves generated by the 50 degree wind in this fetch, the energy from the 50 degree winds can be seen to be proportional to $n_1 + n_2$ where:

$$n_1 := H_{MO1}{}^2 \cdot P_1 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_1 \qquad n_1 = 3.746 \times 10^4\, yr^{-1}$$

$$n_2 := H_{MO2}{}^2 \cdot P_2 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_2 \qquad n_2 = 2.892 \times 10^4\, yr^{-1}$$

$$n_3 := H_{MO3}{}^2 \cdot P_3 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_3 \qquad n_3 = 835.532\, yr^{-1}$$

Where the term $(P_1(24)\ 365\ hr/yr)E_1$ represents the expected value of the number of hourly wind events per year. The n_i's represent the energy from the waves generated by wind in this one direction predicted by linear wave theory.

Beach A will be affected only by winds from 50 degrees and from 340 degrees, as the following analysis shows. Furthermore, wave energies directly perpendicular to shore must be calculated.

Since Beach A is not directly perpendicular to the direction of the waves, the values n_1, n_2 and n_3 must be multiplied by the sin of the angle between the beach and the wave ray to get the component or part of the energy which is directed perpendicular to the beach. The energy directed parallel to shore is not added into the calculation. Wind wave energy parallel to shore adds to the longshore sediment transport, as does tidal energy.

The approximate azimuth of Beach A is 329 degrees. The waves generated by 50 degree winds in this particular fetch will have a propagation direction of 52 degrees. The angle between the beach face and the wave ray is thus 360-329+52 or 83 degrees.

The energy perpendicular to shore from these waves is thus found from:

$\theta := 83\text{deg}$

$$n_1 := H_{MO1}{}^2 \cdot P_1 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_1 \cdot \sin(\theta) \qquad n_1 = 3.719 \times 10^4\, yr^{-1}$$

$$n_2 := H_{MO2}{}^2 \cdot P_2 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_2 \cdot \sin((\theta)) \qquad n_2 = 2.87 \times 10^4\, yr^{-1}$$

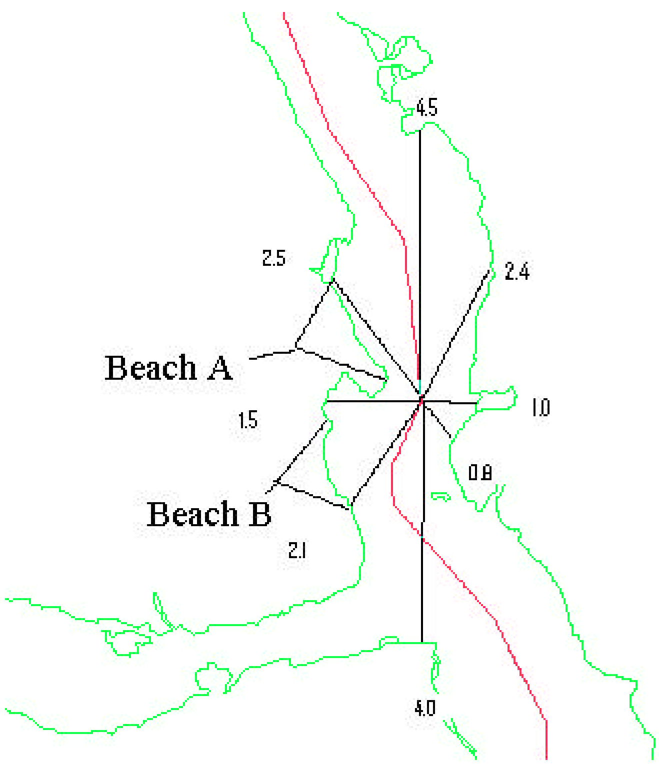
$$n_3 := H_{MO3}{}^2 \cdot P_3 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_3 \cdot \sin((\theta)) \qquad n_3 = 829.304\, yr^{-1}$$

Let the total energy per year perpendicular to Shore A due to waves from winds coming from 50 degrees be

$$E_{50} := n_1 + n_2 + n_3 \qquad E_{50} = 6.672 \times 10^4\, yr^{-1}$$

To complete the analysis, this process is repeated for the other wind directions.

Winds from 130 deg



Beaches in Site 20. Two of the Beaches Analyzed in Site 20.

Beach A, may be affected by winds from 130 degrees, with the same limited fetch. It is necessary to use ACES to determine the direction of the waves that winds from 130 degrees will produce in this fetch. In general, a fetch modifies the wave direction.

The direction of the waves according to ACES is 170 degrees. Since θ=360-329+170=201. These waves will not be incident on Beach A.

Winds from 200, 260 and 340 deg

Wind directions 200, 260 and 340 produce waves in this fetch of incident angles 185, 245 and 353, according to ACES with the fetch in Upper Muir Inlet near Stump Cove. Of these, only the last wind direction will affect Beach A and

$\theta := (353 - 329)\text{deg} \qquad \theta = 24\,\text{deg}$

Site 20 Beach A is sheltered by the topography and coastal features of the site from wave attack in the other directions.

From the wind analysis, there are three categories of wind with values for direction 340 degrees, and the following probablilities of occurence in each category.

Category 1: 1 to 9.999 knots with probability of occurence of 18.07% $\quad P_1 := .180695$

Category 2: 10 to 19.999 knots with probability of occurence of .9195% $\quad P_2 := .009195$

Category 3: 20 to 29.999 knots with probability of occurence of 0.009% $\quad P_3 := 0.000009$

For the fetch shown in the drawings above, using CEDAS for restricted open water fetches, the wind direction of 340 degrees, a duration of 1 hour, the average wind velocity of 5 knots, we find that a significant wave of height 0.13 foot will be generated with a significant period of 0.79 sec.

With the average wind velocity of 15 knots, we find that a significant wave height of .66 feet with the significant wave period of 1.69 sec will be generated.

With the average wind velocity of 25 knots, we find that a significant wave height of 1.49 feet with a significant wave period of 2.47 sec will be generated.

The general direction of the waves are 353 degrees. θ=24 deg

$H_{MO1} := 0.13 \qquad T_{P1} := 0.79\text{s}$

$H_{MO2} := 0.66 \qquad T_{P2} := 1.69\text{s}$

$H_{MO3} := 1.49 \qquad T_{P3} := 2.47\text{s}$

The expected number of waves in an hourly wind event:

$$E_1 := \frac{1}{T_{P1}} \cdot 60\frac{\text{sec}}{\text{min}} \cdot 60\frac{\text{min}}{\text{hr}} \qquad E_1 = 4.557 \times 10^3\,\text{hr}^{-1}$$

$$E_2 := \frac{1}{T_{P2}} \cdot 60\frac{\text{sec}}{\text{min}} \cdot 60\frac{\text{min}}{\text{hr}} \qquad E_2 = 2.13 \times 10^3\,\text{hr}^{-1}$$

$$E_3 := \frac{1}{T_{P3}} \cdot 60\frac{\text{sec}}{\text{min}} \cdot 60\frac{\text{min}}{\text{hr}} \qquad E_3 = 1.457 \times 10^3\,\text{hr}^{-1}$$

$\theta := 24\text{deg}$

$$m_1 := H_{MO1}{}^2 \cdot P_1 \cdot 24 \cdot 365\frac{\text{hr}}{\text{yr}} \cdot E_1 \cdot \sin(\theta) \qquad m_1 = 4.958 \times 10^4\,\text{yr}^{-1}$$

$$m_2 := H_{MO2}{}^2 \cdot P_2 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_2 \cdot \sin(\theta) \qquad m_2 = 3.04 \times 10^4\, yr^{-1}$$

$$m_3 := H_{MO3}{}^2 \cdot P_3 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_3 \cdot \sin(\theta) \qquad m_3 = 103.762\, yr^{-1}$$

Let the total energy per year perpendicular to Beach A due to waves from winds coming from 340 degrees be

$$E_{340} := m_1 + m_2 + m_3$$

Calculation of N

A conversion value to convert the maximum wave height of a wave state to the moment magnitude wave height is 1.8, hence let

$H_{max} := 1$ The design vessel wave height

$$H_{MOV} := \frac{H_{max}}{1.8} \qquad H_{MOV} = 0.556$$

Define V to be the number of vessels "use days" in Glacier Bay per season.

Not every vessel entering Glacier Bay will cause a wake which is incident on Beach A in the above example. Of the 241 total vessel tracks, 2 were counted within 2000 feet of Site 20, Beach A.

$V := \frac{2908}{yr}$ This is the current number of "use days" for permitted vessel entries into Glacier Bay. (refered to as Alternative 1)

$$A := V \cdot \frac{2}{241} \qquad A = 24.133\, yr^{-1}$$

once every .3 days during the 3 month season.

Using this calculation as the basis for the vessel waves which affect each site assumes that the 241 vessel tracks provided by Glacier Bay National Park represent a statistically significant sampling of all vessels which enter the Bay. In fact, we know this is not the case, since the tracks provided include only tour vessels, charter vessels and cruise ships. However the assumption is conservative, because the sampling includes the largest vessels, which are also the vessels which produce the largest wakes.

The value of N for the site would then be:

$$N := \frac{H_{MOV}{}^2 \cdot 15 \cdot A}{E_{50} + E_{340}}$$

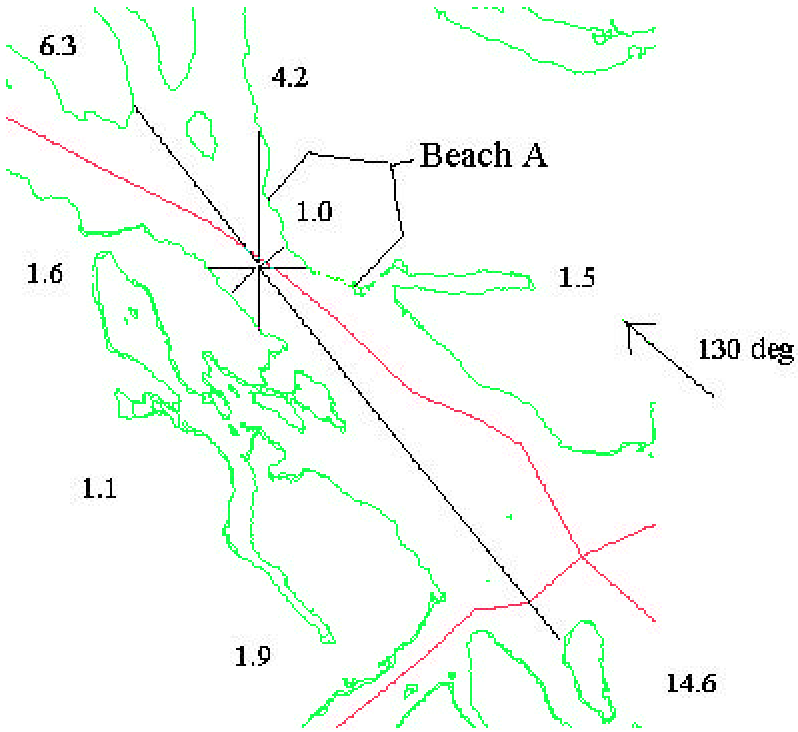
where the value of 15 represents the number of waves per vessel wake.

$$N = 7.611 \times 10^{-4}$$

This is a negligible vessel wake potential.

Example 2

Wave analysis of site 11



Site 11, Beach A, Lower West Arm near Tidal Inlet, fetch distances in miles.

Beach A will not be affected by 50 degree winds.

Beach A has a beach face oriented at azimuth angle of 309 degrees. Wave directions which will be incident on Beach A will be in the range of 129 to 309 degrees.

Using ACES with the fetch shown in the figure above, wave directions given wind directions are

130 degrees - waves at 134 degrees (include)
200 degrees - waves at 153 degrees (include)
260 degrees - waves at 299 degrees (include)
340 degrees - waves at 324 degrees (no effect)

Winds from 130 degrees

From the wind analysis, there are two categories of wind with values for direction 130 degrees, and the following probablilities of occurence in each category.

Category 1: 1 to 9.999 knots with probability of occurence of 20.8%
Category 2: 10 to 19.999 knots with probability of occurence of 4.51%
Category 3: 20 to 29.999 knots with probability of occurence of 0.28%

$P_1 := .208013$

$P_2 := 0.0454$

$P_3 := 0.002845$

For the fetch shown in the drawing above, using CEDAS for restricted open water fetches, the wind direction of 50 degrees, a duration of 1 hour, the average wind velocity of 5 knots, we find that a significant wave of height 0.15 foot will be generated with a significant period of 0.86 sec.

With the average wind velocity of 15 knots, we find that a significant wave height of 0.80 feet with the significant wave period of 1.85 sec will be generated.

With the average wind velocity of 25 knots, we find that a significant wave height of 1.83 feet with a significant wave period of 2.72 sec will be generated.

$H_{MO1} := 0.15 \qquad T_{P1} := 0.86s$

$H_{MO2} := 0.8 \qquad T_{P2} := 1.85s$

$H_{MO3} := 1.83 \qquad T_{P3} := 2.72s$

The expected number of waves in an hourly wind event:

$$E_1 := \frac{1}{T_{P1}} \cdot 60\frac{sec}{min} \cdot 60\frac{min}{hr} \qquad E_1 = 4.186 \times 10^3\,hr^{-1}$$

$$E_2 := \frac{1}{T_{P2}} \cdot 60\frac{sec}{min} \cdot 60\frac{min}{hr} \qquad E_2 = 1.946 \times 10^3\,hr^{-1}$$

$$E_3 := \frac{1}{T_{P3}} \cdot 60\frac{sec}{min} \cdot 60\frac{min}{hr} \qquad E_3 = 1.324 \times 10^3\,hr^{-1}$$

The general direction of the waves are 134 degrees in all instances and the shoreline A is oriented at an angle of 309 degrees.

$\theta := [134 - (309 - 180)]deg \quad \theta = 5\,deg$

$\sin(\theta) = 0.087$

$$m_1 := H_{MO1}{}^2 \cdot P_1 \cdot 24 \cdot 365\frac{hr}{yr} \cdot E_1 \cdot \sin(\theta) \qquad m_1 = 1.496 \times 10^4\,yr^{-1}$$

$$m_2 := H_{MO2}{}^2 \cdot P_2 \cdot 24 \cdot 365\frac{hr}{yr} \cdot E_2 \cdot \sin(\theta) \qquad m_2 = 4.317 \times 10^4\,yr^{-1}$$

$$m_3 := H_{MO3}{}^2 \cdot P_3 \cdot 24 \cdot 365\frac{hr}{yr} \cdot E_3 \cdot \sin(\theta) \qquad m_3 = 9.628 \times 10^3\,yr^{-1}$$

$$E_{130} := m_1 + m_2 + m_3$$

Winds from 200 degrees

From the wind analysis, there are three categories of wind with values for direction 200 degrees, and the following probablilities of occurence in each category.

Category 1: 1 to 9.999 knots with probability of occurence of 11.55%
Category 2: 10 to 19.999 knots with probability of occurence of .70%
Category 3: 20 to 29.999 knots with probability of occurence of .0168%

$P_1 := .115498$

$P_2 := 0.006978$

$P_3 := 0.000168$

For the fetch shown in the drawing above, using CEDAS for restricted open water fetches, the wind direction of 200 degrees, a duration of 1 hour, the average wind velocity of 5 knots, we find that a significant wave of height 0.08 foot will be generated with a significant period of 0.63 sec.

With the average wind velocity of 15 knots, we find that a significant wave height of 0.41 feet with the significant wave period of 1.36 sec will be generated.

With the average wind velocity of 25 knots, we find that a significant wave height of .93 feet with a significant wave period of 1.99 sec will be generated.

$H_{MO1} := 0.08 \qquad T_{P1} := 0.63s$

$H_{MO2} := 0.41 \qquad T_{P2} := 1.36s$

$H_{MO3} := .93 \qquad T_{P3} := 1.99s$

The expected number of waves in an hourly wind event:

$$E_1 := \frac{1}{T_{P1}} \cdot 60 \frac{sec}{min} \cdot 60 \frac{min}{hr} \qquad E_1 = 5.714 \times 10^3\, hr^{-1}$$

$$E_2 := \frac{1}{T_{P2}} \cdot 60 \frac{sec}{min} \cdot 60 \frac{min}{hr} \qquad E_2 = 2.647 \times 10^3\, hr^{-1}$$

$$E_3 := \frac{1}{T_{P3}} \cdot 60 \frac{sec}{min} \cdot 60 \frac{min}{hr} \qquad E_3 = 1.809 \times 10^3\, hr^{-1}$$

The general direction of the waves are 153 degrees in all instances and the since shoreline A is oriented at an angle of 309 degrees degrees.

$$\theta := [153 - (309 - 180)]deg$$

$$\theta = 24\, deg \qquad \sin(\theta) = 0.407$$

$$m_1 := H_{MO1}{}^2 \cdot P_1 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_1 \cdot \sin(\theta) \qquad m_1 = 1.505 \times 10^4\, yr^{-1}$$

$$m_2 := H_{MO2}{}^2 \cdot P_2 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_2 \cdot \sin(\theta) \qquad m_2 = 1.106 \times 10^4\, yr^{-1}$$

$$m_3 := H_{MO3}{}^2 \cdot P_3 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_3 \cdot \sin(\theta) \qquad m_3 = 936.574\, yr^{-1}$$

$$E_{200} := (m_1 + m_2 + m_3)$$

$$E_{200} = 2.705 \times 10^4\, yr^{-1}$$

Winds from 260 degrees

From the wind analysis, there are two categories of wind with values for direction 260 degrees, and the following probablilities of occurence in each category.

Category 1: 1 to 9.999 knots with probability of occurence of 6.05% $P_1 := 0.060527$

Category 2: 10 to 19.999 knots with probability of occurence of 1.07% $P_2 := 0.010674$

Category 3: 20 to 29.999 knots with probability of occurence of .0034% $P_3 := .000034$

For the fetch shown in the drawing above, using CEDAS for restricted open water fetches, the wind direction of 250 degrees, a duration of 1 hour, the average wind velocity of 5 knots, we find that a significant wave of height 0.09 foot will be generated with a significant period of 0.69 sec.

With the average wind velocity of 15 knots, we find that a significant wave height of 0.49 feet with the significant wave period of 1.47 sec will be generated.

With the average wind velocity of 25 knots, we find that a significant wave height of 1.11 feet with the significant wave period of 2.15 sec will be generated.

$H_{MO1} := 0.09$ $T_{P1} := 0.69s$

$H_{MO2} := 0.49$ $T_{P2} := 1.47s$

$H_{M03} := 1.11$ $T_{P3} := 2.15s$

The expected number of waves in an hourly wind event:

$$E_1 := \frac{1}{T_{P1}} \cdot 60 \frac{sec}{min} \cdot 60 \frac{min}{hr} \qquad E_1 = 5.217 \times 10^3\, hr^{-1}$$

$$E_2 := \frac{1}{T_{P2}} \cdot 60 \frac{sec}{min} \cdot 60 \frac{min}{hr} \qquad E_2 = 2.449 \times 10^3\, hr^{-1}$$

$$E_3 := \frac{1}{T_{P3}} \cdot 60 \frac{sec}{min} \cdot 60 \frac{min}{hr} \qquad E_3 = 1.674 \times 10^3\, hr^{-1}$$

The general direction of the waves are 299 degrees in both instances and the shorelines most affected will be oriented perpendicular to this direction

$$\theta := [299 - (309 - 180)]deg$$

$$\theta = 170\, deg \qquad \sin(\theta) = 0.174$$

$$m_1 := H_{MO1}{}^2 \cdot P_1 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_1 \cdot \sin(\theta) \qquad m_1 = 3.891 \times 10^3\, yr^{-1}$$

$$m_2 := H_{MO2}^2 \cdot P_2 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_2 \cdot \sin(\theta) \qquad m_2 = 9.547 \times 10^3 \, yr^{-1}$$

$$m_3 := H_{MO3}^2 \cdot P_3 \cdot 24 \cdot 365 \frac{hr}{yr} \cdot E_3 \cdot \sin(\theta) \qquad m_3 = 74.9 \, yr^{-1}$$

$$E_{260} := m_1 + m_2 + m_3 \qquad E_{260} = 1.351 \times 10^4 \, yr^{-1}$$

Calculation of N

A conversion value to convert the max wave height of a wave state to the moment magnitude wave height is 1.8, hence let

$H_{max} := 1$ The design vessel wave height

$$H_{MOV} := \frac{H_{max}}{1.8} \qquad H_{MOV} = 0.556$$

Define V to be the number of vessels "use days" in Glacier Bay per season.

Not every vessel entering Glacier Bay will cause a wake which is incident on Beach A in the above example. Of the 241 total vessel tracks, 36 were counted within 2000 feet of Site 11, Beach A.

$V := \frac{2908}{yr}$ This is the current number of "use days" for permitted vessel entries into Glacier Bay. (refered to as Alternative 1)

$$A := V \cdot \frac{36}{241} \qquad A = 434.39 \, yr^{-1} \qquad 15 \cdot A = 6.516 \times 10^3 \, yr^{-1}$$

or once every 5 days during the 3 month season.

Using this calculation as the basis for the vessel waves which affect each site assumes that the 241 vessel tracks provided by Glacier Bay National Park represent a statistically significant sampling of all vessels which enter the Bay. In fact, we know this is not the case, since the tracks provided include only tour vessels, charter vessels and cruise ships.

The value of N for the site would then be:

$$N := \frac{H_{MOV}^2 \cdot 15 \cdot A}{E_{130} + E_{200} + E_{260}}$$

where the value of 15 represents the number of waves per vessel wake.

$$N = 0.019$$

This is a moderate level of significance for vessel wake potential.

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1506 West 36th Avenue Anchorage, Alaska 99503 (907) 561-1011 Fax (907) 563-4220

Memorandum

To: File | Project No.: 02056.02

From: Jennifer Wilson | Date: October 3, 2002

Re: *CoastWalkers Polygon Table*

Project: Glacier Bay National Park and Preserve Vessel Quotas and Operating Requirements Environmental Impact Statement, Appendix F Technical Memorandum

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The attached document, *CoastWalkers Polygon Table*, provides a detailed list of the polygons that make up each site as provided in this database. The purpose of this list is to provide an exact location of the beaches studied for the EIS.

CoastWalkers Polygon Table
Listed by Site

Site	CoastWalker Polygons
1	H008
	H009
	H010
	H011
	H012
	H013
	H014
	H015
	H016
	H017
	H018
	H019
	H048
	H049
	H050
	H051
	H052
	H053
	H054
	H055
	H056
2	H096
	H097
	H098
	H099
	H100
3	N120
	Y003
	Y004
	Y005
	Y006
	Y007
	Y008
	Y009
	Y010
	Y011
	Y012
	Y013
	Y014
	Y015
	Y016
	Y017
	Y018
	Y019
	Y020
	Y021

Site	CoastWalker Polygons
	Y022
	Y023
	Y024
	Y025
	Y026
	Y027
	Y028
4	N083
	N084
	N085
	N086
	N087
	N088
	N018
	N019
	N020
	N021
	N022
	N023
	N024
	N025
	N002
	N003
	N004
	N005
	N006
	N007
	N008
5	W001
	W002
	W003
	W004
	W005
	W006
	W007
	W015
	W016
	S083
	S084
	W019
	W020
	W021
	W022
	W023
	W034
	W035

Site	CoastWalker Polygons
	W036
	WO41
	WO42
	WO43
	WO44
	W055
	W056
6	II044
	II045
	II046
	II047
	II048
	II049
	II050
	II051
	II052
	II038
	HH054
	HH055
	HH056
	HH057
	HH058
	HH059
	HH060
	HH061
	HH062
	HH063
	HH049
	HH050
	HH051
	HH052
7	D013
	D014
	D015
	D016
	D017
	D018
	D019
	D020
	D021
	D022
	D023
	D024
	D025
	D026
	D027

CoastWalkers Polygon Table
Listed by Site

Site	CoastWalker Polygons
	D028
	D029
	D030
	D031
	D032
	D033
	D034
	D038
	D039
	D040
	D041
	D042
	D043
	D044
	D045
	D046
	D047
	D048
	D049
	D050
	D051
8	X013
	X014
	X015
	X016
	X017
	X018
	X019
	X020
	X021
	X022
	X023
	X070
	X071
	X072
	X073
	X074
	X075
	X076
	X077
	X078
	X079
	X080
	X081
	X082
	X083

Site	CoastWalker Polygons
	X084
	X085
	X086
	X087
	X088
	X089
	X090
	X091
	X092
	X093
	Z094
	Z095
	Z096
	Z097
	Z098
	Z099
	Z100
	Z101
	Z102
	Z103
	Z104
	Z105
	Z106
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	Z108
	Z109
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	Z112
	Z113
	Z114
	Z115
	Z116
	Z117
	Z118
	Z119
	Z120
	Z121
	Z122
	Z123
	Z124
	Z125
	Z126
	Z127
	Z128
	Z129

Site	CoastWalker Polygons
	Z130
	Z131
	Z132
	Z133
9	X008
	X009
	X010
	X011
	X012
	X032
	X033
	X034
	X035
	X036
	X037
	X038
	X039
	X040
	X041
	X053
	X054
	X055
	X056
	X057
	X058
	X059
	X060
	X061
10	V038
	V039
	V040
	V041
	V093
	V094
	V095
	V096
	V097
	V098
	V099
	V100
	V101
	V102
	V103
	V104
	V105
11	FF004

CoastWalkers Polygon Table
Listed by Site

Site	CoastWalker Polygons
	FF005
	FF006
	FF007
	FF008
	FF009
	FF053
	FF054
	FF055
	FF056
	FF057
	FF058
	FF059
	FF060
	FF061
	FF062
	FF063
	FF064
	FF065
	FF066
	FF067
	GG001
	GG002
	GG003
	GG004
	GG005
	GG006
	GG007
	GG008
	GG009
	GG010
	GG011
	GG012
	GG013
	GG014
	GG015
	GG016
	GG017
	GG018
	GG019
	GG020
	GG021
	GG022
	GG023
	GG024
	GG025
	GG026

Site	CoastWalker Polygons
	HH001
	HH002
	HH003
	HH004
	HH005
	HH006
	HH007
	HH008
	HH009
	HH010
	HH011
	HH012
	HH013
	HH014
	HH015
	HH016
	HH017
	HH018
	HH019
	HH020
	HH021
	HH022
	HH023
	HH024
	HH025
	HH026
	HH027
12	AA001
	AA002
	AA003
	AA004
	AA005
	AA006
	AA007
	AA008
	AA009
	AA010
	AA011
	AA012
	AA013
	AA014
	AA015
	AA016
	AA017
	AA018
	AA019

Site	CoastWalker Polygons
	AA020
	AA021
	AA022
	AA023
	AA024
	AA025
	AA026
	AA027
	AA028
	AA029
	AA030
	AA031
	AA032
	AA033
	AA034
	AA035
	AA036
	AA037
	AA038
	AA039
	AA040
	AA041
	AA042
	DD001
	DD002
	DD003
	DD004
	DD005
	DD006
	DD007
	V011
13	AA083
	AA084
	AA085
	AA086
	AA087
	AA088
	AA089
	AA090
	AA091
	AA092
	AA093
	AA094
	AA095
	AA096
	AA097

CoastWalkers Polygon Table
Listed by Site

Site	CoastWalker Polygons
	AA098
	AA099
	AA100
	AA101
	AA102
	AA103
	AA104
	AA109
	AA110
	CC146
14	CC078
	CC079
	CC080
	CC081
	CC082
	CC083
	CC084
	CC085
	CC086
	CC087
	CC088
	CC089
	CC090
	CC091
	CC092
	CC093
	CC094
	CC095
	CC073
	DD073
	DD074
	DD075
	DD076
	DD077
	DD078
	DD079
	DD080
15	CC117
	CC118
	CC119
	CC120
	CC121
	CC122
	CC123
	CC124
	CC125

Site	CoastWalker Polygons
	CC126
	CC127
	CC128
	CC129
	CC130
16	AA149
	AA150
	AA151
	AA152
	AA153
	AA154
	AA155
	AA160
	AA161
	AA162
	AA163
	BB068
	BB069
	BB070
	BB071
	BB072
	BB073
17	BB082
	BB083
	BB084
	BB085
	BB086
18	BB091
	BB092
	BB093
	BB094
	BB095
	BB096
	BB097
	BB098
	BB099
	BB100
	BB103
	BB104
	BB105
	BB106
	BB107
	BB108
	BB109
	BB110
	BB111

Site	CoastWalker Polygons
	BB112
	BB113
	BB114
	BB115
	BB116
	BB117
	BB118
	BB119
	BB120
	BB121
	BB122
	BB123
	BB124
	BB125
	BB126
	BB127
	BB128
	BB129
	BB130
	BB131
	BB132
	BB133
	BB134
	BB135
	BB136
	BB137
	BB138
	BB139
	BB140
	BB141
	BB142
	BB143
	BB144
	BB145
	BB146
	BB147
	BB148
19	~~NO POLYGONS - Upper Muir Inlet north of McConnel Ridge~~QQ003
	QQ004
	QQ005
	QQ006
	QQ007

CoastWalkers Polygon Table
Listed by Site

Site	CoastWalker Polygons
	QQ008
	QQ009
	QQ010
	QQ011
	TT002
	TT003
	TT004
	TT005
	TT006
	TT007
	TT008
	TT009
	TT010
	TT011
	TT012
	TT013
	TT014
	TT015
	TT016
	TT017
	TT018
	TT019
	TT020
	TT021
	TT022
	TT023
	TT024
	TT025
	TT026
	TT027
	TT028
	TT029
	TT030
	TT031
	TT032
	W001
	W002
	W003
	W004
	W005
	W006
	W007
	W008
	W009
	W010
	W011

Site	CoastWalker Polygons
	W012
	W013
	W014
	W015
	W016
	W017
	W018
	W019
	W020
20	NN073
	NN074
	OO67
	OO68
	OO69
	OO70
	OO71
	OO72
	OO73
	OO74
	OO75
	OO76
	OO77
	OO78
	OO79
	OO80
	OO83
	OO84
	OO085
	OO086
	OO087
	OO088
	OO089
	OO090
	OO091
	OO092
	OO093
	OO094
	OO095
21	~~NO POLYGONS - Upper end of Muir Inlet~~TT033
	TT034
	TT035
	TT036
	TT037

Site	CoastWalker Polygons
	TT038
	TT039
	TT040
	TT041
	TT042
	TT043
	TT044
	TT045
	TT046
	TT047
	TT048
	TT049
	TT050
	TT051
	TT052
	TT053
	TT054
	TT055
	TT056
	TT057
	TT058
	TT059
	TT060
	TT061
	TT062
	TT063
	TT064
	TT065
	TT066
	TT067
	TT068
	TT069
	TT070
	TT071
	TT072
	TT073
	TT074
	TT075
	TT076
	TT077
	TT078
	TT079
	TT080
	TT081
	TT082

CoastWalkers Polygon Table
Listed by Site

Site	CoastWalker Polygons
22	NO POLYGONS - South Marble Island (Photographs show bedrock)

APPENDIX H

Coastal Geomorphology Effects Tables

TABLE 1: ALTERNATIVE 1 – POTENTIAL EFFECTS ON THE PHYSICAL COASTLINE AT 22 SITES IN GLACIER BAY NATIONAL PARK AND PRESERVE

Site	Substrate[a]	Erodability	Vessel Wake Potential Index[b]	Erosion Potential
1	Course Sand and Granule	Moderate	Minor	Minor
2	Pebble	Minor	Minor	Minor
3	Cobble	Minor	Negligible	Negligible
4	Cobbles with boulders	Minor	Minor	Minor
5	Pebble	Minor	Minor	Minor
6	Pebble with cobble	Minor	Negligible	Negligible
7	Boulder with cobble	Minor	Minor	Minor
8	Cobble	Minor	Minor	Minor
9	Granular with pebbles	Moderate to minor	Minor	Minor
10	Boulder with cobbles	Minor	Negligible	Negligible
11	Cobble	Minor	Minor	Minor
12	Cobble	Minor	Moderate	Minor
13	Cobble	Minor	Minor	Minor
14	Granular with pebbles and cobbles	Moderate to minor	Minor	Minor
15	Cobbles	Minor	Moderate	Minor
16	Boulder	Minor	High	Minor
17	Boulder	Minor	Moderate	Minor
18	Pebble	Moderate to minor	Moderate	Moderate
19[c]	Boulder	Minor	Minor	Negligible
20	Granular	Moderate	Negligible	Negligible
21[c]	Boulder	Minor	Minor	Negligible
22[c]	Bedrock	Negligible	Moderate	Negligible

Notes:

a Synthesized from NPS Coast Walkers database.

b Based on the 1996 vessel use-days. Reflects potential vessel wake affect from May through September.

c The physical attribute information is not available for Sites 19, 21, and 22 so an overall potential affect cannot be assigned.

TABLE 1B: NO ACTION ALTERNATIVE VESSEL WAKE POTENTIAL BREAKDOWN. NO ACTION ALTERNATIVE

Site	Vessel Wake Potential Affect[1] June-August	May & September[2]	Combined
1	Negligible	Negligible	Minor
2	Minor	Minor	Minor
3	Negligible	Negligible	Negligible
4	Minor	Minor	Minor
5	Minor	Minor	Minor
6	Negligible	Negligible	Negligible
7	Negligible	Minor	Minor
8	Negligible	Negligible	Minor
9	Minor	Minor	Minor
10	Negligible	Negligible	Negligible
11	Minor	Minor	Minor
12	Minor	Minor	Moderate
13	Negligible	Minor	Minor
14	Minor	Minor	Minor
15	Minor	Minor	Moderate
16	Moderate	Moderate	High
17	Minor	Minor	Moderate
18	Minor	Minor	Moderate
19	Negligible	Negligible	Minor
20	Negligible	Negligible	Negligible
21	Negligible	Negligible	Minor
22	Minor	Moderate	Moderate

[1] Based on the 1996 vessel use-days.
[2] Assumes the maximum allowable vessel traffic is realized, which is a grossly conservative assumption.

TABLE 2: ALTERNATIVE 2 – POTENTIAL EFFECTS ON THE PHYSICAL COASTLINE AT 22 SITES IN GLACIER BAY NATIONAL PARK AND PRESERVE

Site	Substrate[a]	Erodability	Vessel Wake Potential Index[b]	Erosion Potential
1	Course Sand and Granule	Moderate	Minor	Minor
2	Pebble	Minor	Minor	Minor
3	Cobble	Minor	Negligible	Negligible
4	Cobbles with boulders	Minor	Minor	Minor
5	Pebble	Minor	Minor	Minor
6	Pebble with cobble	Minor	Negligible	Negligible
7	Boulder with cobble	Minor	Minor	Minor
8	Cobble	Minor	Minor	Minor
9	Granular with pebbles	Moderate to minor	Minor	Minor
10	Boulder with cobbles	Minor	Negligible	Negligible
11	Cobble	Minor	Minor	Minor
12	Cobble	Minor	Minor	Minor
13	Cobble	Minor	Minor	Minor
14	Granular with pebbles and cobbles	Moderate to minor	Minor	Minor
15	Cobbles	Minor	Moderate	Minor
16	Boulder	Minor	High	Minor
17	Boulder	Minor	Moderate	Minor
18	Pebble	Moderate to minor	Moderate	Moderate
19[c]	Boulder	Minor	Minor	Negligible
20	Granular	Moderate	Negligible	Negligible
21[c]	Boulder	Minor	Minor	Negligible
22[c]	Bedrock	Negligible	Moderate	Negligible

Notes:

a Synthesized from NPS Coast Walkers database.

b Based on 1995 vessel use-days and current regulations. Reflects potential vessel wake affect from May through September.

c The physical attribute information is not available for Sites 19, 21, and 22 so an overall potential affect cannot be assigned.

TABLE 2B: ALTERNATIVE 2 VESSEL WAKE POTENTIAL BREAKDOWN

Site	Vessel Wake Potential Affect[3] June-August	May & September[4]	Combined
1	Negligible	Negligible	Minor
2	Minor	Minor	Minor
3	Negligible	Negligible	Negligible
4	Minor	Minor	Minor
5	Minor	Minor	Minor
6	Negligible	Negligible	Negligible
7	Negligible	Minor	Minor
8	Negligible	Negligible	Minor
9	Minor	Minor	Minor
10	Negligible	Negligible	Negligible
11	Minor	Minor	Minor
12	Minor	Minor	Minor
13	Negligible	Minor	Minor
14	Minor	Minor	Minor
15	Minor	Minor	Moderate
16	Moderate	Moderate	High
17	Minor	Minor	Moderate
18	Minor	Minor	Moderate
19	Negligible	Negligible	Minor
20	Negligible	Negligible	Negligible
21	Negligible	Negligible	Minor
22	Minor	Moderate	Moderate

[3] Based on the 1995 vessel use-days and current regulations.
[4] Assumes the maximum allowable vessel traffic is realized, which is a grossly conservative assumption.

TABLE 3: ALTERNATIVE 3 – POTENTIAL EFFECTS ON THE PHYSICAL COASTLINE AT 22 SITES IN GLACIER BAY NATIONAL PARK AND PRESERVE

Site	Substrate[a]	Erodability	Vessel Wake Potential Index[b]	Erosion Potential
1	Course Sand and Granule	Moderate	Minor	Minor
2	Pebble	Minor	Minor	Minor
3	Cobble	Minor	Negligible	Negligible
4	Cobbles with boulders	Minor	Minor	Minor
5	Pebble	Minor	Minor	Minor
6	Pebble with cobble	Minor	Negligible	Negligible
7	Boulder with cobble	Minor	Minor	Minor
8	Cobble	Minor	Minor	Minor
9	Granular with pebbles	Moderate to minor	Minor	Minor
10	Boulder with cobbles	Minor	Negligible	Negligible
11	Cobble	Minor	Minor	Minor
12	Cobble	Minor	Moderate	Minor
13	Cobble	Minor	Minor	Minor
14	Granular with pebbles and cobbles	Moderate to minor	Minor	Minor
15	Cobbles	Minor	Moderate	Minor
16	Boulder	Minor	High	Minor
17	Boulder	Minor	Moderate	Minor
18	Pebble	Moderate to minor	Moderate	Moderate
19[c]	Boulder	Minor	Minor	Negligible
20	Granular	Moderate	Negligible	Negligible
21[c]	Boulder	Minor	Minor	Negligible
22[c]	Bedrock	Negligible	Moderate	Negligible

Notes:

a Synthesized from NPS Coast Walkers database.

b Based on the maximum allowable vessel use-days in the 1996 Finding of No Significant Impact. Reflects potential vessel wake affect from May through September.

c The physical attribute information is not available for Sites 19, 21, and 22 so an overall potential affect cannot be assigned.

TABLE 3B: ALTERNATIVE 3 VESSEL WAKE POTENTIAL BREAKDOWN

Site	Vessel Wake Potential Affect[5]		Combined
	June-August	May & September[6]	
1	Negligible	Negligible	Minor
2	Minor	Minor	Minor
3	Negligible	Negligible	Negligible
4	Minor	Minor	Minor
5	Minor	Minor	Minor
6	Negligible	Negligible	Negligible
7	Negligible	Minor	Minor
8	Negligible	Negligible	Minor
9	Minor	Minor	Minor
10	Negligible	Negligible	Negligible
11	Minor	Minor	Minor
12	Minor	Minor	Moderate
13	Negligible	Minor	Minor
14	Minor	Minor	Minor
15	Minor	Minor	Moderate
16	Moderate	Moderate	High
17	Minor	Minor	Moderate
18	Minor	Minor	Moderate
19	Negligible	Negligible	Minor
20	Negligible	Negligible	Negligible
21	Negligible	Negligible	Minor
22	Moderate	Minor	Moderate

[5] Based on the maximum allowable vessel use-days in the 1996 FONSI.
[6] Assumes the maximum allowable vessel traffic is realized, which is a grossly conservative assumption.

TABLE 4: ALTERNATIVE 4 – POTENTIAL EFFECTS ON THE PHYSICAL COASTLINE AT 22 SITES IN GLACIER BAY NATIONAL PARK AND PRESERVE

Site	Substrate[a]	Erodability	Vessel Wake Potential Index[b]	Erosion Potential
1	Course Sand and Granule	Moderate	Negligible	Negligible
2	Pebble	Minor	Minor	Minor
3	Cobble	Minor	Negligible	Negligible
4	Cobbles with boulders	Minor	Minor	Minor
5	Pebble	Minor	Minor	Minor
6	Pebble with cobble	Minor	Negligible	Negligible
7	Boulder with cobble	Minor	Minor	Minor
8	Cobble	Minor	Negligible	Negligible
9	Granular with pebbles	Moderate to minor	Minor	Minor
10	Boulder with cobbles	Minor	Negligible	Negligible
11	Cobble	Minor	Minor	Minor
12	Cobble	Minor	Minor	Minor
13	Cobble	Minor	Minor	Minor
14	Granular with pebbles and cobbles	Moderate to minor	Minor	Minor
15	Cobbles	Minor	Minor	Minor
16	Boulder	Minor	Moderate	Minor
17	Boulder	Minor	Minor	Minor
18	Pebble	Moderate to minor	Minor	Minor
19a	Boulder	Minor	Negligible	Negligible
20	Granular	Moderate	Negligible	Negligible
21a	Boulder	Minor	Negligible	Negligible
22a	Bedrock	Negligible	Moderate	Negligible

Notes:

a Synthesized from NPS CoastWalkers database.

b Based on the pre-1985 entry levels with an extended vessel entry period. Reflects potential vessel wake affect from May through September.

c The physical attribute information is not available for Sites 19, 21, and 22 so an overall potential affect cannot be assigned.

Table 4b: Alternative 4 Vessel Wake Potential Breakdown			
Site	**Vessel Wake Potential Affect**[7]		**Combined**
	June-August	**May & September**[8]	
1	Negligible	Negligible	Negligible
2	Minor	Negligible	Minor
3	Negligible	Negligible	Negligible
4	Minor	Minor	Minor
5	Minor	Minor	Minor
6	Negligible	Negligible	Negligible
7	Negligible	Negligible	Minor
8	Negligible	Negligible	Negligible
9	Minor	Minor	Minor
10	Negligible	Negligible	Negligible
11	Minor	Minor	Minor
12	Minor	Minor	Minor
13	Negligible	Negligible	Minor
14	Minor	Minor	Minor
15	Minor	Minor	Minor
16	Moderate	Moderate	Moderate
17	Minor	Minor	Minor
18	Minor	Minor	Minor
19	Negligible	Negligible	Negligible
20	Negligible	Negligible	Negligible
21	Negligible	Negligible	Negligible
22	Minor	Minor	Moderate

[7] Based on the pre-1985 entry levels with an extended vessel entry period.
[8] Assumes the maximum allowable vessel traffic is realized, which is a grossly conservative assumption.

TABLE 5: ALTERNATIVE 5 – POTENTIAL EFFECTS ON THE PHYSICAL COASTLINE AT 22 SITES IN GLACIER BAY NATIONAL PARK AND PRESERVE

Site	Substrate[a]	Erodability	Vessel Wake Potential Index[b]	Erosion Potential
1	Course Sand and Granule	Moderate	Minor	Minor
2	Pebble	Minor	Minor	Minor
3	Cobble	Minor	Negligible	Negligible
4	Cobbles with boulders	Minor	Minor	Minor
5	Pebble	Minor	Minor	Minor
6	Pebble with cobble	Minor	Negligible	Negligible
7	Boulder with cobble	Minor	Minor	Minor
8	Cobble	Minor	Minor	Minor
9	Granular with pebbles	Moderate to minor	Minor	Minor
10	Boulder with cobbles	Minor	Negligible	Negligible
11	Cobble	Minor	Minor	Minor
12	Cobble	Minor	Moderate	Minor
13	Cobble	Minor	Minor	Minor
14	Granular with pebbles and cobbles	Moderate to minor	Minor	Minor
15	Cobbles	Minor	Moderate	Minor
16	Boulder	Minor	High	Minor
17	Boulder	Minor	Moderate	Minor
18	Pebble	Moderate to minor	Moderate	Moderate
19[c]	Boulder	Minor	Minor	Negligible
20	Granular	Moderate	Negligible	Negligible
21[c]	Boulder	Minor	Minor	Negligible
22[c]	Bedrock	Negligible	Moderate	Negligible

Notes:

a Synthesized from NPS Coast Walkers database.

b Based on current entry levels, uses the current operating regulations, and includes an extended operating period. Reflects potential vessel wake affect from May through September.

c The physical attribute information is not available for Sites 19, 21, and 22 so an overall potential affect cannot be assigned.

TABLE 5B ALTERNATIVE 5 VESSEL WAKE POTENTIAL BREAKDOWN

Site	Vessel Wake Potential Affect[9]		Combined
	June-August	May & September[10]	
1	Negligible	Negligible	Minor
2	Minor	Minor	Minor
3	Negligible	Negligible	Negligible
4	Minor	Minor	Minor
5	Minor	Minor	Minor
6	Negligible	Negligible	Negligible
7	Minor	Minor	Minor
8	Negligible	Negligible	Minor
9	Minor	Minor	Minor
10	Negligible	Negligible	Negligible
11	Minor	Minor	Minor
12	Minor	Minor	Moderate
13	Negligible	Minor	Minor
14	Minor	Minor	Minor
15	Minor	Minor	Moderate
16	Moderate	Moderate	High
17	Minor	Minor	Moderate
18	Minor	Minor	Moderate
19	Negligible	Negligible	Minor
20	Negligible	Negligible	Negligible
21	Negligible	Negligible	Minor
22	Minor	Minor	Moderate

[9] Based on current entry levels, uses the current operating regulations, and includes an extended operating period.
[10] Assumes the maximum allowable vessel traffic is realized, which is a grossly conservative assumption.

APPENDIX I

43 Code of Federal Regulations 36.11
Transportation and Utility Systems In and Across, and Access Into, Conservation System Units in Alaska—Special Access.

[Code of Federal Regulations]
[Title 43, Volume 1, Parts 1 to 999]
[Revised as of October 1, 1999]
From the U.S. Government Printing Office via GPO Access
[**CITE: 43CFR36.11**]

[Page 513-515]

TITLE 43--PUBLIC LANDS: INTERIOR

PART 36--TRANSPORTATION AND UTILITY SYSTEMS IN AND ACROSS, AND ACCESS INTO, CONSERVATION SYSTEM UNITS IN ALASKA--Table of Contents

Sec. 36.**11** Special access.

(a) This section implements the provisions of section 1110(a) of ANILCA regarding use of snowmachines, motorboats, nonmotorized surface transportation, aircraft, as well as off-road vehicle use.

As used in this section, the term:

(1) Area also includes public lands administered by the BLM and designated as wilderness study areas.

(2) Adequate snow cover shall mean snow of sufficient depth, generally 6-12 inches or more, or a combination of snow and frost depth sufficient to protect the underlying vegetation and soil.

(b) Nothing in this section affects the use of snowmobiles, motorboats and nonmotorized means of surface transportation traditionally used by rural residents engaged in subsistence activities, as defined in Tile VIII of ANILCA.

(c) The use of snowmachines (during periods of adquate snow cover and frozen river conditions) for traditional activities (where such activities are permitted by ANILCA or other law) and for travel to and from villages and homesites and other valid occupancies is permitted within the areas, except where such use is prohibited or otherwise restricted by the appropriate Federal agency in accordance with the procedures of paragraph (h) of this section.

(d) Motorboats may be operated on all area waters, except where such use is prohibited or otherwise restricted by the appropriate Federal agency in accordance with the procedures of paragraph (h) of this section.

(e) The use of nonmotorized surface transportation such as domestic dogs, horses and other pack or saddle animals is permitted in areas except

where such use is prohibited or otherwise restricted by the appropriate Federal agency in accordance with the procedures of paragraph (h) of this section.

(f) Aircraft. (1) Fixed-wing aircraft may be landed and operated on lands and waters within areas, except where such use is prohibited or otherwise restricted by the appropriate Federal agency, including closures or restrictions pursuant to the closures of paragraph (h) of this section. The use of aircraft for access to or from lands and waters within a national park or monument for purposes of taking fish and wildlife for subsistence uses therein is prohibited, except as provided in 36 CFR 13.45. The operation of aircraft resulting in the harassment of wildlife is prohibited.

(2) In imposing any prohibitions or restrictions on fixed-wing aircraft use the appropriate Federal agency shall:

(i) Publish notice of prohibition or restrictions in ``Notices to Airmen'' issued by the Department of Transportation; and

(ii) Publish permanent prohibitions or restrictions as a regulatory notice in the United States Flight Information Service ``Supplement Alaska.''

(3) Except as provided in paragraph (f)(3)(i) of this section, the owners of any aircraft downed after December 2, 1980, shall remove the aircraft and all component parts thereof in accordance with procedures established by the appropriate Federal agency. In establishing a removal procedure, the appropriate Federal agency is authorized to establish a

reasonable date by which aircraft removal operations must be complete and determine times and means of access to and from the downed aircraft.

(i) The appropriate Federal agency may waive the requirements of this paragraph upon a determination that the removal of downed aircraft would constitute an unacceptable risk to human life, or the removal of a downed aircraft would result in extensive resource damage, or the removal of a downed aircraft is otherwise impracticable or impossible.

(ii) Salvaging, removing, possessing or attempting to salvage, remove or possess any downed aircraft or component parts thereof is prohibited, except in accordance with a removal procedure established under this paragraph and as may be controlled by the other laws and regulations.

(4) The use of a helicopter in any area other than at designated landing areas pursuant to the terms and conditions of a permit issued by the appropriate Federal agency, or pursuant to a memorandum of understanding between the appropriate Federal agency and another party, or involved in emergency or search and rescue operations is prohibited.

(g) Off-road vehicles. (1) The use of off-road vehicles (ORV) in locations other than established roads and parking areas is prohibited, except on routes or in areas designated by the appropriate Federal agency in accordance with Executive Order 11644, as amended or pursuant to a valid permit as prescribed in paragraph (g)(2) of this section or in Sec. 36.10 or Sec. 36.12.

(2) The appropriate Federal agency is authorized to issue permits for the use of ORVs on existing ORV trails located in areas (other than in areas designated as part of the National Wilderness Preservation System) upon a finding that such ORV use would be compatible with the purposes and values for which the area was established. The appropriate Federal agency shall include in any permit such stipulations and conditions as are necessary for the protection of those purposes and values.

(h) Closure procedures. (1) The appropriate Federal agency may close an area on a temporary or permanent basis to use of aircraft, snowmachines, motorboats or nonmotorized surface transportation only upon a finding by the agency that such use would be detrimental to the resource values of the area.

(2) Temporary closures. (i) Temporary closures shall not be effective prior to notice and hearing in the vicinity of the area(s) directly affected by such closures and other locations as appropriate.

(ii) A temporary closure shall not exceed 12 months.

(3) Permanent closures shall be published by rulemaking in the Federal Register with a minimum public comment period of 60 days and shall not be

effective until after a public hearing(s) is held in the affected vicinity and other locations as deemed appropriate by the appropriate Federal agency.

(4) Temporary and permanent closures shall be: (i) Published at least once in a newspaper of general circulation in Alaska and in a local newspaper, if available; posted at community post offices within the vicinity affected; made available for broadcast on local radio stations in a manner reasonably calculated to inform residents in the affected vicinity; and designated on a map which shall be available for public inspection at the office of the appropriate Federal agency and other places convenient to the public; or

(ii) Designated by posting the area with appropriate signs; or

(iii) Both.

(5) In determining whether to open an area that has previously been closed pursuant to the provisions of this section, the appropriate Federal agency shall provide notice in the Federal Register and shall, upon request, hold a hearing in the affected vicinity and other locations as appropriate prior to making a final determination.

(6) Nothing in this section shall limit the authority of the appropriate Federal agency to restrict or limit uses of an area under other statutory authority.

(i) Except as otherwise specifically permitted under the provisions of this section, entry into closed areas or failure to abide by restrictions established under this section is prohibited.

(j) Any person convicted of violating any provision of the regulations contained in this section, or as the same may be amended or supplemented, may be punished by a fine or by imprisonment in accordance with the penalty provisions applicable to the area.

[51 FR 31629, Sept. 4, 1986; 51 FR 36011, Oct. 8, 1986]

APPENDIX J

Consultation Correspondence

United States Department of the Interior

NATIONAL PARK SERVICE
Glacier Bay National Park and Preserve

N1621

February 26, 2003

Michael Payne
Assistant Regional Administrator for Protected Resources
National Marine Fisheries Service
P.O. Box 21668
Juneau, AK 99801-1668

Dear Mr. Payne:

As you are aware, the National Park Service (NPS) is preparing an Environmental Impact Statement (EIS) on vessel quotas and operating requirements in Glacier Bay National Park and Preserve. Specifically, the NPS proposes to establish new or keep existing quotas and operating requirements for four types of motorized watercraft – cruise ships and tour, charter and private vessels – within Glacier Bay proper and in Dundas Bay. The purpose for the action is to address the continuing demand for vessel access into Glacier Bay National Park and Preserve in a manner that assures continuing protection of park resources and values while providing for a range of high-quality recreational opportunities for visitors. The need for action stems from legislation enacted in 2001, wherein the U.S. Congress directed the NPS to identify and analyze in an EIS the possible effects of the 1996 increases in the number of vessel entries issued for Glacier Bay National Park and Preserve and to set the maximum level of vessel entries based on the analysis in this EIS. Congress further directed that the EIS be completed by January 2004. The draft EIS will be available for public review on March 14, 2003. The comment period will extend through May 14, 2003. The final EIS and Record of Decision will be completed by October 3 and November 21, 2003, respectively.

This EIS will build on an Environmental Assessment (EA) completed in 1995 and a Revised EA, Finding of No Significant Effect, and decision completed in 1996. The decision was supported by a 1993 biological opinion, prepared by the NMFS in accordance with Section 7 of the Endangered Species Act (ESA). The decision incorporated conservation recommendations included in the biological opinion.

Based on internal discussions and discussions with and comments from agencies, interest groups, businesses, and the public that occurred in 2002, the NPS has developed and will evaluate in a draft EIS four action alternatives, as well as a no action alternative. We discussed these with Kaja Brix by phone on January 28, 2003.

Listed below are mutual understandings based on our informal consultation with Ms. Brix on January 28. We request your concurrence with these understandings so we can assure we are on the right track with respect to Section 7 consultation for this project.

1. The species (and stocks) listed under the ESA that are present in the area potentially affected by this action are the humpback whale (endangered), the western stock of Steller sea lion (endangered), and the eastern stock of Steller sea lion (threatened).

2. We anticipate that any of the alternatives considered in the draft EIS may adversely affect species listed under the ESA or their critical habitat. Therefore, in accordance with Section 7 of the ESA, formal consultation between the NPS and the National Marine Fisheries Service is necessary and a biological assessment and biological opinion are required.

3. The draft EIS will serve as the biological assessment. A cover letter will be appended to the draft EIS mailed to NMFS; this letter will serve to initiate formal Section 7 consultation.

4. The NMFS will use the information and assessment in the draft EIS to develop the biological opinion.

5. Conservation recommendations identified in the 1993 biological opinion for vessel management in Glacier Bay should serve as a good starting point for developing any new measures that may be needed. The NMFS and NPS will work together to define reasonable mitigation for use in the biological opinion and the final EIS.

6. The draft EIS will include how current measures are working and include additional measures, as needed, to minimize or eliminate potentially adverse effects.

7. In recognition of the Congressionally mandated timeframe for this EIS, the NPS and NMFS will strive to complete formal consultation by the time the Record of Decision is completed in November 2003. Regular, ongoing communications should facilitate this.

8. The NPS and NMFS intend to meet in Juneau in April, near the time of the public hearing on the draft EIS.

The draft EIS will evaluate effects on marine mammals in addition to listed species. We anticipate that NMFS will review and comment on this portion of the EIS as well, based on your agency's authority under the Marine Mammal Protection Act and your expertise.

We appreciated meeting with you last May and have had productive conversations with Ms. Brix since that time. We look forward to meeting with you and Ms. Brix in mid-April in Juneau, sometime close to when our public hearing on the draft EIS occurs. I will contact Ms. Brix to arrange this meeting.

I would appreciate your concurrence with the understandings listed above. Please contact me with any questions or comments you may have (phone: (907) 257-2651; EMail: nancy_swanton@nps.gov)

Thank you.

Sincerely,

Nancy K. Swanton
EIS Project Manager

cc: Kaja Brix, NMFS

I concur: ______________________________ Date: ____________
Michael Payne ARA

I do not concur: ______________________________ Date: ____________
Michael Payne ARA

United States Department of the Interior

NATIONAL PARK SERVICE
Glacier Bay National Park and Preserve
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FEB 21 2003

Ms. Judith E. Bittner, State Historic Preservation Officer
Alaska Office of History and Archaeology
500 West 7th Ave., Suite 1310
Anchorage, AK 99501-3565

Dear Ms. Bittner:

The National Park Service (NPS) is currently proposing changes in vessel management policies for Glacier Bay National Park and Preserve in Southeast Alaska. These changes are currently being reviewed under the National Environmental Policy Act (NEPA) and an Environmental Impact Statement is being coordinated with the Section 106 review. As this is a federal undertaking, this department is required to comply with Section 106 of the National Historic Preservation Act and its implementing regulations 36 CFR 800. NPS contracted with Environment and Ecology who subcontracted to Stephen R. Braund & Associates (SRB&A) to conduct the NEPA and Section 106 review. NPS is responsible for coordinating and conducting consultation with Alaska Native Tribes interested in the undertaking. As the proposed undertaking takes place entirely within the traditional homeland of the Huna Tlingit tribe, the Hoonah Indian Association, a federally recognized tribal government, is being consulted regarding this matter. SRB&A is working with Wayne Howell, cultural anthropologist, National Park Service, Glacier Bay National Park and Preserve to identify and determine eligibility for the National Register of Historic Places for cultural resources (e.g., archaeological resources, historic structural resources, ethnographic resources, and cultural landscapes) within the area of potential effect (APE). The APE includes the waters and coastlines of Glacier and Dundas bays and is located in Glacier Bay National Park and Preserve, Southeast Alaska (Juneau, Mt. Fairweather, and Skagway USGS Quadrangles, Copper River Meridian) and is within an area delineated in the northeast by T32S, R57E; in the southeast by T40S, R58E; in the northwest by T32S, R49E; and in the southwest by T42S, R54E. The enclosed topographic maps assist in delineating the APE [36 CFR 800.11 (e)(1.

NPS has conducted surveys and inventories for cultural resources (archaeological resources, historic structural resources, ethnographic resources, and cultural landscapes) in the APE. NPS has documented cultural resources and has established context within the APE. The enclosed report, "Glacier Bay National Park and Preserve Vessel Quotas and Operating Requirements Environmental Impact Statement Section 106 Report, Literature Review and Recommendations," documents these findings and the agency's implementation of 36 CFR

800.4(b). NPS consulted [illegible] local tribes to establish cultural or re[illegible]ous significance to cultural resources in the APE. Oral histories from local residents added to the role and importance of these cultural resources. Local government comments were solicited and a town meeting was held to obtain public opinion. [36 CFR 800.11(e)(2)].

Based on the archaeological survey, in depth ethnographic research, literature review and consultation, we are seeking your concurrence on the finding of "no historic properties affected" by any of the alternatives outlined by this undertaking (36 CFR Part 800 Sec. 800.4 [d1]). NPS is dedicated to insuring that the vital associations of Huna Tlingit tribal members to their sacred sites within the park are maintained, and this undertaking is one step in that process.

If you have any questions, please contact Wayne Howell at (907) 697-2662 or email at <wayne_howell@nps.gov>.

Sincerely,

Tomie Patrick Lee

Tomie Patrick Lee
Superintendent

Enclosure

The National Park Service cares for special places
saved by the American people
so that all may experience our heritage.

EXPERIENCE YOUR AMERICA.

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to assure that their development is in the best interests of all. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

March 2003

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