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and M. C. Ferguson

November 2022

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

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Distribution and Relative Abundance of Bowhead Whales and Other Marine Mammals in the Western Beaufort Sea, 2021

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ABSTRACT

Aerial line-transect surveys for bowhead whales (*Balaena mysticetus*) and other marine mammals were conducted in the western Beaufort and eastern Chukchi seas from 23 September to 10 October 2021. The primary survey area ranged from Utqiaġvik to Prudhoe Bay, Alaska (157°-148°W, shore to 72°N). Surveys were conducted on a total of 11 days, mainly in the primary survey area due to survey priorities, weather, and logistical limitations. A total of 138 sightings of 200 bowhead whales were documented during the survey period. Sightings occurred from 146.0°W to 157.1°W, though 90% of whales were sighted west of 150°W. Most sightings (150 whales, 75%) were located over the inner continental shelf (≤ 50 m), 48 whales were sighted over the outer continental shelf (51-200 m), and two whales were sighted in the 201-2,000 m depth zone. Sighting rate (whales per on-effort km) was highest in the West Beaufort Sea subarea in the 51-200 m depth zone and in the East subarea in the 0-20 m depth zone. The highest sighting rate per survey block occurred in block 3 (150°-154°W), followed by block 12 (154°-157°W). The area east of Point Barrow to Cape Halkett is a well-documented bowhead whale feeding area where upwelling conditions favorable for concentrating krill on the continental shelf occur and create "krill traps." During 2021 surveys, while small groups of bowhead whales were sighted in the Point Barrow area and survey block 12, they were not sighted in dense aggregations in this area, and few were feeding. However, bowhead whales were sighted in dense aggregations in the Cape Halkett area: (151.9°-152.6°W, 70.7°-71.2°N). Mechanisms leading to the bowhead whale aggregations documented near Cape Halkett in 2021 may have been related to the krill trap, freshwater outflow, or both.

Bowhead whale distribution in the western Beaufort Sea in autumn 2021 was distinctly different from the extremes seen in 2019 and 2020, though similar to other previous survey years. In autumn 2019, the bowhead whale migration was unprecedented; whales were sparse along the inner continental shelf, particularly near Utqiaġvik, Alaska, and whales sighted were farther offshore and in deeper water than previous survey years with similarly light sea ice cover. Conversely, in 2020 bowhead whales were sighted in what may be the densest bowhead whale aggregations documented in the history of the ASAMM and NSB Autumn Aerial Surveys projects, dating back to 1979, and were closer to shore and in shallower water than previous years with similar surveys. During 2021, bowhead whales were sighted both nearshore within the 20-m isobath and offshore near the 200-m isobath, resulting in no significant differences in depth or distance to shore of sightings in the West region compared to previous years with light sea ice cover.

The Arctic and sub-Arctic ecosystems that bowhead whales depend upon are rapidly changing due to the warming climate. Lessons learned from the past, particularly about spatiotemporal variability in bowhead whale density and habitat use, likely do not accurately reflect the present and future ecosystems. Climate-related changes have profound effects throughout ecosystems, including the Alaskan coastal communities who rely on bowhead whales for subsistence.

Aerial survey results from 2019, 2020, and 2021, three sequential years in which the autumn bowhead whale migrations across the western Beaufort Sea were very different from each other and each year unexpected from the next, provide strong justification for annual monitoring of the bowhead whale autumn migration to better understand the future availability of bowhead whales to subsistence hunters and to provide data for sound decision-making by resource managers to minimize or mitigate the effects of human activities on this population of bowhead whales.

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INTRODUCTION

The spatiotemporal distributions and relative densities of the bowhead whale (*Balaena mysticetus*) autumn migrations across the western Beaufort Sea (140°-157°W, shore to 72°N) in 2019 and 2020 were unexpected and unlike any on record, and also the extreme opposite of each other.

In 2019, subsistence hunters from Kaktovik and Nuiqsut, Alaska, (in the eastern and central Alaskan Beaufort Sea, respectively) had to travel farther than usual to find whales. The bowhead whales were largely absent near Utqiaġvik, Alaska, from September to November, resulting in only one harvested whale, which was taken in mid-November. More typically, whales in Utqiaġvik are harvested from mid-September through mid-October.

Observations from hunters were reflected in observations from the Aerial Surveys of Arctic Marine Mammals (ASAMM) survey flights in autumn 2019, which covered the broader extent of the western Beaufort Sea shelf, slope, and basin. From 1979 to 2019, ASAMM line-transect aerial surveys (and predecessors; Clarke et al. 2020) were conducted in the Alaskan Arctic to study spatial and temporal patterns in the density, habitat, and behavior of marine mammals, many of which are hunted for subsistence by Yupik and Iñupiaq Alaska Natives. The ASAMM project was funded under an Inter-Agency agreement between the Bureau of Ocean Energy Management (BOEM) and National Oceanic and Atmospheric Administration's (NOAA) Alaska Fisheries Science Center (AFSC), and co-managed by BOEM and AFSC. The ASAMM survey design and protocols focused on bowhead whales, but the project collected information on all marine mammal species observed. In 2019, ASAMM found that bowhead whales were mostly absent from the nearshore Beaufort Sea during September and October, and whales that were sighted were farther offshore and in deeper water than in previous survey years with similarly light sea ice cover (Clarke et al. 2020). No bowhead whales were detected by ASAMM during autumn 2019 in the eastern Chukchi Sea (67°-72°N, 157°-169°W), also unprecedented compared to previous years during which aerial surveys were conducted in the Chukchi Sea (1982-1991; 2008-2018) (Clarke et al. 2020).

The distribution of bowhead whales in 2019, as observed by both subsistence hunters and ASAMM in the western Beaufort and eastern Chukchi seas, likely resulted from: 1) the migration being farther north than normal, outside the normal ASAMM study area, and therefore fewer whales were present during aerial surveys; 2) the migration being delayed, with the whales remaining in the eastern Beaufort Sea longer and later in the year; or 3) a combination of these and other factors. The underlying causes for this anomalous migration are not completely known.

The Pacific Arctic is a region with dynamic ecosystems that are undergoing unpredictable and rapid changes. During 2019, in addition to record low summer and winter sea ice extents in the Arctic (National Snow and Ice Data Center 2019), other extreme environmental variables were recorded, including warmer surface air and sea surface temperatures, lower snow cover, thawing permafrost, and decreased sea ice thickness (Richter-Menge et al. 2019), which undoubtedly affected primary and secondary productivity, transport of water and krill from the Bering Sea, and freshwater runoff. Very few bowhead whale aggregations, an indication of potential feeding, were observed in the western Beaufort Sea, and feeding behavior was conspicuously absent (Clarke et al. 2020), suggesting that krill and other bowhead whale prey were mostly absent or present in only very low densities in the western Beaufort Sea. The presence of killer whales in the western Beaufort Sea may also have influenced the distribution of bowhead whales (Willoughby et al. 2020). Additionally, underwater sound may also affect bowhead whale behavior, and it may come from a variety of industrial, commercial, and natural sources (e.g., vessel traffic, seismic surveys and mapping, sound used to guide autonomous scientific instruments, and noise from increased wave action resulting from loss of sea ice and the associated increase in storm frequency and intensity, etc.) (Roth et al. 2012, Robertson et al. 2015, Blackwell and Thode 2021, Würsig and Koski 2021).

In 2019, the ASAMM project completed its last year of federally funded field work. Neither BOEM nor NOAA allocated funding for cetacean aerial or vessel-based line-transect surveys in the Arctic in 2020.

The North Slope Borough (NSB), NOAA, and BOEM hosted an Arctic Cetacean Listening Session in January 2020 in Utqiaġvik, Alaska, to gather input from partners and stakeholders to help develop and focus the next generation of research initiatives that will build on the strong foundation that ASAMM established. Participants of this meeting included NSB Department of Wildlife Management, NSB Mayor Harry Brower, Jr., Alaska Eskimo Whaling Commission (AEWC), Alaska Beluga Whale Committee (ABWC), Iñupiat Community of the Arctic Slope, Barrow Whaling Captains' Association (BWCA), Marine Mammal Commission, U.S. Coast Guard, and Alaska Ecological Research contracted with Hilcorp. Recognizing the importance of cetaceans to Yupik and Iñupiaq coastal communities in Alaska, the purpose of the Listening Session was to provide co-management partners with an opportunity to identify what information is needed to promote healthy Arctic cetacean populations and to sustainably manage cetacean subsistence harvests.

The Listening Session concluded that data should continue to be collected that are needed to assess marine mammal population size and trends, distribution, migration, diet, and other indicators of ecosystem and population health. Data collected from aerial surveys in autumn 2020 would help to meet the goal of monitoring the bowhead whale autumn migration. Furthermore, survey methods in future years should be consistent with the existing 41-year ASAMM time series to facilitate comparison with past years, including analysis of variability and trends. The North Slope Borough funded autumn aerial surveys for bowhead whales in 2020 in a collaboration with the Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES).

During the 2020 survey season, bowhead whales were sighted in dense feeding aggregations close to shore from Point Barrow to Oliktok Point in the western Beaufort Sea (Brower et al. 2022b). They were significantly closer to shore and in shallower water than in previous years when similar surveys were conducted (Brower et al. 2022b). By some metrics, these were the densest bowhead whale aggregations documented in the history of ASAMM line-transect aerial surveys in the study area. Bowhead whales observed during the survey were likely feeding on krill. Autumn 2020 provided upwelling conditions favorable for concentrating krill on the continental shelf near Utqiaġvik (Brower et al. 2022b). Bowhead whales were also sighted in high density near the mouth of Harrison Bay, an unusual location for bowhead whale aggregations (Brower et al. 2022b). High densities of feeding bowhead whales in October are also unusual; although bowhead whales are typically present in the study area in October, they are not usually sighted in such high densities.

Arctic and sub-Arctic ecosystems that bowhead whales depend upon are rapidly changing due to the warming climate. The spatiotemporal variability in bowhead whale density and habitat use witnessed in 2019 and 2020 underscores the need to maintain consistent monitoring to accurately describe present and future ecosystems. Climate-related changes have profound effects throughout ecosystems, including the Indigenous communities who rely on bowhead whales for subsistence. In 2019, there were substantial negative impacts to the subsistence communities of northern Alaska, whose cultural, economic, nutritional, and spiritual needs are tied to subsistence hunting, especially hunting of bowhead whales. Impacts to these communities included increased safety risks to each whaling crew due to increased time searching for whales, particularly when weather conditions become more unpredictable and more dangerous (i.e., higher wind and sea state). Greater financial burdens were incurred with increased fuel consumption resulting from more time spent searching for whales farther from the villages. Furthermore, hunting bowhead whales through November limited opportunities to pursue other critical subsistence hunting activities. Finally, the limited harvest of bowhead whales in Utqiaġvik meant the very real potential for food shortages, as the community had to increase reliance either on other subsistence foods or on non-subsistence foods, which are expensive, difficult to obtain, and generally not as nutritious as traditional foods.

Aerial survey results from 2019, 2020, and 2021, three sequential years in which the autumn bowhead whale migrations across the western Beaufort Sea were very different from each other and each year unexpected from the next, provide strong justification for annual monitoring of the bowhead whale autumn migration to better understand the future availability of bowhead whales to subsistence hunters and to provide data for sound decision-making by resource managers to minimize or mitigate the effects of human activities on this bowhead whale population. To continue this annual monitoring of the bowhead whale autumn migration, aerial surveys were conducted in autumn 2021 to collect data on bowhead whale density, distribution, activity states, and calf production. Survey methods were consistent with the existing 42-year ASAMM and NSB aerial survey time series to facilitate comparison with past years, including analysis of variability and trends. The survey objectives were as follows:

i. Conduct aerial line-transect surveys in the western Beaufort Sea to collect data on bowhead whale density, distribution, activities, and calves using survey methods consistent with the existing 42-year ASAMM time series.
ii. Analyze the autumn 2021 aerial survey data with the ASAMM and NSB historical database to investigate spatial and temporal patterns, variability, and trends in bowhead whale density and habitat use in the western Beaufort Sea.

METHODS

Study Area

In 2021, the Beaufort Sea study area covered the western Beaufort Sea, from 140°W to 157°W and the coastline to 72°N and was divided into survey blocks 1-12 (Fig. 1). The Chukchi Sea study area consisted of the eastern Chukchi Sea, from 157°W to 169°W and 67°N to 72°N and included survey blocks 13-23 (Fig. 1). The western Alaskan Beaufort Sea, from Utqiaġvik to Prudhoe Bay, was the highest priority region to survey. Transect lines near Utqiaġvik and Deadhorse (airports with aviation fuel available) could optionally be extended up to 74°N if there were indications that bowhead whales might be traveling farther north than usual. The eastern Alaskan Beaufort Sea, from Prudhoe Bay to the U.S.-Canada border, was of secondary importance. However, this area could have risen in priority if bowhead whales were absent in the western Alaskan Beaufort Sea and there were reasons to believe there may be many whales still migrating from the Canadian Beaufort Sea. The northeastern Chukchi Sea, from Utqiaġvik to Wainwright, comprised the third highest priority area. The rest of the Chukchi Sea was the lowest priority for documenting the bowhead whale migration, but it was important for documenting the presence of other species, such as gray (*Eschrichtius robustus*), humpback (*Megaptera novaeangliae*), fin (*Balaenoptera physalus*), minke (*Balaenoptera acutorostrata*), and killer (*Orcinus orca*) whales.

The northern Chukchi Sea is largely ice-covered from early winter through early spring, although dramatic environmental changes have reduced modern sea ice extent from historical levels (Wood et al. 2015). In spring, open water leads begin to develop as ambient temperatures increase and warmer water flows northward from the Pacific Ocean through the Bering Sea and Bering Strait. The most nutrient-rich waters flow in the Siberian Coastal Current, along the Chukotka Coast. Two less productive water masses, the Alaska Coastal Water and Bering Shelf/Anadyr Water, are found in the eastern Chukchi Sea (Fig. 2). Current flow may be with or against the wind direction. Some of this Pacific-origin water exits the Chukchi Sea through the Chukchi slope current, which likely originates from Barrow Canyon and flows westward along the slope, and the Chukchi and Beaufort seas shelfbreak jets, whose mean flow are to the east in the absence of wind forcing (Corlett and Pickart 2017). In the Beaufort Sea, the Beaufort Gyre moves surface waters clockwise in the offshore regions. Underlying the gyre is the predominantly eastward-flowing Beaufort Undercurrent, which flows subsurface in areas where the sea floor is 51-2,000 m deep and undergoes frequent current reversals (Aagaard 1984, Carmack and MacDonald 2002). In the nearshore shallow waters of the Beaufort inner shelf (≤ 50 m depth), currents tend to follow local wind patterns during periods of open water.

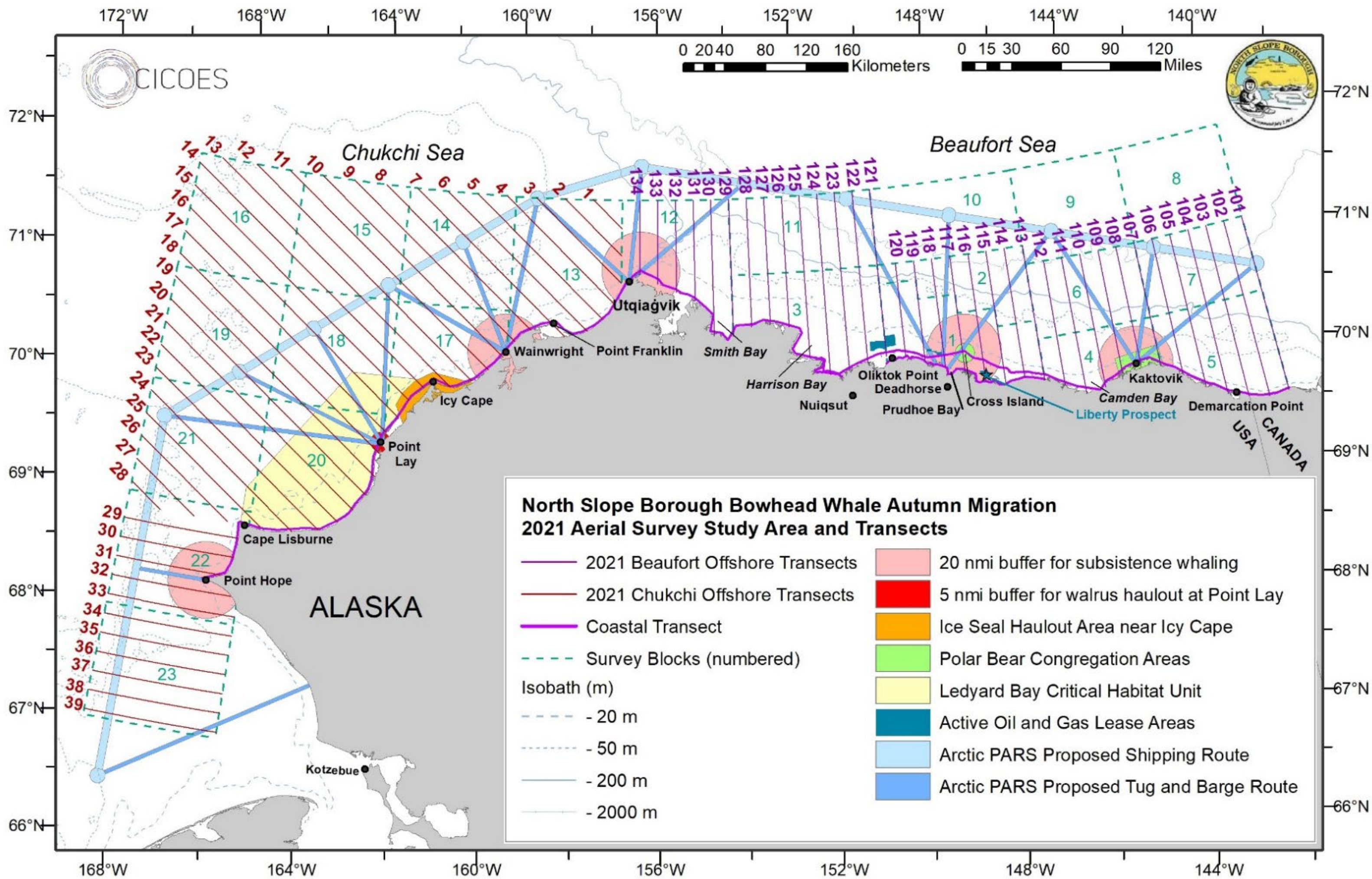

Figure 1. -- Study area and transects for the North Slope Borough Bowhead Whale Autumn Migration 2021 Aerial Survey. The western Alaskan Beaufort Sea, between Utqiaġvik and Prudhoe Bay, was the highest priority area. The eastern Alaskan Beaufort Sea, from Prudhoe Bay to the U.S.-Canada border, was the second highest priority area. The northeastern Chukchi Sea, from Utqiaġvik to Wainwright, was the third highest priority area. The rest of the Chukchi Sea was the lowest priority area.

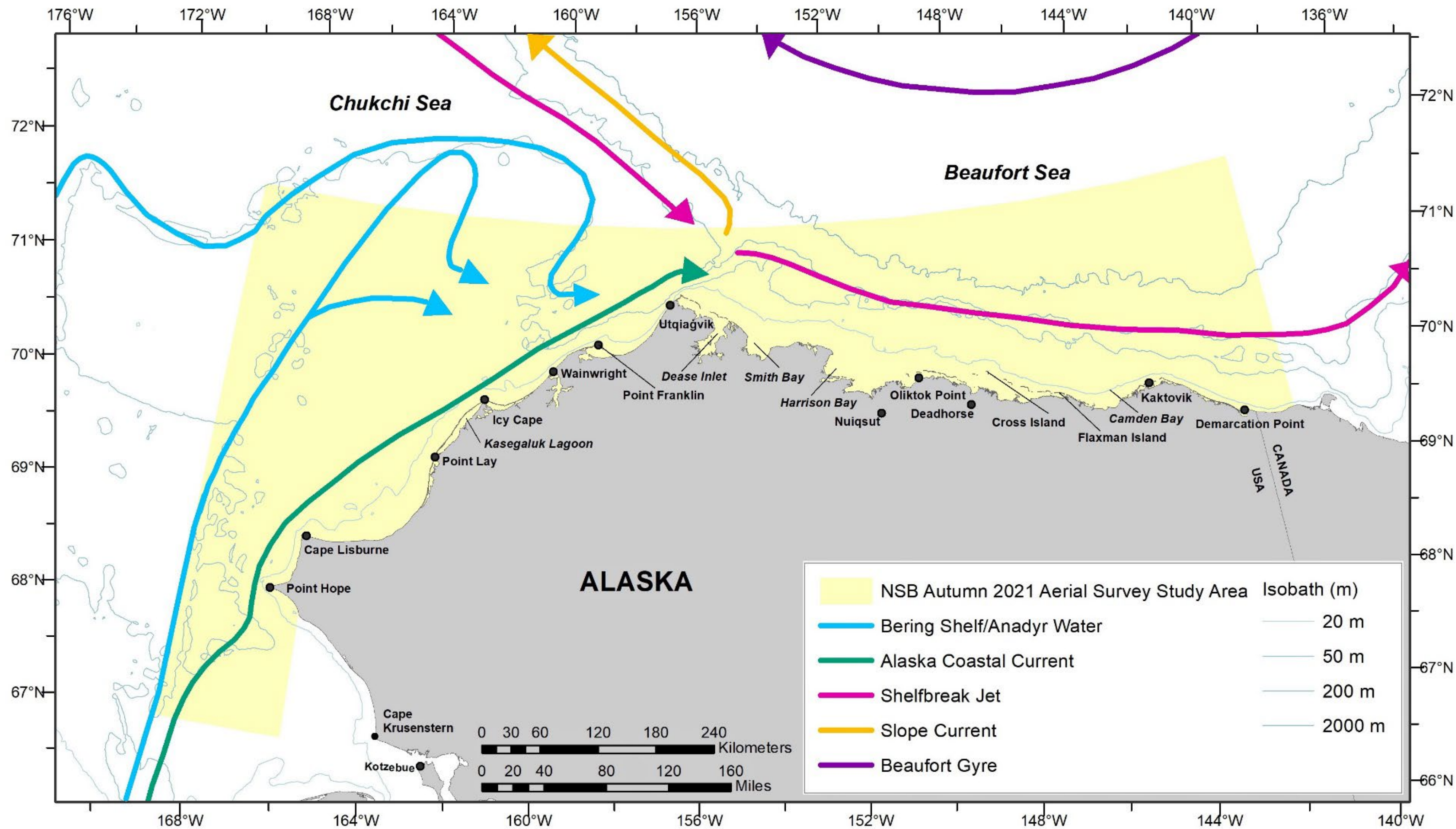

Figure 2. -- Oceanographic features in the eastern Chukchi and western Beaufort seas. Adapted from Corlett and Pickart (2017).

Aerial Line-Transect Surveys

Aerial line-transect surveys were designed to be flown in the western Beaufort and eastern Chukchi seas (Fig. 1; total area 253,000 km^2). Systematic transects were placed 18 km apart, based on a grid with a randomly selected start point. Transects were oriented perpendicular to the coastline, to cut across isobaths, from shore to the Beaufort Sea basin (> 2,000 m), extending a maximum of 181 km offshore. A coastal transect was designed to be flown 1 kilometer offshore between Demarcation Bay in the western Beaufort Sea and Point Hope in the eastern Chukchi Sea. The survey team was based in Utqiaġvik, Alaska, to be located near the primary study area.

The selection of transects or survey blocks to be flown on a given day was non-random, based on reported or observed weather conditions in the study area, avoidance of recently surveyed areas, the need to deconflict airspace with other aerial operations, and avoidance of marine subsistence activities. Surveys were not preferentially conducted in areas or during time periods with a higher likelihood of seeing whales (e.g., based on recent wind conditions, historical ASAMM data, or indigenous knowledge). Weather permitting, the project attempted to distribute effort evenly within the priority areas.

Surveys in 2021 followed the same protocols as were implemented in 2020 and during the ASAMM surveys in 2019; more detailed methods can be found in Clarke et al. (2020).

Surveys were conducted in a Turbo Commander aircraft provided by Clearwater Air, Inc. Surveys were flown at 305-460 m (1,000-1,500 ft) above surface level with a target altitude of 396 m (1,300 ft), 213 km/hr (115 kt/hr) survey speed. The aircraft had bubble windows for the left- and right-side primary observers, allowing unobstructed views from the horizon to directly beneath the aircraft. The field team was comprised of three experienced field biologists. Two of the observers in 2021 had also been observers, data recorders, and team leaders on the former ASAMM project and NSB 2020 surveys (7 and 12 years of experience per observer), ensuring consistency in data collection across years. The third member, a NSB DWM biologist, was new to aerial surveys and received extensive training, including a dedicated practice flight before the first survey in which data were recorded and archived. The two experienced biologists alternated between primary observer and data recorder roles and the NSB DWM biologist served as a primary observer on every flight. The data recorder and pilots served as secondary observers.

The data recorder input sighting data into a laptop computer that was connected to a GPS and running specialized, menu driven ASAMM Survey software. Time and position data (latitude, longitude, altitude) were automatically recorded in 30-seconds intervals or whenever a manual data entry was recorded. Environmental and viewing conditions, including integer-valued Beaufort Sea State, visibility range perpendicular to the aircraft on each side of the plane (< 1 km, 1-2 km, 2-3 km, 3-5 km, 5-10 km, or unlimited), sky conditions (clear, partly cloudy, overcast), integer-valued sea ice percent on each side of the plane, and impediments to visibility (glare, fog, haze, precipitation, ice on the window, low ceiling) on each side of the plane were recorded in 5-minute intervals or whenever conditions changed. Primary observers scanned for sightings, using binoculars only to check potential targets or to get a magnified view of a confirmed target. Declination angles from the horizon to each sighting were measured using handheld Suunto clinometers when the sighting was abeam. One "sighting" was defined as all animals of the same species within 5-body lengths of each other. Once the clinometer angle was recorded, most sightings of large cetaceans (i.e., anything larger than a beluga, *Delphinapterus leucas*) were circled to determine a final group size estimate, confirm species identification, look for calves, and to determine behavior. Both initial and final group size estimates were recorded in the database; if group size could not be determined with certainty, high and low estimates could also be recorded. Calves initially detected from the trackline were distinguished in the database from calves that were only detected during circling. Circling did not commence in special circumstances, such as restrictions due to weather, fuel, time of day, or pilot duty hours, or near sensitive wildlife habitat or subsistence hunting activities. A custom mapping component of the survey software permitted the data recorder to view sightings relative to the aircraft's trackline in real-time, which minimized chances of duplicate sightings being recorded. Sightings that could not be positively identified to species were recorded at the taxonomic level to which they could be identified (e.g., unidentified cetacean). Behaviors were entered as one of several categories (Table 1), although additional details about behaviors could be included in notes. The observers watched for any abrupt and unexpected changes in the animals' initially observed behavior presumably due to the presence of the aircraft; observed responses were recorded in the database, along with the number of animals that responded.

Six survey modes were used for data collection (Table 2): transect, circling from transect, Cetacean Aggregation Protocols (CAPs), CAPs circling, search, and circling from search. During all six of these survey modes, observers were actively surveying, and all sighting and effort data were recorded. Transect effort refers to systematic survey effort along a prescribed transect line. Search refers to non-systematic survey effort during transit or between transects. Circling from search or transect occurred when the aircraft diverted from flat and level flight to circle a localized area to investigate a sighting or potential sightings. Standard line-transect survey protocols were followed until encounter rates of large cetaceans exceeded the observers' ability to accurately record location and clinometer data for each sighting.

In areas with extremely high densities of large cetaceans, CAPs was used, wherein the survey team flew through the high-density patch in passing mode (without circling) to collect accurate encounter rate data, and then flew back through the patch in closing (CAPs circling) mode to collect information on group size, number of calves, and behavior (Appendix A). Determining species, group size, calf presence, and behavior during CAPs passing is difficult because of the high density of sightings and because all sightings detected within 3 km of the trackline were recorded. Statistics for CAPs passing mode that were inferred from CAPs circling data (e.g., group size, number of calves, and feeding or

Table 1. -- Definitions of observed marine mammal behaviors.

Behavior	Definition
Breach	Animal(s) launching a substantial portion of the body above the water surface then falling back down again, creating an obvious splash.
Dead	Animal(s) that is clearly deceased, in water or on beach; carcass often but not always bloated, with sloughing skin and accompanied by oil slicks, feeding birds, or scavenging bears.
Dive	Animal(s) changing swim direction or body orientation relative to the water surface, resulting in submergence; may or may not include lifting the tail out of the water.
Feed	Animal(s) diving repeatedly in a fixed area, sometimes with mud streaming from the mouth and/or defecation observed upon surfacing; synchronous diving and surfacing or echelon formations at the surface, with swaths of clearer water behind the whale(s), or surface swimming with mouth agape (bowhead whales); mouths open and/or throat grooves extended (balaenopterid whales); bubble nets (humpback whales).
Flipper Slap	Animal(s) striking the water surface with a pectoral flipper.
Hunt	Animal(s) actively pursuing prey.
Log Play	Animal(s) milling or thrashing in association with a floating log.
Mate	Whales in ventral-ventral orientation, often with one or more other whales present to stabilize the mating pair.
Mill	Two or more animals moving slowly at the surface with varying headings, in close proximity (within 100 m) to, but not obviously interacting, with other animals.
Rest	Animal(s) at the surface with head, or head and back, exposed, or resting on ice or land; showing no movement.
Roll	Animal(s) rotating on longitudinal axis.
SAG	Surface Active Group – two or more whales within a body length of each other, interacting and socializing at the surface.
Spy Hop	Whale(s) extending head vertically above the water surface.
Stand	Animal(s) standing upright on ground or ice.
Swim	Animal(s) proceeding forward through the water, propelled by tail or limbs.
Tail Slap	Whale(s) striking the water surface with the tail.
Thrash	Animal(s) exhibiting rapid flexure or gyration in the water.
Underwater Blow	Animal(s) exhaling under water, creating a visible bubble.
Unknown	Behavior not able to be determined, usually due to the sighting occurring at some distance from the aircraft location.
Walk/Run	Animal(s) moving on ground or ice at slow or normal pace (walking) or more rapid pace (running).

Table 2. -- Survey mode definitions.

Survey mode	Definition
Transect	Systematic survey effort (non-CAPs) along a prescribed line; sightings not limited to any distance from the trackline; on effort.
Circling from transect	Directed effort searching a small, localized area after diverting from transect; sightings limited to area inside the circle; off effort.
Search	Non-systematic survey effort during transit or between transects; off effort.
Circling from search	Directed effort searching a small, localized area after diverting from search; off effort.
Cetacean Aggregation Protocols (CAPs) - passing	Systematic survey effort along a prescribed transect in an area of high-density large cetaceans; sightings limited to within 3 km of the trackline; on effort; immediately followed by CAPs circling.
CAPs circling	Directed effort searching the area out to 3 km from the trackline immediately after completing CAPs passing; excludes any areas surveyed in CAPs strip mode; off effort.
Deadhead	High-speed, high-altitude transits to and from transects, and areas over land or without any downward visibility; off effort.

milling behavior) are referred to as CAPs-adjusted statistics. Additional detail about the integration of CAPs data is included in Appendix A. Transect and CAPs passing survey modes are considered on effort; search, circling from transect or search, and CAPs circling are considered off effort. Deadhead mode was recorded during transits over land, transits at high speeds or high altitudes, or when weather impeded visibility to the extent that the observers could not collect reliable data.

Generally, when cloud ceilings were consistently less than ~335 m or the wind force was above Beaufort 5, survey flights were redirected to survey blocks or transects with better conditions. Survey flights were aborted when conditions consistently did not meet minimum altitude (305 m), visibility, or wind force (Beaufort 5) requirements.

Altitude and Lateral Adjustments to Avoid Subsistence Hunting and Sensitive Wildlife

The surveys followed the same, or more conservative, protocols used successfully by the previous ASAMM and NSB surveys to avoid interfering with subsistence hunting activities and sensitive areas for wildlife (Clarke et al. 2020, Brower et al. 2022b).

Whenever small boats were seen, the survey plane avoided the boats by at least 9 km (5 nmi) to avoid potential interference with subsistence activities. Most subsistence activity occurs fairly close to shore and within nearshore lagoons, although whalers can be found farther than 64 km (40 mi) offshore. When bowhead whaling was active, a minimum altitude of 458 m (1,500 ft) was maintained within 37 km (20 nmi) of Point Barrow, Cross Island, Kaktovik, and Wainwright, regardless of whether small boats had been sighted in the vicinity that day. If the minimum altitude of 458 m (1,500 ft) could not be maintained, survey effort was truncated to avoid a 37-km (20 nmi) radius around each whaling area, regardless of whether small boats had been sighted in the vicinity that day (Fig. 1).

The survey aircraft did not intentionally overfly any walrus (*Odobenus rosmarus divergens*) or seal haulouts on land or ice. The U.S. Fish and Wildlife Service requested that the survey team remain at least 9 km (5 nmi) offshore of walruses hauled out on land to ensure there was no disturbance to the haulout. Walruses have hauled out on the beach near Point Lay in most years since 2007; in 2021, they began arriving in August. The survey team planned to notify the Point Lay Council by email prior to survey flights in the vicinity of Point Lay whenever walruses were hauled out near Point Lay; however, no flights were conducted near Point Lay in 2021.

If a coastal transect was conducted near the Icy Cape area (transects 12-16), where smaller haulouts of spotted seals (*Phoca largha*) are often encountered, protocol was to increase survey altitude to at least 610 m (2,000 ft) when ceilings allowed and increase lateral distance to 1.9 km (1 nmi) offshore to avoid disturbing seals. If ceilings did not allow for increased altitude near Icy Cape, the survey aircraft would divert farther offshore, to 3.7 km (2 nmi).

Critical habitat for Spectacled Eiders is located in Ledyard Bay. To minimize disturbance to Spectacled Eiders, the survey aircraft was not allowed to fly below 305 m (1,000 ft) in Ledyard Bay. Each transect in Ledyard Bay was permitted to be flown at most once over the course of the survey period, and the aircraft would avoid extensive circling in the area.

To minimize disturbance to polar bears (*Ursus maritimus*), the survey aircraft did not directly fly over Barter Island and did not survey Cross Island, locations where polar bears are known to congregate near bowhead whale bone piles. Circling in polar bear habitat was limited to 15 minutes and greater than 152 m (500 ft) altitude. Particular caution would have been used near Cross Island and Kaktovik/Barter Island if the survey aircraft flew in those areas and needed to circle whale sightings; however, this situation did not arise during the 2021 survey season. The survey aircraft never circled swimming polar bears. Lastly, the aircraft maintained at least 458 m (1,500 ft) altitude within 0.9 km (0.5 nmi) of polar bears when the aircraft was transiting (i.e., on deadhead) the area.

In addition to the items above, higher or lower altitudes were acceptable, as noted below.

- Less than 305 m (1,000 ft), with a minimum of 152 m (500 ft) for brief periods of time (< 10 min) to photograph large whales or carcasses, or to determine group size and calf presence. Extended time at less than 305 m (1,000 ft) did not occur if whales appeared to respond to the aircraft. No circling lower than 458 m (1,500 ft) occurred in areas where walruses had recently been sighted.

- In areas where walruses likely occur in the water or on sea ice, less than 305 m (1,000 ft) was not to be maintained for greater than 10 minutes, except for safety reasons.
- Greater than 458 m (1,500 ft) within 0.9 km (0.5 mi) over walruses hauled out on ice. Walruses will react differently depending on behavioral state, but in general seem to respond to abrupt changes by the aircraft (e.g., turning, change in pitch) more than if the aircraft continues in a straight line. Walruses on ice have responded to the aircraft at 366 m (1,200 ft), so pilots increased altitude to greater than 458 m (1,500 ft) prior to overflights if the pilots or observers detected walruses in advance.
- 305-458 m (1,000-1,500 ft) was flown to avoid localized weather such as low clouds or precipitation.
- Higher altitudes (e.g., greater than 1,219 m; 4,000 ft) were flown during deadheads.
- Altitude would have been adjusted for aircraft deconfliction with manned or unmanned aircraft; however, this situation did not arise during the 2021 survey season.

Safety

The survey team followed strict safety protocols specific to COVID-19 and flight operations. The complete safety protocols are detailed in Appendices B and C, respectively. Below, we summarize the main points from each protocol.

COVID-19 Safety Protocols

The health and safety of Utqiaġvik residents and survey personnel were of utmost importance during the survey period. Strict measures were implemented to ensure that survey scientists and pilots who arrived in Utqiaġvik were COVID-19 negative and remained free of the virus for the duration of their stay. The central pillar of the COVID-19 safety protocols was establishment and maintenance of a 'bubble' of survey personnel. Stringent practices of wearing face masks, social distancing, and severely limiting external contacts were used to maintain the integrity and safety of the bubble, and to prevent the potential spread of the virus. Necessary activities within the bubble wherein social distancing could not be maintained, such as flying in the survey aircraft, were limited to bubble members. Scientists wore face masks during travel on Alaska Airlines to Utqiaġvik, Alaska. Personnel employed frequent hand washing/sanitizing.

Aerial Survey Safety Protocols

Aviation safety protocols were based on training, emergency preparedness, real-time flight following, reporting, and a safety culture that considered safety to be a lifestyle as opposed to a set of rules, as detailed in Appendix C. Every survey flight was satellite-tracked in real-time by the Automated Flight Following (AFF) system via SpiderTracks and followed strict communication and tracking protocols (Fig. 3). Dedicated flight followers at Clearwater Air Inc. and NSB DWM, provided real-time flight following assistance to the project.

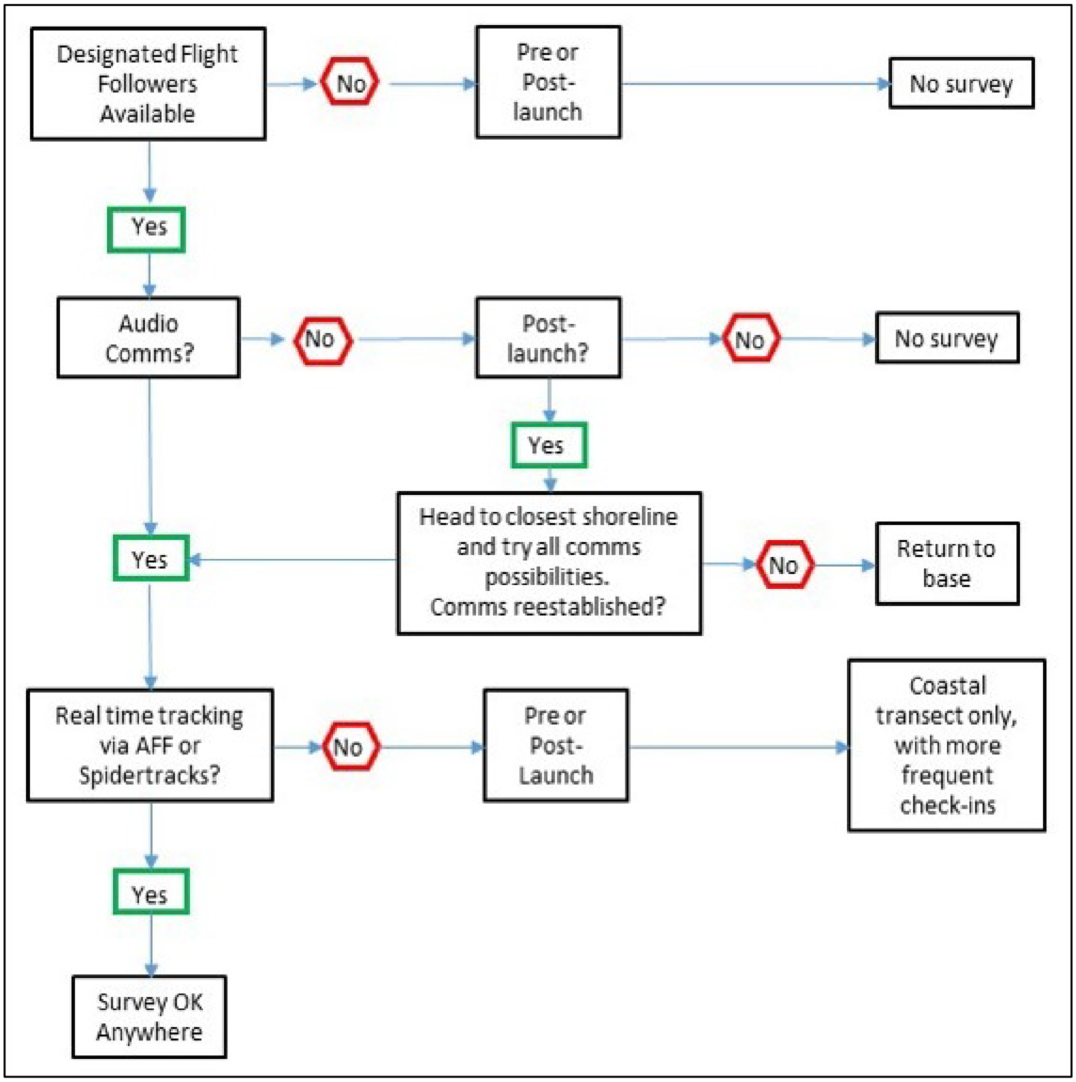

Figure 3. -- Flow chart used to determine whether a survey flight could be initiated, or an existing flight plan should change, pending available communication and flight tracking capabilities.

Analytical Methods

In the analyses presented below, sighting data may be associated with either the location of the aircraft at the time of the sighting or with the location of the sighting that was derived from the altitude and clinometer data. The location of the aircraft is used for fine-scale analyses of encounter rate because each sighting needs to be associated with survey effort, and sightings may be detected at distances greater than 10 km from the aircraft, so the actual position of a distant sighting might occur in a cell that the aircraft did not fly directly over. The location of the sighting is used for all other analyses.

Sighting Rate and Relative Abundance Analyses

Sighting rates (number of whales or walruses per unit [km] effort [WPUE]) quantify relative abundance by accounting for heterogeneity in survey effort and group size across the study area. Sighting rates were derived for three spatial scales, each limited to on-effort sightings by primary observers. Sighting rates were not corrected for availability or perception bias (Buckland 2001).

Sighting rate was calculated for fine-scale areas, using a grid consisting of approximately equilateral cells (5 minutes latitude by 15 minutes longitude, roughly 5 km by 5 km) superimposed across the study area. Sighting rates were calculated for bowhead whales, gray whales, belugas, and walruses. Sighting rates were not calculated for seals or polar bears because they were not priorities for these surveys, and seals are small and difficult to detect and identify to species from the survey altitude.

To calculate sighting rates for bowhead whales, gray whales, and belugas within each survey block in the study area (survey blocks are shown as dashed blue lines on Fig. 1), the number of on-effort whales was divided by effort (kilometers flown on transect and CAPs passing). Although survey blocks are arbitrary geographic areas, they provide a basis for inter-annual comparisons in the eastern Chukchi and western Beaufort seas. Effort over land, between barrier islands and the mainland, and north of the study area was not included in the survey block sighting rate analysis to facilitate comparisons with previous years.

To calculate sighting rates per depth zone for bowhead whales, gray whales, and belugas, the number of on-effort whales was divided by effort (kilometers flown on transect and CAPs passing) per depth zone in the study areas. Depth zones were defined based on depth data in the International Bathymetric Chart of the Arctic Ocean Version 2.23 (Jakobsson et al. 2008), which has a pixel resolution of 2 km. Depth zone analysis in the western Beaufort Sea was computed for two subareas (Fig. 4). The East and West subareas in the western Beaufort Sea are identical to previous analyses (e.g., Clarke et al. 2020) and use depth zones ≤20 m, 21-50 m, 51-200 m, 200-2,000 m, and >2,000 m. The West subarea spans 154°-157°W and includes Barrow Canyon and its surrounding area, which has noticeably different bathymetry than the rest of the western Beaufort Sea survey area. The East subarea spans 140°-154°W, an area that incorporates a well-defined continental shelf and slope. Depth zone analysis in the eastern Chukchi Sea uses slightly different depth zones to better reflect the bathymetric features of the area (≤35 m, 36-50 m, and 51-200 m); the 0-35 m and 51-200 m depth zones were divided into North and South regions because they are separated by large expanses of intermediate (36-50 m) depths (Fig. 4). Projections used for sighting rate analyses for survey blocks and depth zones are included in Appendix D. Depth zone sighting rate analysis includes effort between barrier islands and the mainland. Sightings per depth zone were based on geographic placement of sightings within depth strata, not on the depth associated with each individual sighting in the survey database.

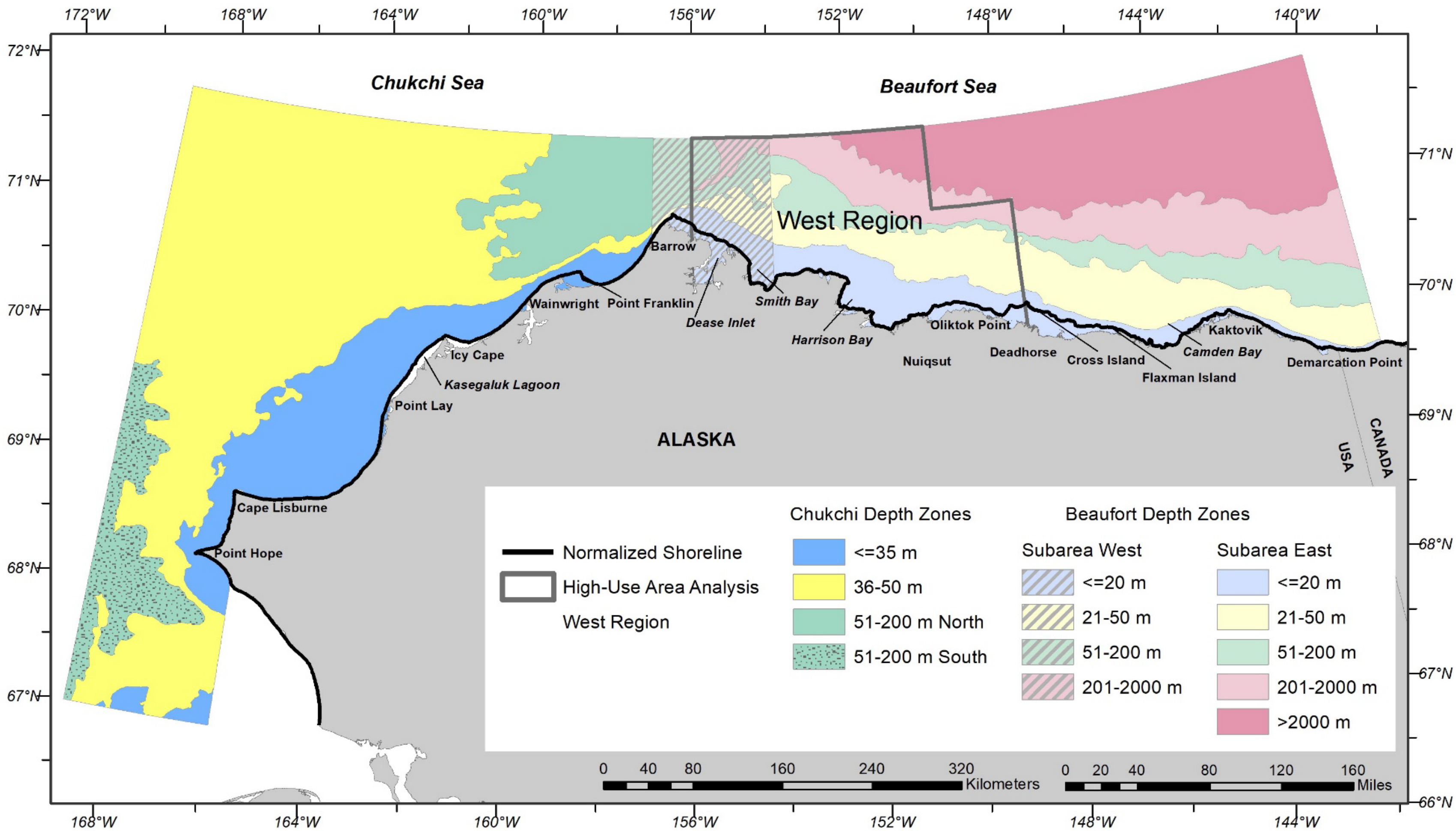

Figure 4. -- West region and normalized shoreline used in bowhead whale high-use area (HUA) analysis, and depth zone subareas used for sighting rate analyses.

Sighting rates calculated for each of the three spatial scales described above for large cetaceans used effort on transect and CAPs passing, in combination with transect and CAPs-adjusted sightings from primary observers. This differs from large cetacean sighting rate analyses for ASAMM prior to 2018, when sighting rate analyses used transect effort only. In 2014-2017, large cetacean sighting rate analyses incorporated sightings and effort on transect combined with sightings and effort during circling from transect. That metric is no longer used, as sightings and effort during circling from transect are considered off effort.

Beluga sighting rates calculated for each of the three spatial scales described above used effort on transect and sightings from primary observers on transect because belugas sighted during CAPs were recorded only in notes, not as individual sightings.

Fine-scale sighting rates for walruses used effort on transect and sightings from primary observers on transect, similar to belugas.

Indices of relative abundance of bowhead whale and gray whale feeding and milling behaviors, quantified as WPUE, were calculated for the fine-scale grid using effort on transect and CAPs passing, in combination with transect and CAPs-adjusted sightings from primary observers.

Analysis of Bowhead Whale High-Use Areas (HUAs) in the Western Beaufort Sea

The majority of the bowhead whales observed in the Beaufort Sea in summer and autumn migrate through the Chukchi Sea to return to wintering areas in the Bering Sea. It was previously thought that most bowhead whales summered in the eastern Beaufort Sea, then actively migrated westward through the western Beaufort Sea in autumn (Moore and Reeves 1993). Previous central tendency analyses (e.g., Treacy 2002a; Monnett and Treacy 2005; Clarke et al. 2011a, 2012) defined bowhead whale observation to be in "migratory corridors." However, results of satellite telemetry studies have shown that some bowhead whales will move back and forth across the Beaufort Sea during summer (Olnes et al. 2020). Furthermore, large dynamic groups of bowhead whales have been documented feeding in the western Beaufort Sea as early as July and continuing into October (e.g., Clarke et al. 2015, 2017b; Ferguson et al. 2021). There is no reliable way, via data collected during line-transect aerial surveys, to differentiate between whales that are actively undergoing a focused, unidirectional, westward autumn migration and whales that are crisscrossing the western Beaufort Sea prior to undergoing directed migration.

To acknowledge that some bowhead whales observed in the western Beaufort Sea in autumn might not be actively migrating, the term "high-use area", or HUA, is used in lieu of migratory corridor for this report. High-use area designation, in this context, describes areas in the western Beaufort Sea where bowhead whales are expected to occur in greatest densities, based on data collected during former ASAMM surveys. High-use areas can be considered a factor for interpreting the relative biological importance of specific areas within the western Beaufort Sea, based on the numbers of whales expected to be present in an area during a particular month or season. High-use areas were not defined based on specific activity states (e.g., migrating or feeding).

Bowhead whale HUAs were analyzed for the West region (148°-156°W) of the western Alaskan Beaufort Sea (Fig. 4), the boundary of which corresponds roughly to oceanographic patterns and the offshore extent of sampling. Oceanographic patterns common to waters off northern Alaska are reviewed in Moore and DeMaster (1998). In brief, cold saline Bering Shelf Water and warm, fresh Alaska Coastal Water enter the western Beaufort Sea through Barrow Canyon. Both water masses are identifiable on the outer shelf (seaward of 50 m) as the eastward flowing Beaufort Undercurrent (Aagaard 1984). Bering Shelf Water has been traced in the Beaufort Sea at least as far east as Barter Island (~143°W), but the Alaska Coastal Water mixes with ambient surface waters as it moves eastward and is not clearly identifiable east of Prudhoe Bay (~147°-148°W).

The northern extent of the West region is based upon historical ASAMM survey effort. The West region extends from 148°W to 156°W and northward from shore to 72°N, except between 148°W and 150°W where the region extends to 71.333°N due to the layout of block 2. The northern boundary for this region corresponds with the boundaries of blocks 2, 11, and 12 (Fig. 4). The western cutoff at 156°W limits the analysis to bowhead whales seen in the western Beaufort Sea. Analyses were not conducted for the Chukchi Sea or east of the West region because few bowheads were sighted there in 2020.

Central tendency analyses were used to compare HUAs from 15 September to 15 October between 2021 and prior years. Two analyses of bowhead whale HUAs in the western Alaskan Beaufort Sea were undertaken, as detailed below.

Bowhead Whale Central Tendency – Analysis 1

Non-parametric statistical tests, via the non-parametric Mann-Whitney *U*-test, were used to examine differences in median depth and distance from shore. Treacy (1998) found that median and mean bowhead whale distance from shore values were only slightly different. The non-parametric test is used for these data because distributions generally do not fit assumptions necessary to use the two-sample *t*-test. The variances are not equal between time periods for both depth and distance from shore; in addition, the depth data are considerably skewed, and the distance-from-shore data are slightly skewed, so neither distribution strictly meets the assumption of normality. When assumptions of the *t*-test are seriously violated, the Mann-Whitney *U*-test may be more powerful than the two-sample *t*-test (Hodges and Lehmann 1956; Zar 1984). Statistical tests were undertaken using Real Statistics Using Excel Resource Pack (Zaiontz 2020).

Bowhead whale HUAs were examined using the median water depth, and mean and median distance from shore, by transect and CAPs-adjusted sightings (Houghton et al. 1984) from 15 September to 15 October 2021. Median distance from shore and depths at bowhead whale sightings in 2021, a year with light sea ice cover (National Snow and Ice Data Center 2020) in autumn, were compared with analogous values from 15 September to

15 October of previous years having light sea ice cover (i.e., 1989, 1990, 1993-2020; Treacy 1990, 1991, 1994, 1995, 1996, 1997, 1998, 2000, 2002a, 2002b; Monnett and Treacy 2005; USDOI MMS 2008; Clarke et al. 2011a, 2011b, 2012, 2013, 2014, 2015, 2017a, b, 2018, 2019, 2020; Brower et al. 2022b).

All transect and CAPs-adjusted bowhead whale sightings by primary observers, regardless of distance from the transect line, were included in the non-parametric central tendency analyses. Neither group size nor survey effort (km) was considered.

One caveat to the non-parametric analyses is that analyzing bowhead whale HUAs based only on number of sightings may be biased because survey effort often varies spatially, both within and across years, and because sightings of a single whale were weighted equally to sightings of several whales. Therefore, there may be more sightings in areas with greater effort and fewer sightings in areas with less effort, even if the density of individuals in the two areas was the same.

Bowhead Whale Central Tendency – Analysis 2

The second method for investigating the central tendency of the autumn bowhead whale distribution in the western Alaskan Beaufort Sea in 2021 involved a three-step process: 1) constructing spatial models of bowhead whale relative abundance (encounter rate) based on bowhead whale sightings from 2021; 2) applying the spatial relative abundance model to predict the expected number of bowhead whales in every cell of a grid overlying the study area; and 3) using the predicted number of bowhead whales in each cell to compute the median distance from shore of the whales sighted in 2021. This analysis was based on transect and CAPs-adjusted bowhead whale sightings made by primary observers from 15 September to 15 October 2021. This analysis did not account for availability or perception bias. Estimates of median distance from shore were calculated only for the West region due to lack of survey effort in the East region. The analysis was conducted in R version 4.0.3 (R Core Team 2020) using packages *sp* (Pebesma and Bivand 2005, Bivand et al. 2013), *maptools* (Bivand and Lewin-Koh 2020), *raster* (Hijmans 2020), *rgeos* (Bivand and Rundel 2020), *rgdal* (Bivand et al. 2020), and *mgcv* (Wood 2017).

To begin, the western Alaskan Beaufort Sea survey area was partitioned into a 5-km by 5-km grid. This grid resolution was chosen as a compromise between having adequate survey effort and sightings in each cell to construct models, versus maximizing the resolution of the distance-from-shore data. All geospatial data were projected into an Equidistant Conic projection (false easting: 0.0; false northing: 0.0; central meridian: -148.0°; latitude of origin: 70.75°; standard parallels: 69.9°, 71.6°; linear unit: meter [1.0]). Data extracted for each cell included the total number of whales sighted, the projected x- and y-coordinates of the midpoint of each cell, and the shortest distance from that midpoint to the normalized shoreline. Bowhead whale relative abundance was modeled as a generalized additive model, parameterized by a Tweedie (Tweedie 1984, Dunn and Smith 2005) distribution with a natural logarithmic link function. Negative binomial models were also considered, but examination of model residuals (Ver Hoef and Boveng 2007) suggests that the Tweedie distribution provided a better fit to the data. The model formula is represented as

$ln(E(W_i)) = ln(\mu_i) = \alpha + s(X_i, Y_i) + offset(ln(L_i))$,

where:

W_i: random variable for the number of individual bowhead whales in cell *i*, with W_i referring to the associated observations and $E(W_i)$ the expected value of W_i;

μ_i: number of individual bowhead whales expected to be observed in cell *i*;

α: intercept;

X_i: projected (equidistant conic) longitude of the midpoint of cell *i*;

Y_i: projected (equidistant conic) latitude of the midpoint of cell *i*;

s( ): smooth function (Wood et al. 2008) of location covariates used to describe bowhead whale relative abundance; this function is parameterized in the model-fitting process;

L_i: length (km) of transect and CAPs passing in cell *i*, which was incorporated into the model as a constant (an offset) to account for spatially heterogeneous survey effort throughout the study area.

The median distance from shore of the autumn distribution of bowhead whales in 2021 was estimated using the spatial model to predict the number of individuals likely to be observed in each cell after a uniform amount of effort (a constant L_i for all *i*) was covered throughout the portion of the study area contained within the West region. The magnitude of L_i used in the predictions does not affect the resulting median statistic as long as L_i is constant across all cells, thereby eliminating apparent variability in bowhead whale distribution due only to spatial heterogeneity in survey effort. The predicted number of individuals per cell was cumulated, beginning with the cell closest to the normalized shoreline and ending with the farthest. The median distance from shore was calculated as the distance corresponding to the midpoint of the cell for which one-half of the total predicted number of individuals was assigned to cells located closer to shore and one-half assigned to cells located farther from shore.

The median is also referred to as the 50th percentile or quantile. An additional analysis that was undertaken defined the location of bowhead whale HUAs in 2021 based on the locations of the 30th, 40th, 50th, 60th, and 70th percentiles of predicted bowhead whale relative abundance for each column of 5-km × 5-km cells in the West region. For example, in this analysis the location of the 30th percentile in a specific column of cells refers to the location where 30% of the predicted number of bowhead whales was closer to shore and 70% was farther offshore. Due to the granularity of the spatial grid used for this analysis, adjacent percentiles may overlap in a single cell in locations where the predicted distribution of bowhead whales changes rapidly with distance from shore. The midpoints of all cells corresponding to the 30th percentile were connected across the entire region to define a linear boundary across the western Alaskan Beaufort Sea corresponding to the 30th percentile of bowhead whale HUAs, and similarly for the 40th, 50th, 60th, and 70th percentiles.

Multiyear Analyses

To expand the utility of data collected in 2021, several multiyear analyses were also conducted. Temporal and spatial parameters for each multiyear analysis were specifically chosen to maximize the amount of relevant information contained in the ASAMM and NSB dataset used to address the objectives of the analysis. These parameters varied substantially across multiyear analyses due to annual differences in when and where surveys were conducted. For example, multiyear analyses for the western Beaufort Sea from mid-September to mid-October justifiably can, in some situations (e.g., sightings near Cape Halkett), incorporate data from 1982 through 2021. Other applications required sightings from primary observers only and, therefore, incorporated data from only 1989 through 2021, which is when details related to primary observers were recorded in the dataset.

RESULTS

Environmental Conditions

In 2021, sea ice cover in the survey area was light. Broken floe sea ice was observed on transect lines 8, 9, and 10 (Fig. 1) on 26 September. On 30 September, broken floe and new sea ice was observed on transect lines 111 and 112 (Fig. 1). New ice started to form in lagoons and other shallow water areas in mid-September. Arctic sea ice extent reached the seasonal minimum on 16 September 2021 (National Snow and Ice Data Center 2021a). Average Arctic sea ice extent for September 2021 was the twelfth lowest since satellite data were first recorded in 1979 (National Snow and Ice Data Center 2021a). Average Arctic sea ice extent for October 2021 was the eighth lowest in the satellite data record, tied with 2017 (National Snow and Ice Data Center 2021b). To examine interannual variability in bowhead whale and other marine mammal distributions and relative abundance, 2021 data were compared to data from previous years with light sea ice cover (1982, 1986-87, 1989-90, 1993-2020).

Survey Effort

The field season commenced 15 September 2021 and ended four days early on 11 October 2021. The decision to end the season early was based on a number of considerations including good coverage of the primary survey area; few remaining flight hours (less than one full survey flight); wide-spread and severe weather entering the study area on 11 October, which was forecast to persist through 15 October; the rising number COVID-19 hospitalization cases in Alaska; and financial considerations. Survey flights were conducted from 23 September to 10 October (Table 3). There were 11 survey days, comprising seven in September and four in October. On six occasions, multiple flights in one day were flown to take advantage of favorable survey conditions or to extend the search for areas with weather suitable for conducting surveys, which required a refuel in Utqiaġvik or Deadhorse. For simplicity, "survey flight" and "survey day" are used interchangeably in this report; that is, a single unique flight number was assigned to each day that the team surveyed, regardless of whether one or multiple flights were flown. Surveys were conducted on 44% of the possible days during the field season (11 out of 25 possible days). Surveys were not conducted on 56% of the possible days (14 out of 25 possible days) due to weather (12 days) or both weather and logistics (2 days).

Survey effort was summarized by hours (hr) or kilometers (km) flown in different survey modes. Over 14,300 km were flown during 55.9 hours total effort (Fig. 5). A total of 6,361 km were flown on effort (transect and CAPs passing) during 28.2 hours (Fig. 6). Kilometers on effort constituted 44% of the total distance flown, corresponding to 45% of the total flight hours. Forty-seven percent of total survey kilometers were flown on deadhead. No flights were flown entirely on deadhead. The average survey distance flown per day was 1,301 km, ranging from 558 km to 2,134 km. The longer distances required two flights per survey.

Table 3. -- Aerial survey flight effort in chronological order, 23 September – 10 October 2021, by survey day. On-effort includes distance (km) and time (hr) during transect and CAPs passing survey modes. Off-effort includes distance during search, circling from search, circling from transect, and CAPs circling survey modes.

Day	Flight No.	On-Effort (km)	Off-Effort (km)	Deadhead (km)	Total (km)	On-Effort (hrs)	Total (hrs)
23 Sep	1	707	326	1,101	2,134	3.2	8.4
24 Sep	2	1,003	270	498	1,770	4.6	7.8
25 Sep	3	504	39	509	1,053	2.2	4.2
26 Sep	4	521	89	499	1,109	2.2	4.3
27 Sep	5	857	121	826	1,804	3.9	7.1
28 Sep	6	637	77	491	1,205	2.8	4.8
30 Sep	7	495	9	980	1,484	2.2	5.1
3 Oct	8	245	35	279	558	1.1	2.2
6 Oct	9	507	122	567	1,196	2.2	4.6
9 Oct	10	788	87	396	1,271	3.4	5.3
10 Oct	11	97	2	626	725	0.4	2.4
Total		**6,361**	**1,177**	**6,772**	**14,309**	**28.2**	**56.2**

At no point during the field season did the survey plane need to directly avoid possible subsistence activities, specifically the autumn bowhead whale hunt near Utqiaġvik. No transects needed to be truncated within a 37-km (20 nmi) radius of Utqiaġvik to avoid potential interference with subsistence whaling.

Aerial surveys supporting sea ice and marginal ice zone research were conducted in the western Beaufort Sea by the NOAA Pacific Marine Environmental Laboratory using a NOAA Twin Otter. Communications with researchers assisted with mitigating adverse effects on survey effort.

Survey coverage in the study area was greatest in blocks 3, 11, and 12 in the Beaufort Sea (Fig. 7) because they are located within the primary study area and are closest to the base airport at Utqiaġvik. When weather conditions were marginal, the survey team remained relatively close to base in case weather conditions started to rapidly worsen. When conditions quickly deteriorated, survey effort was immediately aborted so that the team could return safely to base. When comparing survey results from 2021 with previous ASAMM and NSB surveys, it is important to remember that *in 2020 and 2021 no surveys were flown in the easternmost portion of the study area, from Kaktovik to the U.S.-Canada border, or in the majority of the Chukchi Sea* (Fig. 5) due to survey priorities, limited funding, weather, and logistical limitations. Flight lines, associated sea states, and sightings on individual flights are shown in Appendix E.

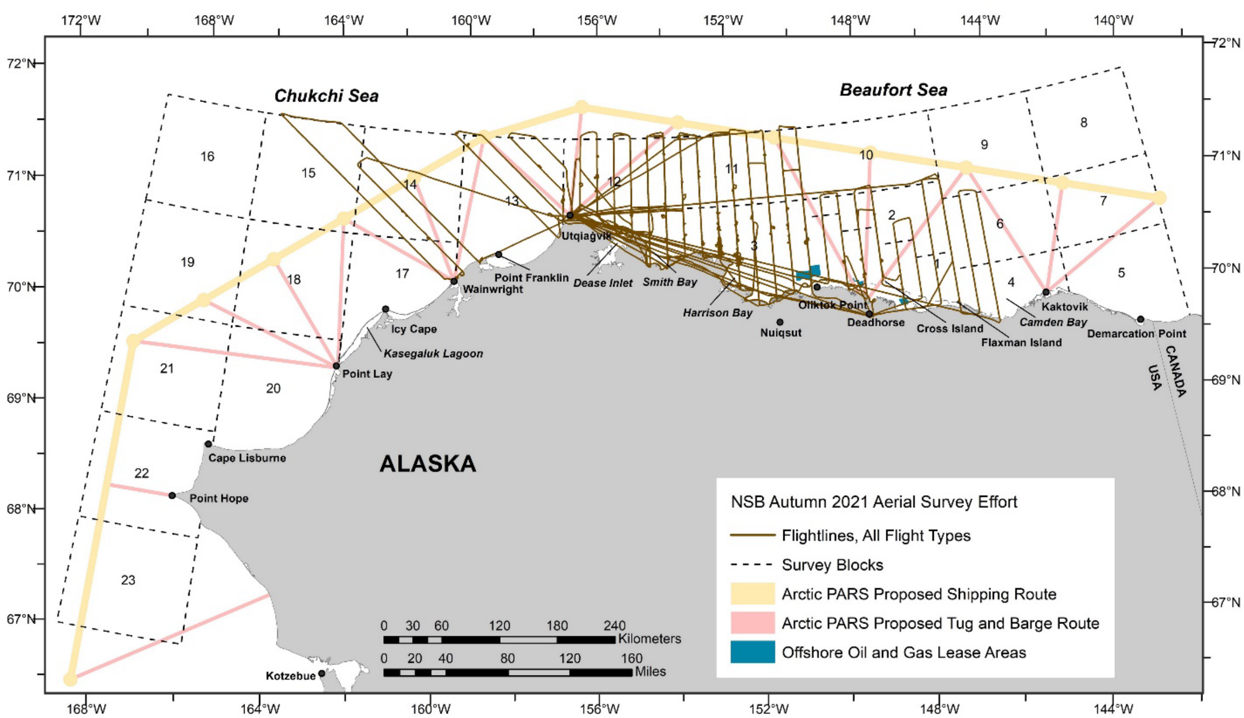

Figure 5. -- Combined flight tracks, all survey modes (transect, CAPs, search, circling, and deadhead), 23 September – 10 October 2021.

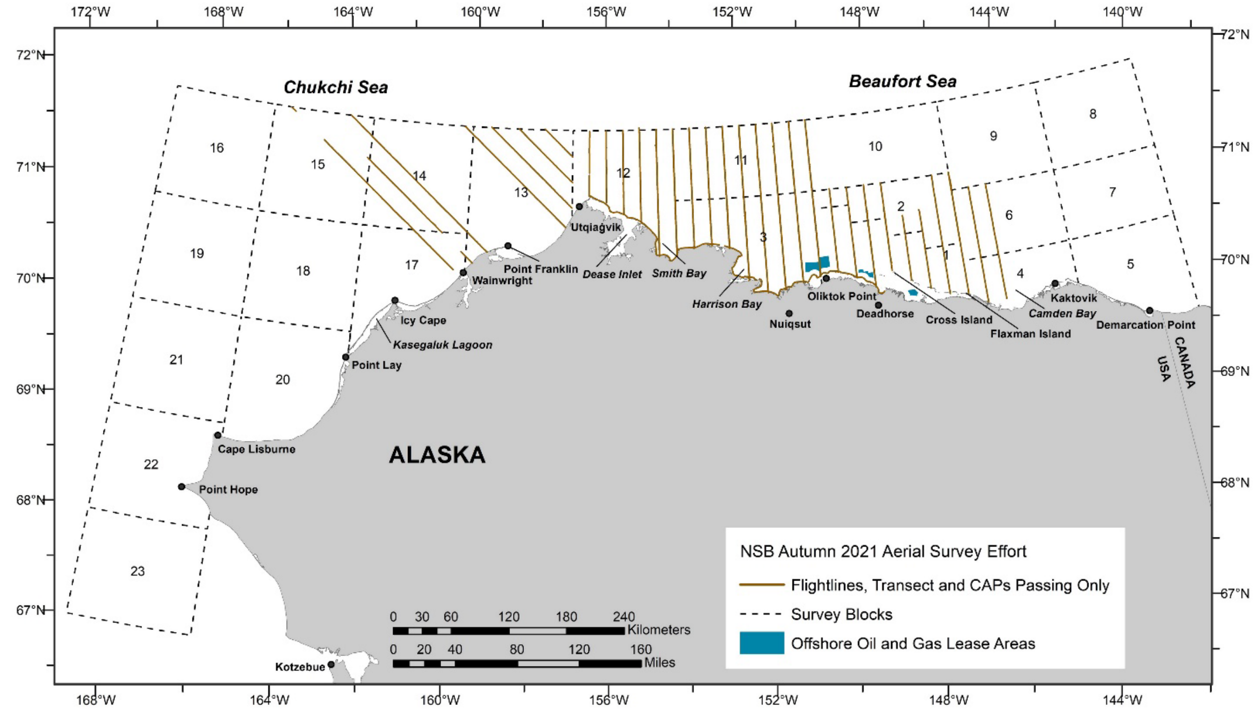

Figure 6. -- Combined on-effort flight tracks, transect and CAPs passing effort only, 23 September – 10 October 2021. Some lines were flown on multiple days.

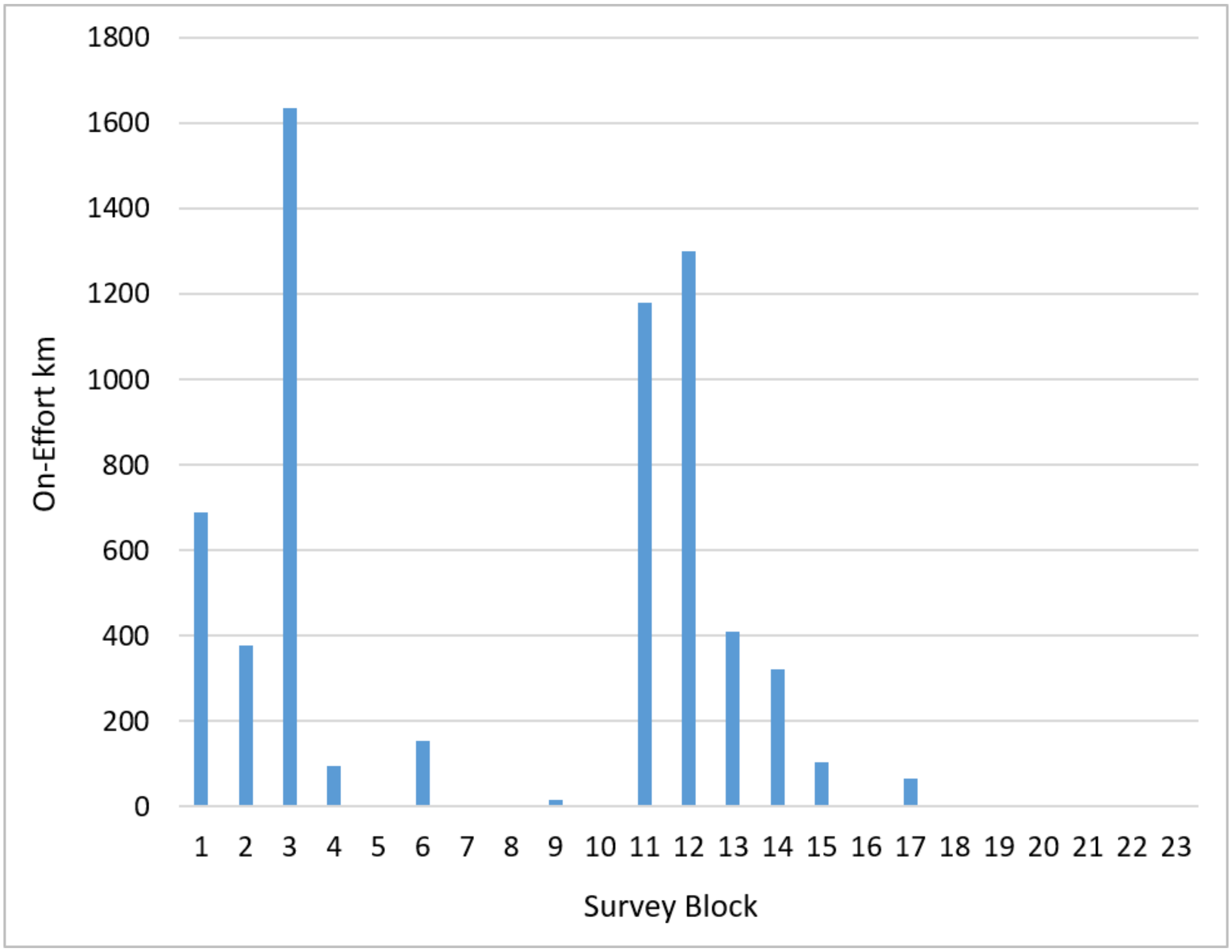

Figure 7. -- Kilometers flown on effort (transect and CAPs passing) per survey block, 23 September – 10 October 2021. The total for block 1 includes 36 km flown inshore of the barrier islands.

Cetaceans

Bowhead Whales

Bowhead Whale Sighting Summary

During the 2021 field season, 138 sightings of 200 bowhead whales from the Western Arctic (also known as the Bering-Chukchi-Beaufort Seas) stock were observed during all survey modes (transect, CAPs, search, and circling) (Table 4; Fig. 8).Observed bowhead whale distribution extended across the western Beaufort Sea from 146.0°W to 157.1°W. The majority (90%) of whales sighted were west of 150°W. Sightings were primarily (150 whales, 75%) over the inner continental shelf (≤ 50 m), with fewer whales (48 whales) sighted over the outer continental shelf (51-200 m) and two whales in the 201-2,000 m

Table 4. -- Summary of cetacean sightings (number of sightings/number of individuals) during transect, CAPs, search, and circling survey modes, in chronological order, 23 September – 10 October 2021, by survey day. Excludes dead and repeat sightings.

Day	Flight No.	Bowhead whale	Gray whale	Beluga	Unidentified cetacean
23 Sep	1	62/81	0	21/25	1/1
24 Sep	2	25/49	3/4	26/50	0
25 Sep	3	2/3	0	1/1	0
26 Sep	4	0	2/2	1/1	0
27 Sep	5	13/23	0	29/76	0
28 Sep	6	3/5	0	60/77	1/1
30 Sep	7	1/1	0	13/16	0
3 Oct	8	1/1	0	26/50	0
6 Oct	9	6/9	0	44/53	1/1
9 Oct	10	25/28	0	18/19	1/1
10 Oct	11	0	0	0	0
TOTAL		**138/200**	**5/6**	**239/368**	**4/4**

depth zone. Over half of the bowhead whales sighted (55%, 110 whales) were in survey block 3 (150°-154°W). Survey effort was conducted in the northeastern Chukchi Sea on two of the 11 survey flights; a total of six bowhead whales were sighted there (block 13, 157.00°-157.03°W), though this is very close to the delineation between the western Beaufort and northeastern Chukchi seas at 157°W.

Bowhead Whale Sighting Rates

There were 87 sightings of 131 bowhead whales on effort (transect and CAPs-adjusted) by primary observers, ranging from one whale per sighting (56 sightings) to 10 whales per sighting (1 sighting). Forty-four percent (58 whales) of all bowhead whales on effort were seen in survey block 3 (150°-154°W), and 34% (45 whales) were seen in survey block 12 (154°-157°W). Highest fine-scale sighting rates (WPUE, 5-km grid) were located just east and northeast of Point Barrow (Fig. 9).

The highest sighting rate per survey block occurred in block 3 (0.0353 WPUE), followed by block 12 (0.0346 WPUE) (Table 5, Fig. 10). Sighting rate was highest in the West Beaufort Sea subarea in the 51-200 m depth zone and in the East subarea in the 0-20 m depth zone (0.0589 WPUE and 0.0470 WPUE, respectively) (Table 6, Fig. 11).

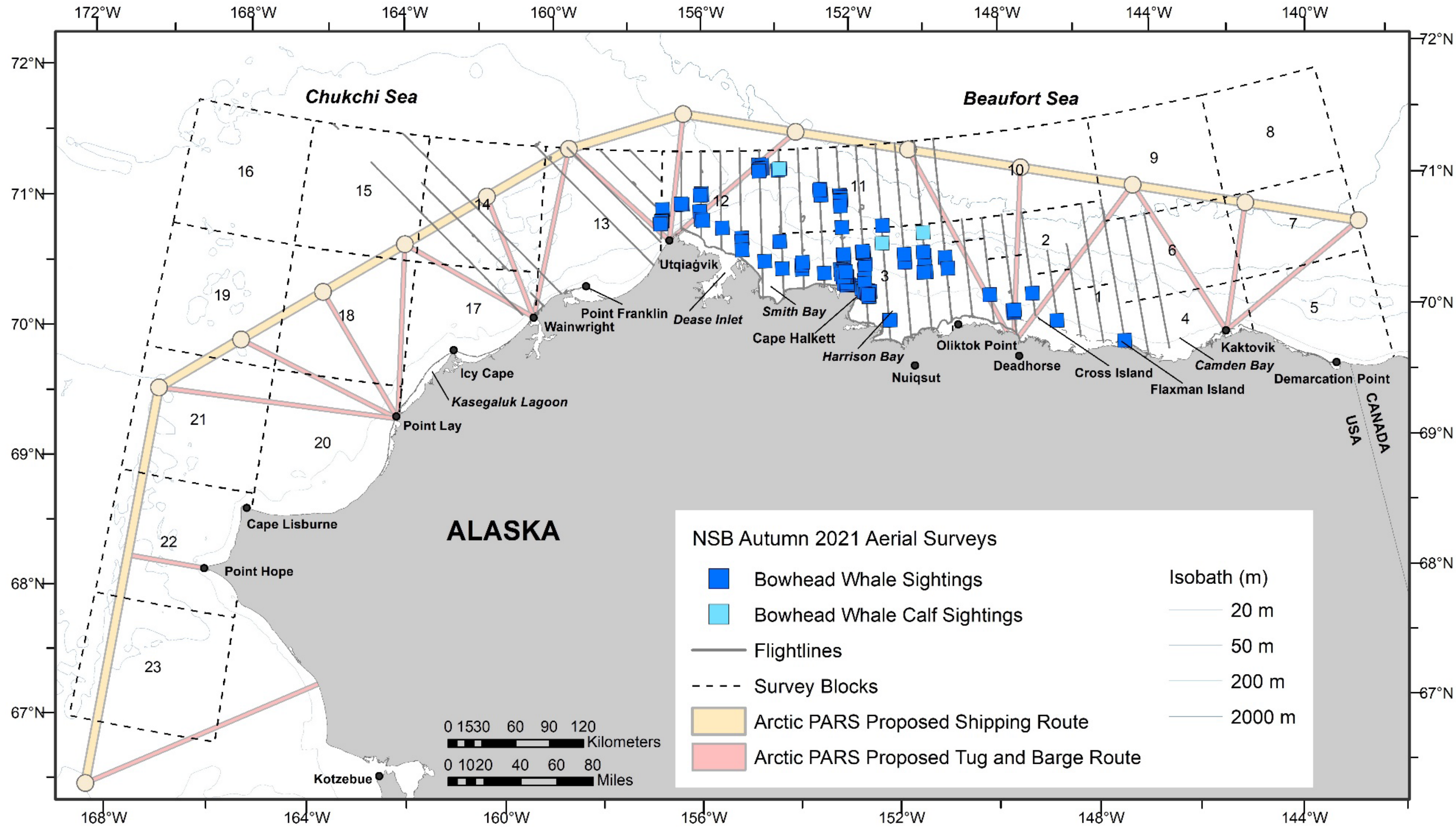

Figure 8. -- Bowhead whale and bowhead whale calf sightings, all survey modes, with transect, CAPs, search, and circling effort, 23 September – 10 October 2021. Deadhead flight tracks are not shown.

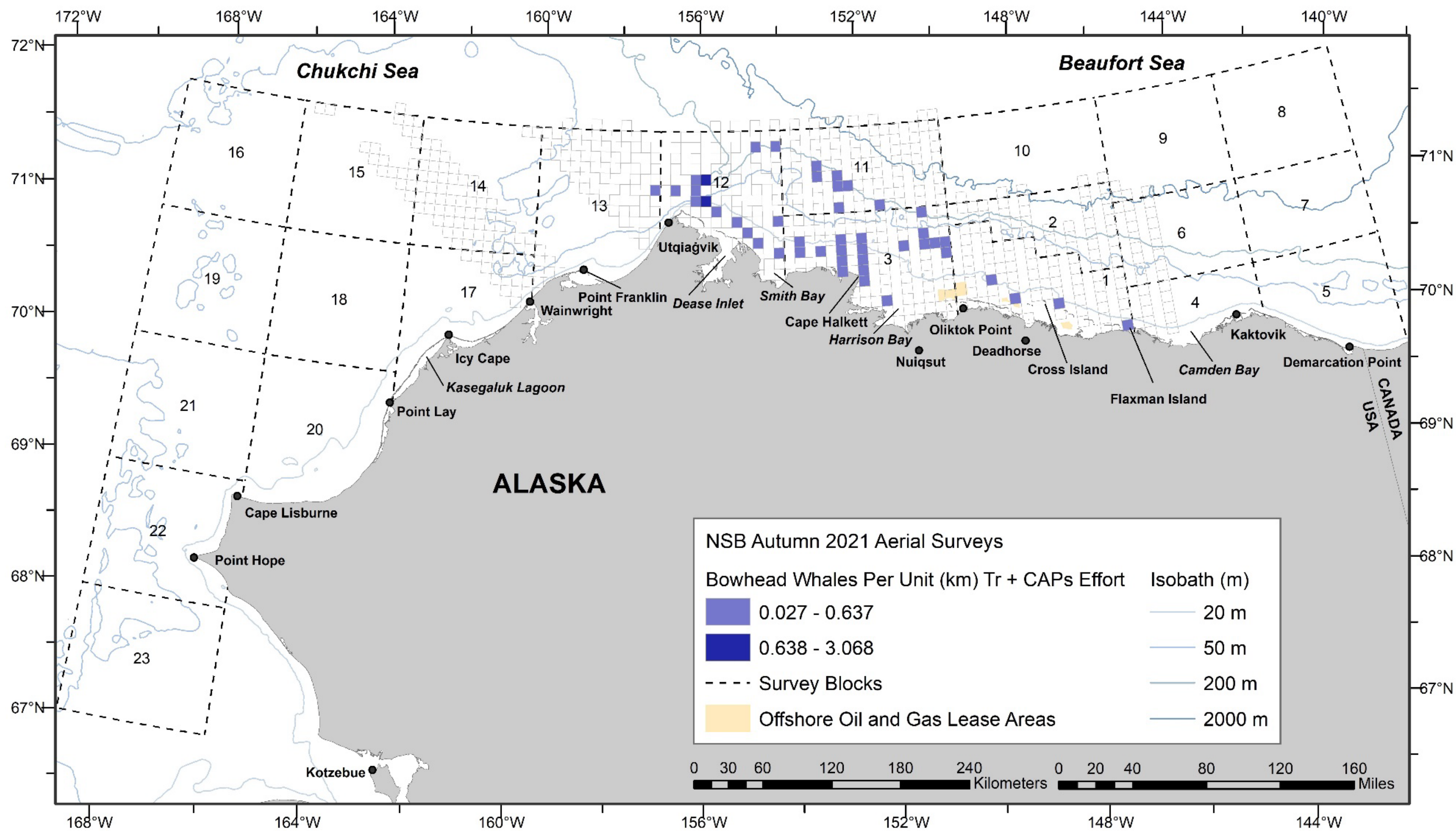

Figure 9. -- Bowhead whale on-effort sighting rates (WPUE; sightings from primary observers only). Empty cells indicate sighting rates of zero. Transect (Tr) and CAPs survey effort were not conducted in areas without cell outlines.

Table 5. -- On-effort (transect and CAPs passing) kilometers (km), number of bowhead whale on-effort sightings (primary observers only), and bowhead whale sighting rate (WPUE = bowhead whales per km surveyed) per survey block, 23 September – 10 October 2021. NA – surveys were not conducted. The total for block 1 includes 36 km flown inshore of the barrier islands. Minor discrepancies within the table are due to rounding error.

BLOCK	km	Sightings	Bowhead whales	WPUE
1	688	8	15	0.0218
2	377	0	0	0.0000
3	1,637	41	58	0.0353
4	94	0	0	0.0000
5	0	0	0	NA
6	154	0	0	0.0000
7	0	0	0	NA
8	0	0	0	NA
9	15	0	0	0.0000
10	1	0	0	0.0000
11	1,179	12	13	0.0110
12	1,299	26	45	0.0346
Total	5,445	87	131	0.0240

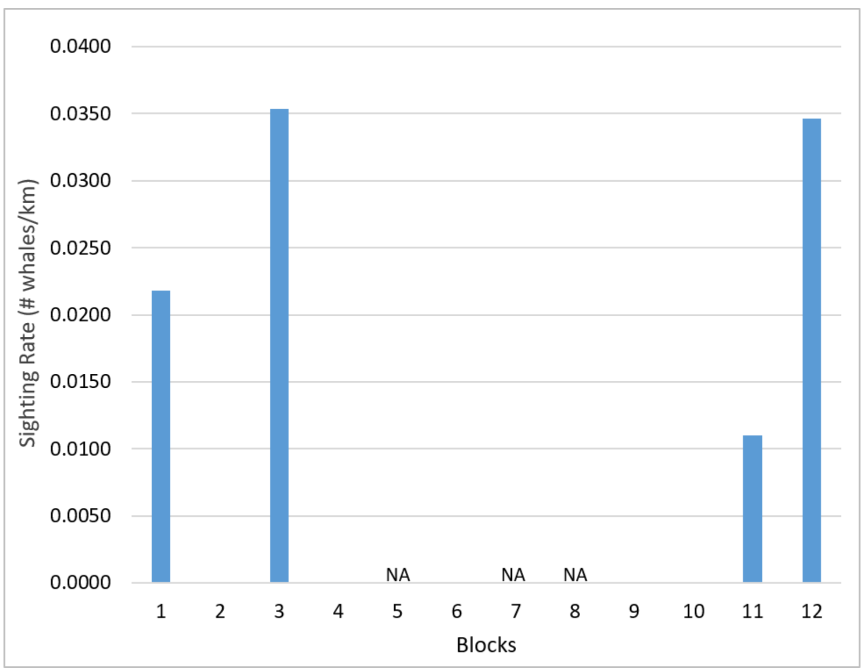

Figure 10. -- Bowhead whale on-effort sighting rates (WPUE; sightings from primary observers only) per survey block, 23 September – 10 October 2021. NA – surveys were not conducted. Sighting rates of zero were removed from blocks 2, 4, 6, 9, and 10 of the graph for clarity.

Table 6. -- On-effort (transect and CAPs passing) kilometers (km), number of bowhead whale on-effort sightings (primary observers only), and bowhead whale sighting rate (WPUE = bowhead whales per km surveyed) per depth zone, 23 September – 10 October 2021. Minor discrepancies within the table are due to rounding error.

DEPTH ZONE	km	Sightings	Bowhead whales	WPUE
154°W-157°W				
0-20 m	458	8	11	0.0240
21-50 m	339	2	11	0.0325
51-200 m	356	15	21	0.0589
201-2,000 m	139	1	2	0.0144
140°W-154°W				
0-20 m	1,125	34	53	0.0470
21-50 m	1,176	14	18	0.0153
51-200 m	633	11	11	0.0174
201-2,000 m	935	2	4	0.0043
> 2,000 m	256	0	0	0.0000
Total	5,416	87	131	0.0242

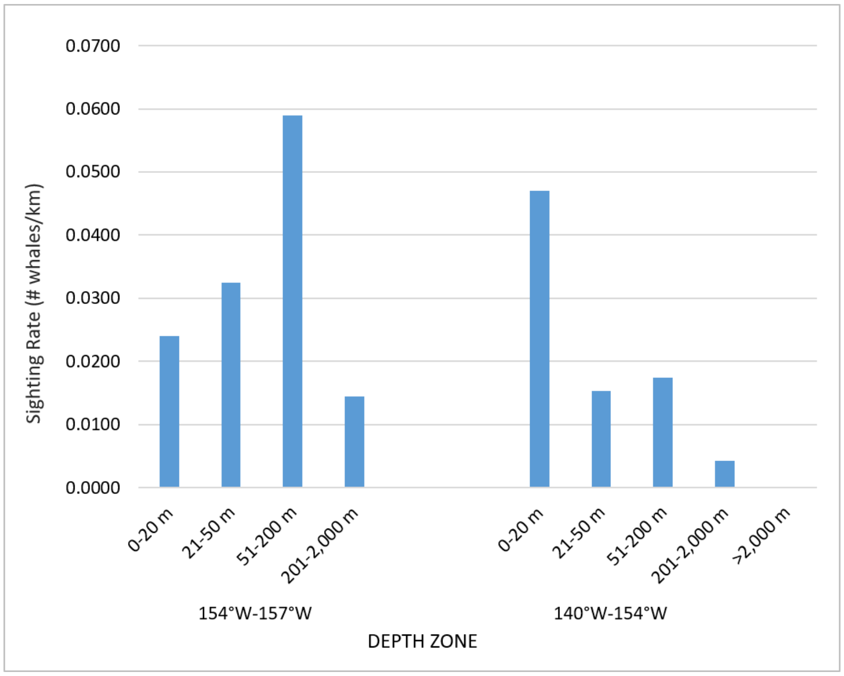

Figure 11. -- Bowhead whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) per depth zone, 23 September – 10 October 2021. Sighting rate of zero was removed from depth zone > 2,000 m of the graph for clarity.

Bowhead Whale Behaviors

Bowhead whale behaviors observed during all survey modes (i.e., transect, CAPs, search, and circling) and by primary and secondary observers in 2021 are summarized in Table 7. The behavior most often recorded was swimming (45%), followed by feeding (22%). Feeding behavior was likely underreported due to the difficulty of identifying this behavior for animals feeding on benthic or mid-water prey; milling was recorded in situations where obvious evidence of feeding was not directly observed but was suspected. One sighting of 10 bowhead whales was classified as "other" due to the dynamic behavior of the whales. The behavior of milling is recorded for groups of whales swimming slowly in different directions; however, this group was different enough that it did not fit that definition. These whales were breaching, tail slapping, and swimming fast in different directions with lots of white water. Behavior was recorded as unknown for 26 whales, likely because the sightings were too brief or far away to determine a behavior. No bowhead whales appeared to respond to the survey aircraft.

Table 7. -- Bowhead whales (number of sightings/number of individuals) observed during transect, CAPs, search, and circling survey modes, by behavioral category, 23 September – 10 October 2021. Excludes dead and same-day repeat sightings.

Behavior	**Bowhead whales**
Breach	1/1
Feed	29/43
Log Play	2/2
Mill	6/15
Other	1/10
Rest	6/11
SAG	1/3
Swim	69/89
Unknown	23/26
TOTAL	**138/200**

Bowhead whale feeding behavior, which includes sightings reported as milling, was observed in 35 sightings of 58 whales from 148.5°W to 157.1°W (Fig. 12). The majority of feeding and milling whales (81%, 47 whales) were sighted from 150.4°W to 152.5°W, in survey block 3.

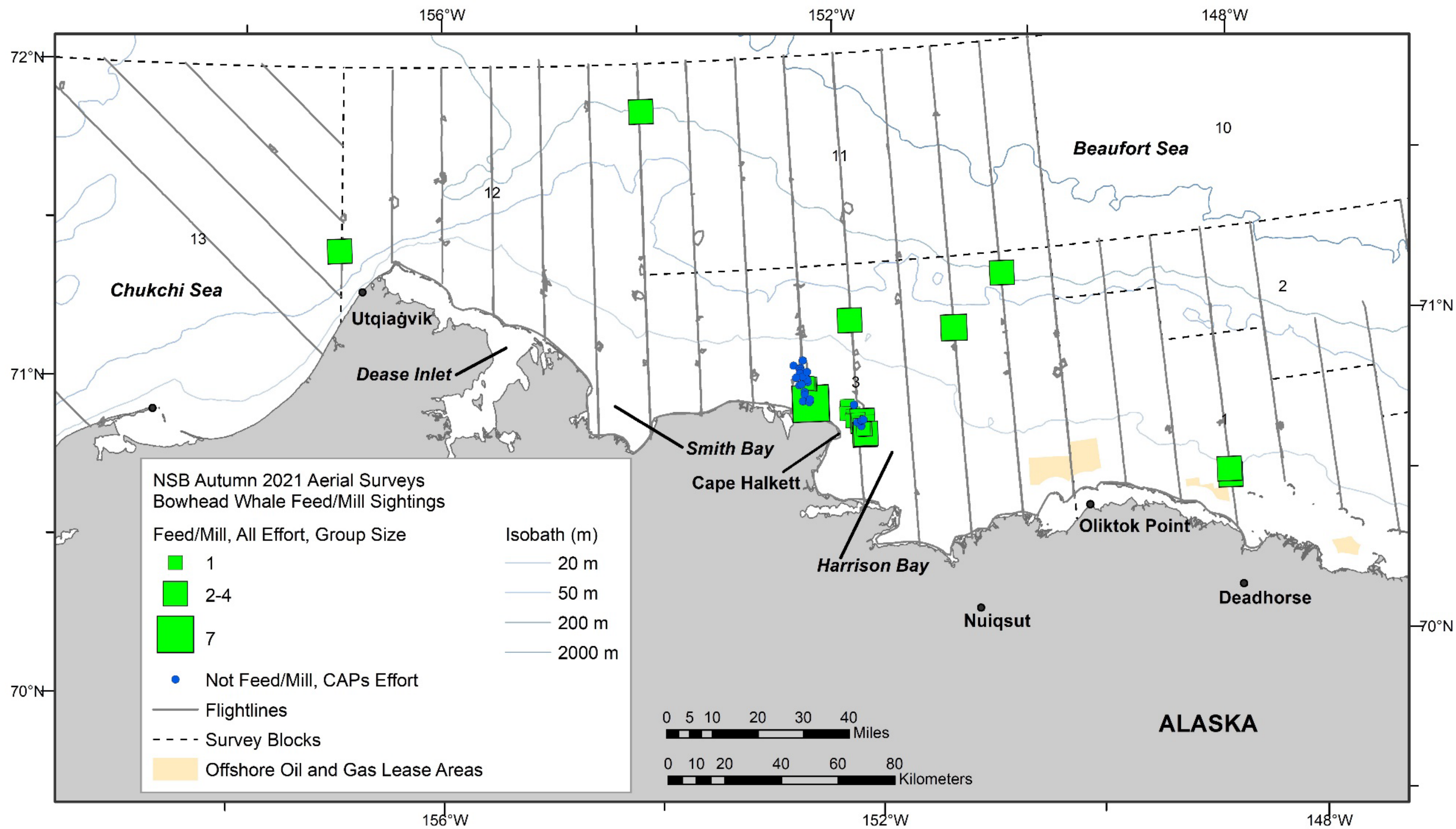

Figure 12. --Bowhead whale feeding and milling sightings during transect, CAPs, search, and circling survey modes, 23 September – 10 October 2021. Non-feeding and non-milling sightings on CAPs and circling from CAPs that were associated with CAPs sessions in which feeding or milling whales were sighted are also included because these whales were likely also feeding.

Cetacean Aggregation Protocols effort is used when densities of bowhead whales become so high that the data recorder needs to be able to enter data more rapidly than the standard, comprehensive data entry protocols allow. During CAPs passing effort, behavior is not routinely recorded; however, behavior is recorded during CAPs circling effort and is used to infer the proportion of CAPs passing whales that were feeding and milling. In the CAPs sessions from 2021, it is reasonable to assume that even though not all whales could definitively be determined to be feeding, all whales in the area were there to feed because there were so many whales in such a small area. For this reason, the non-feeding and non-milling CAPs whales are plotted on the feeding and milling maps in Figures 12 and 31 to give a better visual representation of the densities of whales likely feeding in the area.

In 2021, most feeding and milling bowhead whales (81%, 51 whales) were sighted in very shallow water (4-18 m), very close to shore (2.6-10.9 km). Water depths at sightings of feeding and milling whales ranged from 4 m to 237 m, and distance from shore ranged from 2.6 km to 86.6 km.

Fine-scale sighting rates (WPUE, 5-km grid) for feeding and milling bowhead whales are shown in Fig. 13. Highest fine-scale sighting rates (WPUE, 5-km grid) were located at Cape Halkett and northwest of Prudhoe Bay.

The area between roughly Cape Halkett and Point Barrow (~152°-157°W) encompasses a well-documented bowhead whale "krill trap" feeding area (Moore and Reeves 1993; Mocklin et al. 2011; Shelden et al. 2017). Here, upwelling-favorable winds, followed by decreased winds, can aggregate and hold krill on the continental shelf between water masses, forming a "krill trap" (Ashjian et al. 2010). To limit data biases, surveys were not preferentially conducted in the krill trap area on days with a higher likelihood of seeing bowhead whales, based on recent wind conditions, though it could be surveyed if it had not been surveyed recently and the weather was reported to be good in the area. In 2021, surveys were conducted in this area on six days; bowhead whales were observed on five of the days that surveys were conducted, and were documented feeding and milling on three of those days (Fig. 14). On some of the days that this area was flown and no bowhead whales were sighted, survey effort was limited due to poor weather. Bowhead whales were not sighted in dense aggregations in the Point Barrow area or survey block 12 (154°-157°W), but they were sighted in dense aggregations in the Cape Halkett area: (151.9°-152.6°W, 70.7°-71.2°N) (Fig. 14); 86 bowhead whales were observed here, and 50% (43 whales) of them were recorded as feeding or milling. Although half of the aggregation near Cape Halkett were not documented as feeding or milling, it is presumed these whales were in this area to feed.

Bowhead Whale Calves

Of the 200 bowhead whales sighted, 15 were identified as calves (Fig. 8). Similar to previous NSB and ASAMM surveys (e.g., Clarke et al. 2020; Brower et al. 2022), most calves

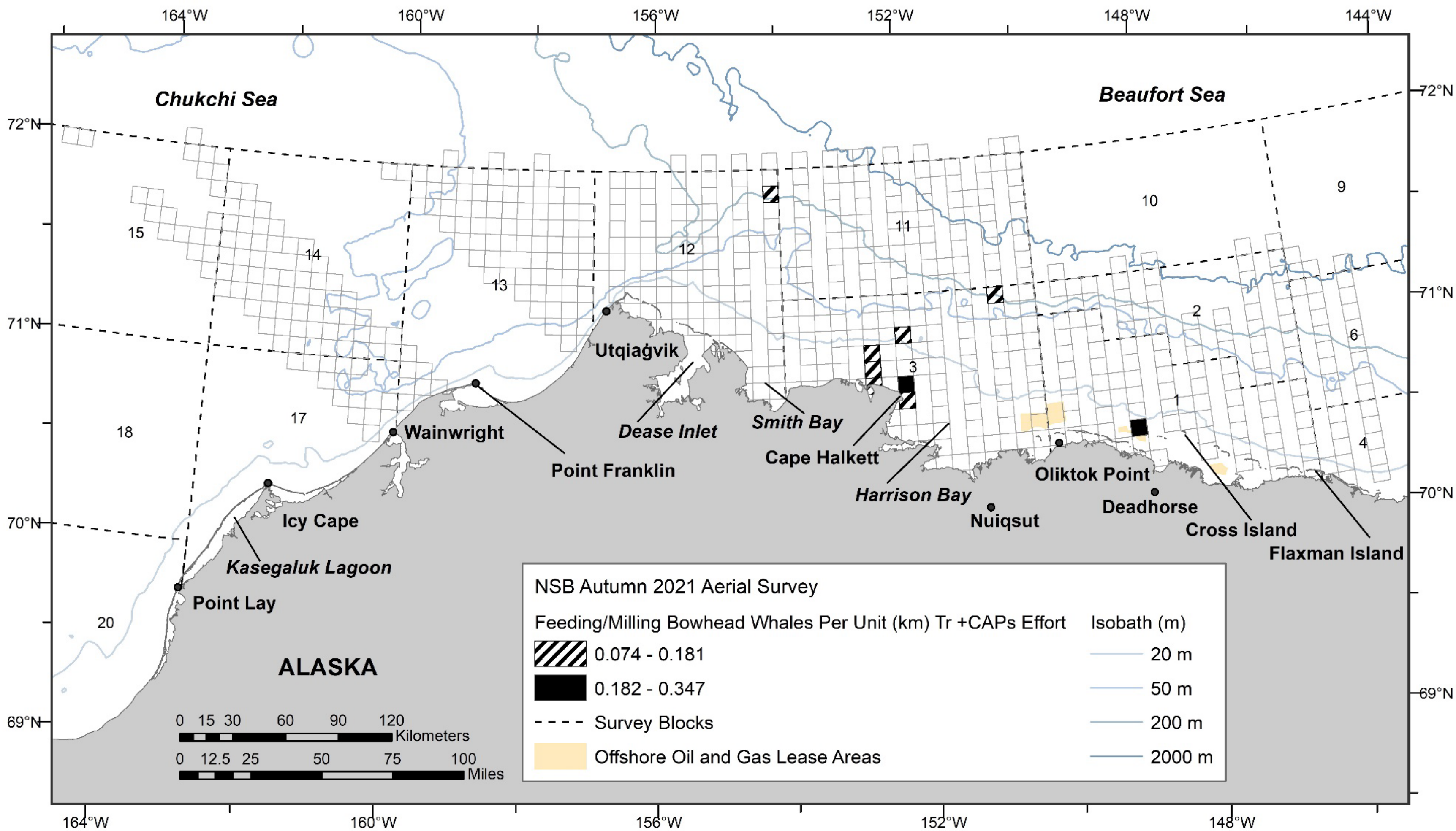

Figure 13. -- Bowhead whale on-effort feeding and milling sighting rates (WPUE; sightings from primary observers only), 23 September – 10 October 2021. Empty cells indicate sighting rates of zero. Transect (Tr) and CAPs survey effort were not conducted in areas without cell outlines.

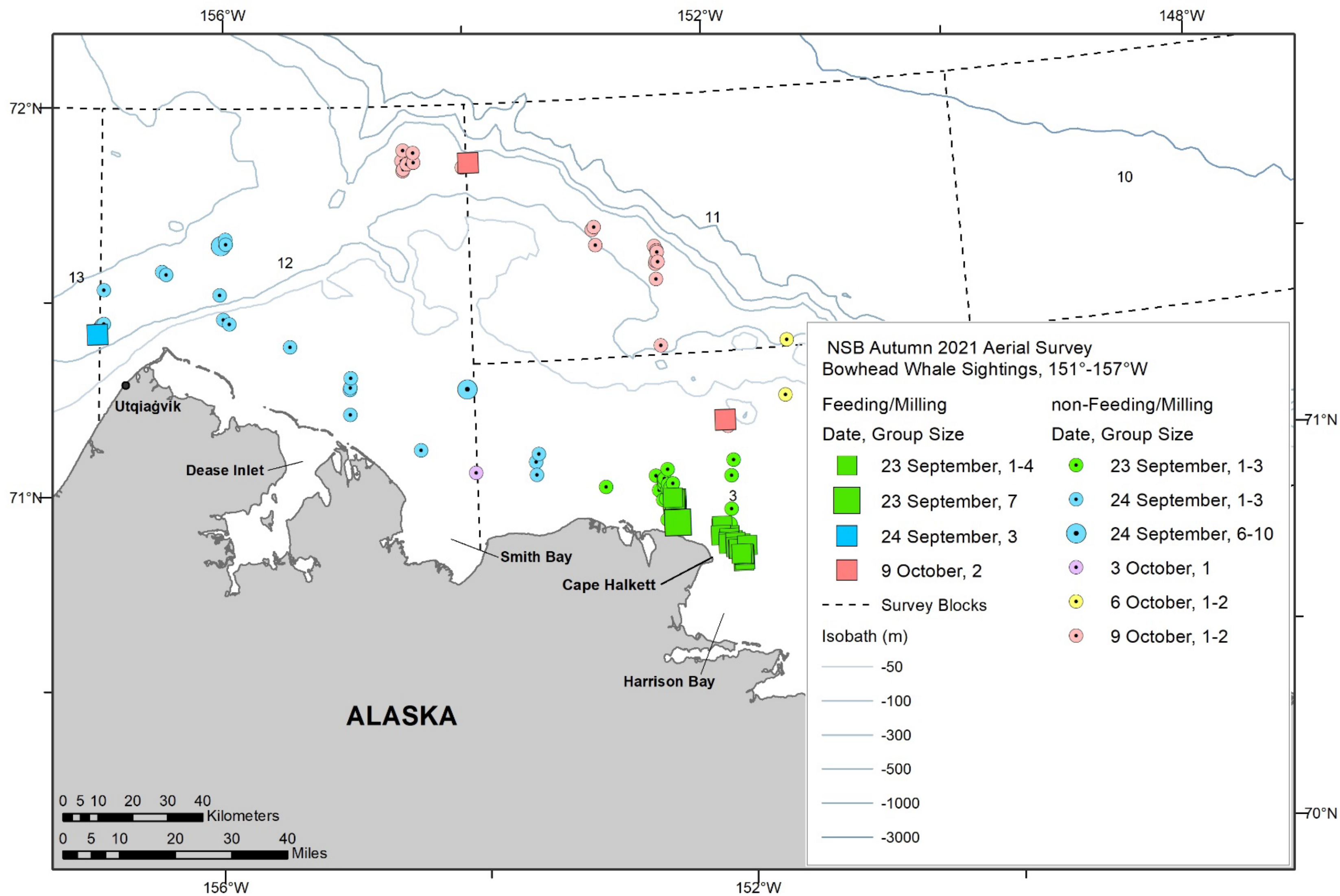

Figure 14. --Bowhead whale sightings by date and group size, 151°-157°W, observed during transect, CAPs, search, and circling survey modes, 23 September – 10 October 2021. "Non-Feeding/Milling" means that the whales were not recorded as engaging in feeding or milling behavior during the period of time in which they were observed.

(11 calves, 73%) were sighted after circling was initiated and likely would not have been observed if circling had not commenced. Calves were sighted in September and October, distributed from 148.0°W to 156.1°W. Calves were observed with adult bowhead whales that were swimming, milling, resting, and within the group of 10 whales with dynamic movements. Calves were not sighted in two feeding aggregations on 23 September 2021; this lack of calf sightings might have been due to their small size, the number of whales in the vicinity, and the opaque, muddy water resulting from bowhead whale feeding activities. One calf was observed swimming without an adult nearby and no adults were noted in the general vicinity. The calf ratio (number of calves sighted on effort by primary or secondary observers/number of total whales on effort) was 0.094.

Bowhead Whale Central Tendency – Analysis 1

Bowhead whale distribution in the western Beaufort Sea in 2021, based on transect and CAPs sightings by primary and secondary observers, shared similarities with the distribution of on-effort sightings observed during 15 September – 15 October in previous years having light sea ice cover (i.e., 1982, 1986, 1987, 1989, 1990, 1993-2020) (Fig. 15).

Summary statistics for bowhead whale data from the western Beaufort Sea West region from 15 September to 15 October 1989-2021 are presented in Table 8. Summary statistics are from sightings made by primary observers only. Limiting sightings for this analysis to only primary observers results in the exclusion of > 500 sightings across all years but provides tighter data constraints resulting in a more robust analysis. In the West region, mean depth at bowhead whale sightings made on effort by primary observers in 2021 was 60 m (SD = 70.1 m, range 5-237 m) and median depth was 18 m (Table 8). Mean and median distances to the normalized shoreline were 36.0 km (SD = 29.0 km, range 4-87 km) and 21.6 km, respectively (Table 8).

To evaluate whether significant displacements occurred in western Beaufort Sea bowhead whale HUAs during 15 September - 15 October 2021 compared to previous years with light sea ice cover, estimates of median depth and distance from shore were compared with pooled data from previous years. From 15 September to 15 October 2021 in the West region, there were no significant differences in depth (median depth 18 m vs. 20 m, $Z = 0.090$, $P = < 0.9281$) or distance from shore (median distance from shore 21.6 km vs. 22.6 km, $Z = 0.957$, $P = < 0.3383$) of bowhead whale sightings compared to previous years with light sea ice cover.

Bowhead Whale Central Tendency – Analysis 2

The 2021 spatial relative abundance model for autumn (15 September – 15 October) incorporated 80 bowhead whale sightings of 124 total individuals in the West region (Fig. 16). The model identified three areas with high relative abundance of bowhead whales in autumn 2021: the head of Barrow Canyon, off Cape Halkett, and northwest of Prudhoe Bay (Figs. 16 and 17).

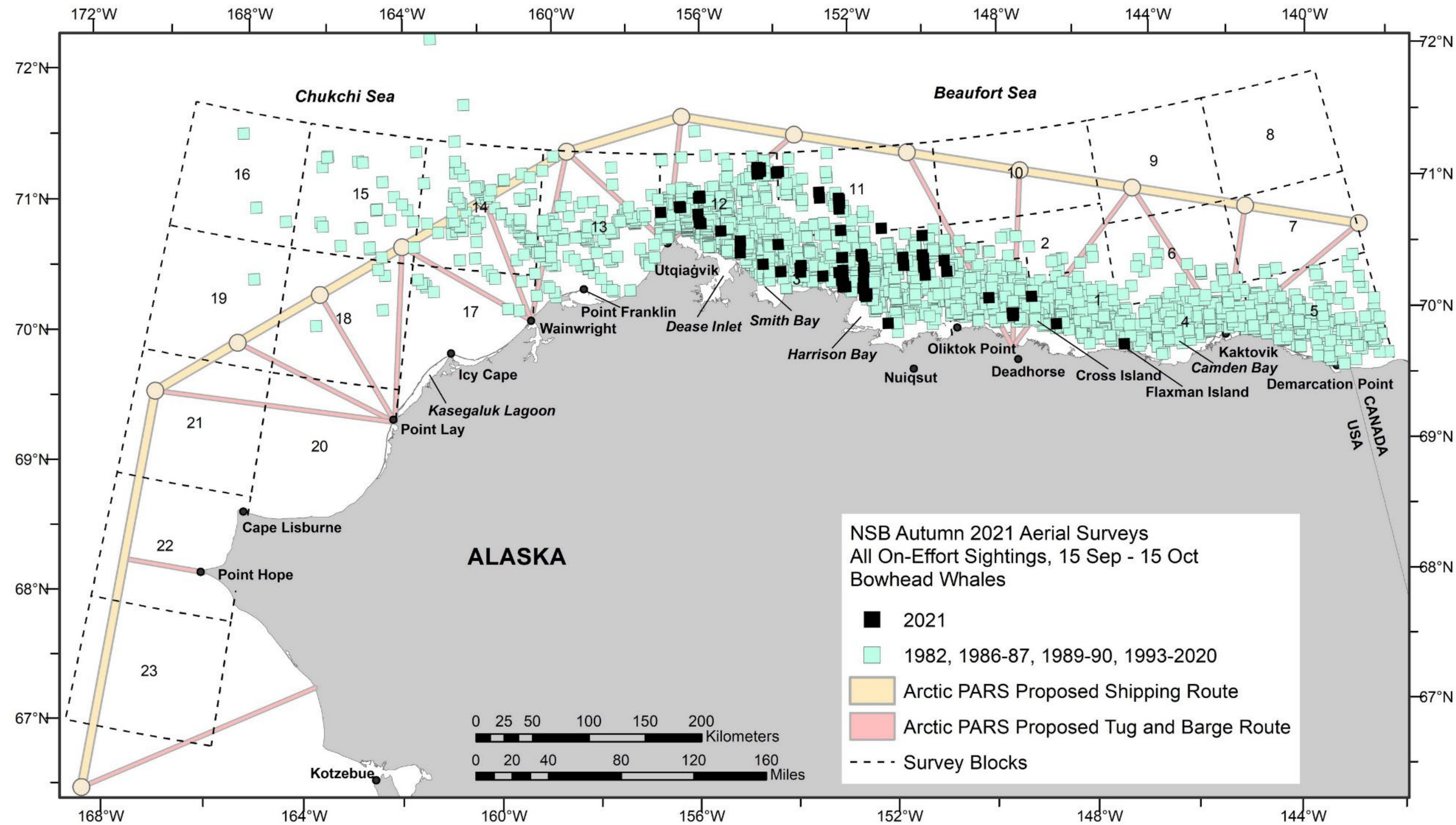

Figure 15. -- Bowhead whale sightings 15 September – 15 October, in years with light sea ice cover: 1982, 1986-1987, 1989-1990, 1993-2020, and 2021. Includes all on-effort sightings from primary and secondary observers.

Table 8. -- Central tendency statistics for depth (m) and distance from shore (km) at bowhead whale on-effort sightings between 15 September and 15 October in the western Beaufort Sea West region, by year, 1989-2021. OE-Si = number of on-effort sightings made by primary observers.

		Depth				Distance from shore			
Year	**OE-Si**	**Median**	**Mean**	**SD**	**Min-Max**	**Median**	**Mean**	**SD**	**Min-Max**
1989	5	19	16	7.0	7-24	25.3	20.6	14.5	4-35
1990	5	27	29	8.9	20-39	27.4	30.2	7.2	24-41
1991	1	383	383	-	-	72.8	72.8	-	-
1992	6	57	66	20.4	52-106	53.1	52.5	6.7	43-63
1993	18	20	23	10.0	12-49	24.5	26.6	13.2	11-61
1994	2	13	13	0.7	12-13	15.0	15.0	6.0	11-19
1995	6	50	258	514.6	35-1308	50.3	56.2	23.5	32-102
1996	3	35	35	2.5	32-37	38.4	38.1	1.3	37-39
1997	54	19	25	19.0	5-100	21.5	24.2	10.8	7-52
1998	49	17	62	283.1	7-2001	17.7	24.7	19.7	3-118
1999	15	15	17	5.7	10-35	16.1	16.1	5.5	6-31
2000	9	19	33	53.1	5-173	23.1	23.6	21.4	3-73
2001	0	-	-	-	-	-	-	-	-
2002	10	25	36	27.5	11-88	31.2	31.9	11.8	9-48
2003	29	20	50	67.3	12-310	27.2	28.9	15.7	2-72
2004	31	22	24	11.2	5-51	23.3	22.1	8.6	5-42
2005	1	22	22	-	-	17.8	17.8	-	-
2006	11	33	44	33.2	17-141	38.6	41.3	12.3	23-63
2007	6	23	24	8.6	13-36	24.0	25.2	6.2	18-33
2008	28	16	17	6.0	7-40	16.7	16.7	7.5	4-37
2009	37	17	31	46.4	8-239	15.7	20.3	16.4	4-81
2010	18	19	31	40.5	10-189	18.1	23.5	16.5	3-76
2011	24	20	21	4.9	15-31	25.4	25.6	8.1	16-56
2012	43	27	58	106.6	15-648	26.7	37.1	20.7	11-76
2013	22	29	87	87.6	6-258	22.1	40.3	31.1	3-87
2014	67	17	38	53.7	5-220	20.2	28.9	24.4	2-84
2015	85	15	17	8.8	6-52	15.1	18.6	12.2	4-69
2016	74	50	67	55.9	11-227	51.9	51.9	18.3	11-90
2017	48	15	20	32.6	7-239	14.0	15.2	7.1	5-43
2018	129	120	120	93.4	3-341	51.3	47.8	22.6	2-88
2019	16	50	94	118.0	25-503	56.9	59.2	15.2	37-91
2020	179	16	18	11.1	5-77	16.1	18.4	14.5	1-81
2021	79	18	60	70.1	5-237	21.6	36.0	29.0	4-87

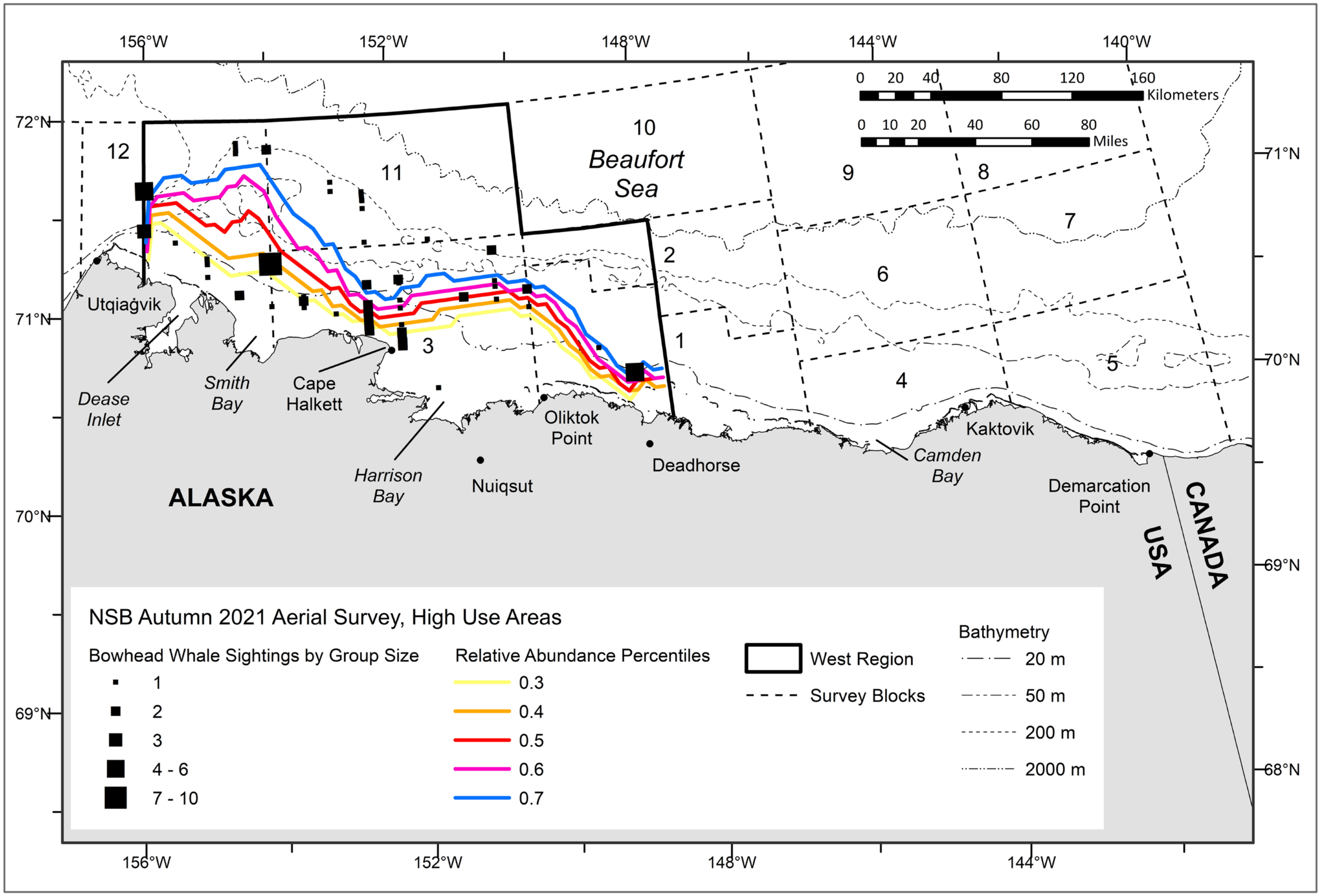

Figure 16. -- Autumn (23 September – 10 October) 2021 bowhead whale transect and CAPs passing sightings (primary observers only) by group size. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

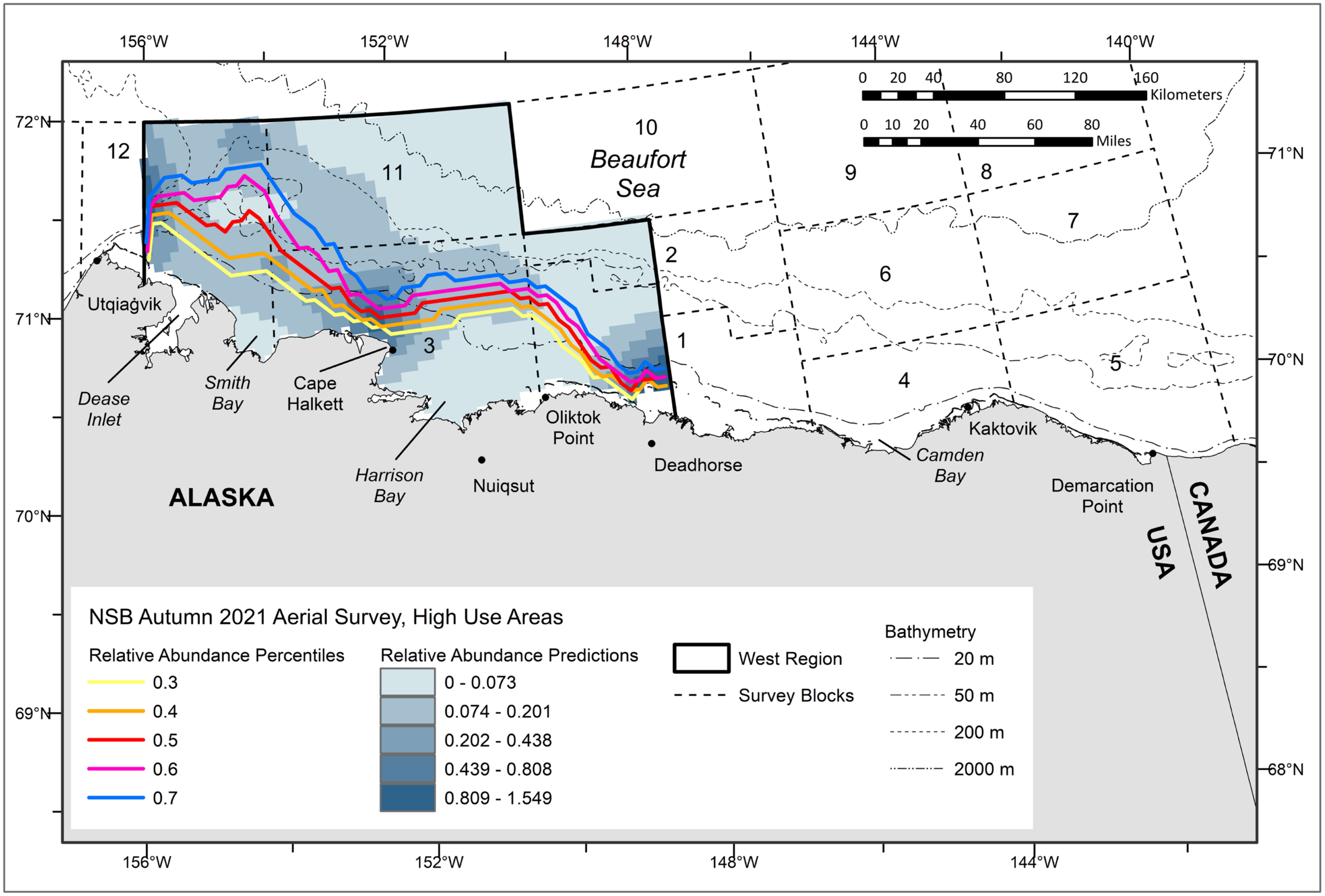

Figure 17. -- Autumn (23 September – 10 October) 2021 bowhead whale relative abundance predictions. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

The estimated median distance-from-shore in the West region for autumn 2021 that was derived using the spatial model was 28.4 km (Table 9). The model-derived results were 6.8 km farther from shore in the West region compared to the results from the analysis of bowhead whale sightings that were unadjusted for transect effort or group size (median value of 21.6 km; Table 8).

Table 9. -- Percentiles of bowhead whale predicted distribution (km) from the spatial model for the western Beaufort Sea West region.

Percentile	Distances (km)
30th	14.9
40th	20.9
50th	28.4
60th	35.9
70th	45.8

Gray Whales

Gray Whale Sighting and Behavior Summary

Five sightings of six gray whales were observed during all survey modes (transect, CAPs, search, and circling) (Table 4, Fig. 18). Two gray whales (one swimming and one feeding) were sighted 48.7 to 50.9 km from shore northwest of Wainwright in water 49-52 m deep. Four gray whales were observed swimming 117.9 to 134.0 km from shore near 72°N in the Hanna Shoal area in water 38-39 m deep. One of these whales was documented at 72.03°N, north of the study area. No gray whales appeared to respond to the survey aircraft. No gray whale calves were seen.

Gray Whale Sighting Rates

There were two sightings of three gray whales on effort by primary observers at 159.9°W and 160.8°W; fine-scale sighting rates are shown in Fig. 19. On-effort gray whales were sighted in blocks 13 and 14 (Table 10, Fig. 20), with a higher sighting rate in block 13 (0.0049 WPUE) than block 14 (0.0031 WPUE). Gray whale sighting rates by depth zone were highest in the 36-50 m depth zone (0.0047 WPUE) followed by the 51-200 m depth zone (0.0022 WPUE), both in the northeastern Chukchi Sea (Table 11, Fig. 21). Gray whale distribution in 2021 using on-effort sightings overlapped the distribution of on-effort sightings observed in previous years having light sea ice cover (Fig. 22); however, historically there have been few gray whale sightings from 15 September to 15 October in the Hanna Shoal area.

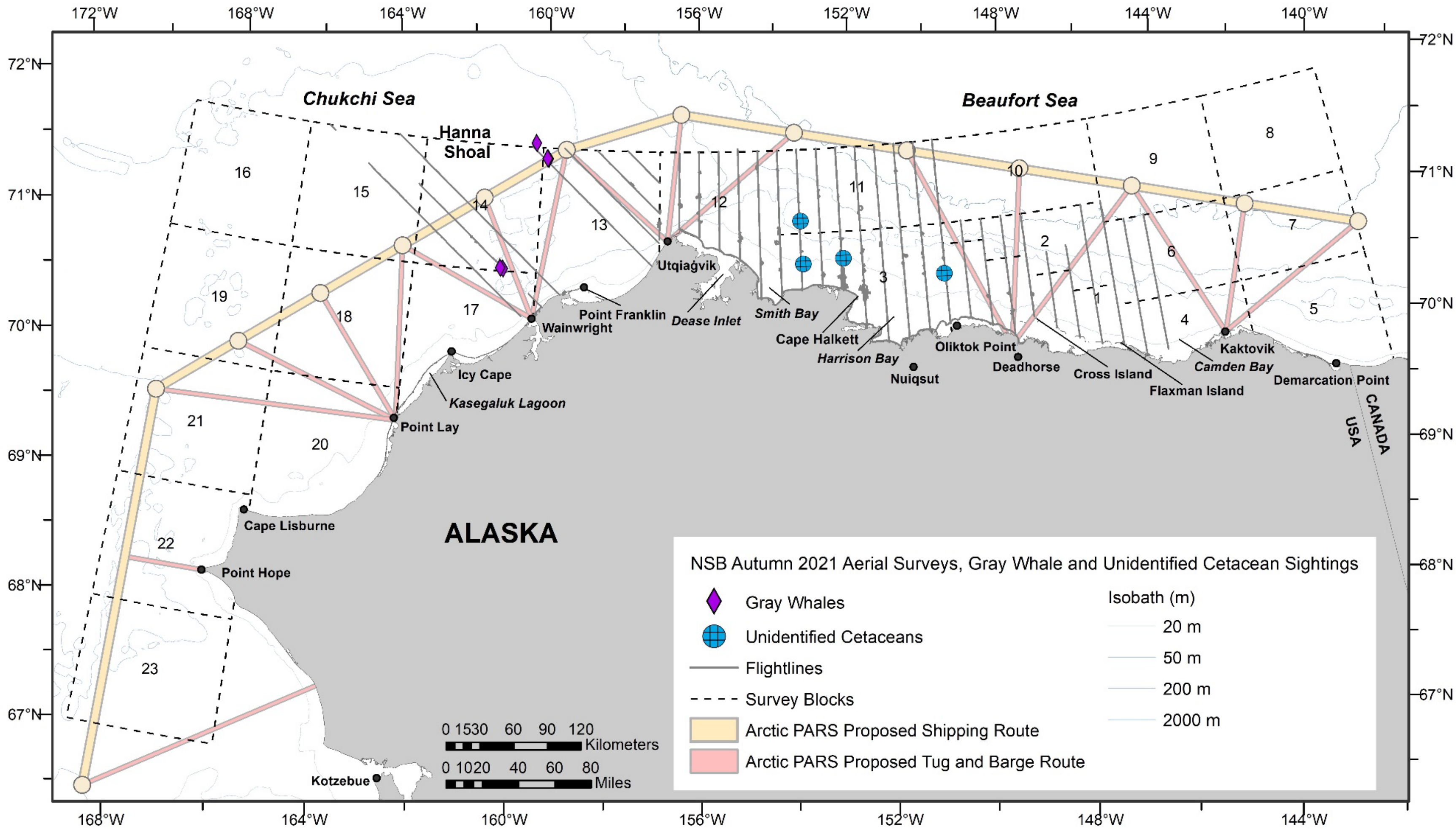

Figure 18. --Gray whale and unidentified cetacean sightings, all survey modes, with transect, CAPs, search, and circling effort, 23 September – 10 October 2021. Deadhead flight tracks are not shown. Unidentified cetaceans are included on this map to conserve space in this report; the species identification of the unidentified whales remains unknown.

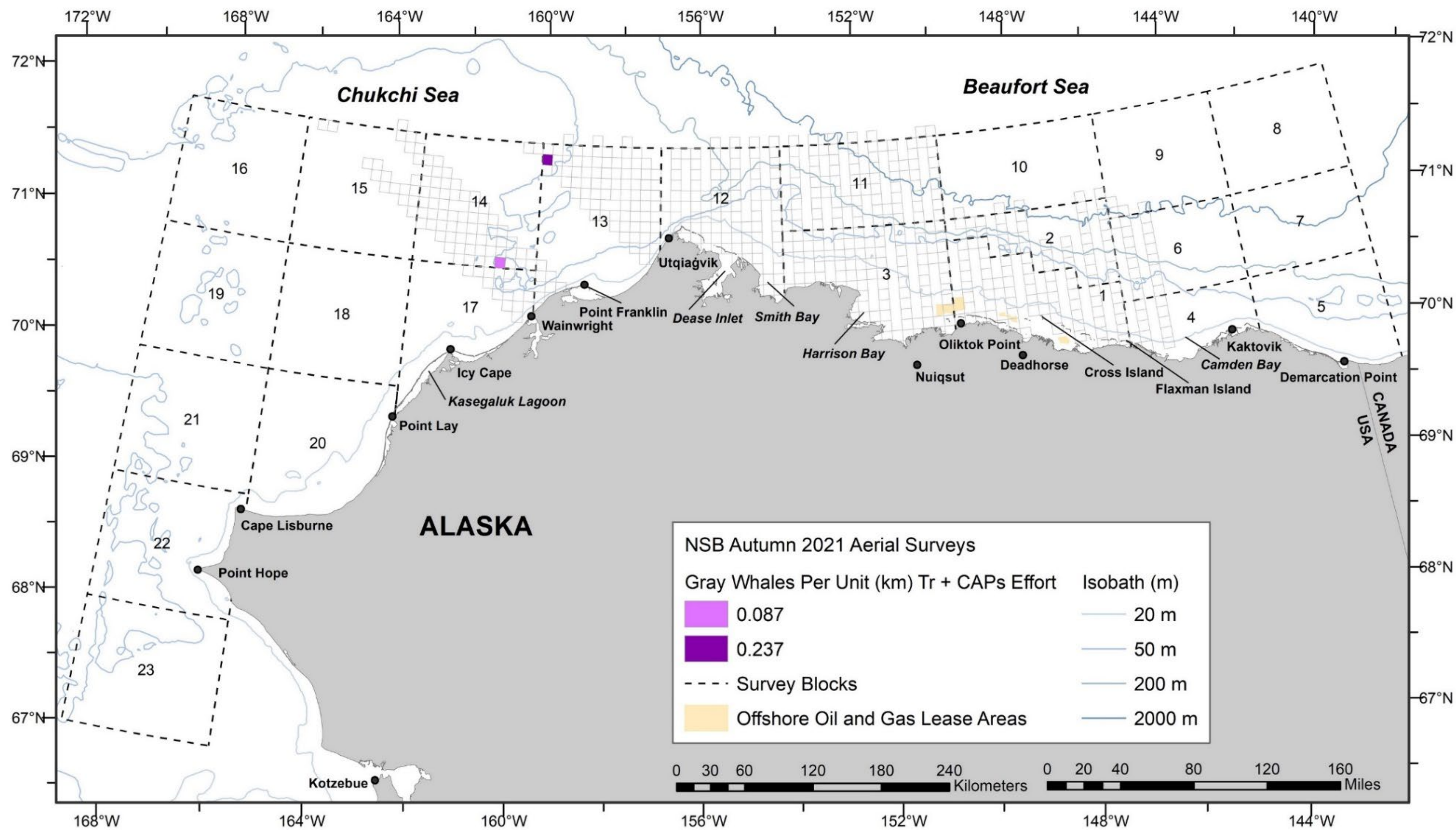

Figure 19. --Gray whale on-effort sighting rates (WPUE; sightings from primary observers only) in the study area, 23 September – 10 October 2021. Empty cells indicate sighting rates of zero. Transect (Tr) and CAPs survey effort was not conducted in areas without cell outlines.

Table 10. -- On-effort (transect and CAPs passing) kilometers (km), number of gray whale on-effort sightings (primary observers only), and gray whale sighting rate (WPUE = gray whales per km surveyed) per survey block, 23 September – 10 October 2021. NA – surveys were not conducted; surveys were also not conducted in survey blocks 18-23. The total for block 1 includes 36 km flown inshore of the barrier islands. Minor discrepancies within the table are due to rounding error.

BLOCK	km	Sightings	Gray whales	WPUE
1	688	0	0	0.0000
2	377	0	0	0.0000
3	1,637	0	0	0.0000
4	94	0	0	0.0000
5	0	0	0	NA
6	154	0	0	0.0000
7	0	0	0	NA
8	0	0	0	NA
9	15	0	0	0.0000
10	1	0	0	0.0000
11	1,179	0	0	0.0000
12	1,299	0	0	0.0000
13	409	1	2	0.0049
14	323	1	1	0.0031
15	104	0	0	0.0000
16	0	0	0	NA
17	66	0	0	0.0000
Total	6,347	2	3	0.0005

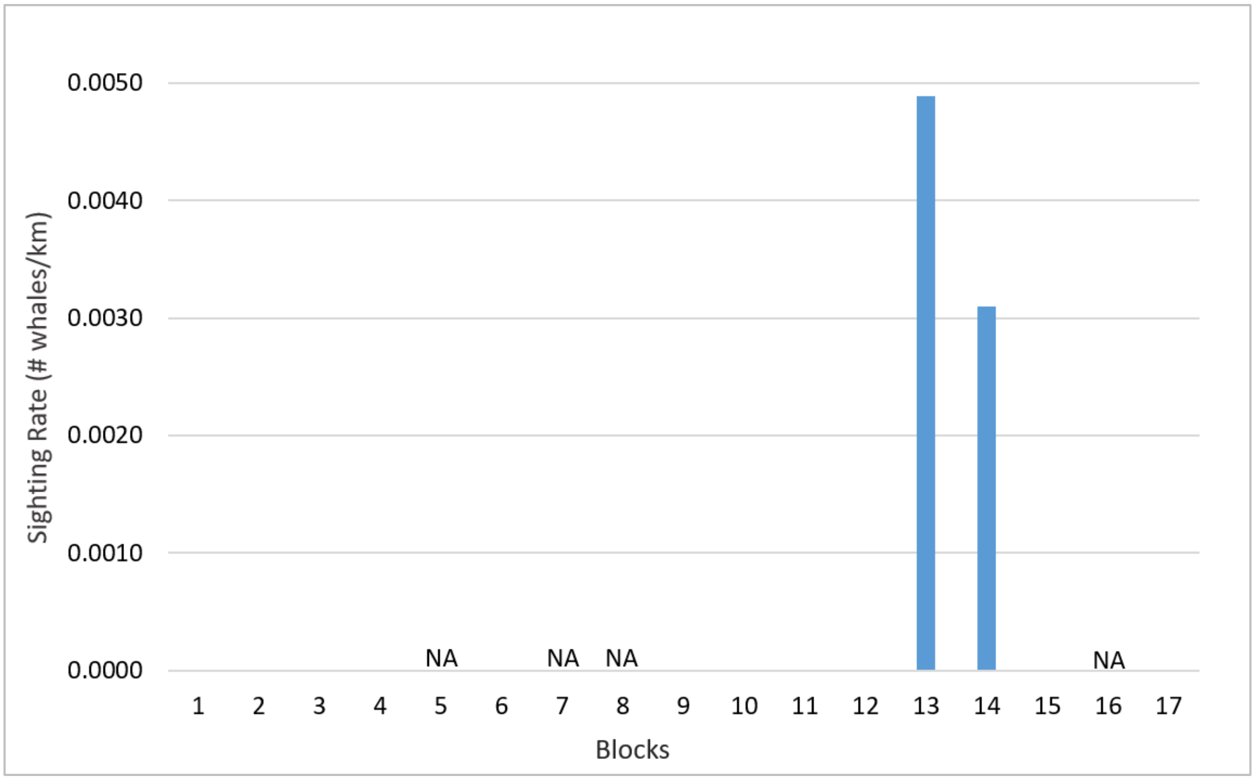

Figure 20. -- Gray whale on-effort sighting rates (WPUE; sightings from primary observers only) per survey block in the study area, 23 September – 10 October 2021. NA – surveys were not conducted. Sighting rates of zero were removed from blocks 1-4, 6, 9-12, 15, and 17 of the graph for clarity. Neither transect nor CAPs passing effort was flown in survey blocks 18-23.

Table 11. -- On-effort (transect and CAPs passing) kilometers (km), number of gray whale on-effort sightings (primary observers only), and gray whale sighting rate (WPUE = gray whales per km surveyed) per depth zone, 23 September – 10 October 2021. NA – surveys were not conducted. Minor discrepancies within the table are due to rounding error.

DEPTH ZONE	km	Sightings	Gray whales	WPUE
157°W-169°W				
0-35 m	30	0	0	0.0000
36-50 m	422	1	2	0.0047
51-200 m N	450	1	1	0.0022
51-200 m S	0	0	0	NA
154°W-157°W				
0-20 m	458	0	0	0.0000
21-50 m	339	0	0	0.0000
51-200 m	356	0	0	0.0000
201-2,000 m	139	0	0	0.0000
TOTAL	**2,194**	**2**	**3**	**0.0014**

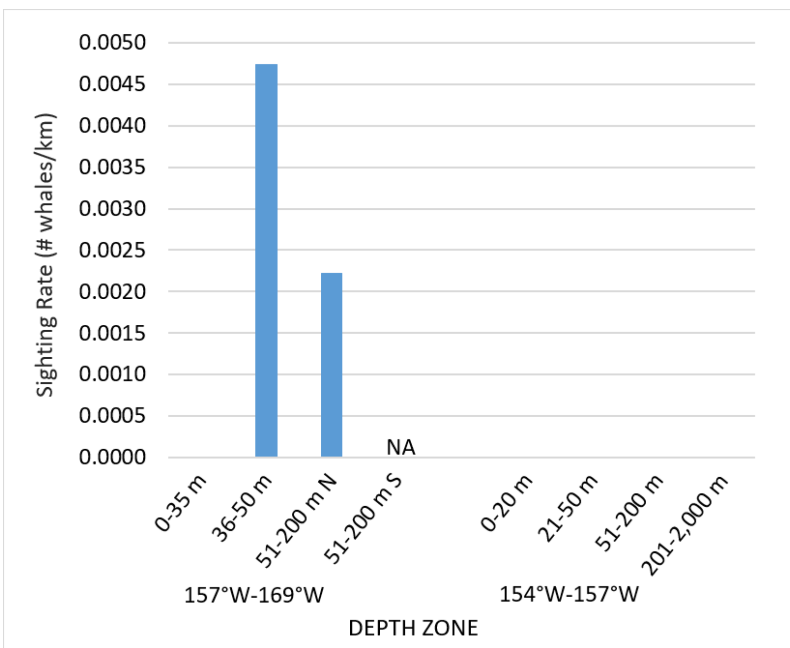

Figure 21. -- Gray whale on-effort sighting rates (WPUE; sightings from primary observers only) per depth zone in the eastern Chukchi and western Beaufort seas, 23 September – 10 October 2021. NA – surveys were not conducted. Sighting rates of zero were removed from depth zones 0-35 m, and 0-20 m through 201-2,000 m of the graph for clarity.

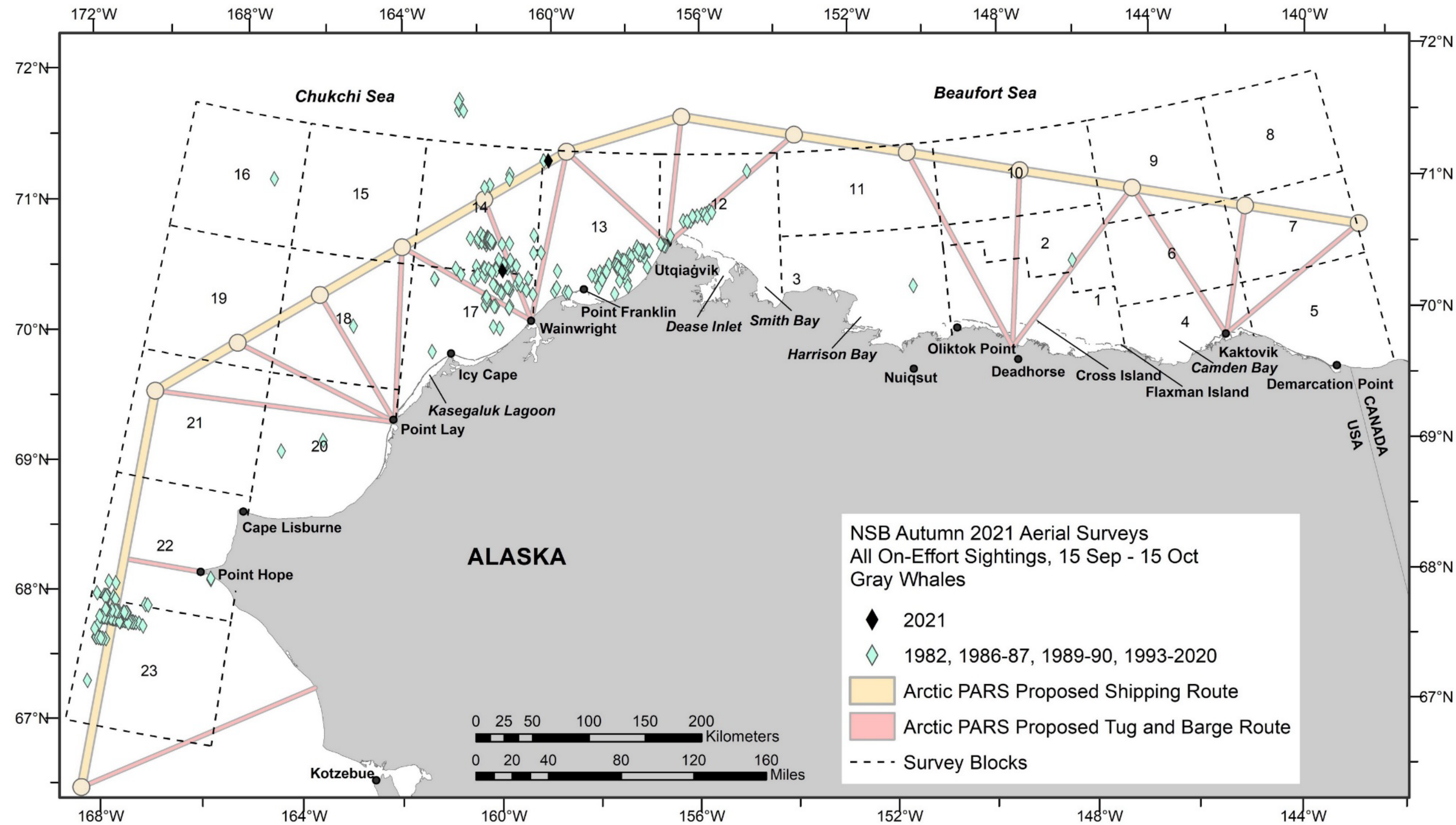

Figure 22. -- Gray whale sightings 15 September – 15 October, in years with light sea ice cover: 1982, 1986-1987, 1989-1990, 1993-2020, and 2021. Includes all on-effort sightings from primary and secondary observers.

Belugas

Beluga Sighting Summary

There were 239 sightings of 368 belugas observed during all survey modes (transect, CAPs, search, and circling) (Table 4, Fig. 23). Beluga stock affiliation cannot be determined from aerial surveys, and sightings likely included belugas from the Eastern Chukchi Sea (ECS) and Beaufort Sea (BS) stocks (Hauser et al. 2014). Most belugas were sighted in the western Beaufort Sea (both the West and East subareas), predominantly in Barrow Canyon and along the continental slope. Beluga distribution in 2021 was similar to previous years with light sea ice cover in autumn in the western Beaufort Sea (Fig. 24).

Beluga Sighting Rates

Belugas were seen on effort from 70.4°N to 72.0°N between 144.9°W and 163.7°W. There were 235 sightings of 363 belugas on transect by primary observers, ranging from one beluga per sighting (189 sightings) to 17 belugas per sighting (1 sighting). Some of the larger beluga groups were pooled counts due to rapid sighting rates. The area with the highest fine-scale sighting rates was offshore in Barrow Canyon and eastward along the Beaufort Shelf Break (Fig. 25).

Sighting rates by survey block were highest in blocks 10 (2.0724 WPUE) and block 2 (0.2041 WPUE) (Table 12, Fig. 26). Sighting rates by depth zone were highest in the 201-2,000 m depth zone in both the West and East Beaufort Sea subareas (0.6207 and 0.2600 WPUE, respectively) (Table 13, Fig. 27).

Beluga Behaviors and Calves

Beluga behaviors observed during transect, search, and circling survey modes are summarized in Table 14. The behavior most often recorded was swimming (94%). One beluga was initially sighted swimming and then changed swim direction, apparently in response to the survey aircraft, which overflew the sighting at 360 m (1,181 ft).

There were six sightings of seven beluga calves during transect, search, and circling survey modes (Fig. 23). Animals identified as calves likely included belugas up to a few years old. Calves nurse for up to two years but may remain with their mothers after weaning (Suydam 2009), often forming triads when a new calf is born. Color is not necessarily a good indication of age because beluga calves lighten progressively over time, changing from charcoal gray at birth to blue-gray then light gray before becoming completely white by 7-9 years of age. Calf sightings extended from 151.4°W to 155.0°W, primarily in Barrow Canyon and along the Beaufort Shelf Break. Beluga calves may be underrepresented in the dataset because of their small size, dark color, and the infrequency of circling over beluga sightings.

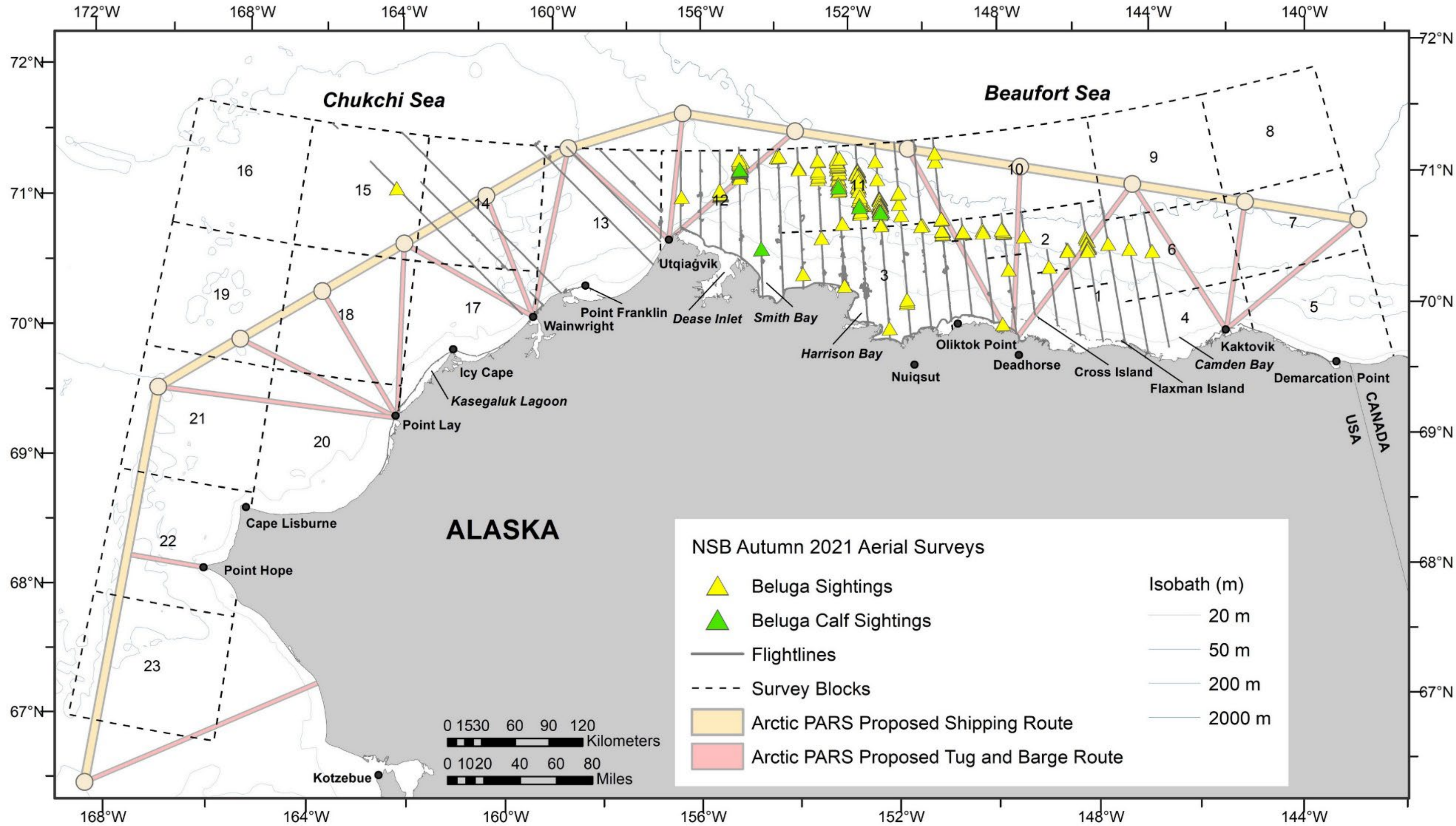

Figure 23. -- Beluga and beluga calf sightings, all survey modes, with transect, CAPs, search, and circling effort, 23 September – 10 October 2021. Deadhead flight tracks are not shown.

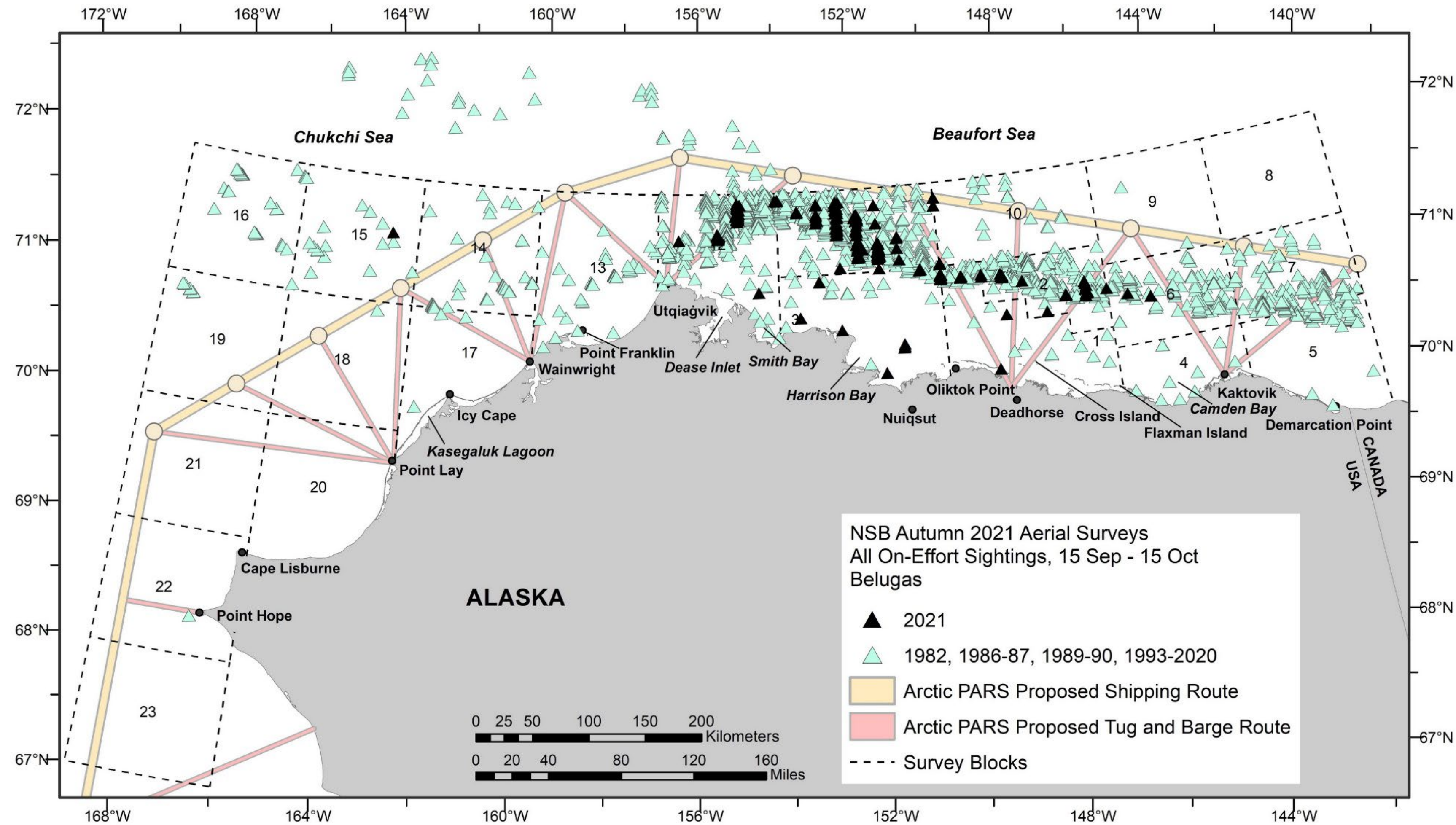

Figure 24. -- Beluga sightings 15 September – 15 October, in years with light sea ice cover: 1982, 1986-1987, 1989-1990, 1993-2020, and 2021. Includes all on-effort sightings from primary and secondary observers.

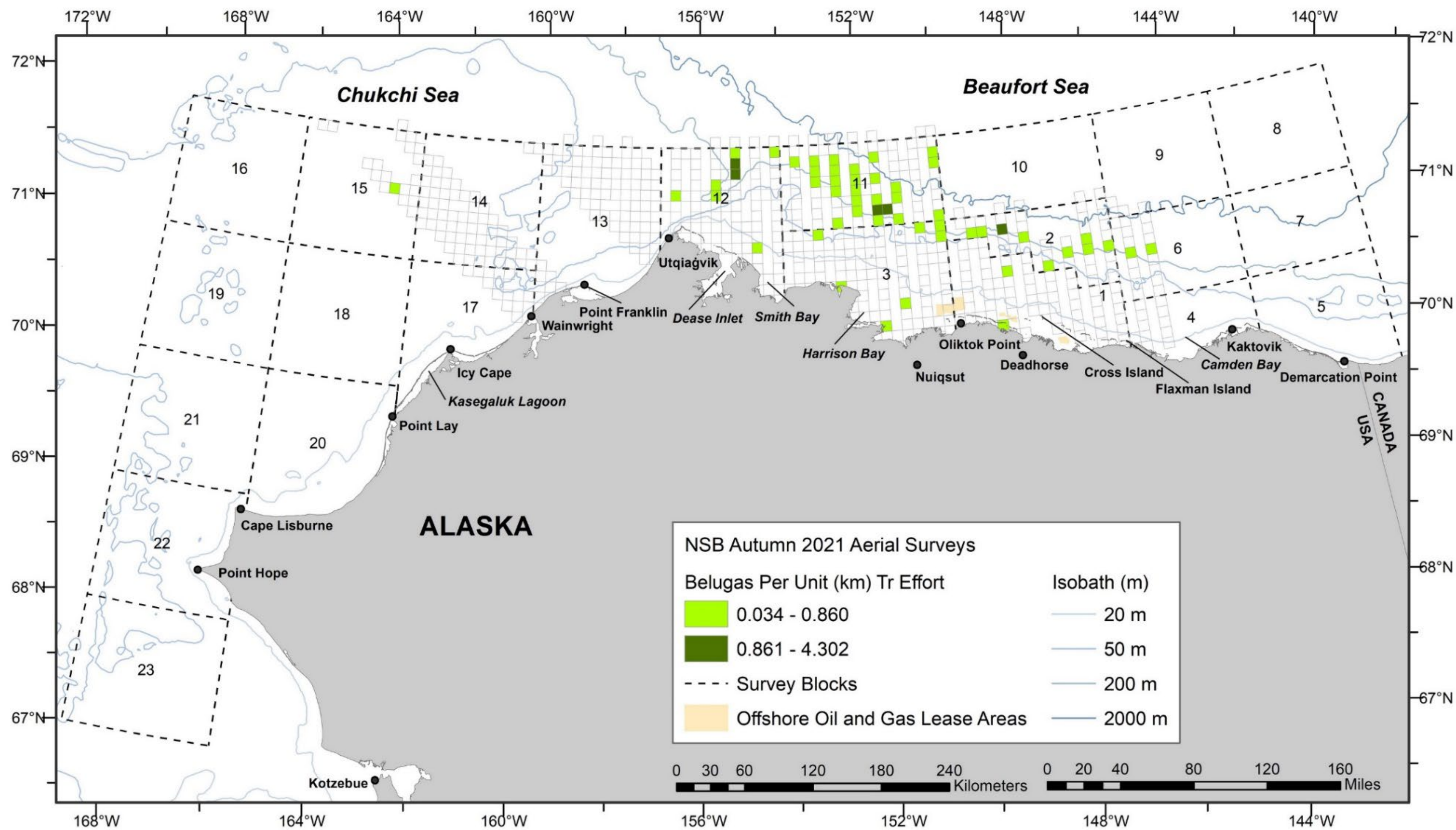

Figure 25. -- Beluga on-effort sighting rates (WPUE; sightings from primary observers only) 23 September – 10 October 2021. Empty cells indicate sighting rates of zero. Transect (Tr) survey effort was not conducted in areas without cell outlines.

Table 12. -- On-effort (transect) kilometers (km), number of beluga transect sightings (primary observers only), and beluga sighting rate (WPUE = belugas per transect km surveyed) per survey block, 23 September – 10 October 2021. NA – surveys were not conducted. The total for block 1 includes 36 km flown inshore of the barrier islands. Minor discrepancies within the table are due to rounding error.

BLOCK	km	Sightings	Belugas	WPUE
1	688	2	3	0.0044
2	377	34	77	0.2041
3	1,605	17	26	0.0162
4	94	0	0	0.0000
5	0	0	0	NA
6	154	2	2	0.0130
7	0	0	0	NA
8	0	0	0	NA
9	15	0	0	0.0000
10	1	3	3	2.0724
11	1,179	124	152	0.1289
12	1,299	52	99	0.0762
13	409	0	0	0.0000
14	323	0	0	0.0000
15	104	1	1	0.0096
16	0	0	0	NA
17	66	0	0	0.0000
Total	6,315	235	363	0.0575

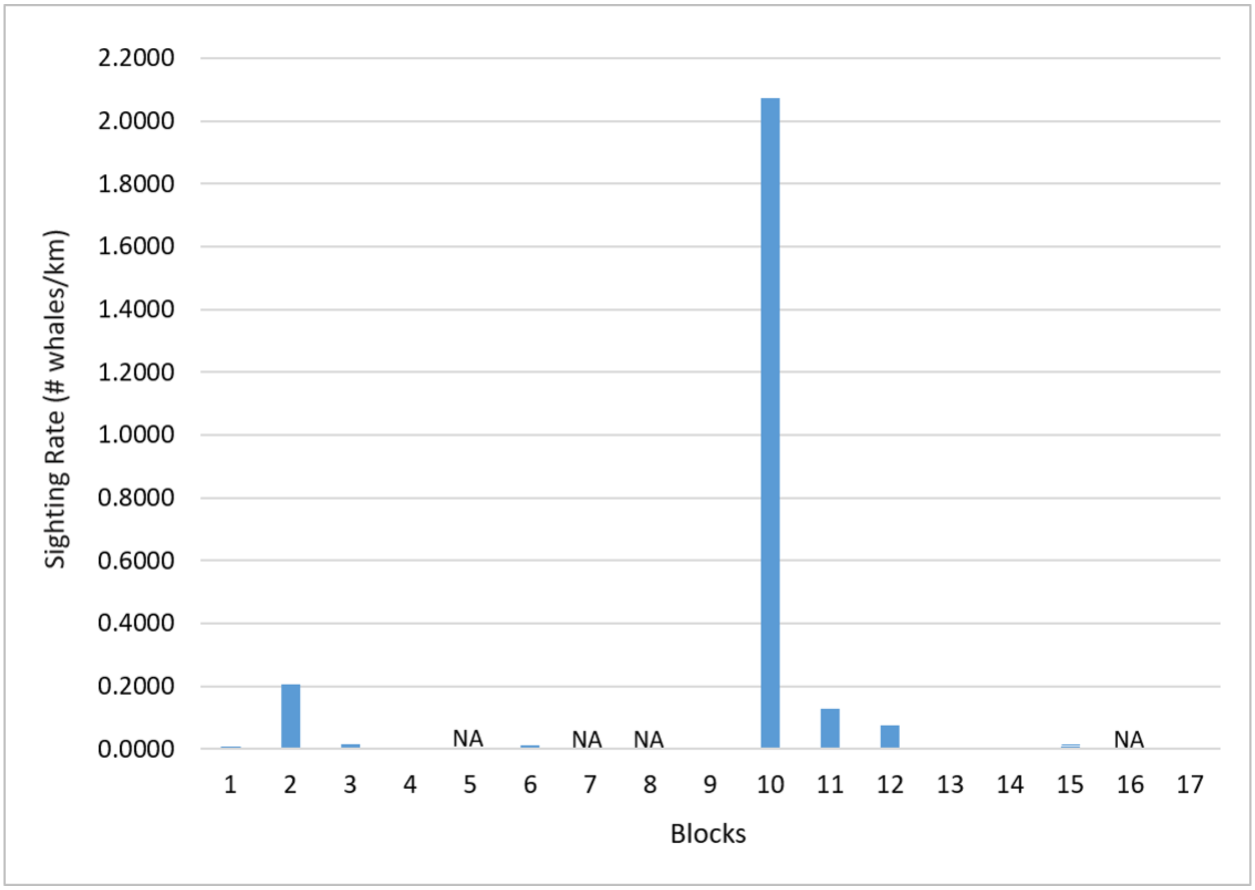

Figure 26. --Beluga on-effort sighting rates (WPUE; sightings from primary observers only) per block, 23 September – 10 October 2021. NA – surveys were not conducted. Sighting rates of zero were removed from block 4, 9, 13, 14, and 17 of the graph for clarity. Neither transect nor CAPs passing effort was flown in survey blocks 18-23.

Table 13. -- On-effort (transect) kilometers (km), number of beluga transect sightings (primary observers only), and beluga sighting rate (WPUE = belugas per transect km surveyed) per depth zone, 23 September – 10 October 2021. NA – surveys were not conducted. Minor discrepancies within the table are due to rounding error.

DEPTH ZONE	km	Sightings	Belugas	WPUE
157°W-169°W				
0-35 m	30	0	0	0.0000
36-50 m	422	1	1	0.0024
51-200 m N	450	0	0	0.0000
51-200 m S	0	0	0	NA
154°W-157°W				
0-20 m	458	1	10	0.0218
21-50 m	339	0	0	0.0000
51-200 m	356	3	3	0.0084
201-2,000 m	139	48	86	0.6207
140°W-154°W				
0-20 m	1,094	6	6	0.0055
21-50 m	1,176	2	7	0.0060
51-200 m	633	3	4	0.0063
201-2,000 m	935	168	243	0.2600
> 2,000 m	256	3	3	0.0117
TOTAL	**6,287**	**235**	**363**	**0.0577**

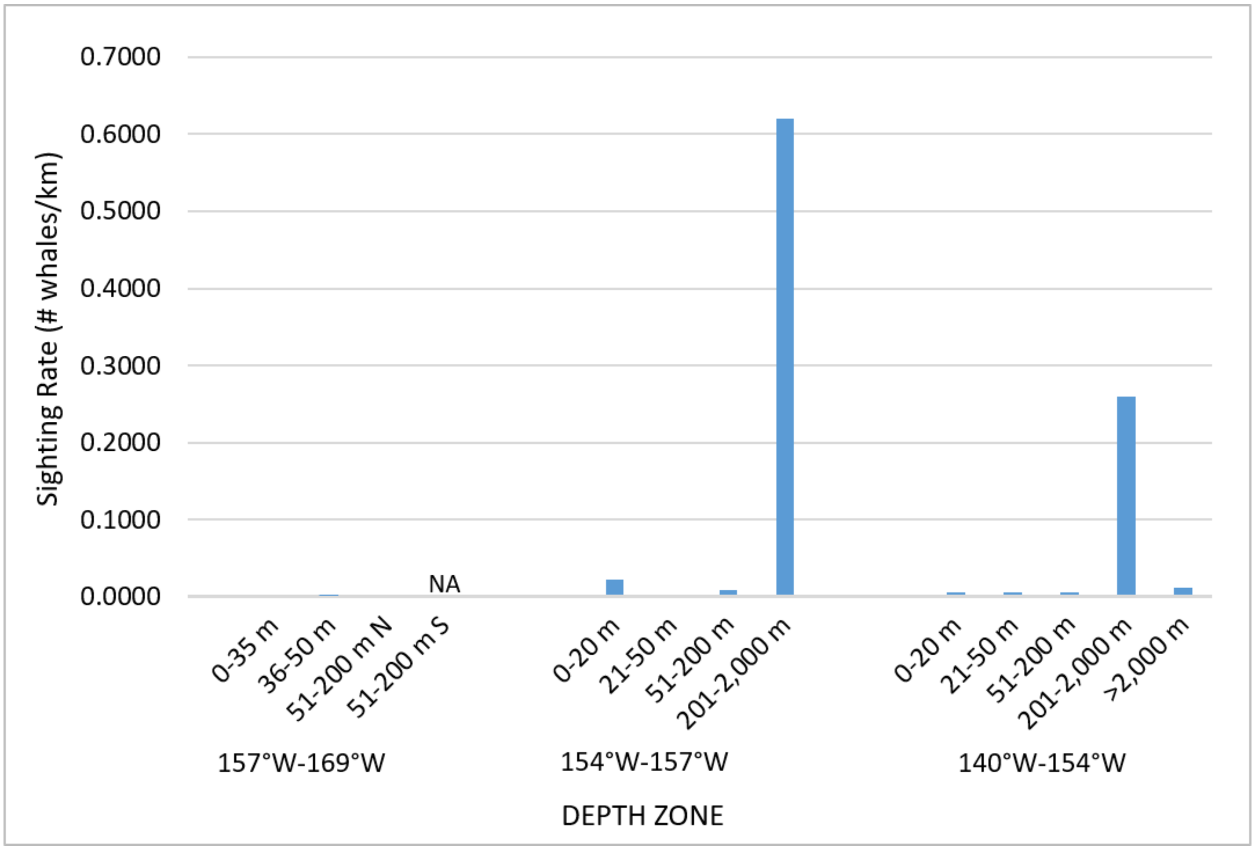

Figure 27. -- Beluga on-effort sighting rates (WPUE; sightings from primary observers only) per depth zone, 23 September – 10 October 2021. NA – surveys were not conducted. Sighting rates of zero were removed from depth zones 0-35 m through 51-200 m N (157°W-169°W) and 21-50 m (154°W-157°W) of the graph for clarity.

Table 14. -- Belugas (number of sightings/ number of individuals) observed during transect, search, and circling survey modes, by behavioral category, 23 September – 10 October 2021. Excludes dead and same-day repeat sightings.

Behavior	Belugas
Mill	1/9
Rest	7/9
Swim	228/345
Unknown	3/5
TOTAL	**239/368**

Unidentified Cetaceans

Sightings were recorded as unidentified when a positive species identification was not possible. This usually occurred when an animal dived and could not be resighted, when the sighting was greater than 3 km from the trackline, or when environmental conditions such as fog, low cloud ceilings, glare, or sea state hindered efforts to relocate the initial sighting. There were four sightings of single unidentified cetaceans observed during all survey modes (transect, CAPs, search, and circling) (Table 4, Fig. 18). One unidentified cetacean was sighted ~65 km offshore from the eastern side of Smith Bay without other whales nearby, one unidentified cetacean was sighted ~40 km offshore to the northwest of Cape Halkett with one bowhead whale mom-calf pair and another bowhead whale nearby, one unidentified cetacean was sighted ~50 km offshore of Oliktok Point with one bowhead whale nearby, and one unidentified cetacean was sighted ~35 km northeast of Smith Bay with no other whales in the area. None of the unidentified cetaceans appeared to respond to the survey aircraft.

Pinnipeds

Walruses

There were 30 sightings of 2,201 Pacific walruses observed during transect, search and circling survey modes (Table 15, Fig. 28). Walruses were sighted on 26 September in the eastern Chukchi Sea from 161.2°W to 163.4°W in survey blocks 14, 15, and 17. Most walruses (77%, 20 sightings of 1,704 walruses) were in block 14, located on the southern side of walrus feeding grounds on Hanna Shoal. No walruses were encountered on the only other flight in the Chukchi Sea on 24 September. The majority of walruses sighted (97%, 2,133 walruses) were hauled out on sea ice in areas of 10-40% broken floe; other walruses were swimming and resting in open water. All walruses were sighted on transect by primary observers. The highest fine-scale transect sighting rate of walruses was observed at 162.5°W, on the southwestern side of Hanna Shoal (Fig. 29). One walrus was sighted swimming and then dove, apparently in response to the survey aircraft, which overflew the sighting at 335 m (1,099 ft).

Other Pinnipeds

There were 19 sightings of 20 bearded seals (*Erignathus barbatus*), all of which were sighted on transect (Table 15, Fig. 28). The bearded seals were distributed from 147.4°W to 161.0°W and were resting, diving, and swimming in open water. No bearded seals appeared to react to the survey aircraft. Other pinnipeds not identifiable to species were recorded as either unidentified pinnipeds (one sighting of one unidentified pinniped) or small unidentified pinnipeds (214 sightings of 504 small unidentified pinnipeds) (Table 15, Fig. 28). Unidentified pinnipeds likely included sightings of ringed (*Pusa hispida*), spotted, ribbon (*Histriophoca fasciata*), and bearded seals, in addition to small walruses. Small

Table 15. -- Summary of pinniped and polar bear sightings (number of sightings/number of individuals) during transect, search, and circling survey modes, in chronological order, 23 September – 10 October 2021, by survey day. Excludes dead and repeat sightings.

Day	Flight No.	Walrus	Bearded seal	Unidentified pinniped*	Polar bear
23 Sep	1	0	0	8/40	0
24 Sep	2	0	9/10	103/217	0
25 Sep	3	0	0	0	1/1
26 Sep	4	30/2,201	2/2	2/2	0
27 Sep	5	0	8/8	40/76	0
28 Sep	6	0	0	2/2	0
30 Sep	7	0	0	24/27	0
3 Oct	8	0	0	0	0
6 Oct	9	0	0	22/86	0
9 Oct	10	0	0	14/55	0
10 Oct	11	0	0	0	0
TOTAL		**30/2,201**	**19/20**	**215/505**	**1/1**

* Includes sightings designated as 'unidentified pinniped' and 'small unidentified pinniped'

unidentified pinnipeds likely only included sightings of small pinnipeds (ringed and spotted seals and possibly juvenile bearded seals). Unidentified pinniped distribution ranged from 144.9°W to 163.6°W. All unidentified pinnipeds were sighted in open water; behaviors included diving, feeding, milling, resting, and swimming. Some of the pinnipeds were sighted in large groups up to 25 individuals; these seals were documented as milling or feeding based on the localized diving behavior and association with diving birds at the surface. Five small unidentified pinnipeds appeared to react to the survey aircraft by diving; two were initially sighted resting and three were initially sighted diving. The altitude that these sightings were flown over ranged from 308-401 m (1,010-1,315 ft).

Polar Bears

There was one sighting of one polar bear, observed while circling from transect on a bowhead whale carcass approximately 20 km west of Cape Halkett. (Table 15, Fig. 28). The bear was wading from shore, in shallow water, heading towards the carcass in the swash zone. The bear did not appear to react to the survey aircraft. Cross Island and the waters off Kaktovik were not surveyed in 2021. These are areas where polar bears typically congregate in the autumn due to the presence of bowhead whale carcasses hauled there by subsistence whalers.

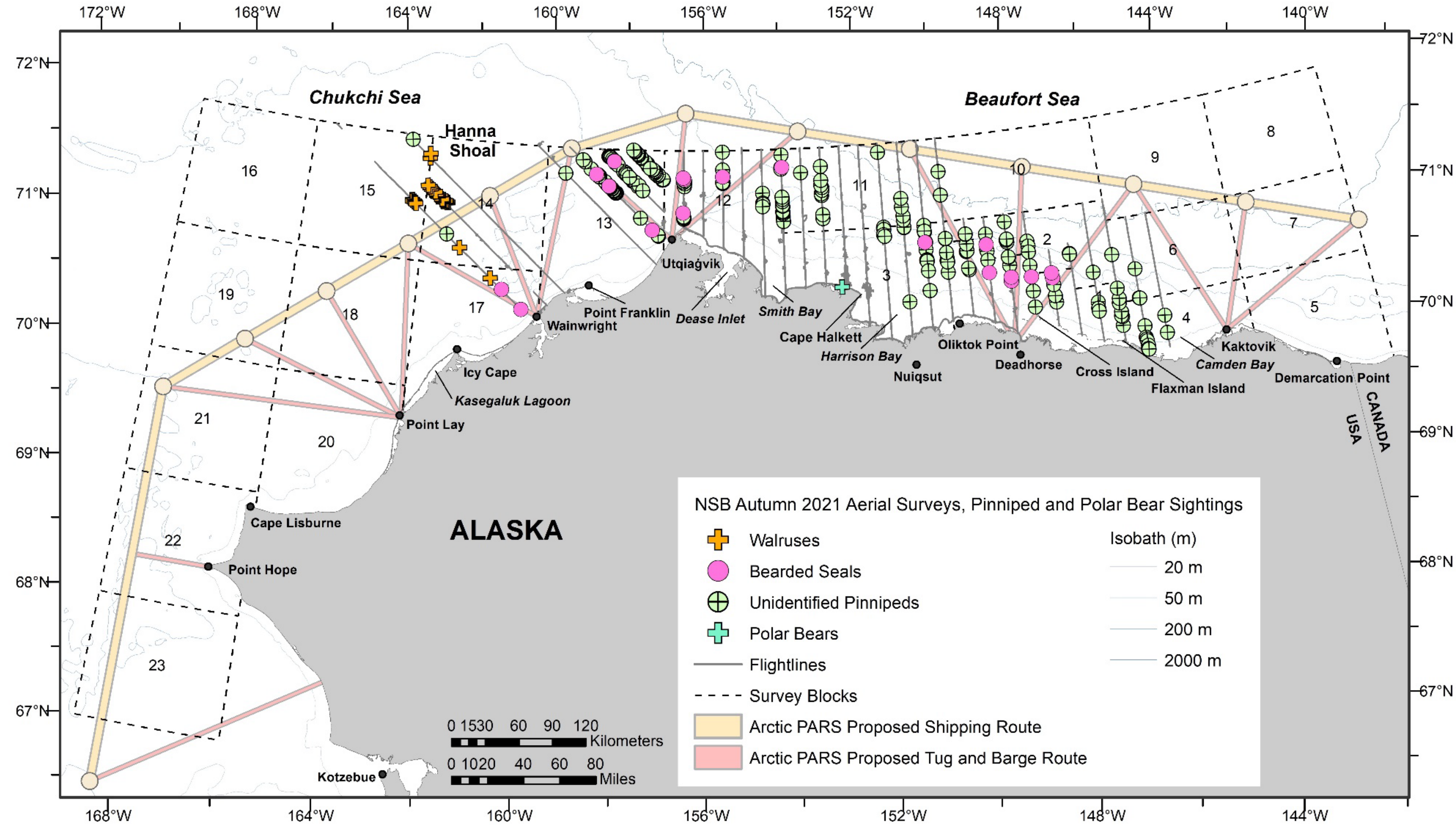

Figure 28. -- Walrus, bearded seal, unidentified pinniped, and polar bear sightings, all survey modes, with transect, CAPs, search, and circling effort, 23 September – 10 October 2021. Deadhead flight tracks are not shown.

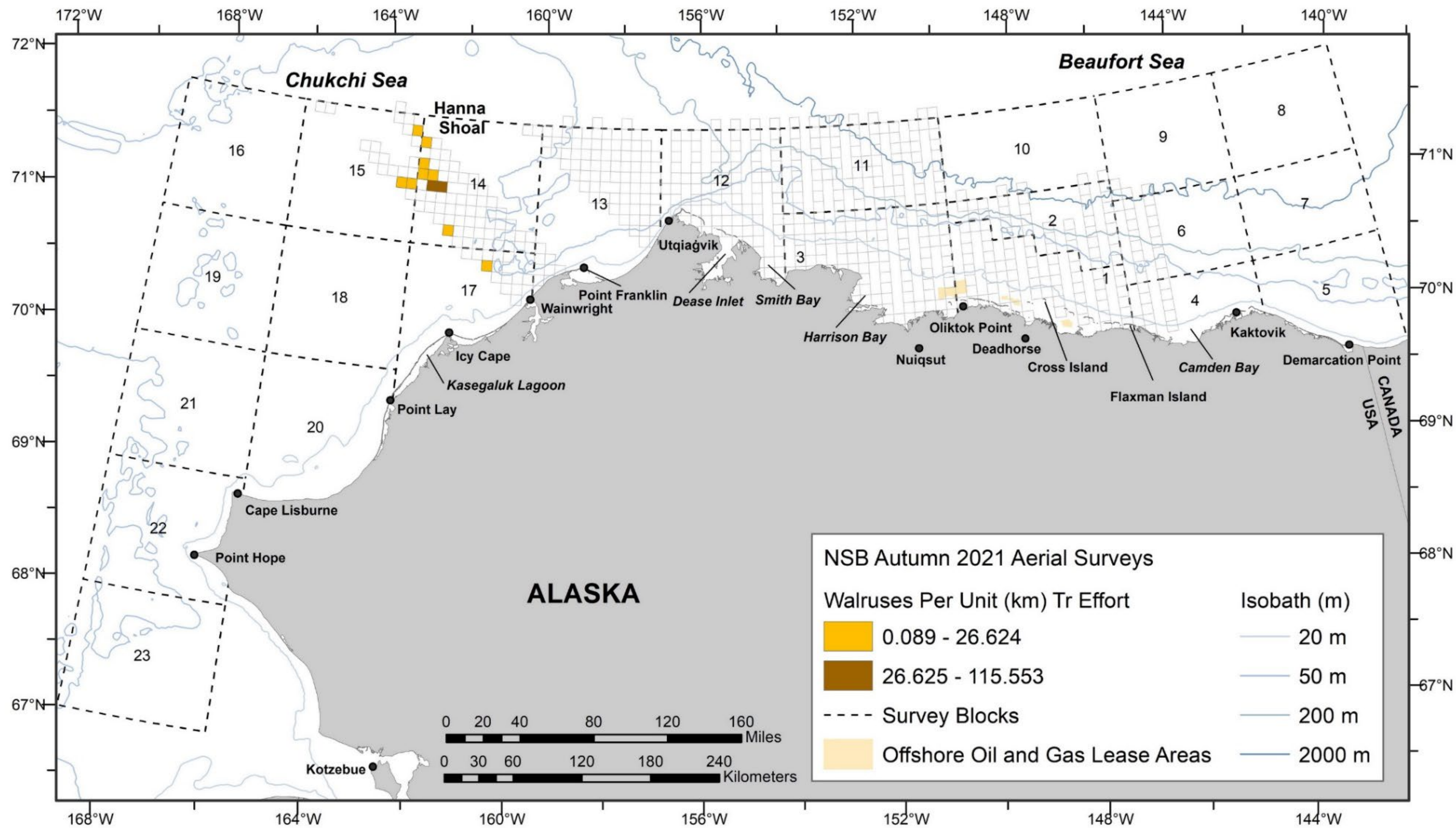

Figure 29. -- Walrus on-effort sighting rates (WPUE; transect sightings from primary observers only), 23 September – 10 October 2021. Empty cells indicate sighting rates of zero. Transect (Tr) survey effort was not conducted in areas without cell outlines.

Dead Marine Mammals

There were 14 sightings of 15 dead marine mammals in 2021: three bowhead whales, one gray whale, two belugas, four unidentified cetaceans, four walruses, and one unidentified marine mammal (Fig. 30, Table 16). On 25 September, one bowhead whale carcass was sighted onshore ~20 km to the west of Cape Halkett. On 3 October, one bowhead whale carcass was sighted floating ~50 km to the east of Point Barrow. Imagery review of the remains confirms these were unique whales and indicates that probable killer whale predation was the cause of death for both bowhead whales. On 9 October, one bowhead whale was sighted floating ~60 km offshore of Smith Bay; probable cause of death could not be determined based on the imagery collected. The gray whale carcass was documented on 26 September, beached ~20 km southwest of Point Franklin, with injuries attributed to killer whale predation. On 28 September, one beluga carcass was sighted ~155 km offshore north of the eastern side of Harrison Bay. On 9 October, another beluga carcass was sighted floating ~90 km northeast of Smith Bay. Images of both belugas were reviewed to determine whether they were the same whale, however, there were no discernable features on either whale and both are considered unique strandings. Unidentified cetacean carcasses were documented on 26 and 28 September and 9 October and were distributed from 70.6°N to 71.5°N and 152°W to 160°W. Three sightings of four beach-cast walruses were documented on the Chukchi Sea coast ~5-40 km northeast of Wainwright on 26 September. One unidentified marine mammal carcass was the remains of a polar bear kill site, sighted on a piece of broken floe sea ice ~90 km northwest of Wainwright on 26 September.

Level A stranding forms were completed and forwarded to personnel at the NSB-DWM (all strandings), NMFS (cetacean and ice seals) and USFWS (walruses).

Debris

In 2021 the project standardized debris data collection protocols so that all debris sighting were marked. A total of 22 pieces of debris were recorded between 147.0°W-158.1°W (Fig. 30). Debris ranged in size from seal-sized to as wide as a bowhead whale; size was not recorded or able to be inferred for at least three sightings. Four items were likely “duck ponds” used to catch and contain oil and other mechanical fluids. Also sighted were two pieces of Styrofoam and one float with nothing attached.

Table 16. -- Summary of dead marine mammal sightings during transect, search, and circling survey modes, in chronological order, 23 September – 10 October 2021. Excludes repeat sightings.

Flight No.	Date	Latitude (°N)	Longitude (°W)	Species	No. Animals	Habitat
3	25-Sep-21	70.877	152.633	bowhead whale*	1	beach
4	26-Sep-21	70.860	159.260	gray whale*	1	beach
4	26-Sep-21	70.858	159.273	walrus	2	beach
4	26-Sep-21	70.660	159.990	unidentified cetacean	1	beach
4	26-Sep-21	70.673	159.969	walrus	1	beach
4	26-Sep-21	70.686	159.940	walrus	1	beach
4	26-Sep-21	71.248	161.636	unidentified marine mammal	1	broken floes
6	28-Sep-21	71.782	151.011	beluga	1	open water
6	28-Sep-21	71.272	152.448	unidentified cetacean	1	open water
8	3-Oct-21	71.353	155.007	bowhead whale*	1	open water
10	9-Oct-21	71.467	152.026	unidentified cetacean	1	open water
10	9-Oct-21	71.184	152.520	unidentified cetacean	1	open water
10	9-Oct-21	71.584	153.502	beluga	1	open water
10	9-Oct-21	71.384	154.027	bowhead whale	1	open water

* Injuries consistent with killer whale predation

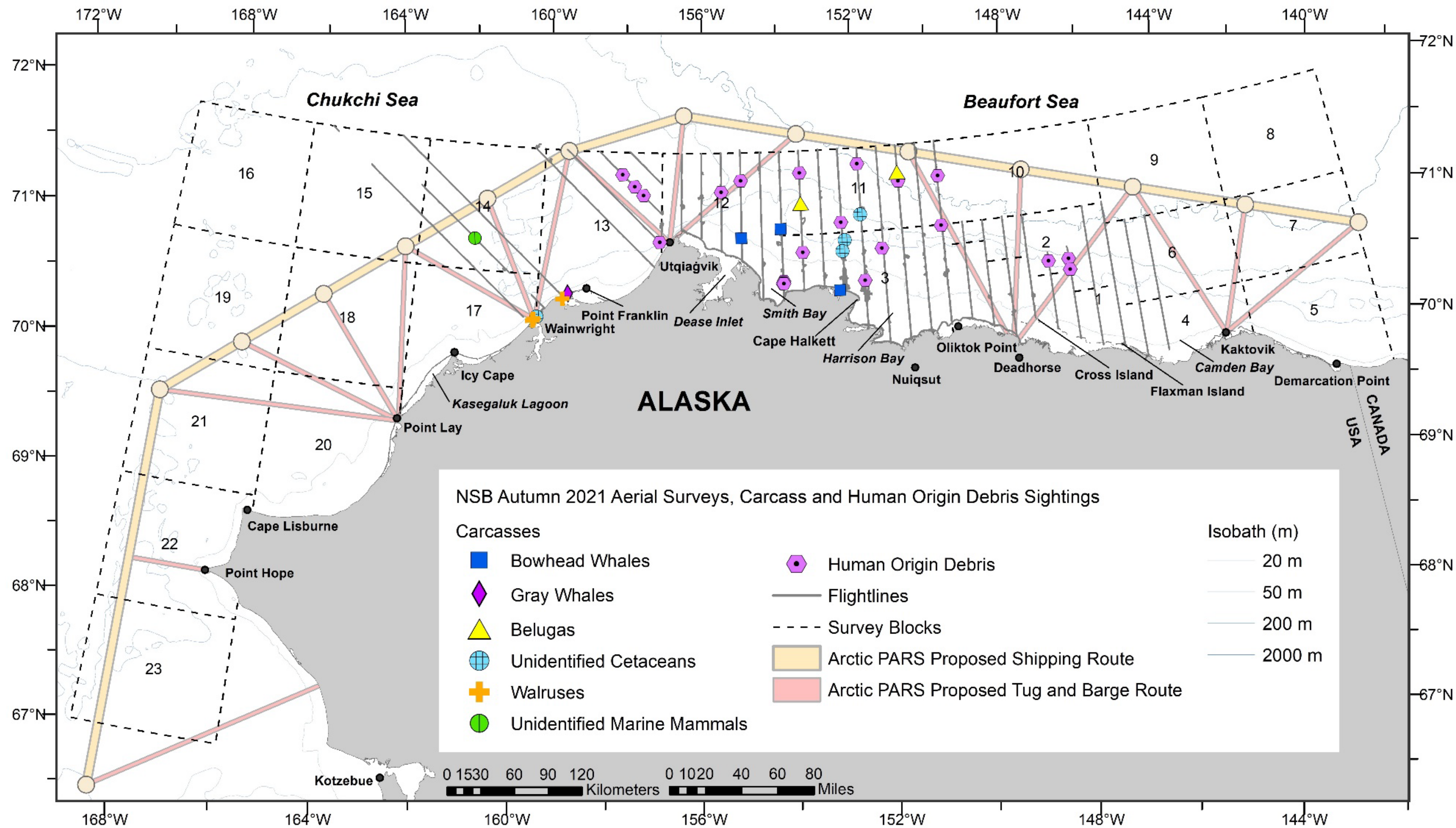

Figure 30. --Marine mammal carcasses and human origin debris sightings, all survey modes, with transect, CAPs, search, and circling effort, 23 September – 10 October 2021. Deadhead flight tracks not shown.

Accomplishments and Community Engagement

Data from 2021 were shared throughout the field season with NSB residents, researchers, and interested parties within other agencies.

Daily reports of flight and sighting information were sent to NSB, AEWC, BWCA, BOEM, NOAA, University of Washington (UW), Woods Hole Oceanographic Institution, Marine Mammal Commission, and the University of Alaska.

All Level A stranding forms (14 total forms) were sent to the relevant agencies for cetacean, ice-seal, and walrus strandings: U.S. Fish and Wildlife Service, NMFS, NSB, and the Alaska Marine Advisory Program.

Gray whale sighting data were shared with the NOAA Gray Whale Unusual Mortality Event Task Force.

Community engagement in 2021 included:

- Daily communications with NSB to ensure that aerial survey activities would not interfere with subsistence whaling activities.
- Communicating with the NSB Search and Rescue to familiarize them with our project.

Recent Media Articles 2019-2022 (full list provided in Appendix G)

Bauman, M. 2020. “NOAA study shows evidence of killer whale predation on bowheads.” The Cordova Times. Sep 18, 2020. Available at https://www.thecordovatimes.com/2020/09/18/noaa-study-shows-evidence-of-killer-whale-predation-on-bowheads/

Bauman, M. 2020. “North Slope Borough, NOAA, UW collaborate on whale study.” The Cordova Times. Nov 14, 2020.

Ealry, W. 2020. “A subsistence staple, bowhead whales now face predation from killer whales as Arctic sea ice shrinks.” KOTZ-Kotzebue (89.9FM), Sep 20, 2020 and KNBA (90.3 FM) Public Radio News, Oct 9, 2020. https://www.knba.org/news/2020-10-09/a-subsistence-staple-bowhead-whales-now-face-predation-from-killer-whales-as-arctic-sea-ice-shrinks.

Fricke, R. 2021. “A whale murder mystery in the Arctic.” University of Washington, Climate, Polar Science News. Feb 4, 2021

Herz, N. 2019. “Whalers in Utqiaġvik can’t remember hunting this late without landing a bowhead.” Alaska’s Energy Desk. Oct 25, 2019.

Herz, N. 2019. “A month into Utqiaġvik’s whaling season, none have been landed.” Alaska’s Energy Desk – Anchorage. Oct 25, 2019.

Herz, N. 2019. “No Bowhead Sightings yet for Alaskan Whalers. Some Blame Climate Change.” NPR. Oct 29, 2019.

NOAA Fisheries. 2019. “Alaska Region Marine Mammal Stranding Network, Fall/Winter 2019 Newsletter”. Nov 4, 2019. Mahoney, B., Savage, K., Kuletz, K., Snyder, J., Jensen, A., Wright, S., Kumar, S., Gann, D., Belovarac, J., Auletta, J., and Rouse, N.

NOAA Fisheries. 2020. “First Direct Evidence of Killer Whale Predation on Bowhead Whales in the U.S. Pacific Arctic Documented by Scientists.” Sep 14, 2020.

NOAA Fisheries. 2020. “North Slope Borough, NOAA, University of Washington and Cooperative Institute for Climate Ocean and Ecosystem Studies Scientists Collaborate to Monitor Whales in 2020 in Northern Alaska.” Nov. 9, 2020.

Oliver, Shady Grove. 2019. “Utqiaġvik whalers still hope to land a bowhead as season wanes.” Anchorage Daily News. Nov 7, 2019.

Oliver, Shady Grove. 2019. “Season nears end with no whales yet for Utqiaġvik.” The Arctic Sounder. Nov 9, 2019.

Oliver, Shady Grove. 2019. “No whales in sight as fall season nears end.” The Arctic Sounder. Nov 15, 2019.

Oliver, Shady Grove. 2019. “Utqiaġvik finally celebrates first successful bowhead hunt of season.” Anchorage Daily News. Nov 20, 2019.

Perez, T. 2020. “Research group sees big difference in whale counts from 2019 to 2020.” Alaska’s News Source. Nov 11, 2020.

Robinson, G. 2019. “Gray whale die off, bowhead whale population estimates are focus of annual NOAA survey.” Anchorage KTUU. July 26, 2019.

Robinson, G. 2020. “Killer whale take advantage of warming Arctic to hunt bowhead whale in new waters.” Alaska’s News Source, KTUU Channel 2 News. Sep 17, 2020.

Rosen, Y. 2020. “Bite wounds confirm it: Killer whale are attacking bowheads in Alaska’s Chukchi and Beaufort seas.” Arctic Today. Nov 2, 2020.

Rozell, N. 2021. “Bowhead whales: A recent success story.” Stories in the News, Jan 31, 2021 and Seward Journal, Feb 8, 2021.

Rust, S. and Xia, R. 2020. “As gray whale migration reaches its peak, scientist fear another unexplained die-off.” Los Angeles Times. Jan 24, 2020.

Shankman, S. 2019. “Alaska’s Big Whale Mystery: Where Are the Bowheads?” Inside Climate News. Nov 1, 2019.

Venton, D. 2020. "Scientists Count Gray Whales Following Unusual Spate of Deaths Last Spring." KQED Science. Feb 3, 2020.

Wolfe, D. 2022. Gray whales are dying along the Pacific Coast. The warming Arctic may be to blame. www.cnn.com/interactive/2022/03/climate/gray-whale-pacific-arctic-climate-change/. CNN 16 March 2022.

Recent Publications and Posters (full list provided in Appendix G)

Blackwell, B. S., A. M. Thode, A. S. Conrad, M. C. Ferguson, C. L. Berchok, K. M. Stafford, T. A. Marques, and K. H. Kim. 2021. Estimating acoustic cue rates in bowhead whales, *Balaena mysticetus*, during their fall migration through the Alaskan Beaufort Sea. The Journal of the Acoustical Society of America 149: 3611-3625. https://doi.org/10.1121/10.0005043.

Brower, A., J. Clarke, A. Willoughby, and M. Ferguson. 2019. Changes in Gray Whale Foraging Occurrence in the Eastern Chukchi Sea, 2009-2018. Poster presented at the World Marine Mammal Conference, Barcelona, Spain, December 2019.

Brower, A., M. Ferguson, and A. Willoughby. 2022a. Bowhead Whale Distribution and Relative Density in Relation to Remote-Sensed Physical and Biological Environmental Data in the Pacific Arctic, 2014-2019. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-438, 234 p.

Brower, A., A. Willoughby, and M. Ferguson. 2022b. Distribution and Relative Abundance of Bowhead Whales and Other Marine Mammals in the Western Beaufort Sea, 2020. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-439, 155 p.

Clarke, J. T., A. Brower, M. Ferguson, A. Willoughby, and A. Rotrock. 2020. Distribution and relative abundance of marine mammals in the eastern Chukchi Sea, eastern and western Beaufort seas, and Amundsen Gulf, 2019. Annual Report, OCS Study BOEM 2020-027, 603 p. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115-6349.

Clarke, J. T., M. C. Ferguson, S. Okkonen, A. A. Brower, and A. L. Willoughby. 2022. Bowhead Whale Calf Detections in the Western Beaufort Sea During the Open-Water Season, 2012-2019. Arctic Science 8:531–548. https://doi.org/10.1139/AS-2021-0020.

Ferguson, M. C. 2022. Spatial modeling, parameter uncertainty, and precision of density estimates from line-transect surveys: a case study with Western Arctic bowhead whales (Publication No. 29060719) [Master's thesis, University of Washington].

Ferguson, M. C. 2020. Bering-Chukchi-Beaufort Seas bowhead whale (*Balaena mysticetus*) abundance estimate from the 2019 aerial line-transect survey. SC/68B/ASI/09 presented at the International Whaling Commission Scientific Committee Meetings, May 2020. 47 pp.

Ferguson, M. and Givens, G. 2020. Summary of 2019 Abundance Estimates for Bering-Chukchi-Beaufort Seas Bowhead Whales. SC/68B/ASI/10 presented at the International Whaling Commission Scientific Committee Meetings, May 2020.

Ferguson, M. C., J. T. Clarke, A. A. Brower, A. L. Willoughby, and S. R. Okkonen. 2021. Ecological variation in the western Beaufort Sea. *In:* J.C. George and J.G.M. Thewissen (eds.), The Bowhead Whale *Balaena mysticetus*: biology and human interactions. Academic Press, pp. 365-379.

Ferguson, M. C., J. T. Clarke, A. L. Willoughby, A. A. Brower, and A. D. Rotrock. 2021. Geographically stratified abundance estimate for Bering-Chukchi-Beaufort Seas bowhead whales (*Balaena mysticetus*) from an August 2019 aerial line-transect survey in the Beaufort Sea and Amundsen Gulf. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-428, 54 p.

Givens, G. H., M. C. Ferguson, J. T. Clarke, A. Willoughby, A. Brower, and R. Suydam. 2020. Abundance of the eastern Chukchi Sea stock of beluga whales, 2012-17. Arctic, 73(4):405-550. https://doi.org/10.14430/arctic71592.

Moore, S. E., J. T Clarke, S. R. Okkonen, J. M. Grebmeier, C. L. Berchok, and K. M. Stafford. 2022. Changes in gray whale phenology and distribution related to prey variability and ocean biophysics in the northern Bering and eastern Chukchi seas. PLoS ONE 17(4): e0265934. https://doi.org/10.1371/journal.pone.0265934.

Stafford, K. M., E. V. Farley, M. C. Ferguson, K. J. Kuletz, and R. Levine. 2022. Northward range expansion of subarctic upper trophic level animals into the Pacific Arctic region. Oceanography. https://doi.org/10.5670/oceanog.2022.101.

Stimmelmayr, R., J. Citta, K. Scheimreif, M. Ferguson, G. Givens, A. Willoughby, A. Brower, A. Von Duyke, G. Sheffield, B. Person, T. Sformo, L. de Sousa, and R. Suydam. 2022. 2020-2021 Health Report for the Bering-Chukchi-Beaufort seas bowhead whales – Preliminary Findings. Paper SC/68D/ASW/03 presented to the International Whaling Commission Scientific Committee, virtual event, 2022.

Stimmelmayr, R., J. Craig George, J. Clarke, M. Ferguson, A. Willoughby, A. Brower, G. Sheffield, K. Staffort, G. Givens, A. Von Duyke, T. Sformo, B. Person, L. de Sousa, and R. Suydam. 2020. 2018–2019 Health report for the Bearing-Chukchi-Beaufort seas bowhead whale – preliminary finding. SC/68b/ASW/03 presented at the International Whaling Commission Scientific Committee Meetings, virtual meetings 2020.

Torres, L., C. Bird, F. Rodríguez-González, F. Christiansen, L. Bejder, L. Lemos, J. Urban, S. Swartz, A. Willoughby, J. Hewitt, and K. C. Bierlich. 2022. Range-wide comparison of gray whale body condition reveals contrasting sub-population health characteristics and vulnerability to environmental change. Frontiers in Marine Science, Whales and Climate. https://doi.org/10.3389/fmars.2022.867258.

Willoughby, A., M. Ferguson, R. Stimmelmayr, J. Clarke, and A. Brower. 2019. Killer whale predation on bowhead whales in the Pacific Arctic – on the rise? Poster presented at the World Marine Mammal Conference, Barcelona, Spain, December 2019.

Willoughby, A. L., M. C. Ferguson, R. Stimmelmayr, J. T. Clarke, and A. A. Brower. 2020. Bowhead whale (*Balaena mysticetus*) and killer whale (*Orcinus orca*) co-occurrence in the U.S. Pacific Arctic, 2009–2018: evidence from bowhead whale carcasses. Polar Biology 43: 1669–1679. https://doi.org/10.1007/s00300-020-02734-y.

Willoughby, A. L., R. Stimmelmayr, A. A. Brower, J. T. Clarke, and M. C. Ferguson. 2020. Gray whale carcasses in the Eastern Chukchi Sea, 2009– 2019. SC/68b/IST/02 presented to the International Whaling Commission, Cambridge.

Willoughby, A. L., R. Stimmelmayr, A. A. Brower, J. T. Clarke, and M. C. Ferguson. 2020. Bowhead whale carcasses in the eastern Chukchi and western Beaufort seas, 2009-2019. SC/68B/ASW/02 Rev1 presented to the International Whaling Commission Scientific Committee, virtual meeting May 2020.

Willoughby, A. L., R. Stimmelmayr, M. C. Ferguson, J. T. Clarke, and A. A. Brower. 2022. Gray whale (*Eschrichtius robustus*) and killer whale (*Orcinus orca*) co-occurrence in the eastern Chukchi Sea, 2009–2019: evidence from gray whale carcasses documented during aerial surveys. Polar Biology 45:737–748. https://doi.org/10.1007/s00300-022-03015-6.

Willoughby, A., M. Ferguson, B. Hou, C. Accardo, A. Rotrock, A. Brower, J. Clarke, S. Hanlan, M. Foster Doremus, K. Pagan, and L. Barry. 2021. Belly port camera imagery collected to address cetacean perception bias during aerial line-transect surveys: Methods and sighting summaries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-427, 111 p.

Willoughby, A., J. Clarke, A. Brower, M. Ferguson, L. Barry, R. Hardee, S. Hanlan, N. Metheny, and H. Foley. 2020. A Yarn of Wayward Whales in the Eastern Chukchi and Eastern Beaufort Seas, 2019. Poster presented at the Alaska Marine Science Symposium, Anchorage, Alaska, January 2020.

Stimmelmayr, R., J. Citta, K. Scheimreif, M. Ferguson, G. Givens, A. Willoughby, A. Brower, A. Von Duyke, G. Sheffield, B. Person, T. Sformo, L. de Sousa, and R. Suydam. 2022. 2020-2021 Health Report for the Bering-Chukchi-Beaufort seas bowhead whales – Preliminary Findings. Paper SC/68D/ASW/03 presented to the International Whaling Commission Scientific Committee, virtual event, 2022.

Presentation Venues (full list provided in Appendix G)

Alaska Beluga Whale Committee Workshop, Anchorage, AK. 2019.

Alaska Eskimo Whaling Commission, Anchorage, AK. 2019, 2021.

Alaska Marine Science Symposium, Anchorage, AK. 2020.

Arctic Cetacean Listening Session, Utqiaġvik, AK. 2020.

Camden Bay Collaborative Study Workshop, Anchorage, AK, 2020.

Distributed Biological Observatory Workshops, Seattle, WA. 2020.

NOYO Center for Marine Science, virtual event, March 2021.

Preview of Ecological and Economic Conditions, 2020, 2021.

Sitka Sound Science Center's Whale Fest 2021, virtual event, Nov 2021.

US-Russia Area V Marine Mammal Meetings, Anchorage, AK. 2020.

World Marine Mammal Conference, Barcelona, Spain, 2019.

Papers in preparation or review

Brower, A., M. Ferguson, J. Clarke, E. Fujioka, and S. DeLand. *In prep.* Biologically important areas II for cetaceans within U.S. and adjacent waters – Aleutian Islands and Bering Sea region.

Clarke, J., M. Ferguson, A. Brower, E. Fujioka, and S. DeLand. *In prep.* Biologically important areas II for cetaceans within U.S. and adjacent waters – Arctic region.

Ferguson, M.C., D.L. Miller, J.T. Clarke, A.A. Brower, A.L. Willoughby, and A.D. Rotrock. *In prep*. Estimated abundance of Western Arctic bowhead whales from an August 2019 aerial line-transect survey in the Beaufort Sea and Amundsen Gulf.

Ferguson, M.C, A. Brower, A. Willoughby, C. Sims. *In prep*. Distribution and Estimated Abundance of Eastern Bering Sea Belugas from Aerial Line-Transect Surveys in 2017.

Ferguson, M.C., S. Toth, J. Clarke, A. Willoughby, A. Brower, and T. White. *In review*. Biologically important areas for bowhead whales (*Balaena mysticetus*): Optimal site selection with integer programming.

Halliday, W., N. Le Baron, J. Citta, J. Dawson, T. Doniol-Valcroze, M. Ferguson, S. Ferguson, S. Fortune, L. A. Harwood, M. P. Heide-Jørgensen, E. Lea, L. Quakenbush, B. Young, D. Yurkowski, and S. Insley. *In Review.* Vessel strike risk to bowhead whales (*Balaena mysticetus*) during the summer and implications for conservation and management in the North American Arctic.

Joyce, T.W., M.C. Ferguson, C.L. Berchok, D.L. Wright, J.L. Crance, E.K. Braen, T. Eguchi, W.L. Perryman, and D.W. Weller. *In prep*. The role of sea ice in the distribution, habitat use, and phenology of eastern North Pacific gray whales.

Willoughby, A.L., M.C. Ferguson, R. Stimmelmayr, J.T. Clarke, A.A. Brower. *In review*. Bowhead whale (*Balaena mysticetus*) carcasses documented during the 2019 aerial surveys in the eastern Chukchi and western Beaufort seas: A follow up to evidence of bowhead whale and killer whale (*Orcinus orca*) co-occurrence during 2009–2018.

DISCUSSION

Bowhead whale distribution in the western Beaufort Sea in autumn 2021 was distinctly different from the extremes seen in 2019 and 2020, though similar to other previous survey years. In autumn 2019, the bowhead whale migration was unprecedented; whales were sparse along the inner continental shelf, particularly near Utqiaġvik, Alaska, and whales were sighted farther offshore and in deeper water than previous survey years with similarly light sea ice cover (Clarke et al. 2020). Conversely, in 2020 bowhead whales were sighted in what may be the densest bowhead whale aggregations documented in the history of the ASAMM and NSB Autumn Aerial Surveys projects, dating back to 1979, and were closer to shore and in shallower water than previous years with similar surveys (Brower et al. 2022b). During 2021, bowhead whales were sighted both nearshore within the 20-m isobath and also offshore near the 200-m isobath, resulting in no significant differences in depth or distance to shore of sightings in the West region compared to previous years with light sea ice cover (1989-90 and 1993-2020, all years pooled).

The area east of Point Barrow to Cape Halkett is a well-documented bowhead whale feeding area. Euphasiids (krill) are advected north from the Bering Sea to the Chukchi Sea and Beaufort Sea Slope (Berline et al. 2008). Upwelling favorable winds advect krill onto the Beaufort Sea shelf where a change in wind direction or relaxation of winds and local currents create conditions conducive to aggregating prey, known as a "krill trap" (Ashjian et al. 2010, 2021a, b; Okkonen et al. 2011, 2020). During years when "krill trap" formations occur in this area, large aggregations of feeding bowhead whales may be observed, often leading to increased bowhead whale sighting rates (e.g., Clarke et al. 2017, Brower et al. 2022b). Accordingly, this feeding area east of Point Barrow to Cape Halkett has been designated a bowhead whale core-use area with high estimated bowhead whale densities and documented bowhead whale lingering (indicative of feeding behavior) in autumn based on satellite tag data collected from 2006 to 2019 (Citta et al. 2018, 2021, Olnes et al. 2020) and a summer and autumn bowhead whale hotspot based on aerial survey data collected from 2007 to 2012 (Kuletz et al. 2015).

The dense bowhead whale feeding aggregations documented in 2021 were nearshore of Cape Halkett on the eastern edge of this bowhead whale feeding area (Fig. 31). Bowhead whales have been documented feeding in this area in previous years (Fig. 31), primarily 1997, 1998, and 2014. Those years had high densities of bowhead whales documented feeding nearshore of the western Beaufort Sea coast, and unusually nearshore from Camden Bay to Prudhoe Bay (144°W-150°W) in 1997 and 2014 (Clarke et al. 2015, Okkonen et al. 2018). Bowhead whale prey is thought to be concentrated in this area by upwelling events followed by high river discharges, which create a front that aggregates the prey (Okkonen et al. 2018). The mechanisms leading to the bowhead whale aggregations documented near Cape Halkett in 2021 may have been related to the krill trap, freshwater outflow, or both.

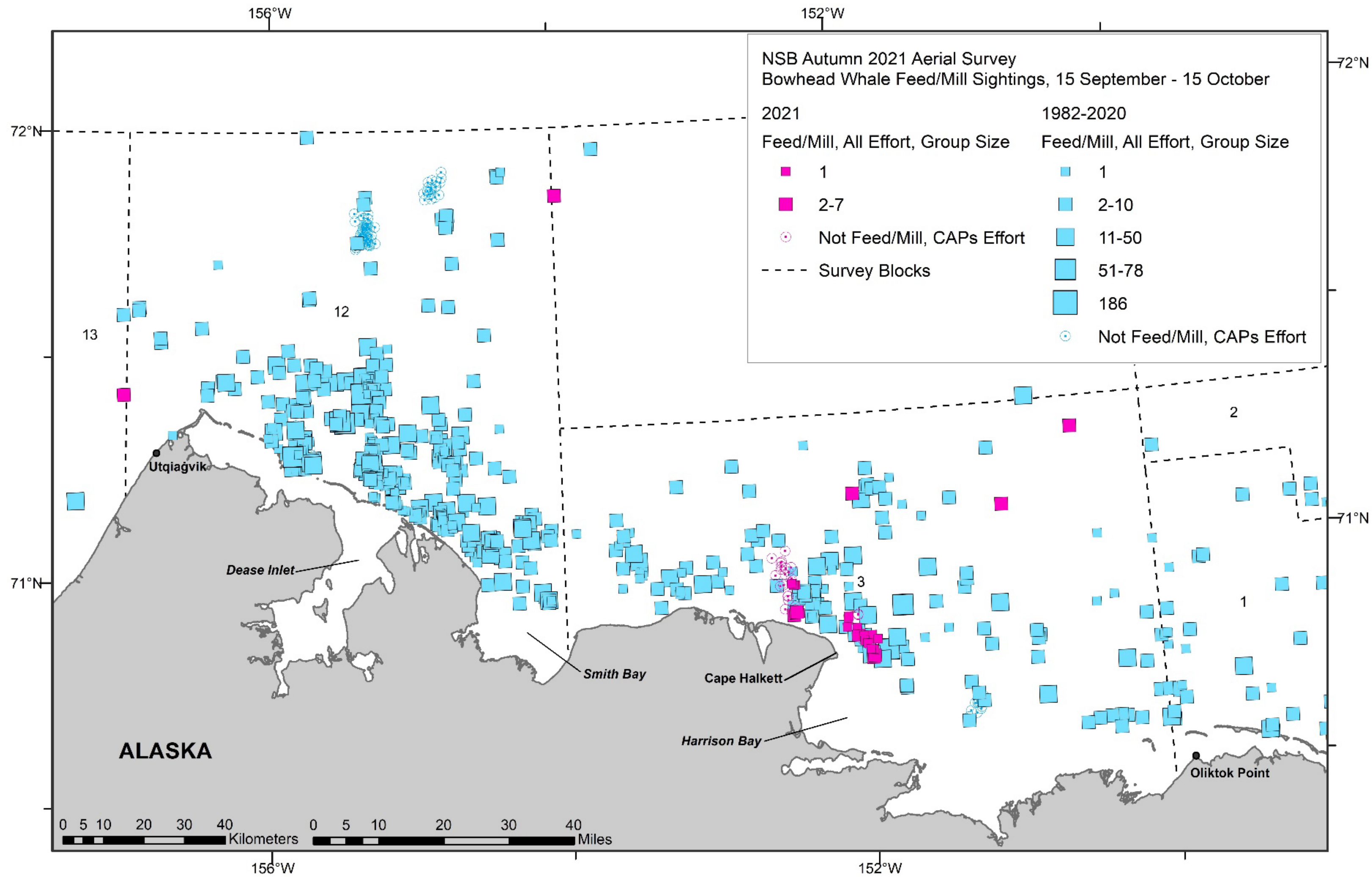

Figure 31. -- Bowhead whale feeding and milling sightings during transect, CAPs, search, and circling survey modes, 15 September – 15 October 1982-2021. Non-feeding and non-milling sightings on CAPs and circling from CAPs that were associated with CAPs sessions in which feeding or milling whales were sighted are also included because these whales were likely also feeding. CAPs effort began in 2018.

Bowhead whale feeding aggregations are ephemeral due to upwelling, wind speed and direction, river discharge, and oceanic front formation mechanisms that act to aggregate bowhead whale prey in the western Beaufort Sea (Ashjian et al. 2010, 2021a, b; Okkonen et al. 2011, 2018; Brower et al. 2022a). The feeding aggregations in the Cape Halkett area were documented on 23 September; the area was flown again on 28 September and only three bowhead whales were sighted (one of which was a calf). This suggests prey aggregation conditions changed and the prey was no longer concentrated by 28 September.

Although there were no bowhead whale feeding aggregations documented from Point Barrow to Smith Bay during the official survey flights in 2021, prior to the first survey flight of the 2021 season, a training flight was conducted to train the new aerial observer on survey protocol and marine mammal detection. During this flight, a bowhead whale feeding aggregation of 59 whales was sighted from 155.0°W to 155.8°W and 4.5 to 10 km from shore near Cooper Island and the Plover Islands (Unpubl. data, available at Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration). This flight was flown on 18 September. Prior to that, bowhead whale aggregations were also documented from a vessel on the water on 5, 6, and 8 September in the same area (K. Stafford, Oceanographer, Applied Physics Laboratory, University of Washington, Seattle, WA, Pers. commun., September 2021). It is unknown whether bowhead whales were present and feeding between 9 and 17 September.

Bowhead whale sightings were generally closer inshore in September 2021 than October 2021 (September: 1-60 km from shore; October: 19-87). This spatiotemporal distribution matches bowhead whale distribution in September and October 2000-2018 pooled results from similar aerial surveys (Ferguson et al. 2021) and satellite tagged bowhead whale distribution in September and October 2006-2019 (Citta et al. 2021). Bowhead whale distribution in October 2020, however, was quite different with large aggregations of bowhead whales close to shore (Brower et al. 2022b).

The bowhead whale calf ratio (number of calves on effort/number of total whales on effort) from 15 September to 15 October in 2021 (0.094) was similar to bowhead whale calf ratios in many previous years (Fig. 32). Primary and secondary observers are included in calf ratios because primary observers were not recorded until 1989 and including secondary observers in the calf ratios allows us to make comparisons back to 1982. Annual calf ratios for 15 September – 15 October 1982-2021 were similar to calf ratios spanning all of September and October in 1982-2019 (Clarke et al. 2020). Calf ratios were highest in 2001 (0.333) and 2019. The calf ratio from 15 September – 15 October 2001 was particularly high because only three bowhead whales, including one calf, were sighted. However, in early September 2001, 20 bowhead whales, including one calf, were sighted and the 1 September – 30 October 2001 calf ratio (0.087) is similar to other years with high calf ratios, but not as extraordinarily high as when limiting the data to only 15 September – 15 October.

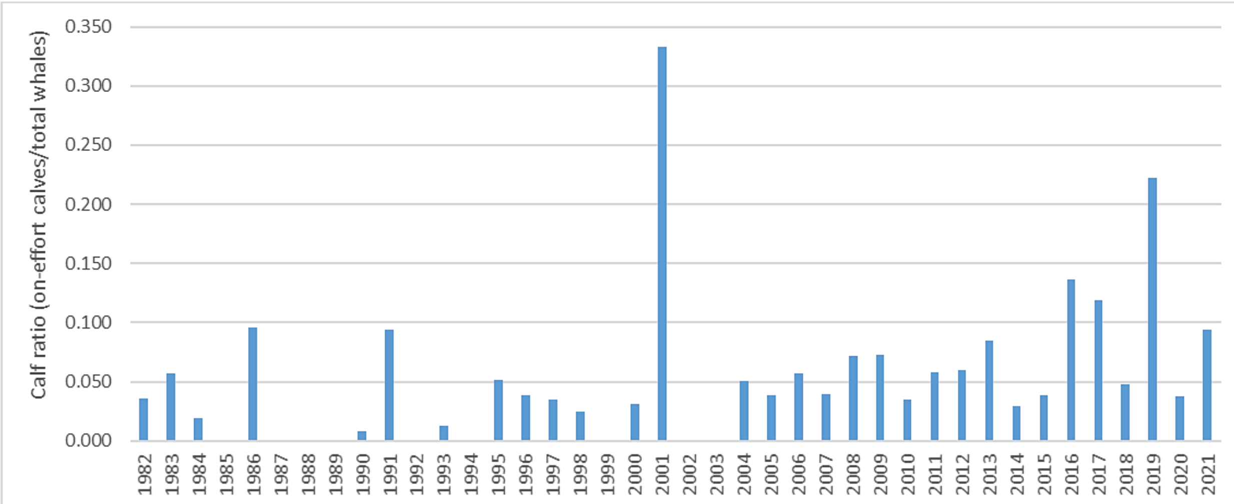

Figure 32. -- Bowhead whale annual calf ratios (number of bowhead whale calves on effort per number of total bowhead whales on effort, primary and secondary observers included), 15 September – 15 October.

An analysis to compare bowhead whale calf ratios and calf sighting rates from 15 September – 15 October 2009-2021, using on-effort sightings and effort from 140° to 160°W, can be found in Appendix F.

A bowhead whale photographed on 27 September (Flight 5), ~45 km northwest of Prudhoe Bay was matched to a photograph of the same whale taken in 1985 (J.C. George, retired NSB-DWM Biologist, and Barbara Tudor, Independent Researcher, pers. commun., October 2021). Bowhead whales can be distinguished individually based on the persistence of white scars from healed injuries that contrast with their black bodies (George et al. 2021). The 36 years between these sightings is the longest photographic recapture of the Bering-Chukchi-Beaufort bowhead whale population (J.C. George, retired NSB-DWM Biologist, pers. commun., October 2021). In both photos, the whale has white pigment on its chin, peduncle, and flukes, which is indicative of mature whales (George et al. 2021). Although the whale's age is unknown, male and female bowhead whales reach reproductive maturity in their mid-twenties (George et al. 1999, 2021), and extensive whitened pigmentation on the peduncle and flukes are typical of much older animals (George et al. 2021). Because the animal was sighted with a calf in 2021, we know that the animal was a reproductive female. Based on her advanced age related pigmentation, it is likely that in 1985 she was possibly 50 years old or more, and in 2021 she could have been 86 years or older. This information supports the hypothesis that reduced fecundity is delayed, or nonexistent, in bowhead whales compared to other mammals (Schultz et al. 2021). Another long-term photographic match was made between a bowhead whale initially photographed in 1985 and subsequently photographed in August 2016, representing a 31-year recapture (J.C. George, retired NSB-DWM Biologist, pers. commun., August 2016). This whale was matched based on its extensive entanglement scars. The information gained from these recaptures provides valuable insight into the life history of these whales and underscores the value of the historical and contemporary aerial imagery datasets.

In addition to the two bowhead whale carcasses with injuries consistent with killer whale predation seen on this survey, the NSB Department of Wildlife Management stranding program in Kaktovik, Utqiaġvik, and Wainwright documented seven more bowhead whale carcasses in 2021 (Stimmelmayr et al. 2022). Post-mortem examination indicated these carcasses also had injuries consistent with killer whale predation (Stimmelmayr et al. 2022). These findings are consistent with the frequency of probable killer whale predation on bowhead whale carcasses (2009–2018) and gray whale carcasses (2009–2019) documented in the eastern Chukchi and western Beaufort study areas (Willoughby et al. 2020, 2022).

Two intact beluga carcasses were observed in 2021: one on 28 September (~140 km north of Harrison Bay) and one on 9 October (~80 km north of Smith Bay). Both carcasses were photographed, are considered unique animals, and represent 16% of the beluga carcasses documented since 2009. Prior observations of beluga carcasses documented during ASAMM surveys in the eastern Chukchi and western Beaufort seas include 10 sightings of 10 beluga carcasses from July to October 2009 to 2019. From 1980 to 2008, there are 16 records of beluga carcasses; one record in July 1981 was for 30 belugas near Point Lay and is believed to be related to the subsistence hunt.

All sightings of human origin marine debris were recorded in 2021; in prior years, debris was noted only if it was especially unusual. If these aerial surveys continue in the future, these data may provide valuable and new baseline information on marine debris in this region. Undoubtedly, in the coming years, marine debris in the Arctic will increase along with the global human population and increased Arctic access. Ingested plastic has already been documented in several examined bowhead whales harvested along the North Slope (Stimmelmayr et al. 2021). Microplastic ingestion and the accumulation of plastic toxins has been reported for humpback and fin whales who take in large amounts of water when feeding and through trophic level transfer (Fossi et al. 2014, 2016; Alava 2020; Eisfeld-Pierantonio et al. 2022). Human origin marine debris affects nearly 70% of cetacean species through ingestion or entanglement (Eisfeld-Pierantonio et al. 2022).

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APPENDIX A: Cetacean Aggregation Protocols (CAPs)

Version 23, 10 September 2021

Background

During all ASAMM surveys, when surveying aggregations of large cetaceans (bowhead, gray, humpback, fin, and minke whales), data collection on those large cetacean species should take precedence over any other species. Data should not be recorded on pinniped or small cetacean sightings so that the ability to record accurate and complete data for targeted cetacean species is not compromised.

Temporary marks indicating distances of 1 km (0.5 nmi) and 3 km (1.6 nmi) from the transect should be made on each bubble window for each observer at the beginning of every flight (Appendix Table A1). Observers should check the accuracy of the 1-km and 3-km marks with their clinometer a few times over the course of a flight, in case the observer's posture in the window changes substantially and affects the location of these marks.

Appendix Table A1. -- Clinometer angles associated with CAPs distances at survey altitudes 1,000 ft, 1,300 ft, and 1,500 ft.

Altitude (ft)	3 km	1 km
1,000	5.8°	17°
1,300	7.5°	21.7°
1,500	8.7°	24.5°

The definition of a "sighting" is all whales within 5 body lengths of each other. For example, a sighting could comprise a single whale, one cow-calf pair swimming closely together, or several whales located within 5 body lengths of each other. A patch of tens of whales causing a broad disturbance on the surface of the water should be counted as a single sighting only if all whales are within 5 body lengths of their nearest neighbor. Whales separated from neighbors by greater than 5 body lengths should be recorded as separate sightings. The final group size estimate for a sighting can be updated to incorporate additional animals associated with (e.g., within 5 body lengths of) the initial detection. Any whale sighted during circling that was not in close proximity to the originally detected sighting will be considered a separate sighting on circling.

An aggregation is a high-density patch of cetaceans. An aggregation may span several transects (Appendix Fig. A1).

Data Collection

Low Sighting Density

When a sighting is detected in an area of low sighting density, the clinometer and an initial estimate of group size should be recorded when the aircraft is on the transect and the sighting is abeam. The aircraft should circle the sighting, as weather and fuel allow, to confirm species identification, obtain a final estimate of group size, determine whether calves are present, and record any other relevant sighting data. Circling should only occur over areas that have already been surveyed on effort (i.e., passed abeam). **The observer on the opposite side of the aircraft from the original transect sighting should avoid scanning for new animals on the outside of the circle while circling.**

Sightings during circling-from-transect will inevitably occur. Guidelines for entering s(ighting) on circling:

- S on circling are low priority and should not compromise the team's ability to accurately record s on transect. For example, it might be a good idea to not enter s on circling detected immediately prior to a resume transect in an area of moderately-high to high density because that might tie up the data recorder and affect the ability to record upcoming s on transect.
- Do not enter any s on circling that are located on fresh transect and have a chance of being sighted from transect.
- S on circling located inside the circle can be recorded.
- S on circling located far from the transect (e.g., > 3 km) are the lowest of the low priority.

High Sighting Density

CAPs will be triggered when the density of large cetacean sightings on transect exceeds the observers' ability to mark, **record an accurate clinometer for**, and circle every sighting (Appendix Fig. A2). Also consider entering CAPs mode if you detect several s on circling-from-transect within a short period of time. There may be circumstances when the pilots detect extremely dense aggregations of large cetaceans prior to detection by observers; in those situations, the pilots will communicate this information to the team leader to assist with decisions concerning if and when CAPs should be initiated.

There are two strategies for dealing with high-density aggregations of large cetaceans, CAPs passing and CAPs strip. CAPs passing is implemented in areas where large cetacean sighting densities are dispersed enough that the observers are able to mark individual sightings and accurately collect sighting data within 3 km of the trackline. CAPs strip is initiated when large cetacean sighting density becomes so high that it is impossible to record groups of whales within 5 body lengths of each other as individual sighting events. CAPs strip is limited to sightings within 1 km of the track.

CAPs PASSING

During CAPs passing, the first step is to continue to fly directly on the transect without circling (i.e., survey in "passing mode"), and record data for large cetacean sightings located within 3 km of the transect. If a group (whales within 5 body lengths of each other) extends beyond 3 km from the trackline, the data recorder should record the total group size in the FinalGrp field, and note in the comments how many whales were within 3 km and how many were outside 3 km. Only primary observers should call out sightings.

CAPs CIRCLING

When the aircraft reaches the point where large cetacean density has obviously diminished to background levels, CAPs circling will commence. During CAPs circling, the full suite of ASAMM sighting data should be recorded for each cetacean sighting that is located ≤ 3 km of the transect covered during CAPs passing mode. It might be most effective for the aircraft to travel approximately 1.5 km from the trackline while scanning for sightings during CAPs circling so that each observer is responsible for scanning the same perpendicular distance from the aircraft. In general, while circling during CAPs, do not record data for cetaceans located > 3 km from the transect. The only exception is when a group of whales, all within 5 body lengths of each other, extends beyond 3 km from the transect. In this case, the data recorder should record the total group size in the FinalGrp field, and note in the comments how many whales were within 3 km and how many were outside 3 km. Sightings recorded during CAPs circling do not need to match sightings during CAPs passing mode. We do not expect or need to obtain a direct match because sightings in passing mode are used to estimate encounter rate, while sightings on circling are used to infer average group size, number of calves present, and species ID. During CAPs circling, it is acceptable to circle a fresh mud plume until a cetacean surfaces in order to record the sighting as s on CAPs circling. Note that if CAPs strip is initiated in association with a CAPs segment, circling should not be conducted in the area flown in CAPs strip mode.

When both sides of the transect have been surveyed under CAPs circling out to a maximum of 3 km from the transect (with the exception of CAPs strip segments), the survey team will do one of the following: a) return to the point on the transect downstream of the aggregation where only unsurveyed transect lies ahead and proceed to survey using standard ASAMM protocols; b) deadhead (e.g., if weather, fuel, or other logistical constraints require returning to base); or c) repeat CAPs passing survey mode in the current CAPs segment. Option "c" would be initiated if, based on CAPs circling sightings, the team has reason to believe that during the initial CAPs passing effort the whales were diving synchronously and many whales were underwater, and conditions (fuel, weather, etc.) allow. The subsequent effort should include, at a minimum, CAPs passing over the same section of transect as flown initially, and preferably would include a second CAPs circling session (although that is not a necessity). Sighting data should not be entered as "repeat" on the second pass. The data recorder should include notes either in the database or in the log book describing the events and decision-making, and should change the entries associated with one CAPs passing trial to saved=0[1].

If the aggregation extends farther than the initial CAPs segment, a new CAPs session can be started.

[1]The advantage of changing the entries associated with one CAPs passing trial to saved=0 is that entry, sighting, environmental, flight type, and enttag data from both CAPs passing trials will be easily accessible if they are found to be useful in future analyses. (This "easy access" to the original data is not maintained if one CAPs passing trial is changed to "deadhead".) We do not think both CAPs sessions should be kept as saved = 1 because we anticipate data from only one of the two CAPs sessions will be used in analyses. Keeping both CAPs sessions as saved = 1 would maintain the aircraft position data for plotting flight tracks and computing effort, but we do not anticipate needing this data.

CAPs STRIP

If, during transect or CAPs passing mode, the large cetacean sighting density becomes so high that it is impossible to record groups of whales within 5 body lengths of each other as individual sighting events, the survey mode will become a strip transect, "CAPs strip", in which it is assumed that every large cetacean at the surface in the field of view within a certain distance of the transect is detected and recorded. To meet this strict assumption of 100% detectability of surfaced cetaceans, observers should include animals located only within 1 km of the transect. Observers may pool sightings into single sighting events for each side of the aircraft (Appendix Fig. A3). Because strip-transect methods assume that 100% of surfaced cetaceans will be detected and counted in passing mode, the area covered during CAPs strip will not be included in subsequent circling effort (Appendix Fig. A2). When the sighting density within the aggregation thins to a level at which it is possible to resume collecting data for individual sightings (groups), resurvey the CAPs strip two more times. After the third CAPs strip transect, resume collecting sighting-specific CAPs passing mode sighting data. Sightings should be pooled only during CAPs strip mode, never during CAPs passing or CAPs circling modes.

Additional Considerations

CAPs sessions should always include, at a minimum, CAPs passing and CAPs circling. If conditions (weather, fuel, etc.) will not support CAPs circling, CAPs should not be initiated because the resulting data would be incomplete. There is no time limit for collecting data during CAPs, assuming weather and fuel allow. There is no limit to the "length" along the transect of a CAPs segment; however, CAPs circling should never extend beyond the bounds of the initial CAPs segment (gray areas in Appendix Fig. A2). Continue to enter environmental updates as time allows during CAPs, CAPs strip, and CAPs circling survey modes.

CAPs will not be used during search effort. Do not survey in search mode between transects in areas with known moderately high to high densities of large whales (e.g., western edge of block 23) because searching between transects in those areas has a relatively high chance of taking s on transect away from the next transect. If you find yourself surprised by moderately-high to high densities of large whales during a search between transects, enter the original s on search, mop up the relevant s on circling-search, then resume and switch to deadhead mode as quickly as possible. Deadhead for the remainder of the transit between transects.

In situations where large whale density slowly increases on transect and the team determines that the density is enough to initiate CAPs, it is possible to backtrack along a transect to return to a logical trigger point to implement CAPs. In that situation, all of the original effort and sightings on transect located perpendicular to the CAPs segment should be identified and changed to deadhead events (see example in Appendix Fig. A4). The data recorder can make a note saying where transect effort should end and deadhead effort should begin so that the data editor can make the necessary edits during post-flight processing. During final data editing, be sure that there is a note near the beginning of the deadhead section that reads, "backtracking to begin CAPs". It is unusual for ASAMM to have deadhead effort in the middle of bowhead aggregations, so this note should help explain the situation to data users.

CAPs should not be initiated if visibility is < 1-2 km on either side of the aircraft, or the aircraft is frequently passing through cloud layers that obscure visibility. CAPs can be initiated when visibility is 2-3 km, but the limited visibility should be noted. CAPs can be initiated during the coastal transect. Because sightings are limited to 1 km on the shoreward side of the coastal transect, conduct all CAPs sessions during coastal transect effort as CAPs strip, recording sightings only out to 1 km, replicating the strip three times, and do not circle sightings.

CAPs should not be initiated in areas where walruses are hauled out on ice or along the coast. Care should be taken when initiating CAPs near known areas of polar bear aggregations (i.e., near Barter and Cross islands). CAPs can be initiated in those areas but circling needs to be limited to 15 minutes.

The following "shades of gray" should also be considered when deciding whether to begin CAPs:

- An s on transect at approximately clino 7.5 or farther when the aircraft altitude is 1,300 ft is on the edge of the CAPs 3-km strip. In an area of moderately-high large cetacean density, diverting to circle distant sightings will likely result in s on circling, which may or may not have been detectable from the transect.
- In areas with multiple species of large cetaceans (e.g., southern Chukchi Sea), CAPs passing will likely result in many unidentified cetacean sightings. The team leader needs to make a judgment call regarding whether the inability to positively ID sightings to species is outweighed by the advantages of getting accurate encounter rates during CAPs passing or strip modes, supplemented by group size, calf numbers, and species ID info from CAPs circling modes.
- If the team refrains from calling sightings located on fresh transect during circling-from-transect, those sightings may be detected from the trackline after resuming transect mode. This discipline helps justify staying in transect mode rather than entering CAPs mode.

Due to the subjective nature of the CAPs decision-making process, it is quite possible that CAPs may be initiated prematurely or in an area that can be adequately surveyed in transect mode. When in "CAPs fail" (i.e., after starting CAPs, but realizing there are not many whales in the area), return to specific s on CAPs passing locations during CAPs circling to increase your chances of finding animals. Depending on the time passed since marking the s on CAPs passing, the separation of sightings, and other factors, it might be possible to gather additional info for the s on CAPs passing sighting during CAPs circling. If there is confidence that an s on CAPs passing was resighted during CAPs circling, enter the resight as an s on CAPs circling and, post-flight, make a note in the s on CAPs passing stating what s on CAPs circling it corresponds to. If a sighting is found during CAPs circling in the general vicinity of an s on CAPs passing, but there is not very high confidence that the exact same sighting was relocated during CAPs circling, enter it as an s on CAPs circling; no additional notation needed.

There is interest in beluga presence in the eastern Beaufort Sea and Amundsen Gulf and a value in knowing whether a lack of beluga sightings recorded during CAPs was due to there being zero sightings of belugas during CAPs or if it was due to the team not recording belugas that were sighted during CAPs. Therefore, at the end of CAPs circling and right before the start transect or deadhead, make an environmental update to record presence or absence of belugas during the CAPs session.

In the notes for the environmental update, state either "zero belugas sighted during CAPs session" or "~X # of belugas sighted during CAPs session", and note the approximate number of belugas (keep it simple, e.g., < 5, 5-25, > 25, > 100, etc.).

Specific Data Collection Steps

Steps shown in Appendix Fig. A5. FltType and EntTag are provided in ( ) for data editing assistance, and are entered automatically into the database.

In the ASAMM database, habitat auto-populates to open water during CAPs passing and CAPs strip. If CAPs takes place in sea ice, make a note in the notes field of the data or the green book to update Habitat, Icetype, Icepercent_l, and Icepercent_r. The percentages can be a general estimate for the CAPs area.

1. When CAPs protocol is triggered, select **end transect** (4, 1).
2. Select **CAPs** (7, 1). The flight track will change to a different color, which will be useful once CAPs circling commences. Make sure the 3-km layer is visible on the map. Continue along "fresh" transect in passing mode.
3. Limit sightings during CAPs passing, circling, and strip to large cetaceans (i.e., do not record belugas, killer whales, pinnipeds, polar bears, etc.).
4. When a large cetacean sighting is made, select **sighting on CAPs** (7, 3), and enter abbreviated sighting information, including observer, species, clino, group size, calf number, NoReacted (number reacted – leave blank if no reaction), and behavior. Species ID will trickle down to subsequent sighting events and can be manually changed. Behavior will not trickle down; it is o.k. to leave the behavior field empty during CAPs, but record it, if possible.
    a. Environmental updates (7, 2) should be entered as needed during CAPs.
    b. Do not include any sightings that are > 3 km (1.6 nmi) from the trackline.
    c. Record unique species separately.
    d. Do not pool sightings.
5. If large cetacean density is extraordinarily high, necessitating the need to pool sightings, select **CAPs strip** (11, 1) and continue along the transect in passing mode. The flight track will change to a different color.
    a. During CAPs strip, observers on each side of the aircraft should keep a running tally of large cetaceans within 1 km (0.54 nmi) of the transect. Select the **CAPs left** or **right sighting** (11, 3) button, and enter abbreviated sighting information, including observer, species, clino, group size, calf number, NoReacted (number reacted – leave blank if no reaction), and behavior. The clino should reflect the center of the group. Record unique species separately. Data should be entered separately for each side of the aircraft. Several pooled and unpooled sightings may be entered during CAPs

strip. It will be assumed that all CAPs strip sightings (11, 3) are pooled, regardless of the number of sightings per record.

b. Do not include any sightings beyond the 1-km strip, because the survey is in strip-transect mode.

c. When the extremely dense area of sightings has been surveyed once, enter **CAPs circling** (9, 1), and make a U-turn to get back to where CAPs strip effort was ended. Enter **CAPs strip** (11, 1) and fly the exact area just covered in CAPs strip along the same transect but in the opposite direction. Update environmental conditions (11, 2) at the start of the second pass. Record all CAPs strip sightings (11, 3) in the same manner as 4a above.

d. At the point where the CAPs strip protocol started in 4a above, enter **CAPs circling** (9, 1), make another U-turn to get back to where CAPs strip effort should begin, enter **CAPs strip** (11, 1) and fly the exact area for the third time. Update environmental conditions (11, 2) at the start of the third pass, and record data from that pass in the same manner as 4a above.

e. Environmental updates (11, 2) can be entered whenever survey conditions change.

6. After the third CAPs strip pass through the extremely high density area, if the aggregation continues and more CAPs passing effort is needed, select **CAPs** (7, 1), and continue on the transect through unsurveyed waters collecting CAPs passing data.

7. When CAPs passing or strip protocol are no longer necessary because large cetacean sightings have returned to normal manageable levels, commence **CAPs circling** (9, 1), and start recording detailed sighting data. If the normal manageable levels follows CAPs passing effort, go directly into CAPs circling. The area in which circling occurs should include 3 km off either side of the transect, back to where the CAPs passing session began. Circling may start on either side of the transect, and it is okay to cross the transect to obtain data for sightings on circling.

    a. Areas surveyed in CAPs strip mode <u>should not</u> be included in CAPs circling. If CAPs passing effort was conducted, and then CAPs strip effort was conducted, the plane will need to backtrack across the CAPs strip effort to get to the area where CAPs passing effort was conducted and where CAPs circling effort needs to be conducted. Enter CAPs circling (9, 1) immediately after CAPs strip effort and use CAPs circling effort while backtracking to get to the area where circling should occur.

8. **Sightings on CAPs circling** (9, 3) should be recorded as closely as possible to the actual sighting location. Record the full suite of ASAMM sighting data (species, min/max/final group size, number of calves, calf detection certainty, reactions, behavior) for each cetacean sighting that is located ≤ 3 km of the transect covered during CAPs passing mode. Only large cetaceans should be recorded; do not record small cetaceans or non-cetaceans.

    a. Sightings will be attributed to whoever (right or left observer, data recorder, 4th observer, or pilot) made the sighting.

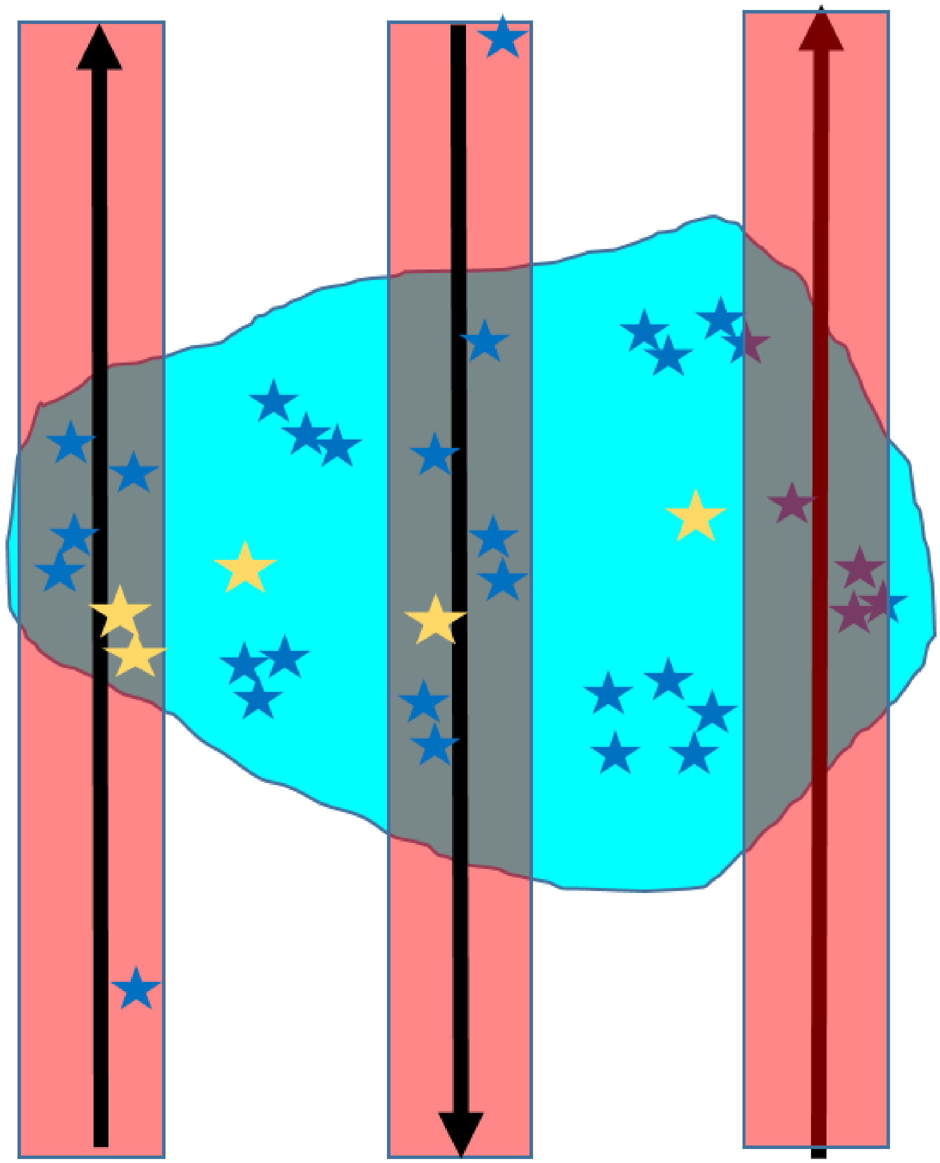
b. Sightings do not have to "match" those from the initial CAPs passing mode.

c. Sightings should not be lumped together during CAPs circling - no pooling! If density of cetaceans is such that all individual sightings cannot be recorded, record a random sample of sightings without biasing towards "large" or "small" groups.

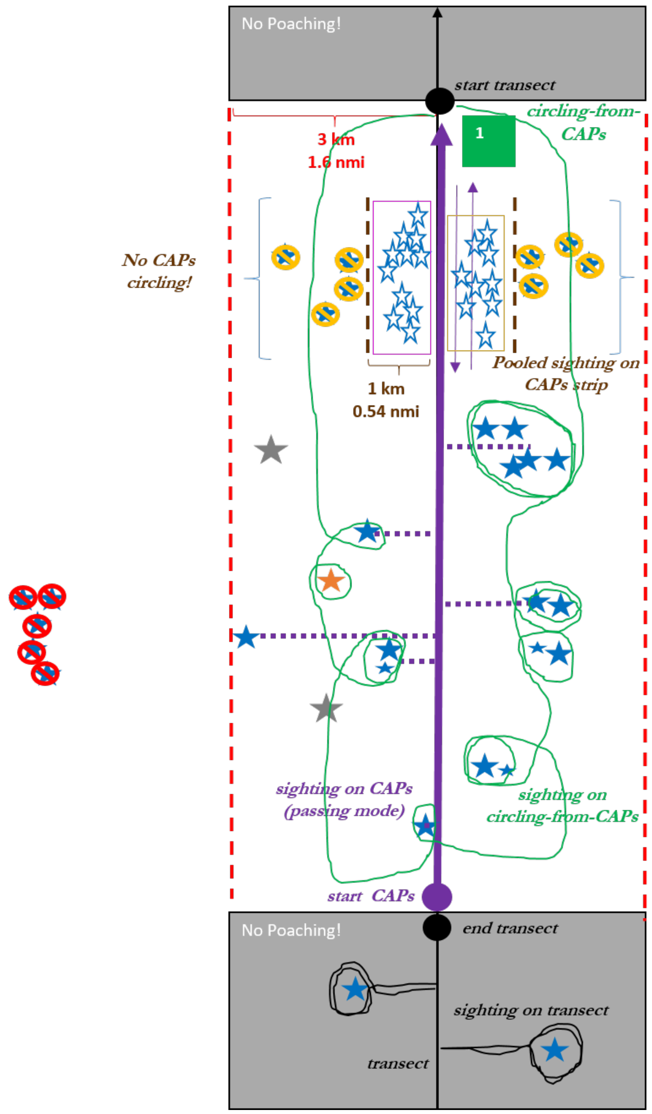
d. Enter sightings of individual species separately.

e. Continue to enter environmental updates (9, 2), as needed.

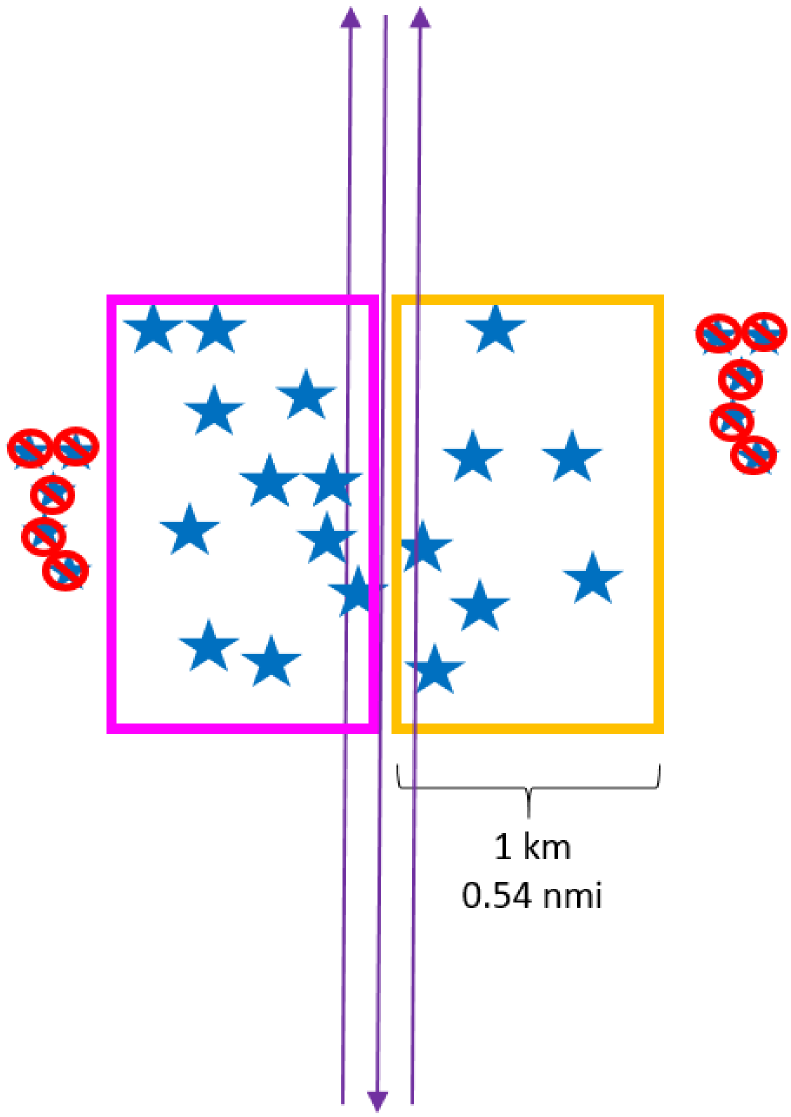
9. When the entire CAPs area (sans any CAPs strip area) has been circled to obtain detailed cetacean sighting information and the CAPs session is finished, make an environmental update to record presence/absence of belugas during the CAPs session; in the notes, state either "zero belugas sighted during CAPs session" or "~X # of belugas sighted during CAPs session", and note the approximate number of belugas (keep it simple, e.g., < 5, 5-25, > 25, > 100, etc.). Then do one of the following: a) return to the point on the transect downstream of the aggregation where only unsurveyed transect lies ahead, **start transect** (2, 1), and proceed to survey using standard ASAMM protocols; b) **deadhead** (1, 1) (e.g., if weather, fuel, or other logistical constraints require returning to base); or c) repeat **CAPs passing** (7, 1) survey mode in the current CAPs segment if the team suspects that the whales are diving synchronously and many whales were underwater during the initial CAPs passing effort. If time and conditions allow, consider repeating **CAPs circling** (9, 1) also. If option "c" is chosen, change the entries associated with one CAPs passing trial to saved=0. Include detailed notes in the database or version history detailing what was done, and why.



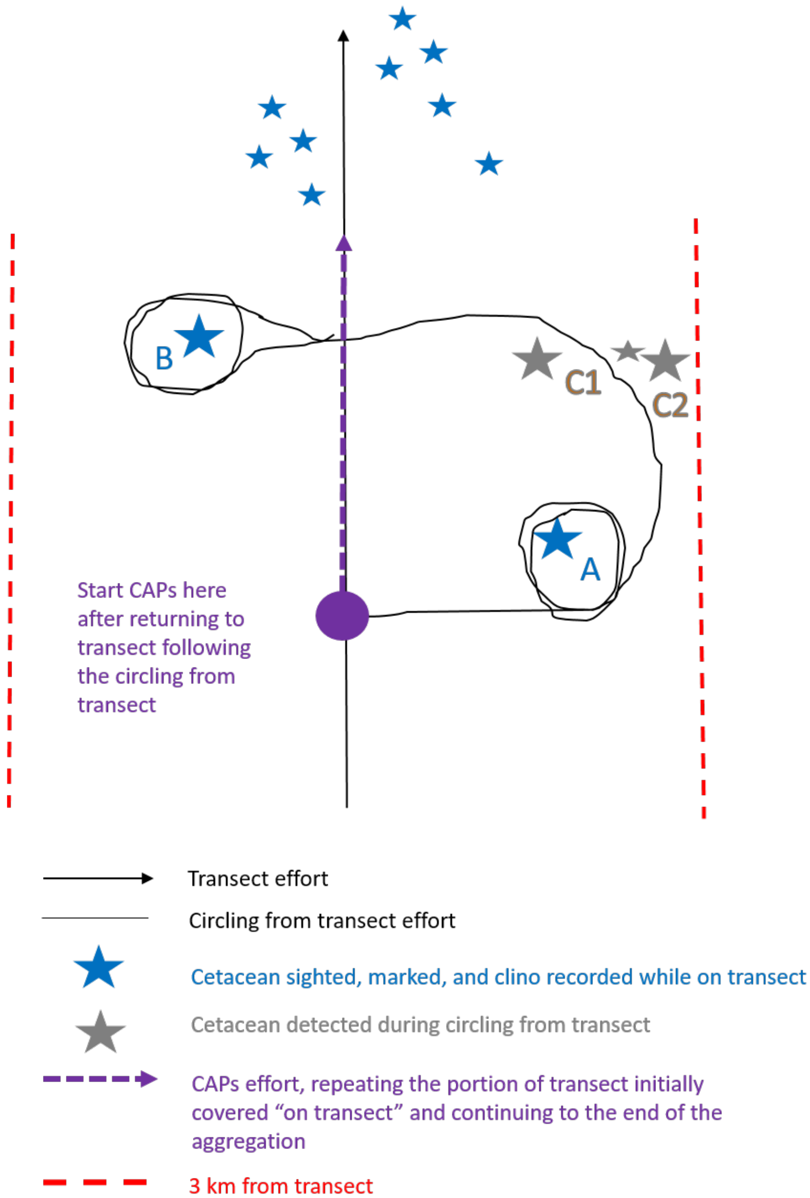
Appendix Figure A1. -- A cetacean sighting comprises all whales within 5 body lengths of each other. The final group size estimate for a sighting can be updated to incorporate additional animals detected near the initial detection (e.g., within ~ 5 body lengths of the cetaceans that were initially sighted). An aggregation comprises all cetaceans in a high-density patch of cetaceans, including those beyond 3 km from a transect, depicted within the turquoise blob. An aggregation may span more than one transect. The survey and analytical methods allow for whales in an aggregation to go undetected. Black arrows: transects. Salmon shading: 3-km strip on each side of a transect. Stars: individual whales, with different colors used to depict different species.



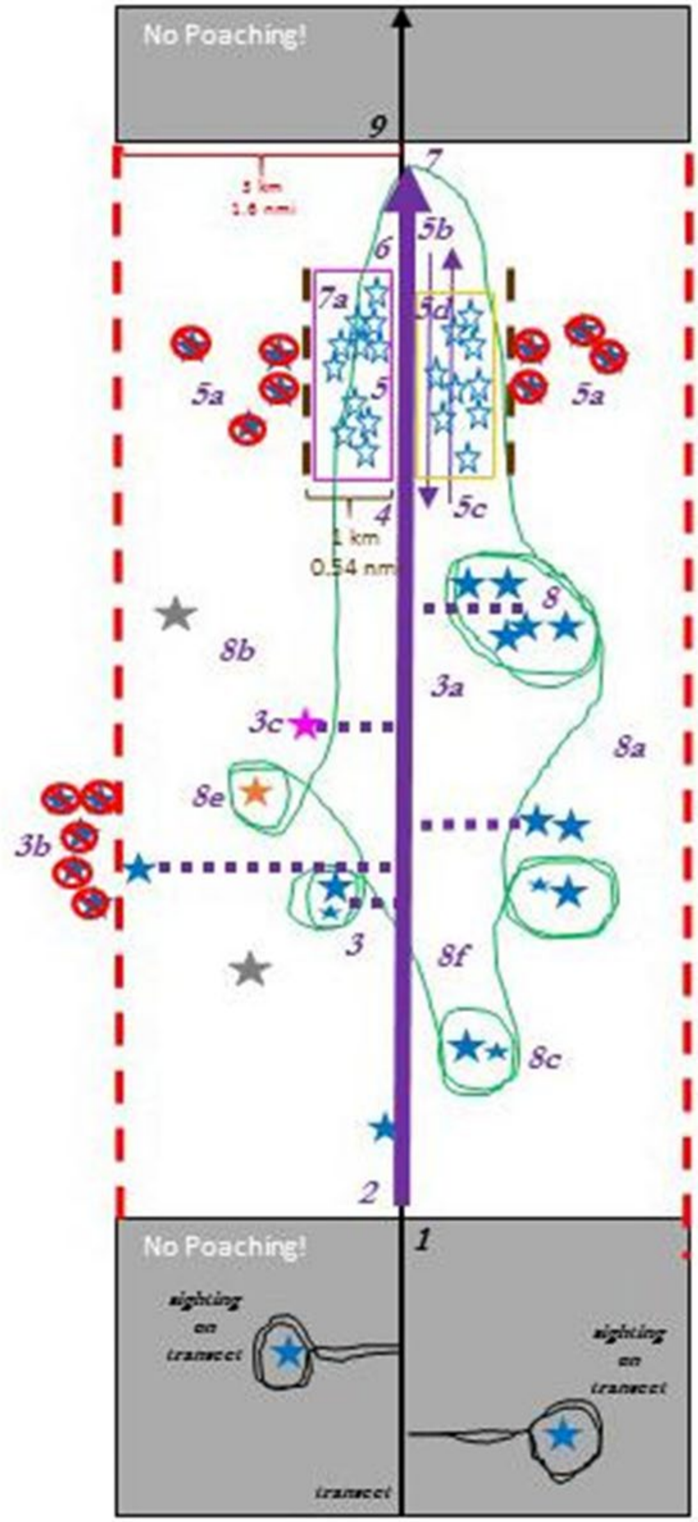
Appendix Figure A2. -- Black: transect and circling-from-transect, surveyed using standard ASAMM protocols, from bottom to top of figure. Purple: CAPs passing mode effort (solid line) and perpendicular distances to sightings (dotted lines). Magenta and yellow boxes: CAPs strip effort in extremely high-density area, only 1 km wide. Green "1": commence CAPs circling. Green line: CAPs circling effort; no circling along CAPs strip section. Red dashed line is 3 km (1.6 nmi) from transect. Red circle-and-slash symbols: do not count these cetaceans during CAPs because they are >3 km from transect and not within 5 body lengths of the whale located < 3 km from transect. Orange circle-and-slash symbols: do not count these cetaceans during CAPs strip or CAPs circling because they are > 1 km from transect. Solid blue and orange stars: cetaceans detected during either CAPs passing or CAPs circling mode; species denoted by color, and calves denoted by small stars. Open blue stars: cetaceans detected during CAPs strip. Some cetacean sightings will be detected only during CAPs passing mode, some will be detected only during CAPs circling mode, and some will never be detected (gray stars). While in CAPs passing or CAPs circling mode, do not record sightings that are located before start CAPs or after the initial divert to circling during CAPs (green "1"); these off-limit areas are shaded gray.



Appendix Figure A3. -- Schematic of CAPs strip mode. During CAPs passing mode, if sighting density precludes the ability to enter a new sighting record for each sighting, survey the high-density area using strip-transect methods. Make three passes through the area (depicted by adjacent purple arrows but actually flown along the exact same path), without circling. It is okay to pool sightings located on one side of the aircraft into a single sighting record for that side. It is okay to record multiple pooled sighting events per side per pass. For each sighting record, enter group size, number of calves, species, behavior, NoReacted (number reacted – leave blank if no reaction), and clinometer corresponding to the center of the pooled sightings. Focus only on the animals located within 1 km of the transect; do not include cetaceans farther than 1 km from the transect in the group size estimate for a pooled sighting. The area in which pooled sightings are recorded should not be included in the area subsequently circled during CAPs circling.



Appendix Figure A4. -- Schematic illustrating "backtracking" to start CAPs. Cetaceans A and B were detected from the transect at approximately the same time. Cetacean A was marked with a clinometer; the aircraft continued on the transect to mark and record the clinometer for B before diverting to circle from transect. The aircraft circled B first, then crossed the transect to circle A. While flying towards A, cetacean sightings C1 and C2 were detected for the first time, and the team realized they were entering a high-density patch of cetaceans. Because C1 and C2 were not detected (or marked) from the transect and are not within 5 body lengths of A or B, they cannot be combined with the group size estimates for the transect sightings and should not be recorded. Upon returning to the transect at the point perpendicular to sighting A, end the transect and start a CAPs session. Continue surveying the aggregation using standard CAPs protocols (not shown in diagram; refer to Appendix Figs. A2 and A3). Note that all of the original effort and sightings on transect located perpendicular to the CAPs segment should be identified and changed to deadhead events.



Appendix Figure A5. -- CAPs protocol with data collection steps.

Data Integration

Here, we summarize how CAPs data are incorporated into analyses, just in case you're curious.

Survey effort on CAPs passing and CAPs strip is equivalent to transect effort and is included in total on-effort kilometers for sighting rate and high-use-area (HUA) analyses. Survey effort on CAPs circling is considered off-effort.

Sightings made during CAPs passing may be identified to species, but sightings may need to be recorded as unidentified cetaceans, particularly sightings that are farther from the trackline and in areas where multiple large cetacean species are expected to occur (e.g., southcentral Chukchi Sea and near Point Barrow).

We use many stats to incorporate sightings from CAPs into sighting rate and HUA analyses:

1. Species ID: Species ID for sightings identified to species during CAPs passing are unchanged. For each CAPs session, sightings entered as unidentified cetaceans during CAPs passing are adjusted based on the proportion of sightings positively identified to each large whale species during CAPs circling. The resulting adjusted number of CAPs passing sightings assigned to each species might not be an integer value; that is, the CAPs-adjusted number of sightings might be a real number, with non-zero digits to the right of the decimal place.
2. For each CAPs session, average group size and average number of calves per CAPs passing sighting are updated based on CAPs circling statistics.
    a. Average group size and average number of calves are computed for each positively identified species. These statistics are computed separately for CAPs passing and CAPs circling.
    b. The CAPs-adjusted average group size corresponds to the average group size from either CAPs passing or CAPs circling, whichever is largest.
    c. Similarly, the CAPs-adjusted average number of calves per sighting corresponds to the average from either CAPs passing or CAPs circling, whichever is largest.
    d. The total CAPs-adjusted number of sightings, whales, and calves used in sighting rate and HUA analyses result from summing sightings, whales, and calves identified to species during CAPs passing with sightings, whales, and calves assigned proportionally to species based on CAPs circling statistics.
3. Behavior is left unchanged for CAPs passing sightings with behaviors recorded in the original survey data. For CAPs passing sightings lacking behavior in the original survey data, behavior is adjusted for each species according to the proportion of sightings during CAPs circling that were recorded as feeding/milling. Only two behavior states are possible for CAPs-adjusted data: feeding/milling or not feeding/milling.

APPENDIX B: COVID-19 Protocols

UW Fieldwork Health and Safety Plan (COVID-19 Prevention): Return: Phase 3

August 24, 2021

RE: 2021 North Slope Borough Autumn Migration Aerial Surveys - MML Whales

To Ivonne Ortiz:

The University of Washington has designated the Aerial surveys of the bowhead whale fall migration in the Western Beaufort Sea, based out of Utqiaġvik, Alaska as an essential function for the period of September 14 – October 17, 2021, and is being deployed by the minimum staff necessary. This fieldwork is authorized by the North Slope Borough and carried out aboard a plane owned by Clearwater Air, Inc.. This designation and authorization allows this critical research to go forward under the Washington State Governor's "Safe Start Reopening Plan".

This is a collaborative project between the North Slope Borough, the University of Washington, and the NOAA Marine Mammal Laboratory and is funded by the North Slope Borough of Alaska. The goals of the survey are to understand the distribution of bowhead whales near Utqiaġvik, Alaska. This is of particular concern to the local Alaska Native community because bowhead whales were unusually rare near Utqiaġvik in 2019 due to warmer oceanographic conditions. The survey aircraft is owned by a private company, Clearwater Air, Inc. and will be contracted by the North Slope Borough specifically for these surveys. Once the survey plane is in Utqiaġvik, only the survey crew (2 pilots; and 3 scientists: Amy Willoughby and Amelia Brower, CICOES; Kayla Scheimreif, NSB) will have access to the aircraft.

An approved COVID Health and Safety Plan for this fieldwork is on file in the CICOES Unit Folder and will be provided upon request. Names of employee(s) providing critical in-person services in support of this activity include: Amelia Brower and Amy Willoughby, staff with the University of Washington's Cooperative Institute for Climate, Ocean, and Ecosystem Studies [CICOES] and NOAA-NMFS-AFSC-MML.

Sincerely,

John Horne
CICOES Executive Director

Cc: Amelia Brower
Amy Willoughby

Unit	College of the Environment, CICOES		
Plan Created for	North Slope Borough (NSB) Autumn 2021 Aerial Surveys	**Date of revision:**	08/02/21
PI/Supervisor	Ivonne Ortiz, ivonne.ortiz@noaa.gov		
Field Team Leader/ Chief Scientist	Amelia Brower, CICOES, amelia.brower@noaa.gov COVID-19 Supplemental Information: *Unless otherwise designated, this individual is considered to be the on-site COVID-19 supervisor who is responsible for oversight of project-specific health and safety plan implementation relative to COVID-19 prevention, mitigation and response measures.*		
Activity Description	Aerial surveys of bowhead whale autumn migration		
Field Site Location(s)	Western Beaufort Sea, based out of Utqiaġvik, Alaska		
Date(s) of Fieldwork	September 14 – October 17, 2021; first potential survey date is September 15 and last potential survey date is October 15		

Fieldwork is an important part of teaching, research, and clinical practice at the University of Washington. It is also an extension of on-campus work, and adherence to University policy and a professional code of conduct by all members of a project field team while participating in University-sponsored fieldwork is required. This UW Fieldwork Health and Safety Plan (COVID Prevention) is required for lone workers as well as field teams, and is intended to help you prepare for health and safety problems you might encounter when fieldwork takes you away from University facilities. This template is provided as a resource to field teams as a framework for field teams in their predeparture planning and preparation.

In addition, this Fieldwork Health and Safety Plan (COVID Prevention) template has been modified to include information relevant to COVID-19 mitigation measures to be undertaken when either the UW or the Washington State county(ies) in which the fieldwork is to be done in compliance with the Governor's Roadmap to Healthy Washington and Campus Reopening Guide. The conditions for returning to fieldwork should be evaluated against the current Washington State Phases as best as possible to determine what is allowable, and what precautions are necessary.

Note that not all elements of this plan are appropriate for all fieldwork. Local fieldwork with no overnight stay will not require as many elements as fieldwork with extensive travel and/or multiple overnight stays. Please consult your local unit requirements if you are unsure which apply to your fieldwork.

Instructions for the PI:

1. Complete the Returning to In-Person Research: Decision Tree and the Returning to In-Person Research Involving Fieldwork Decision Tree. If your work is allowable, perform a Field Work Risk Assessment.
2. Complete this UW Fieldwork Health and Safety Plan (COVID Prevention) template (insert specifics for your project, delete irrelevant sections, add sections that may be unique to your work) and provide a copy to your unit administrator or other designated individual for use in an emergency. Note that additional templates are available on the EH&S Website, but these do not mention precautions for COVID-19, which should be included in your plan.
3. Complete appropriate training for your site, operations, and personnel (e.g., first aid, task-specific training).
4. Obtain immunizations and prophylaxis for your destination, if applicable.

5. Hold a pre-trip meeting with your group and/or supervisor to review your field safety plan, travel logistics, packing lists, personnel safety and security concerns, conduct expectations, and any remaining training needs. This meeting should be held remotely if possible.
6. As applicable, register your fieldwork with:
   a. UW International Travel Registry for location-specific travel alerts and emergency/travel assistance contacts.
   b. UW Youth Program Registration System for projects that involve individuals under the age of 18.

In addition, the fieldwork must have an approved project-specific Health and Safety Plan that explicitly addresses the additional health and safety measures to be taken to mitigate the spread of COVID-19 and respond to potential or confirmed cases in the field. This UW Fieldwork Health and Safety Plan (COVID Prevention) Template can be used or an existing Health and Safety Plan. If applicable, the fieldwork must also meet the criteria for continuation for research involving human subjects or travel.

This UW Fieldwork Health and Safety Plan (COVID Prevention) should be approved according to the processes established by each Dean-level unit. See the University of Washington COVID-19 Prevention Plan for the Workplace for further details on unit-level prevention plan requirements and approvals.

Approved by:	*John Horne, Director CICOES*	*08/22/2021*

Additional Resources

UW Field Operations Safety Webpage
UW Field Operations Safety Manual
COVID-19 Prevention Guidelines for Small Boat Operations.
COVID-19 Health and Safety Resources
UNOLS News Coronavirus Considerations Document

<table>
<tr><th colspan="2">Site Information</th></tr>
<tr><td>Location(s)</td><td>Describe the location(s) of the fieldwork and housing, if different. Attach a work and route planincluding address(es) and/or geographic coordinates (i.e., latitude/longitude), as appropriate.
Utqiaġvik, Alaska
Field work
Base of operations will be Utqiaġvik, Alaska. Aerial surveys will take place over the western Beaufort Sea and possibly the eastern Chukchi Sea in a survey aircraft owned and operated by Clearwater Air, Inc(CWA). The survey team will consist of 2 pilots and 3 scientists (2 CICOES and 1 North Slope Borough[NSB]).

King Eider Inn (1752 Ahkovak St, Utqiaġvik, AK 99723)
The King Eider Inn is a small hotel with approx. 20 rooms. The owners have increased cleaning and disinfecting of common areas and rooms and made available in the lobby hand sanitizer and face masks.As in previous years, housekeeping will access private guest rooms only once a week to change linens and conduct other weekly cleaning of the bathrooms and kitchenettes. The 2 pilots and 2 CICOES scientists will stay at the King Eider Inn, each will have their own room with bathroom and kitchenette. When leaving or returning to the King Eider Inn, team members will wear masks, practice physical distancing, and wash or sanitize hands. A side exit may be used if the lobby is busy. The NSB scientist lives by herself in Utqiaġvik and will reside at her place of residence.

See Appendix 1_Route Plan and King Eider Inn to Hospital Directions.PDF</td></tr>
<tr><td>Site Information</td><td>Briefly describe physical conditions of site (e.g., elevation, terrain, environment, expectedweather).

The village of Utqiaġvik is a small, mostly native Iñupiat community along the Arctic coast. The village has all the necessary infrastructure: aircraft fuel, hotel, hospital, grocery store, etc. The survey aircraft is asmall twin engine turbo prop aircraft with seating for 5 people. Surveys will take place only in good weather conditions when it is safe to launch and land the survey aircraft. If inclement, unsafe weather is encountered during flight, an alternate flight path will be taken. The pilot is responsible for filing a flight plan and has the authority to alter or abort a flight due to weather conditions.</td></tr>
<tr><td>Travel to Site</td><td>How will participants get to the field site? Note any dangerous roads, conditions.

The CICOES scientists will travel via Alaska Airlines to Utqiaġvik, AK. The state of Alaska has no requirements for vaccinated (both scientists are fully vaccinated), travelers to receive COVID tests or self-quarantine prior to travel (7/26/21, https://covid19.alaska.gov/travelers/). The pilots, who are Alaskaresidents, will travel from Anchorage to Utqiaġvik via the survey aircraft.

COVID-19 Supplemental Information: Please indicate how participants will travel to/from thefield in a way that minimizes the spread of COVID-19. As examples:

<u>Travelling to SEA-TAC airport:</u>
• If using a shared car service, scientist(s) will wear a face mask and sanitize hands as necessary.
• Whenever possible scientists will have a family member drop them off at the airport.
<u>In Utqiaġvik:</u>
• Upon arrival via Alaska Airlines, scientists will walk from airport to the King Eider Inn.
• Survey members will walk from the King Eider to the survey aircraft.
• When CICOES scientists use the NOAA truck, they will wipe down the interior, handles, and gas cap with disinfecting wipes upon arrival and departure.</td></tr>
</table>

Site Ownership	*What agency, organization, or individual controls access to your field site(s)?* Name: Clearwater Air, Inc. Address: 1100 Merrill Field Drive, Anchorage, AK 99501 Phone: 907-301-3311 Email: andrew.harcombe@clearwaterair.com
Site Access	*Are there any particular restrictions or challenges to accessing site? Are collecting or camping permits required? Note any alternate routes or suggested parking areas; gate access codes, etc. Make special note if isolated or remote.* COVID-19 Supplemental Information: Not all public lands or other research sites may be open during the pandemic. Please make sure to obtain written confirmation from the property owner or responsible agency if the site(s) are otherwise closed to the public or to permitted research. In addition, once your fieldwork has been approved, you should receive an authorization letter on university letterhead. Make sure all members of the field team have a copy of this authorization letter and it can be made available upon request. Is/are your site(s) open to the public, or do you have written confirmation of your ability to access the site? ☐ Open to the public ☐ Written confirmation of access ☒ N/A Are there access restrictions related to COVID-19 mitigation measures that exceed those of the University of Washington? ☐ Yes ☒ No If yes, have you integrated these measures into this Health and Safety Plan? ☐ Yes ☒ No The survey aircraft is owned by a private company, Clearwater Air, Inc. and will be contracted by the North Slope Borough specifically for these surveys. Once the survey plane is in Utqiaġvik, only the survey crew (2 pilots; and 3 scientists: Amy Willoughby and Amelia Brower, CICOES; Kayla Scheimreif, NSB) will have access to the aircraft. The entry point for the survey crew to access the airstrip and aircraft is a short walk across the street from the hotel where the crew will be staying to a gated fence, for which the crew will have the access code. This entry point to the airstrip requires no interaction or contact with airport personnel.
Environmental Hazards	*Describe any dangerous wildlife, insects, endemic diseases, poisonous plants, etc. that participants may encounter. Note intended mitigation measures; discuss prior to trip.* Polar bears are rare visitors to town, and the North Slope Borough Dept. of Wildlife Management uses scare tactics to chase bears out of town as soon as a bear is reported. All survey crew are versed in bear avoidance strategies and are aware of their surroundings while walking. Bear noise deterrents are available for use. People in town leave their cars unlocked so anyone needing shelter will have it.

International	☐ Register your travel with the UW International Travel Registry for location-specific travel alerts and emergency/travel assistance contacts. Familiarize yourself with the UW emergency travel assistance benefits available to you. In addition, encourage all members of your field team to register themselves with the U.S. Department of State Smart Traveler Enrollment Program to receive emergency alerts from the local U.S. Embassy or Consulate. ☐ Review the UW Office of Global Operations Support guidance on import/export controls, transportation of specialized equipment, and data security must be considered. COVID-19 Supplemental Information: All official travel outside the U.S. by UW employees and students is restricted. Faculty and staff researchers may apply for an exceptional waiver to the current official travel restrictions. This may require endorsement by their Dean/s and the UW Office of Research. NA

Security	*Personal safety risks and conduct expectations during both work and free time should be considered and discussed in advance (e.g., alcohol or drug use, leaving the group, situational awareness, sexual harassment, and local crime/security concerns). Review expectations and set the tone for a safe, successful trip. In addition, describe any current travel alerts or restrictions. Note intended mitigation measures; discuss with field team prior to trip.* The CICOES scientists have been working together and conducting surveys out of Utqiaġvik for 6-12 years and are familiar with the culture and safety of the village. The NSB scientist lives and works in Utqiaġvik and is familiar with the culture and safety of the village. CWA pilots are Alaska residents and experienced in living and working in similar remote, cultural settings. Expectations of personnel including but not limited to: conduct expectations, field safety plans, travel logistics, packing lists, and personnel safety and security concerns will be covered in a virtual training prior to arriving in Utqiaġvik. An in-person training with all 5 members will occur upon arrival to Utqiaġvik and will cover any new information, including COVID-19 safety procedures and survey protocols. Any changes that occur during the field season will be communicated among survey team members and documented as needed. For international travel, check the U.S. State Department travel site for current travel, advisories and important safety and security information. Contact the UW Global Travel Security Manager at travelemergency@uw.edu or 206-616-7927 for international travel consultations. NA COVID-19 Supplemental Information: All official travel outside the U.S. by UW employees and students is restricted. Faculty and staff researchers may apply for an exceptional waiver to the current official travel restrictions. This may require endorsement by their Dean/s and the UW Office of Research. NA

No Go Criteria	*What are the possible conditions under which approach to - or activities at - the site should be stopped or canceled? e.g. heavy rains, electrical storms, snow, temperatures > 100 degrees, within 2 hours of high tide, wave heights over 1 meter, field team readiness, etc.* Traveling to Utqiaġvik, AK: The CICOES scientists will travel from Seattle, WA to Utqiaġvik, AK via Alaska Airlines on the scheduled day of departure. If inclement weather prevents travel from Seattle, then travel will proceed on any following day when the weather clears. If inclement weather delays the team in Anchorage or Fairbanks, the team will wait at the airport until the next available flight; however, if the next available flight isn't until the next day, the team will seek out lodging in town. All precautions will be taken to find lodging that is following strict cleaning and sanitizing protocols to reduce the chance of being exposed to COVID-19. The survey aircraft will transit from Anchorage to Utqiaġvik, AK carrying the survey pilots and avoiding commercial travel for them. The CWA aircraft will leave Anchorage on the scheduled departure date. If departure is delayed due to inclement aviation weather in Anchorage and/or Utqiaġvik, then aircraft will transfer as soon as it is safe to do so. The NSB scientist lives in Utqiaġvik, AK. During field operations: The survey aircraft does not launch when weather conditions at the airport are below minimum visibility standards set by the airport, or when conditions are predicted to be below minimums while the aircraft is out surveying. An alternate airport landing is required in case airport conditions at the base of operations are not conducive to landing, and enough fuel is always reserved in order to divert to the alternate airport. Cloud ceilings need to be a minimum of 1100 feet in the survey area to conduct surveys at an altitude of 1000 ft. In the event of an emergency landing and potential overnight in Deadhorse, the team will take all precautions to find lodging that is following strict cleaning and sanitizing protocols to reduce the chance of being exposed to COVID-19. COVID-19 Supplemental Information: ☒ The UW Returning to Research Involving Fieldwork Decision Tree must be completed. If the questions in the Decision Tree cannot be answered Yes or N/A at any point during the project, the fieldwork may not proceed. Both the "Returning to In-Person Research Decision Tree" and the "Returning to In-Person Research Involving Fieldwork Decision Tree" were completed; answers were all Yes or NA. A confirmed or suspected case of COVID-19 by any personnel involved in the survey would stop or cancel operations.
Expected Weather	*Note extreme conditions that could impact the trip or require additional planning, (e.g. high heat, wind, rain, snow, approaching storm).* The survey aircraft will not launch in extreme weather conditions as mentioned above.
Drinking Water Availability	☒ *Plumbed water available* ☐ *Water cooler with ice provided* ☐ *Bottled water provided* ☐ Natural source and treatment methods (e.g. filtration, boiling, chemical disinfection):
Access to Shade/Shelter	*If forecast temperatures exceed 80°F, shade must be provided by natural or artificial means for rest breaks. What will be available to the field team members?* ☒ Building structures ☐ Trees ☐ Temporary Canopy/Tarp ☐ Vehicle with A/C ☐ Other:

High Heat Procedures	*Required when temperatures are expected to exceed 95° F: If possible, limit strenuous tasks to morning or late afternoon hours. Rest breaks in shade must be provided at least 10 minutes every 2 hours (or more if needed). Effective means of communication, observation and monitoring for signs of heat illness are required at all times. Pre-work safety discussion required.* ☒Direct supervision ☒ Buddy system ☒ Reliable cell or radio contact ☐ Other:
Cold Weather Procedures	*Required when temperatures drop below normal and wind speed increases, allowing heat to leave a body more rapidly: If possible, schedule heavy work during the warmer part of the day. Provide frequent breaks in warm areas. Acclimatize new workers and those returning after time away from work. Effective means of communication, observation and monitoring for signs of cold stress are required at all times. Pre-work safety discussion required.* ☒Direct supervision ☒ Buddy system ☒ Reliable cell or radio contact ☐ Other:

Emergency Services and Contact Information			
Local Contact	Robert Suydam, Senior Wildlife Biologist, Robert.Suydam@north-slope.org	**University Contact** Not on trip. Should have a copy of this plan.	Ivonne Ortiz, ivonne.ortiz@noaa.gov Collen Marquist, marquist@uw.edu **Frequency of check ins:** Team will check in with Ivonne and Collen via email once at the beginning upon arrival and once at the end before coming back.
Lodging Location	King Eider Inn, 1752 Ahkovak St, Utqiaġvik, AK 99723		
Local Emergency Number	911		
Emergency Medical Services	Samuel Simmonds Memorial Hospital, 7000 Uula St, Utqiaġvik, AK 99723, 907-852-4611 SSMH is a certified Level IV Trauma Center. https://arcticslope.org/services/hospital-services/		
Nearest Emergency Department	*Evacuation plan and transportation options to the nearest Emergency Department; include estimated transport time, contact information and driving directions from the site to the nearest provider of emergency medical care. Attach map with specific directions.* Samuel Simmonds Memorial Hospital, 7000 Uula St, Utqiaġvik, AK 99723, Appendix 1_Route Plan and King Eider Inn to Hospital Directions.pdf is a map of the route from King Eider Inn to hospital. The Marine Mammal Laboratory and Clearwater Air will have vehicles in Utqiaġvik that can be used for transport.		
Cell Phone Coverage	**Primary Number:** Amelia Brower; Amy Willoughby **Coverage:** Spotty **Nearest location with reliable coverage:** Landline at the King Eider Inn, ask to be transferred to one of our rooms		
Satellite phone/other device	**Device carried?** ☒yes ☐no **Type/number:** Iridium 9555, phone number: **Location/access:** This satellite phone is carried in the aircraft emergency ditching bag and will only be turned on in an emergency ditching scenario. This phone number will also be shared with Clearwater Air, Robyn Angliss (NOAA AFSC MML CAEP Program Lead).		

Nearby Facilities	*What facilities are available at or near the site: restrooms, water, gas, public phone, store? If none, where are the nearest services along the route?* COVID-19 Supplemental Information: In order to minimize the risk of spreading COVID-19 to or from the field team, visits to nearby facilities should be minimized and done only to support field operations. Members of the field team who visit facilities away from the field site(s) or otherwise interact with individuals outside of the field team must: ● maintain social distancing of at least 6 feet at all times; ● wear appropriate PPE (e.g., disposable gloves, masks); and ● wash or sanitize their hands thoroughly prior to and after each visit. UW is now in Phase 3. The survey crew will have all necessary facilities in their hotel rooms or place of residence.
Side Trips	*Are side trips planned or allowed during free time? Before or after the planned activities? Are there restrictions, specific rules, or expected code of conduct?* **None** *COVID-19 Supplemental Information:* *In order to minimize the risk of spreading COVID-19 to or from the field team, there should be NO recreational side trips away from a field site. The response above should be "None".* UW is now in Phase 3. There will be no recreational side trips.

Participant Information	
Field Team/ Participants	Primary Field Team Leader: Amelia Brower Secondary Field Team Leader: Amy Willoughby ☒ Field Team/Participant list is attached and includes training documentation See Appendix 2_Science Field Team participant list and training documentation_2021.docx Amelia Brower, CICOES, UW Amy Willoughby, CICOES, UW Kayla Scheimreif, NSB ☐ Other attachment: e.g. course roster **NA** COVID-19 Supplemental Information: The field team should be reduced to the minimum number necessary to safely carry out the work. Field team consists of 5 people (2 pilots, 3 scientists), which is the minimum number necessary to conduct these aerial surveys.
Physical Demands	*List any physical demands required for this trip and training/certification provided. (e.g. diving, swimming, hiking, climbing, high altitudes, respirators, heights, confined or restricted spaces, etc. (Consult with EH&S regarding appropriate training & documentation.)* Surveys take place inside a small airplane cabin and time aloft can be up to 6 hours. Each member of the science crew has experience conducting biological surveys and all crew are very comfortable in this environment.
Mental Demands	*List any unique mental demands required for this trip, e.g. long travel days, high stress environments, different cultural norms, etc.* Surveys take place inside a small airplane cabin while flying offshore over the Arctic Ocean. Ample and sufficient emergency gear are brought on board, and each member of the science crew has experience conducting biological surveys and are very comfortable in this environment.

Lone Worker	Is anyone working alone? ☐ Yes ☒ No *If yes, describe a communications plan with strict check-in procedures (daily at a minimum) and actions to be taken in the event of a failure to establish contact when expected. If cell coverage is unreliable, a satellite communication device and/or personal locator beacon must be carried.*
First Aid Training	UW policy (APS 10.5) requires that all academic and/or research field teams must include at least one person with valid first aid certification. The level of first aid training required will depend on the type of activity the team is pursuing; the location; and the availability, response time, and means of communication by and with emergency response units. The EH&S Training office, ehstrain@uw.edu) can advise on the first aid training and certification requirements on a case-by-case basis. *List team members trained in first aid, type of training received (e.g., First Aid, CPR, Wilderness First Aid), and date of certification. Copies of first aid certification should be attached to this plan.* COVID-19 Supplemental Information: Compression-only CPR is an acceptable alternative for those who are unwilling, unable, untrained, or are no longer able to perform full CPR. See Appendix 2_Science Field Team participant list and training documentation_2021.docx Team will be flying daily from/to Utqiaġvik to conduct the surveys, and the Samuel Simmonds Memorial Hospital (SSMH) is a certified Level IV Center. Therefore UW only requires First Aid/ CPR Training. Amelia Brower – Appendix 2a_A.Brower_Safety_Certifications.PDF First Aid & CPR Training, valid through June 2023 Aviation Egress, safety, and cold water survival, valid through February 2023 Amy Willoughby – Appendix 2b_A.Willoughby_Safety_Certifications.PDF First Aid & CPR Training, valid through August 2022 Aviation Egress, safety, and cold water survival, valid through February 2023 Kayla Scheimreif – Appendix 2c_K.Scheimreif_Safety_Certifications.PDF Wilderness First Aid & CPR Training, valid through April 2024 Aviation Egress, safety, and cold water survival, valid through July 2024
Packing List	☒ Attach a copy of the packing list for your field team/participants, including information on who is responsible for providing specific supplies and/or PPE as applicable. See Appendix 3_Packing list for COVID prevention_2021.PDF
Immunizations or Required Medical Evaluation	For travel-related immunizations or medical advice, contact UW Travel Medicine 6-8 weeks in advance of departure. Consultations include country-by-country analysis of project itinerary and anticipated activities. List required immunizations/prophylaxis or required medical evaluation, if applicable. **NA**
Participant Emergency Contact Information	While the University cannot require field participants to provide current emergency contact information and proof of medical insurance, PIs are encouraged to request this information from all field trip participants so that they have the information on hand to give to medical providers if the field team participants are not able to do so themselves. This information should be 1) treated as confidential (i.e., locked, limited access and distribution); 2) accessed and shared only with health providers during an emergency; and 3) shredded immediately upon completion of the trip. ☒ Encourage field team members to ensure their emergency contact information in Workday is current for use in case of an emergency. ☐ Check box if optional Emergency Contact Information/Medical Information Forms have been collected. (See Appendix A) If yes, describe security measures to be taken to ensure information is kept confidential and available to be used by medical personnel in the event of an emergency. Emergency contact information will be shared with project lead, Amelia Brower, who will keep confidential. CICOES employees' Workday emergency contact information is up to date.

Volunteers	UW Risk Services describes volunteers and the process for ensuring their work is authorized in writing and in advance so that they have access to both UW liability coverage and limited workers' compensation coverage (medical payments only) for their approved duties. ☐ If your project involves volunteers, create a volunteer service agreement for each volunteer that documents the person's name, a description of the duties they'll be performing, and the dates and hours of work. Volunteer service should not be engaged in by individuals if is it is not permitted by their visa status and/or immigration law rules. **NA**
Minors	University Policy (APS 10.13) requires all UW and third party led youth programs to register with the UW Youth Program Registration System (YPRS). If your field project is employing volunteers or is otherwise engaging individuals under age 18: ☐ register project in the YPRS; ☐ confirm completion of both background checks and the two required trainings for all authorized personnel before your program start date. It is recommended that you begin the YPRS registration process at least 1 month prior to the program start date. Contact the Youth at UW Program if you have questions. **NA**
Attestations of Health	Fieldwork involving daily travel to field site from home • Participants should follow the same protocols for daily attestations of health as UW researchers going into a UW facility (i.e., Daily attestations of well-being through Workday or other communications with a supervisor if Workday is not an option) • Personnel who feel ill may not participate in fieldwork and should notify their supervisor that they are unable to do so. In addition, if a member of their household develops symptoms of illness they must stay home and self-quarantine according to current CDC recommendations. Fieldwork involving travel to a remote field site for longer than one day • Members of the field team who exhibit any symptoms of illness within 72 hours prior to departure MUST stay home. • Field team participants must submit an attestation (See Appendix B) to the field team leader immediately prior to departure before being allowed to participate. • Field Team leaders should incorporate daily in-person health check-ins as part of routine operations. Team members will follow the above guidance and guidance provided on page 20 and 22 of this document. The COVID-19 Symptom Attestation Prior to Departure for Fieldwork Involving Overnight Travel.docx (Appendix B) will be emailed prior to departure.
COVID-19 Virus Testing and Quarantine	Fieldwork involving travel to a remote field site for longer than one day. Members of the field team must quarantine and get tested for COVID-19 according to the EH&S COVID-19 Quarantine and Testing Risk Framework for Field Work. "EHS COVID-19 Quarantine and Testing Risk Framework for Field Work is no longer effective as of July 8, 2021." (https://www.ehs.washington.edu/resource/covid-19-quarantine-and-testing-risk-framework-field-work- updated-7821-997 accessed on 27 July 2021)

Activities, Equipment, and Supplies – Consult with EH&S for specific training and requirements	
Research Activities	*Briefly describe the goal of your field operations, e.g. collection of samples, observation of animals/environment, interviews with human subjects, etc.* Aerial surveys will be conducted in the western Beaufort Sea to sight and document location, group size, habitat, and activities of bowhead whales and all other marine mammals detected. Please see Appendix 4_SoW_NSB_Autumn_Surveys_2021_UW.
Field Transportation	*What vehicles will be used during field operations? e.g. chartered boat, paddle craft, car, ATV, truck with trailer, snowmobile, chartered plane or helicopter, etc.* Clearwater Air, Inc. Turbo Commander aircraft NOAA truck Clearwater Air vehicle Who is authorized to operate/use each vehicle? Clearwater Air, Inc. is authorized to operate the aircraft and the Clearwater Air vehicle. CICOES and NSB employees are authorized to occupy the aircraft and Clearwater Air vehicle. CICOES employees are authorized to operate the NOAA truck. CICOES, NSB, and Clearwater employees are authorized to occupy the truck. The driver is responsible for wiping down common touch areas and keys. Masks will be worn when more than one person is in a vehicle. COVID-19 Supplemental Information: Briefly describe additional transportation logistics that have been added in response to COVID-19. Vehicles should be single-occupancy to the extent possible and PPE/masks should be used when they aren't. During transit between Seattle and Utqiaġvik, personnel will wear a face mask and will frequently wash hands or use hand sanitizer, and will maintain at least 6 feet distance from others whenever possible. While on the Alaska Airlines aircraft, personnel will wear a face mask and will frequently sanitize surfaces around their seating area. No one outside the survey team will be allowed in the NOAA truck, the Clearwater Air vehicle, or the survey aircraft. Before entering the NOAA truck and Clearwater Air vehicle at the beginning of a drive, all surfaces will be wiped down. Before the start of each survey flight, one survey team member will be assigned to wipe down all surfaces on the survey aircraft. If relevant, please see UW EH&S Guidelines for COVID-19 Prevention During Small Boating Operations. **NA**
Research Tools	*Briefly describe tools or equipment that will be used to access the research site or during research activities. Indicate specific training required before use, e.g. sharps (knives, razors, needles), hand tools, chainsaws, power tools, heavy machinery, tractors, specialty equipment, firearms; lasers, portable welding/soldering devices; other hazardous equipment or tools. COVID-19 Supplemental Information:* ● Field crew members should be assigned individual field equipment (e.g., GPS units, binoculars, spotting scope, clipboard, and other miscellaneous field gear) for the duration of the field season to the extent possible. ● Prior to use, field equipment should be cleaned with a disinfecting cleaner. Equipment should be sanitized again before it is returned at the end of the field season. ● If at any time there is a need to share equipment, crew members should wipe down the equipment first with disinfecting cleaner and thoroughly wash their hands afterward. *Briefly describe additional tool/equipment logistics that have been added in response to COVID- 19.* Additional precautions in response to COVID-19 include: assigning crew members individual field equipment for the duration of the field season, frequently sanitizing high-touch areas, and frequent hand washing.

Other Research Hazards	*Describe other potential research-associated hazards e.g. handling or shipping hazardous materials (chemical, biological, radiation, and explosives), handling animals, climbing or working at heights, rigging; shoring/trenching, digging/entering excavations, caves, other confined spaces; drone use.* Only the survey crew will be allowed in the survey aircraft, all equipment will arrive to Utqiaġvik with survey personnel or on the survey aircraft.
Personal Protective Equipment	*Required: e.g., boots, safety glasses, PFDs, hardhats, etc. (if PPE is expected to be provided by the participant, it should be included in the attached packing list). Recommended: e.g., walking sticks, gloves, long pants, hats, insect repellant, sunscreen (if PPE is expected to be provided by the participant, it should be included in the attached packing list)* COVID-19 Supplemental Information: Keeping a distance (at least 6 feet) from other people is the best protection against COVID-19; however, wearing a mask can add another layer of protection, especially if you must be inside with others. Masks can help protect others by containing respiratory droplets when the mask wearer coughs, sneezes or speaks. Face coverings must not interfere with other PPE (e.g., eye shields), required for safety and must be compatible with all safety requirements. **Face coverings are required:** When you are indoors where other people are present. A face covering is not needed when working alone in a private office or work area. When you are outdoors whenever keeping a 6-foot distance from other people may not be possible. A face covering is not needed when you are outdoors (e.g., walking, exercising) and you are able to stay 6 feet away from other people. Cloth face coverings do not replace job-specific requirements for use of personal protective equipment (PPE). EH&S provides a PPE selection matrix that can be used as a reference. Individual PPE should be assigned to each member of the field team. Describe when/how PPE is to be stored, used, cleaned, and disposed of as well as training on appropriate PPE use that will be done prior to use. Personnel will maintain at least 6 feet distance from other people whenever possible, wear face masks when there is any chance of coming within 6 feet of other people, and frequently wash hands with soap and water (when available) or use hand sanitizer. Pre-departure briefing will review protocols for physical distancing, face coverings, hand hygiene, and cleaning of personal and work spaces. Each member will have their own disinfectant cleaning supplies for their rooms. The aircraft will have disinfectant cleaning supplies onboard. ☒ Attach a copy of the list of PPE required to safely implement your field work that will be provided by the PI/Supervisor. An adequate supply of masks and disposable gloves should be included on this list. (Surgical masks or N-95 respirators are critical supplies that must continue to be reserved for healthcare workers and other medical first responders. They should not be used for fieldwork.) PPE should be purchased in advance to confirm availability prior to departure and the location of supplies should be announced to all team members. Please see Appendix 3_Packing list for COVID prevention_2021.PDF in compliance with the guidance listed above.
Supplies	*Briefly describe the supplies needed to support the fieldwork, both for research/teaching and supporting functions (e.g., food, water, toilet paper). Indicate what will be brought from the point of departure and what will be acquired in the field.* COVID-19 Supplemental Information: Tissues, hand sanitizer and soap/potable water should be provided by the PI/Supervisor. Review the EH&S Cleaning and Disinfection Resources to help select appropriate disinfection products, including the use of EPA-registered disinfectants, and the manufacturer's instructions for safe and effective use of all cleaning and disinfection products. Contact EH&S at ehsdept@uw.edu with questions aboutcleaning and disinfection procedures. Attach a copy of a list of COVID-19-related cleaning/disinfecting supplies required to safely implement your field work. These products should be purchased in advance to confirm availability and the location of supplies should be announced to all team members. Please see Appendix 3_Packing list for COVID prevention_2021.PFD

First Aid Supplies	An emergency first aid kit should be available to the entire field team at all times. Location and description of group medical/first aid kit(s): Who is carrying it, where is it stored. Brief description of contents. The first aid kit is located in the emergency ditch bag and is carried on the plane. The kit contains gauze, bandages, bandage tape, pain medications, motion sickness medication, SAM splint, syringe, and super glue. If a member field team requires urgent medical attention, emergency services should be called immediately. COVID-19 Supplemental Information: First aid kits must include single use thermometers and/or thermometers that can be sanitized between uses. If a member of the field team requires immediate first aid that cannot be self-administered, another crew member may assist. All members of the field team involved in the emergency response (including the injured party) will sanitize their hands prior to and after care and wear personal protective equipment (e.g., gloves, face masks). Each team member will have a personal thermometer that will be used to take their temperature at the beginning of each day.
Cleaning and Sanitizing Procedures	*Briefly describe the cleaning and sanitizing procedures and responsibilities for all members of the field team. Description should include expectations regarding equipment, common spaces, food preparation/clean-up/storage, and actions that should be taken to mitigate damage to equipment, pests, wildlife incursions, spread of illness, etc.* COVID-19 Supplemental Information: ● In alignment with public health recommendations, field teams should undertake enhanced cleaning and disinfection procedures. Increase the frequency of cleaning and disinfecting, focusing on high-touch surfaces in common areas, restrooms, etc. Increased frequency of cleaning and disinfecting with attention to these areas helps remove bacteria and viruses, including the novel coronavirus. Identify all high touch surfaces in communal spaces and disinfect them before and after use, and daily at a minimum. ● Schedule any communal use equipment such that appropriate cleaning can take place before and after use. ● Participants should be able to wash their hands often with soap and water, for at least 20 seconds, or use hand sanitizer that contains at least 60% alcohol if soap and water are not available. Following the above guidance, personnel will wipe down their hotel room upon arrival. Housekeeping will enter hotel rooms only once a week to change linens, clean kitchenettes, and resupply. Personnel will wipe down their hotel room after each weekly cleaning. Personnel will wipe down seating areas in airport waiting areas, on Alaska Airlines jets, in field vehicles, and in the survey aircraft. Personnel willcomply with recommendations for frequent hand washing with soap and water, when available, and useof hand sanitizer when hand-washing facilities are not available.

Food and Meals	Briefly describe how food and beverages will be made available to the field team (including preparation, distribution, and procurement). Indicate what will be brought from the point of departure and what will be acquired in the field. COVID-19 Supplemental Information: Fieldwork involving daily travel to field site from home ● Individuals who travel daily to a field site should pack in their food/water each day. Provisions should not be shared with other crew members. Fieldwork involving travel to a remote field site for longer than one day ● Where practicable, establish social distancing policies and procedures around meals. E.g., ○ Adjusting mealtimes to facilitate social distancing while eating ○ Shift food service operations away from self-service ○ Participants should wash or sanitize their hands before and after meals Survey team will bring food with them by packing coolers and dried goods in their luggage and then will make quick trips to the grocery store for food supplies. Each team member will have their own hotel room with kitchenette to prepare their own food. There will be no in-person restaurant dining.

Additional Considerations	
Insurance	**Equipment Insurance** University property and equipment is not automatically insured. UW Equipment Insurance is a campus-wide online program administered by Risk Services which provides optional, low cost coverage to University departments for owned, leased or borrowed equipment used for UW work. **Travel Insurance** University employees, including student employees, are covered by Washington State L&I for work-related injuries. However, for personal health care issues, employees may want to look into getting supplemental insurance when away from home on travel. Students, including student employees, **must** purchase CISI travel insurance prior to international travel and can contact CISI at 1.855.327.1419 (toll-free) or 1.630.694.9794 (accepts Collect calls). COVID-19 Supplemental Information: All official travel outside the U.S. by UW employees and students is restricted. Faculty and staff researchers may apply for an exceptional waiver to the current official travel restrictions. This may require endorsement by their Dean/s and the UW Office of Research. Note that even with a waiver, personal evacuation insurance may be required, as UW insurance does not cover international travel at this time. **NA**
Animal Research	☐ Does your fieldwork require a Collection, Import, Transfer or other permit? If yes, attach a copy of all permits to this Plan. ☐ If research will be done with animals at a foreign site, identify whether institutional reviews will be required and whether there will be additional costs for those reviews. **NA**

Human Subjects Research	If research will be done with human subjects at the foreign site, determine which of the following reviews will be required. Also, identify whether translation services will be required and if there will be additional costs for foreign reviews. ● UW human subjects review ● Sponsor's requirement for human subjects review ● Foreign collaborator's requirement for human subjects review Compensation for research subjects in economically disadvantaged settings should be consistent with local norms. See guidance from the U.S. Department of Health and Human Services on international human subjects. COVID-19 Supplemental Information: Please see the Human Subjects Division website for the latest information on permissible human subjects research. **NA**

Campus Contacts	
Primary Department Contacts	*Unit chair/director:* John Horne, CICOES Director, jhorne@uw.edu *Unit Administrator:* Fred Averick, faverick@uw.edu These individuals should have access to a copy of your final project Health and Safety Plan.
Mental Health	Employees: CareLink (24 hours a day, 7 days a week) Students ● Bothell: Counseling Center ● Seattle: Counseling Center and Hall Health Mental Health ● Tacoma: Counseling & Psychological Services (uwtcaps@uw.edu) ● While Abroad – The UW Student Abroad Insurance has mental health coverage. Students can arrange to see a mental health provider in-person locally or remotely. National Suicide Prevention Lifeline (24 hours a day, 7 days a week)
Environmental Health and Safety (EH&S)	ehsdept@uw.edu
International Assistance	Emergency assistance 1. Take whatever actions are necessary to assure your immediate safety. 2. Call the local emergency number. 3. Call CISI 4. Contact the UW Global Emergency line for further assistance. Non-emergency assistance If the incident is no longer an immediate or potential risk to health, safety or security, report it to the UW Global Travel Security Manager during the next business day at and/or travelemergency@uw.edu. For time sensitive matters, please call versus emailing.

Report Injuries and Accidents	Report any work-related injury or illness to your supervisor as soon as possible. After reporting the incident to your supervisor, submit a report of the incident within 24 hours to EH&S via the UW's Online Accident Reporting System (OARS). **Call EH&S immediately if the incident involves any of the following:** ● In-patient hospitalization ● Recombinant/synthetic DNA exposure or spill ● Fatality EH&S must immediately report any employee in-patient hospitalization or fatality to Washington State Department of Labor & Industries (L&I). Do not move any equipment involved in the incident until EH&S receives clearance from L&I. **Outside of EH&S business hours (8:00 a.m. to 5:00 p.m., Monday to Friday), call the UW Police Department (UWPD).** UWPD will notify an EH&S on-call staff member.
Report Harassment	All members of the UW community have the right to a non-harassing (both sexual and non- sexual in nature) and non-discriminatory environment both on campus and in fieldwork situations. Individuals are encouraged to bring up safety and well-being concerns for themselves or others with the following individuals: **Field Team** ● Field Team Leader/Chief Scientist: Amelia Brower ● Another senior person (e.g., Co-PI, ship captain, bosun): Ivonne Ortiz ● Other members of the science team: Amy Willoughby ● Field Buddy: TBD ● On-site anonymous reporting mechanism: NA UW Resources and Reporting (NOTE: UW Advocates and Offices may be contacted regardless of the institutional affiliation(s) of the individuals involved). Confidential Advocates for support, information and assistance ● Faculty/Postdocs/Staff - Victim Advocate: UWPDAdvocate@uw.edu ● Students Bothell: Violence Prevention and Advocacy Program Manager, uwbvae@uw.edu Seattle: Livewell Student Advocate: hwadvoc@uw.edu Tacoma: Assistant Director for Student Advocacy and Support, uwtsva@uw.edu Other University Resources ● SafeCampus: 24 hours a day, 7 days a week ● UW Global Emergency Line for international assistance ● Office of Ombud (office hours): ombuds@uw.edu Other ● Campus/Home Buddy: TBD

COVID-19 Supplemental Information

Reporting Cases of COVID-19	If a member of the field team shows any symptoms of COVID-19 infection, they should do the following: 1. Isolate themselves from all other members of the field team 2. Contact their health care provider in advance or a UW Medicine facility to discuss whether they should be evacuated and/or tested. Do not go directly to a clinic. 3. Contact UW EH&S Employee Health Center at covidehc@uw.edu. They will help facilitate testing and provide next steps for field group tracking and contract tracing. Field team leads are required to direct personnel to follow the steps in the FAQ "What do I do if I feel sick?," which includes the above information. **Will comply.**

First Aid Reference – Signs & Symptoms Relevant to Conditions of Proposed Fieldwork		
Signs & Symptoms	**Treatment**	**Response Action:**
POTENTIAL ISSUE SPECIFIC TO PROPOSED FIELDWORK *(examples below)*		
HEAT EXHAUSTION • Dizziness • Headache • Sweaty skin • Weakness • Cramps • Nausea and/or vomiting • Rapid heart rate	1. Stop all exertion. 2. Move to a cool shaded place. Hydrate with cool water.	Heat exhaustion is the most common type of heat illness. Initiate treatment. If no improvement, call 911 and seek medical help. Do not return to work in the sun. Heat exhaustion can progress to heat stroke.
HEAT STROKE • Confused, disoriented, irritable, combative • Convulsions/seizures • Fainting • Poor balance/coordination • Hot, dry and red skin • Fever, body temperature above 104 °F	1. Move (gently) to a cooler spot in shade. 2. Loosen clothing and spray clothes and exposed skin with water and fan. 3. Cool by placing ice or cold packs along neck, chest, armpits and groin (Do not place ice directly on skin)	**Call 911 or seek medical help immediately.** Heat stroke is a life-threatening medical emergency. A victim can die within minutes if not properly treated. Efforts to reduce body temperature must begin immediately!
COLD STRESS (moderate to severe) • Shivering stops • Confused, disoriented • Poor coordination • Dilated pupils • Pulse/breathing slow • Loss of consciousness	1. Move to a warm, dry area. 2. Remove wet clothes and replace with dry clothes, cover the body (including the head and neck – NOT face) with layers of blankets; and with a vapor barrier. Warm bottles or hot packs can be placed in armpits, sides of chest, and groin. 3. If conscious, give warm, sweetened, non-alcoholic drinks.	**Call 911 or seek medical help immediately.** Hypothermia can be a life-threatening medical emergency. A victim can die if not properly treated. Efforts to rewarm the individuals must begin immediately!
COVID-19 People with COVID-19 have had a wide range of symptoms reported – ranging from mild symptoms to severe illness. Symptoms may appear 2-14 days after exposure to the virus and may include: • Cough • Shortness of breath or difficulty breathing • Fever • Chills • Muscle pain • Sore throat • New loss of taste or smell • Runny nose • Headache • Nausea or vomiting • Diarrhea The UW Coronavirus website and CDC are resources for current lists of COVID-19symptoms.	If members of the field team begin experiencing symptoms while in the field, they should avoid all contact with other members of the field team. Describe specific isolation plans for individuals who exhibit mild symptoms of COVID-19 and evacuation plans for individuals when isolation is not possible, and/or who exhibit symptoms of concern, and/or who are directed to leave the field site by medical professionals. Additional UW guidance on health, wellness, and prevention FAQs can be found on the UW COVID-19	**When to Seek Emergency Medical Attention** Look for emergency warning signs* for COVID-19. **If someone is showing any of these signs, seek emergency medical care immediately:** • Trouble breathing • Persistent pain or pressure in the chest • New confusion • Inability to wake or stay awake • Bluish lips or face *This list is not all possible symptoms. Please call a medical provider for any other symptoms that are severe or concerning to you. Members of the field team who develop a suspected or confirmed case of COVID-19 should report it to UW EH&S Employee Health covidehc@uw.edu

Signature of PI/Supervisor:

I approve this safety plan and acknowledge that it has been prepared for fieldwork under my supervision.

Name	Signature	Date	Phone Number
Ivonne Ortiz		8/12/2021	

Field Team/Participant Roster - Training Documentation

I understand that this Project Health and Safety Plan is intended to document hazard assessments, communication plans, emergency procedures, and training requirements for the proposed fieldwork. This plan also identifies hazards, as well as precautions and actions to be taken to address and mitigate those hazards, to significantly mitigate the risk of COVID-19 exposure and transmission, but is not a substitute for self-isolation for individuals who may have concerns about their health or that of others. I verify that I have read this Fieldwork Health and Safety Plan, understand its contents, am voluntarily participating in the fieldwork, and agree to comply with its requirements. (A PI may choose to collect this documentation by email to help avoid the need to meet in-person prior to departure.)

Name/Contact Information	Signature	Date	Training Completed[1]
Amelia Brower Amelia.brower@noaa.gov Field Team Leader/Chief Scientist		8/3/2021	Wilderness First Aid – Apr 2019 First Aid – June 2021 CPR – June 2021 Aircraft Ditch & Helicopter Emergency Egress Device Training – Feb 2020 Cold Water Survival – Jun 2010
Amy Willoughby Amy.willoughby@noaa.gov		8/3/2021	First Aid – August 2020 CPR – August 2020 Aircraft Ditch & Helicopter Emergency Egress Device Training – Feb 2020 Cold Water Survival – 2014
Kayla Scheimreif kayla.scheimreif@north-slope.org		8/3/2021	Wilderness First Aid – April 2021 CPR – April 2021 Aircraft Ditch & Helicopter Emergency Egress Device Training – July 2021 Cold Water Survival – July 2021

[1] All academic and/or research field teams must include at least one individual with valid first aid certification.

Appendices

1) Appendix 1_Route Plan and King Eider Inn to Hospital Directions
2) Appendix 2_Science Field Team participant list and training documentation_2021
3) Appendix 2a_A.Brower_Safety_Certifications.PDF
4) Appendix 2b_A.Willoughby_Safety_Certifications.PDF
5) Appendix 2c_K.Scheimreif_Safety_Certifications.PDF
6) Appendix 3_Packing list for COVID prevention_2021.PDF
7) Appendix 4_SoW_NSB_Autumn_Surveys_2021_UW.PDF

Appendix B. COVID-19 Symptom Attestation Prior to Departure for Fieldwork Involving Overnight Travel The following text should be sent by email to a field team leader by all members of the field team immediately prior to departure for fieldwork involving overnight travel. Daily attestations in Workday should be made for fieldwork that is conducted by daily travel to the site from the participants' homes. Members of the field team who do not submit attestations are not allowed to participate in fieldwork.

In the last 72 hours, have you experienced any of the following symptoms:

- A new fever (100.4 F or higher) or a sense of having a fever?
- A new cough that you cannot attribute to another health condition?
- New shortness of breath that you cannot attribute to another health condition?
- A new sore throat that you cannot attribute to another health condition?
- New muscle pain that you cannot attribute to another health condition or that may have been caused by a specific activity, such as physical exercise?
- New gastrointestinal symptoms, such as nausea, vomiting or diarrhea that you cannot attribute to another health condition?
- New respiratory symptoms, such as a runny nose, that you cannot attribute to another health condition?
- New chills that you cannot attribute to another health condition?
- New loss of taste or smell that you cannot attribute to another health condition?
- A new headache that you cannot attribute to another health condition or emotional reason?
- New fatigue that you cannot attribute to another health condition?

If you are sick or have one or more of the above symptoms:

- You must stay home and cannot participate in the fieldwork until at least 10 days since symptoms first appeared and at least 24 hours with no fever without fever-reducing medication and symptoms have improved.
- Follow your department's procedure for calling out sick or requesting to work from home.
- Contact your health care provider for medical guidance.
- Follow the guidance on the FAQ What do I do if I feel sick? at the UWs Novel coronavirus & COVID-19 facts & resources webpage.

By sending this email, I attest that

I have read the above statement. YES
and
I attest that I do not have any of the above symptoms. YES
and
I have not knowingly been in contact with COVID-19 cases or high-risk regions for at least 14 days. YES

Signed,

Amelia Brower
Research Scientist, CICOES

Amy Willoughby
Research Scientist, CICOES

Kayla Scheimreif
Wildlife Biologist, NSB DWM

CICOES Field Operations Emergency* Notification Plan

North Slope Borough Bowhead Whale Survey 2021

***Emergency:** Any accident, injury, illness, or other incident that seriously threatens the health or safety of a field researcher/tech or otherwise requires that the individual be transported to shore or removed from his/her temporary duty work assignment.

Group 1

MUST PROVIDE INFORMATION FROM FORM ON BACK TO GROUP 2 CONTACTS

First notification of an emergency typically reported by a member of this group

Dedicated Flight Follower at the Bureau of Land Management, Dept. of Interior

(907) 267-1360

blm_ak_adc_dispatch@blm.gov

Group 2

MUST COMPLETE INFORMATION FORM ON BACK

First person (1.) to notify Horne and Marquist by phone with a follow-up email.

2. CICOES Executive Director

John Horne
W: (206) 221-6890
C:
jhorne@uw.edu
Notify Ortiz

CICOES Associate Director

Ivonne Ortiz
W:
ivonne.ortiz@noaa.gov

1. NOAA Emergency Contact

Robyn Angliss
C:
Robyn.Angliss@noaa.gov
Notify Horne and Marquist

2. CICOES Safety Manager

Collen Marquist
W: (206) 685-6548
C:
marquist@uw.edu
Notify Group 3

OARS Reporting

Collen Marquist

https://www.uwb.edu/safety/

Emergency-preparedness/oars

Group 3

Notified by CICOES Safety Manager

Stephanie Harrington, COE Assoc Dean	**W: (206) 543-0878**	stephah@uw.edu
Fred Averick, Asst Director	**W: (206) 616-6763**	faverick@uw.edu
Abby Zorn, CICOES HR Manager	**W: (206) 543-5216**	azorn@uw.edu

INFORMATION REQUIRED FOR EMERGENCY REPORT COMMUNICATION

Name/Position of person reporting the emergency:

Group 1 reporter:

____

Group 2 reporter:

____

Location and contact information of person reporting the emergency:

WHO?
Name of person involved: ____

WHEN?
Date and time of the incident:

____
____

WHERE?
Where did the incident occur?

____
____
____

WHAT?
Sequential facts describing what happened:

____
____
____
____

HOW?
How is emergency response taking place?

____
____
____
____

Further action to be taken:

____
____
____
____

FAMILY TO CONTACT?
Injured party's Emergency Contact Information:

____
____
____

APPENDIX C: Safety and Logistics Plan, 2021

The North Slope Borough Aerial Surveys of the Bowhead Whale Fall Migration project is co-managed and conducted by the North Slope Borough (NSB) and University of Washington, and funded by NSB. Priority Area 1 from Utqiaġvik to Prudhoe Bay and Priority Area 2 from Prudhoe Bay to just east of the US/Canada border make up the primary study area covers the western Beaufort Sea, from 140° to 157°W and the coastline to 72°N (Appendix Fig. C1). Priority Area 3 from Utqiaġvik to Wainwright and Priority Area 4 south of Wainwright comprise a secondary study area covering the eastern Chukchi Sea, from 157° to 169°W and 67° to 72°N (Appendix Fig. C1). The 2021 field season will begin on 15 September with the UW scientists arriving in Utqiaġvik, Alaska. Surveys will begin on 16 September, are weather-dependent, and will run until 15 October. This safety plan provides information about emergency support services, aviation safety protocols, firearms protocols, and protocols for mitigating risks to project personnel posed by wildlife encounters on the ground.

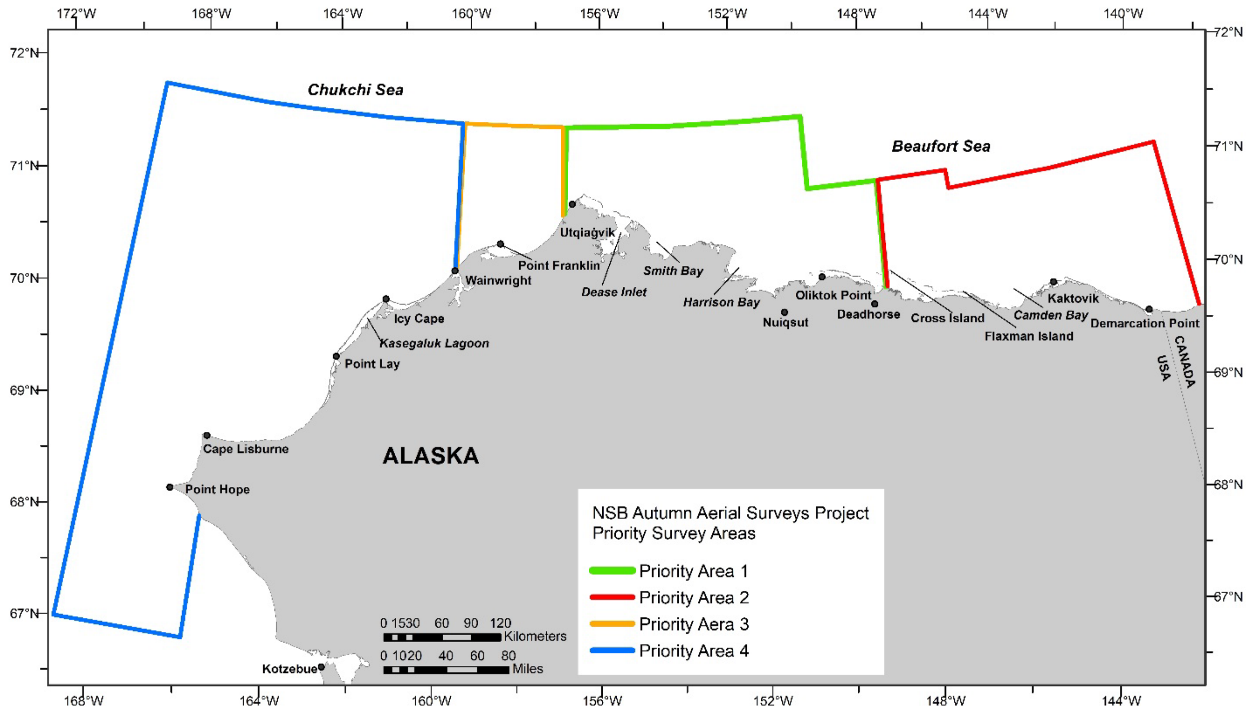
Emergency Support Services at the Base of Operations

The project will operate from its base in Utqiaġvik, located on the North Slope of Alaska (Appendix Fig. C1). Lodging in Utqiaġvik will be provided by the King Eider Inn. One Turbo Commander, operated by Clearwater Air, Inc., will be stationed at the base, and will be available to the project under an exclusive use contract for the duration of the field season. A refueling and emergency alternate landing site is Deadhorse, also located on the North Slope of Alaska.

Primary emergency support services in Utqiaġvik include 9-1-1, the Samuel Simmonds Memorial Hospital, and the North Slope Borough Search and Rescue (NSB SAR) Department. The hospital is an outpatient unit providing emergency clinic and urgent care, including a Level IV Trauma Center with 45 beds and 17 ventilators, among other things. It is open for emergencies 24 hours a day and accepts non-emergency walk-ins until 1630 Alaska Standard Time. It is located at 7000 Uula St., and the phone number is 907-852-4611.

The NSB SAR crew are well-trained and have well-maintained equipment to provide a rapid response. They are available around the clock at 907-852-0401 and 907-852-2822. At the beginning of the field season, the survey team will make contact with the NSB SAR to let them know of our presence and activities, including our aircraft type, call sign, emergency frequencies, contact phone numbers, and map of the study area and survey blocks. This contact has a dual purpose: to introduce our project in the event that we should need assistance and to let NSB SAR know that our aircraft and crew could be available for coordination and assistance should the occasion arise for a SAR effort while we are based in Utqiaġvik.

Medical assistance and emergencies in Deadhorse will be handled by a medical clinic operated by British Petroleum. The clinic is referred to as the “MCC” (main construction camp). MCC can facilitate MedEvac air transfers, triage trauma, and provide a spectrum of acute care, emergency medicine, and first aid. The clinic is open and staffed around the clock, 365 days a year; they are located on oilfield lease land, and their phone number is 907-659-5239. Access to the facility is via the Central Check Point gate, beyond which oil field security will provide an escort to MCC. Deadhorse is also served by the North Slope Borough Police, who can be reached by calling 9-1-1.



Appendix Figure C1. -- North Slope Borough Autumn Aerial Surveys study areas by priority; Priority Area 1 being the highest priority and Priority Area 4 being the lowest priority for documenting the bowhead whale migration.

Both Utqiaġvik and Deadhorse are served by commercial jets at least once daily, weather permitting. It is also possible that the survey aircraft could be used for an emergency medevac to Anchorage. There are two main hospitals in the Anchorage area, both of which provide emergency services 24 hours a day:

Alaska Regional Hospital
2801 DeBarr Road
Anchorage, AK 99508
907-276-1131

Providence Alaska Medical Center
3200 Providence Drive
Anchorage, AK 99508
907-562-2211

Aviation Safety Protocols

The aircraft used during the 2021 season will include Turbo Commander (twin turbine, high fixed-wing) aircraft. The Commanders were used by the survey team during previous aerial survey field seasons flown with the same protocols. The aviation safety protocols are based on training, emergency preparedness, flight following, and reporting, as detailed below.

Training

Each person flying on the surveys must have a combination of annual, periodic, and one-time trainings. The field team will be thoroughly briefed on aircraft operations and COVID-19 protocols, will have practiced donning the Ice Commander Immersion Suits, and will participate in aircraft egress drills. The egress drills will allow each team member the opportunity to practice preparing for and surviving an in-air emergency so that everyone onboard the aircraft knows precisely what their responsibilities are in an emergency situation. These trainings will review emergency materials, including use of GPS units, satellite phones, personal locator beacons (PLB), and aircraft and marine band handheld radios.

The Clearwater Air Pilots in Command (PIC) have an average of over 8,500 hours flying experience and considerable experience flying small aircraft in arctic Alaska. All PICs also conduct a comprehensive Flight Risk Assessment (Appendix Fig. C2) as part of survey planning, which incorporates inputs about crew, environment, operations, and aircraft, and allows for inputs from aircraft management.

These NSB surveys will follow NOAA's aviation safety policy, which is available online: (https://sites.google.com/a/noaa.gov/omao-intranet-dev/operations/hq/safety/aviation-safety/safety-training). Annual training for personnel participating in NOAA aerial surveys includes reviewing three of NOAA's aviation safety modules: 1) NOAA Aviation Policy and Procedures; 2) Basic Aviation Safety and Survival; and 3) Aviation Health. In addition, NOAA requires all personnel participating in aerial surveys to complete a water ditching, safety, and survival course once every 5 years; AFSC policy is more stringent, requesting this training once every 3 years due to the remote and harsh environments that our field teams operate in. This survey follows AFSC's guidelines for ditching certification. Aerial survey personnel may optionally be trained in the use of helicopter emergency egress devices. Aerial survey personnel must be current in first aid and Cardiopulmonary Resuscitation training. Finally, all aerial survey personnel who conduct NOAA operations in cold environments must have training in aviation safety and cold weather survival.

Emergency Preparedness

Emergency preparedness for survey flights will be achieved by wearing appropriate clothing, maintaining and having access to necessary emergency gear, being knowledgeable about aviation safety risks, feeling comfortable voicing safety concerns, and having reliable protocols in place that will be followed in the event of an emergency.

During surveys, all personnel onboard the aircraft will wear either flight or dry suits and be outfitted with Switliks or other personal floatation devices containing emergency equipment. Onboard safety equipment will include an impact-triggered emergency locator transmitter (ELT) installed in the aircraft, an 8-person search and rescue life raft equipped with an emergency survival kit, PLB, portable marine and aviation band transceivers, satellite telephone, flares, immersion suits, battery fire containment bag, and helicopter emergency egress breathing devices. The emergency satellite telephone and radios will be charged and tested at the beginning of the field season. All safety gear will be maintained and inspected according to the manufacturer's instructions.

Risk Assessment Template.xlsx

Clearwater Air

Flight Risk Assessment

Multi-Engine IFR

PIC: **SIC:** **Aircraft:** **Date:**

For single pilot operations use score in parenthesis.

Crew				Total
≤ 10 Hrs in last 30 days		1(3)	1	1
≤ 2000 hrs TT			1	0
≤ 200 hrs in type		2(4)	1	0
Fatigue (Less than 8 hours of sleep)		2(4)	1	0
Divorce / Separation / Death		2(4)	1	0
Illness requiring medication		2(4)	1	0
Crew Total				1

Aircraft				
Inoperative Instruments (MEL)		1		0
Max Gross T/O Weight		2		2
Aircraft Hangared		-2		0
Preflight deicing required		2		2
Weight and Balance Completed		-1		-1
Aircraft Total				3

Environment				
Departure: Vis ≤3 Miles		3		3
Departure: Vis 3-5 Miles		1		0
Icing Conditions Forecast		2		2
Ice on Runway		2		0
Arrival:Precision Approach Available		-2		-2
Fog in Forecast		3		3
Wind ≥ 20 knots		2		2
Arrival Forecast: ≤ Special VFR		4		0
Arrival: Vis ≤ 3 miles		2		0
Arrival Forecast: Night		2		0
Alternate Forecast: Wx ≤ 5mile vis		4		4
Enviroment Total*				12

***If Enviroment total score is ≥15 weather observer must be used.**

Grand Total	**27**
Go	≤23
Manager Approval	23-34
NO GO	>34

PIC Initials: ____________________

Operations				
2nd Survey Flt of the day (≥5.5 Hrs)		3		0
Late departure (after 5pm)		2		0
Reposition Flight		1		0
Max Endurance Survey Flight		3		3
Survey Altitude ≤ 500 ft		4		0
Offshore ≥ 50 miles		3		3
Circling on Target required		2		2
Near/Over Mountainous Terrain		2		0
New Survey Type		1		0
Slow Flight Required ≤ 115kts		3		3
Remote Fueling		2		0
Operations Total				11

Appendix Figure C2. -- Sample pre-flight Risk Assessment completed prior to every survey flight.

Safety is everyone's responsibility. Aerial survey team members are encouraged to ask questions or voice concerns if they notice any potential safety hazards. Any team member has the right to "call" (i.e., abort) a flight based on questionable weather conditions or other safety considerations.

Every survey flight will be satellite-tracked in real-time by the Automated Flight Following (AFF) system via SpiderTracks (Clearwater Air). AFF is software that automatically tracks the location and velocity of specially equipped aircraft, providing this information in near-real-time to dispatchers, aviation managers, and other authorized users. The equipment includes geolocation and data communication devices that use satellite-based technology. Clearwater Air Inc. and NSB DWM personnel will provide real-time flight following assistance to the project.

Aviation Safety Reporting

Clearwater has implemented an online Safety Management System for reporting any safety, security, quality, compliance, or environmental concerns that may arise during the season, which is accessible via a link on the Safety tab on Clearwater's webpage (www.clearwaterair.com). Clearwater management encourages NSB personnel to utilize this tool to address any aviation safety concerns. The link for reporting concerns can be found at http://clearwatersms.com/MySafety/PublicIssueReporting.aspx.

Survey personnel have been instructed that, in the event of an incident, hazard, maintenance, or airspace issue, Project Management should be informed immediately.

During a survey flight, if a safety orange object (e.g., life vest, raft, streamer) is sighted or if people are sighted and there is suspicion that they might be in distress (e.g., in the middle of nowhere, waving their arms; smoke signals), survey personnel are instructed to take the following steps:

1. Make a comment in the data to note the position and time of sighting, and include a brief description of what was seen. The pilots will also mark the position on their GPS and, if it is clear that it is an emergency, they will report the sighting to Flight Service.
2. Circle to try to get more information about whether it likely represents a genuine emergency. Descend to a lower altitude and take photographs to get a better look at the scene, if necessary.
3. If it is an emergency and people are in distress:
    a. Contact local Search and Rescue, who have an established protocol for dealing with these situations.
    b. If the survey aircraft has enough fuel to continue circling, do so. For as long as safety will allow, stay in visual contact with the people in order to update rescuers on the location and status of the emergency.
    c. Try to make contact via marine band radio.
4. DO NOT take any measures that would jeopardize the safety of the survey team.

Firearms

The survey project does not provide firearms and no personal observer firearms are allowed on the survey aircraft. Clearwater Air pilots may use their discretion regarding whether they bring personal firearms onto the plane. Some of the lodging facilities allow firearms but with special considerations or restrictions. Pilots will inquire prior to the field season as to firearms rules.

Ground Safety and Bear Awareness

The North Slope is home to two bear species, polar bears and brown bears. Awareness of their presence and behavior is important for personal safety. The survey team has bear deterrent air horns for carrying during survey flights or when on the ground. Situational awareness is the best form of defense. Field personnel has access to a Bear Awareness and Defense Training Manual on the survey laptops.

In Utqiaġvik, polar bear sightings are common along the beach and, on occasion, in town. While walking around town it is important to remain aware of surroundings and places to take cover, including flagging down anyone in a vehicle. The King Eider Inn managers usually hear the latest on if/where bears are present. If survey personnel think a bear has gone undocumented, they will report it to the local law enforcement authorities.

Brown bears are year-round residents in Deadhorse, and are frequently seen. Walking around Deadhorse is frowned upon, due to the bear presence, industrial activity, and truck traffic in the area. Polar bears are rarely sighted in Deadhorse, are far less habituated to human activity, and may be far more aggressive than resident brown bears. If survey personnel observe any bears anywhere in Deadhorse, they will immediately report the sighting to local law enforcement authorities.

Contact Information

Project Management maintains an updated list of emergency contact information for the team members participating in the surveys. Additional emergency contact information is provided in the master contact list, which is distributed to survey personnel.

APPENDIX D: GIS Projections

For Calculating Distance from Shore Values in the Access Database

For the Chukchi: "Central_Meridian", -163.0

PROJCS["Chukchi Equidistant Conic",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Equidistant_Conic"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-163.0],PARAMETER["Standard_Parallel_1",68.5],PARAMETER["Standard_Parallel_2",71.5],PARAMETER["Latitude_Of_Origin",70.0],UNIT["Meter",1.0]]

For the Beaufort: "Central_Meridian", -148.0

PROJCS["Beaufort Equidistant Conic",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Equidistant_Conic"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-148.0],PARAMETER["Standard_Parallel_1",70.5],PARAMETER["Standard_Parallel_2",71.5],PARAMETER["Latitude_Of_Origin",71.0],UNIT["Meter",1.0]]

For Calculating Distance from Shore Values in the Bowhead Whale Central Tendency – Analysis 2

All geospatial data are projected into an Equidistant Conic projection (false easting: 0.0; false northing: 0.0; central meridian: -148.0°; latitude of origin: 70.75°; standard parallels: 69.9°, 71.6°; linear unit: meter [1.0]).

Data Frames in the Annual Maps

Because this is just for cartographic purposes, Universal Transverse Mercator (UTM) is retained and has been used since 2007.
NAD_1983_UTM_Zone_5N
Authority: Custom
Projection: Transverse_Mercator
False_Easting: 500000.0
False_Northing: 0.0
Central_Meridian: -154.0
Scale_Factor: 0.9996
Latitude_Of_Origin: 70.0
Linear Unit: Meter (1.0)
Geographic Coordinate System: GCS_North_American_1983
Angular Unit: Degree (0.0174532925199433)
Prime Meridian: Greenwich (0.0)

Datum: D_North_American_1983
Spheroid: GRS_1980
Semimajor Axis: 6378137.0
Semiminor Axis: 6356752.314140356
Inverse Flattening: 298.257222101

Flightlines_19.Gdb\Fltln_Bygrid_Asaed

Flightlines are in a single feature class so have to be one projection. Therefore this equidistant conic covers the Chukchi Sea to Beaufort Sea.

PROJCS["Beaufort-Chukchi Equidistant Conic",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Equidistant_Conic"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-155.0],PARAMETER["Standard_Parallel_1",69.0],PARAMETER["Standard_Parallel_2",71.0],PARAMETER["Latitude_Of_Origin",70.0],UNIT["Meter",1.0]]

Miscellaneous Other Projection Info

When getting actual locations of sightings (XofWhale, YofWhale) the plane's location is projected to the UTM zone that it falls within before calculating direction and distance to actual location. The projection of the new location point is removed before writing the coordinates to the table.

APPENDIX E: 2021 Daily Flight Summaries

23 September 2021, Flight 1

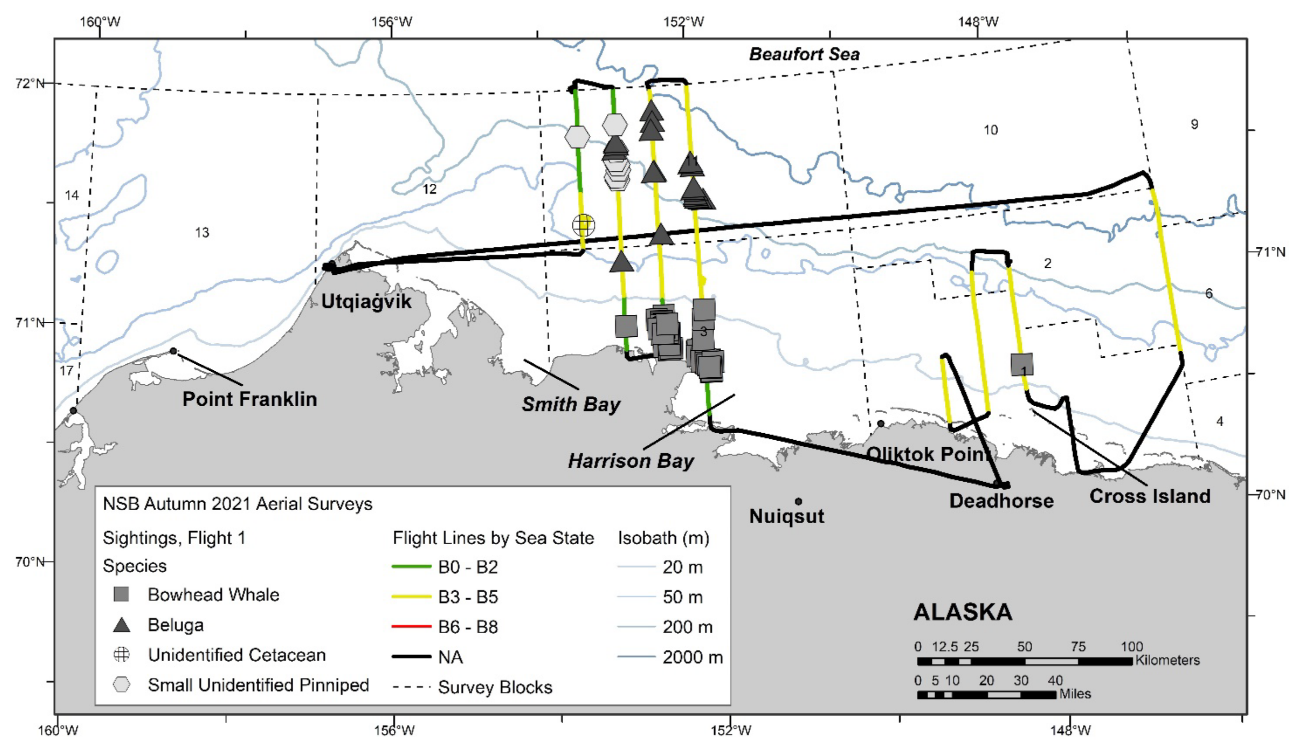
Flight was a complete survey of transects 125, 126, and 127 and a partial survey of transects 113, 117, 118, 119, and 128. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, ice on window, low ceilings, and precipitation, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including two calves), belugas, one unidentified cetacean, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
1	9/23/2021 11:17	70.685	148.009	bowhead whale	rest	2	1	1
1	9/23/2021 14:26	70.819	151.976	bowhead whale	.	1	0	3
1	9/23/2021 14:26	70.831	152.013	bowhead whale	.	1	0	3
1	9/23/2021 14:26	70.835	151.972	bowhead whale	.	1	0	3
1	9/23/2021 14:26	70.837	151.968	bowhead whale	.	1	0	3
1	9/23/2021 14:26	70.838	151.950	bowhead whale	.	1	0	3
1	9/23/2021 14:28	70.886	152.032	bowhead whale	.	1	0	3
1	9/23/2021 14:28	70.888	152.032	bowhead whale	.	1	0	3
1	9/23/2021 14:30	70.879	152.100	bowhead whale	feed	1	0	3
1	9/23/2021 14:30	70.885	152.095	bowhead whale	feed	1	0	3
1	9/23/2021 14:33	70.858	152.042	bowhead whale	feed	1	0	3
1	9/23/2021 14:35	70.861	152.108	bowhead whale	feed	1	0	3
1	9/23/2021 14:37	70.845	152.021	bowhead whale	feed	1	0	3
1	9/23/2021 14:37	70.852	152.044	bowhead whale	feed	1	0	3
1	9/23/2021 14:39	70.843	152.049	bowhead whale	feed	1	0	3
1	9/23/2021 14:41	70.838	152.054	bowhead whale	feed	1	0	3
1	9/23/2021 14:42	70.833	151.961	bowhead whale	feed	1	0	3
1	9/23/2021 14:42	70.835	151.960	bowhead whale	feed	4	0	3
1	9/23/2021 14:42	70.840	152.000	bowhead whale	feed	1	0	3
1	9/23/2021 14:43	70.828	151.998	bowhead whale	feed	1	0	3
1	9/23/2021 14:44	70.823	151.980	bowhead whale	feed	1	0	3
1	9/23/2021 14:44	70.822	151.978	bowhead whale	feed	1	0	3
1	9/23/2021 14:45	70.830	151.910	bowhead whale	feed	1	0	3
1	9/23/2021 14:49	70.791	151.948	bowhead whale	feed	2	0	3
1	9/23/2021 14:49	70.794	151.938	bowhead whale	feed	3	0	3
1	9/23/2021 14:51	70.807	151.938	bowhead whale	feed	1	0	3
1	9/23/2021 14:51	70.809	151.943	bowhead whale	feed	1	0	3
1	9/23/2021 14:51	70.809	151.959	bowhead whale	feed	1	0	3
1	9/23/2021 15:01	70.927	152.017	bowhead whale	swim	1	0	3

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
1	9/23/2021 15:05	71.011	151.999	bowhead whale	swim	1	0	3
1	9/23/2021 15:08	71.051	151.975	bowhead whale	swim	1	0	3
1	9/23/2021 15:28	71.516	151.884	beluga	unknown	3	0	11
1	9/23/2021 15:31	71.520	151.930	beluga	unknown	1	0	11
1	9/23/2021 15:31	71.524	151.974	beluga	swim	1	0	11
1	9/23/2021 15:31	71.532	151.985	beluga	swim	1	0	11
1	9/23/2021 15:31	71.538	151.990	beluga	swim	1	0	11
1	9/23/2021 15:32	71.553	151.976	beluga	swim	1	0	11
1	9/23/2021 15:32	71.560	152.017	beluga	swim	1	0	11
1	9/23/2021 15:32	71.569	152.001	beluga	rest	1	0	11
1	9/23/2021 15:35	71.658	152.003	beluga	swim	1	0	11
1	9/23/2021 15:36	71.670	152.032	beluga	swim	2	0	11
1	9/23/2021 15:36	71.675	152.020	beluga	swim	1	0	11
1	9/23/2021 15:54	71.901	152.495	beluga	swim	1	0	11
1	9/23/2021 15:55	71.854	152.495	beluga	swim	1	0	11
1	9/23/2021 15:56	71.819	152.518	beluga	unknown	1	0	11
1	9/23/2021 16:01	71.647	152.510	beluga	swim	1	0	11
1	9/23/2021 16:01	71.643	152.523	beluga	swim	1	0	11
1	9/23/2021 16:09	71.382	152.469	beluga	swim	2	0	11
1	9/23/2021 16:24	71.038	152.499	bowhead whale	log play	1	0	3
1	9/23/2021 16:24	71.023	152.592	bowhead whale	.	1	0	3
1	9/23/2021 16:25	71.015	152.528	bowhead whale	.	1	0	3
1	9/23/2021 16:25	71.012	152.534	bowhead whale	.	1	0	3
1	9/23/2021 16:25	71.005	152.530	bowhead whale	.	2	0	3
1	9/23/2021 16:25	71.000	152.503	bowhead whale	.	1	0	3
1	9/23/2021 16:25	70.998	152.536	bowhead whale	.	1	0	3
1	9/23/2021 16:26	70.961	152.547	bowhead whale	.	1	0	3
1	9/23/2021 16:27	70.938	152.500	bowhead whale	.	1	0	3
1	9/23/2021 16:27	70.938	152.497	bowhead whale	.	2	0	3
1	9/23/2021 16:27	70.929	152.497	bowhead whale	.	1	0	3
1	9/23/2021 16:27	70.909	152.523	bowhead whale	.	1	0	3
1	9/23/2021 16:28	70.908	152.454	bowhead whale	.	1	0	3
1	9/23/2021 16:28	70.905	152.462	bowhead whale	.	1	0	3
1	9/23/2021 16:30	70.898	152.421	bowhead whale	feed	1	0	3
1	9/23/2021 16:32	70.894	152.465	bowhead whale	feed	2	0	3
1	9/23/2021 16:32	70.895	152.465	bowhead whale	feed	1	0	3
1	9/23/2021 16:35	70.901	152.445	bowhead whale	feed	7	0	3
1	9/23/2021 16:35	70.914	152.452	bowhead whale	swim	1	0	3
1	9/23/2021 16:39	70.969	152.463	bowhead whale	swim	1	0	3

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
1	9/23/2021 16:40	70.962	152.441	bowhead whale	feed	1	0	3
1	9/23/2021 16:40	70.961	152.448	bowhead whale	feed	1	0	3
1	9/23/2021 16:40	70.961	152.454	bowhead whale	feed	1	0	3
1	9/23/2021 16:40	70.964	152.468	bowhead whale	feed	1	0	3
1	9/23/2021 16:43	70.991	152.484	bowhead whale	swim	2	1	3
1	9/23/2021 16:43	70.976	152.468	bowhead whale	swim	1	0	3
1	9/23/2021 16:45	70.986	152.509	bowhead whale	swim	1	0	3
1	9/23/2021 16:47	70.985	152.576	bowhead whale	swim	1	0	3
1	9/23/2021 16:50	70.962	152.526	bowhead whale	swim	3	0	3
1	9/23/2021 16:55	71.001	152.465	bowhead whale	swim	1	0	3
1	9/23/2021 17:08	71.002	152.992	bowhead whale	swim	1	0	3
1	9/23/2021 17:20	71.278	153.007	beluga	swim	1	0	3
1	9/23/2021 17:35	71.747	153.030	beluga	swim	1	0	11
1	9/23/2021 17:36	71.765	152.998	beluga	swim	1	0	11
1	9/23/2021 17:36	71.777	153.005	beluga	swim	1	0	11
1	9/23/2021 18:07	71.433	153.478	unid cetacean	unknown	1	0	11



Appendix Figure E1. -- Flight 1 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

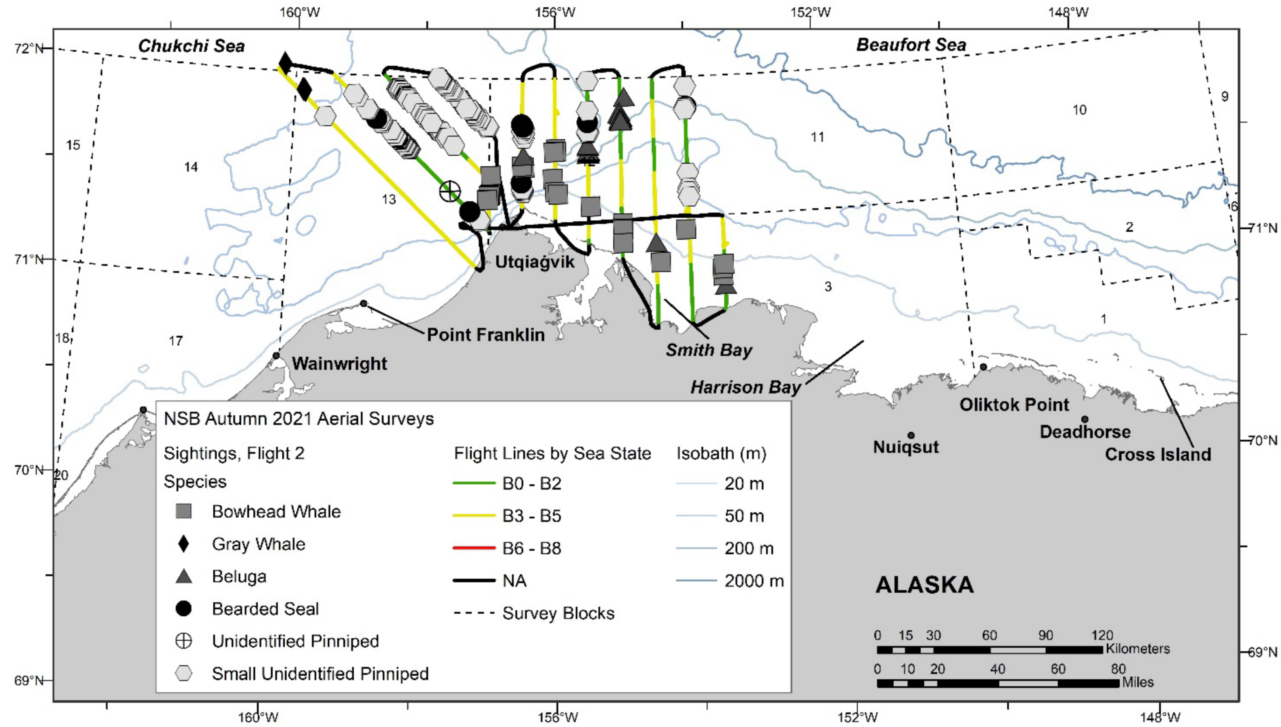
24 September 2021, Flight 2

Flight was a complete survey of transects 1, 2, 3, 4, 129, 130, 131, 133, and 134 and a partial survey of transects 128 and 132. Survey conditions included clear to overcast skies, 0 km to unlimited visibility, with glare, ice on the window, low ceilings, and precipitation, and Beaufort 1-4 sea states. Sea ice was 0-60% grease/new ice in the area surveyed. Sightings included bowhead whales (including four calves), gray whales, belugas (including one calf), bearded seals, one unidentified pinniped, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

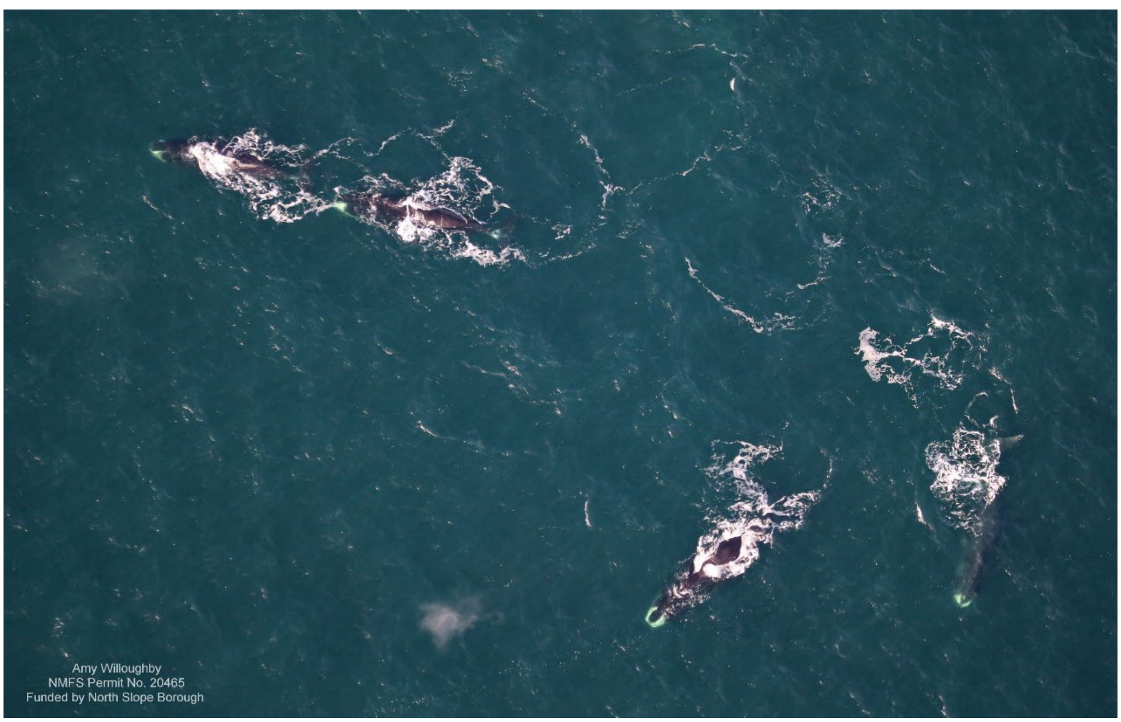
Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
2	9/24/2021 11:54	71.575	156.471	bowhead whale	unknown	1	0	12
2	9/24/2021 11:55	71.581	156.505	bowhead whale	swim	1	0	12
2	9/24/2021 12:01	71.632	156.487	beluga	swim	1	0	12
2	9/24/2021 12:29	71.664	155.991	bowhead whale	swim	1	1	12
2	9/24/2021 12:37	71.652	155.985	bowhead whale	swim	2	0	12
2	9/24/2021 12:37	71.649	156.023	bowhead whale	swim	6	1	12
2	9/24/2021 12:50	71.521	156.038	bowhead whale	rest	1	0	12
2	9/24/2021 12:55	71.458	156.007	bowhead whale	swim	1	0	12
2	9/24/2021 12:57	71.448	155.960	bowhead whale	swim	3	0	12
2	9/24/2021 13:15	71.387	155.472	bowhead whale	swim	1	0	12
2	9/24/2021 13:23	71.641	155.496	beluga	swim	1	0	12
2	9/24/2021 13:23	71.642	155.516	beluga	swim	1	0	12
2	9/24/2021 13:23	71.645	155.505	beluga	swim	1	0	12
2	9/24/2021 13:23	71.650	155.492	beluga	swim	1	0	12
2	9/24/2021 13:23	71.651	155.494	beluga	swim	1	0	12
2	9/24/2021 13:23	71.653	155.506	beluga	swim	2	0	12
2	9/24/2021 13:23	71.654	155.497	beluga	swim	1	0	12
2	9/24/2021 13:23	71.657	155.502	beluga	swim	1	0	12
2	9/24/2021 13:24	71.678	155.513	beluga	swim	1	0	12
2	9/24/2021 13:24	71.684	155.517	beluga	swim	1	0	12
2	9/24/2021 13:41	71.911	154.946	beluga	swim	2	0	12
2	9/24/2021 13:43	71.840	155.019	beluga	swim	2	0	12
2	9/24/2021 13:43	71.835	155.037	beluga	swim	1	0	12
2	9/24/2021 13:44	71.828	155.022	beluga	swim	1	0	12
2	9/24/2021 13:44	71.815	154.992	beluga	swim	1	0	12
2	9/24/2021 13:44	71.812	154.994	beluga	swim	1	0	12
2	9/24/2021 13:44	71.808	155.018	beluga	swim	1	0	12
2	9/24/2021 13:44	71.806	155.015	beluga	swim	1	0	12
2	9/24/2021 13:45	71.801	155.024	beluga	swim	10	0	12
2	9/24/2021 13:45	71.800	155.003	beluga	swim	3	0	12
2	9/24/2021 13:45	71.800	154.990	beluga	swim	1	0	12

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
2	9/24/2021 13:45	71.799	155.004	beluga	swim	1	0	12
2	9/24/2021 13:45	71.797	155.004	beluga	swim	1	0	12
2	9/24/2021 13:59	71.305	154.989	bowhead whale	swim	1	0	12
2	9/24/2021 14:02	71.280	154.993	bowhead whale	swim	1	0	12
2	9/24/2021 14:03	71.275	154.996	bowhead whale	swim	1	0	12
2	9/24/2021 14:07	71.211	154.997	bowhead whale	swim	1	0	12
2	9/24/2021 14:27	71.115	154.443	bowhead whale	rest	2	1	12
2	9/24/2021 14:36	71.213	154.506	beluga	swim	10	1	12
2	9/24/2021 15:30	71.268	154.055	bowhead whale	mill	10	1	12
2	9/24/2021 16:00	70.999	153.503	beluga	swim	2	0	3
2	9/24/2021 16:01	71.041	153.533	bowhead whale	log play	1	0	3
2	9/24/2021 16:06	71.074	153.536	bowhead whale	unknown	2	0	3
2	9/24/2021 16:06	71.095	153.511	bowhead whale	swim	1	0	3
2	9/24/2021 18:51	71.534	156.974	bowhead whale	swim	1	0	12
2	9/24/2021 18:55	71.447	156.972	bowhead whale	swim	1	0	12
2	9/24/2021 18:56	71.444	156.988	bowhead whale	SAG	3	0	12
2	9/24/2021 18:56	71.440	156.991	bowhead whale	swim	1	0	12
2	9/24/2021 18:56	71.438	157.002	bowhead whale	swim	2	0	13
2	9/24/2021 19:02	71.420	157.030	bowhead whale	swim	1	0	13
2	9/24/2021 19:02	71.419	157.020	bowhead whale	mill	3	0	13
2	9/24/2021 19:47	72.034	160.182	gray whale	swim	1	0	0
2	9/24/2021 19:55	71.914	159.856	gray whale	swim	2	0	13
2	9/24/2021 19:57	71.917	159.882	gray whale	swim	1	0	13



Appendix Figure E2. -- Flight 2 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Despite so much white water this bowhead whale cow's entanglement scarred peduncle did not go unnoticed. The mom-calf pair was sighted in a group of 10 whales, approximately 35 km north of Smith Bay, Alaska, on flight 2, 24 September 2021.



Four bowhead whales who were part of a group of 10 whales sighted together approximately 35 km north of Smith Bay, Alaska, on Flight 2, 24 September 2021.

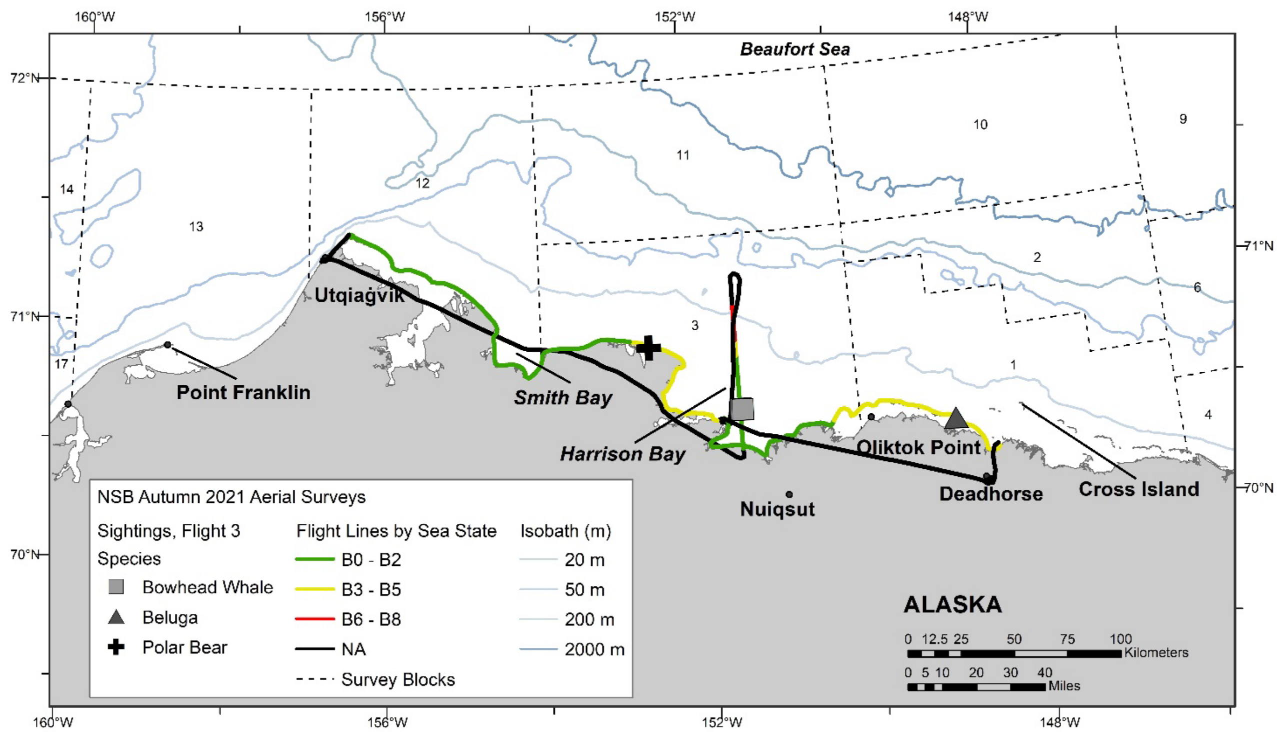
A young bowhead whale lifts a log out of the water with its head and shoulder. The behavior is referred to as "log play" and the log is likely used for rubbing the skin. This whale and the log play behavior was observed approximately 20 km northeast of Smith Bay, Alaska, on Flight 2, 24 September 2021.

25 September 2021, Flight 3

Flight was a partial survey of transect 124 and a partial coastal transect from Deadhorse to Point Barrow. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with ice on window, low ceilings, and precipitation, and Beaufort 1-6 sea states. Sea ice was 0-90% grease/new and broken floe ice in the area surveyed. Sightings included bowhead whales (including one carcass), one beluga, and one polar bear. The bowhead whale carcass was sighted in the swash zone approximately 50 km east of Smith Bay, Alaska. The polar bear was sighted at the bowhead whale carcass.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude °N	Longitude °W	Species	Behavior	Group Size	Calf No.	Block
3	9/25/2021 11:56	70.594	151.492	bowhead whale	swim	1	0	3
3	9/25/2021 11:58	70.591	151.473	bowhead whale	rest	2	0	3
3	9/25/2021 13:15	70.468	148.798	beluga	swim	1	0	1
3	9/25/2021 15:26	70.877	152.633	bowhead whale	dead	1	0	3
3	9/25/2021 15:31	70.877	152.621	polar bear	walk	1	0	3



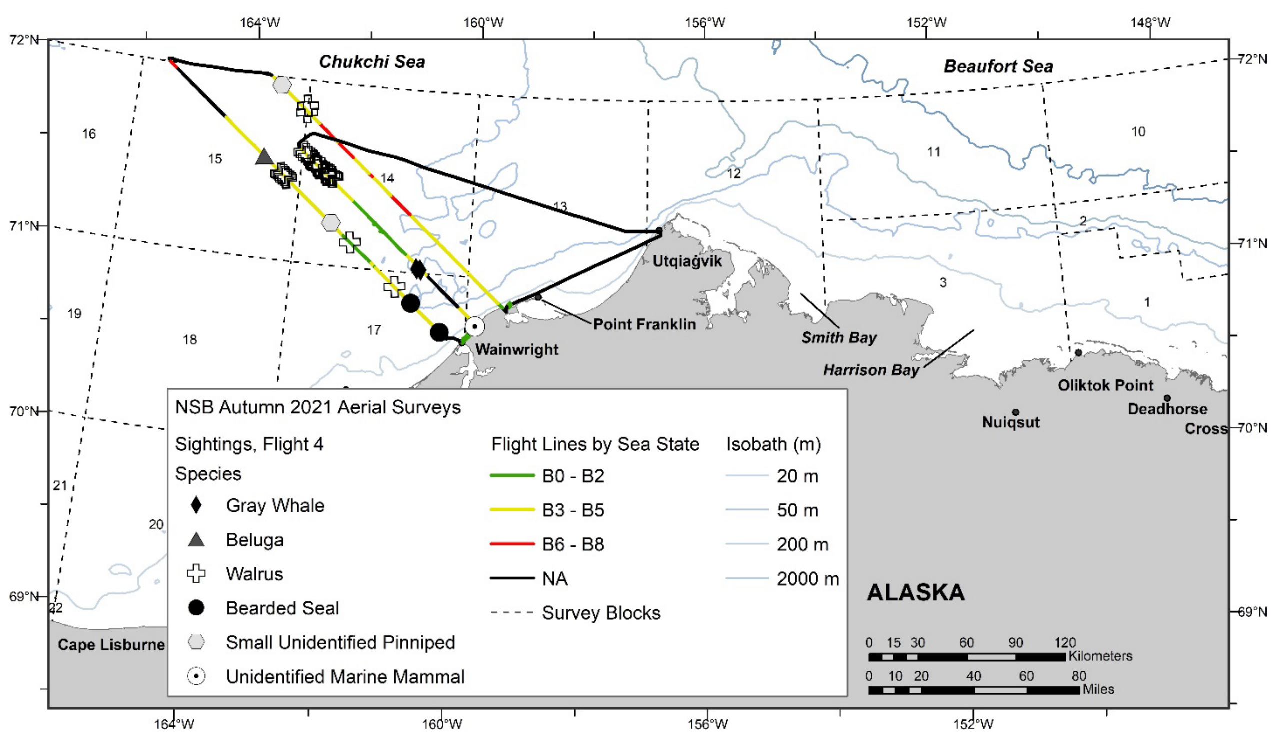
Appendix Figure E3. -- Flight 3 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

26 September 2021, Flight 4

Flight was a complete survey of transect 8 and a partial survey of transects 9 and 10. Survey conditions included clear to overcast skies, <1 km to unlimited visibility, with fog, glare, ice on the window, low ceilings, and precipitation, and Beaufort 2-6 sea states. Sea ice was 0-40% broken floe ice in the area surveyed. Sightings included gray whales (including one carcass), one beluga, one unidentified cetacean carcass, walruses, bearded seals, small unidentified pinnipeds, and one unidentified marine mammal carcass. The gray whale carcass was beached ~20 km to the southwest of Point Franklin. The unidentified cetacean carcass was beached ~3 km northeast of Wainwright, Alaska. The unidentified marine mammal was the remains of a polar bear kill site on a piece of broken floe sea ice ~90 km northwest of Wainwright, Alaska.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
4	9/26/2021 11:57	70.860	159.260	gray whale	dead	1	0	13
4	9/26/2021 13:22	71.558	163.667	beluga	swim	1	0	15
4	9/26/2021 14:08	70.660	159.990	unid cetacean	dead	1	0	13
4	9/26/2021 14:32	71.020	160.814	gray whale	swim	1	0	14
4	9/26/2021 14:33	71.025	160.882	gray whale	feed	1	0	14



Appendix Figure E4. -- Flight 4 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

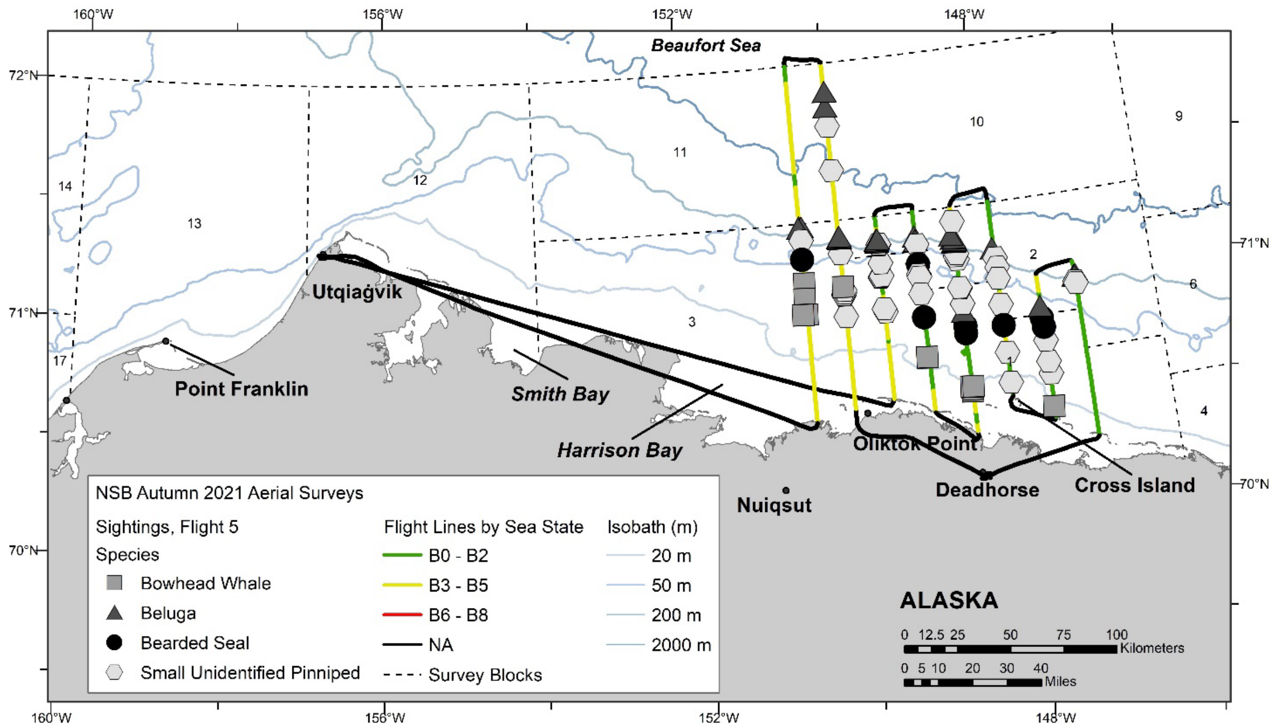
27 September 2021, Flight 5

Flight was a complete survey of transects 117, 118, 119, 120, 121, and 122 and a partial survey of transects 115 and 116. Survey conditions included overcast skies, <1 km to unlimited visibility, with ice on the window, low ceilings, and precipitation, and Beaufort 2-4 sea states. Sea ice was 0-30% grease/new ice in the area surveyed. Sightings included bowhead whales (including four calves), belugas, bearded seals, and small unidentified pinnipeds.

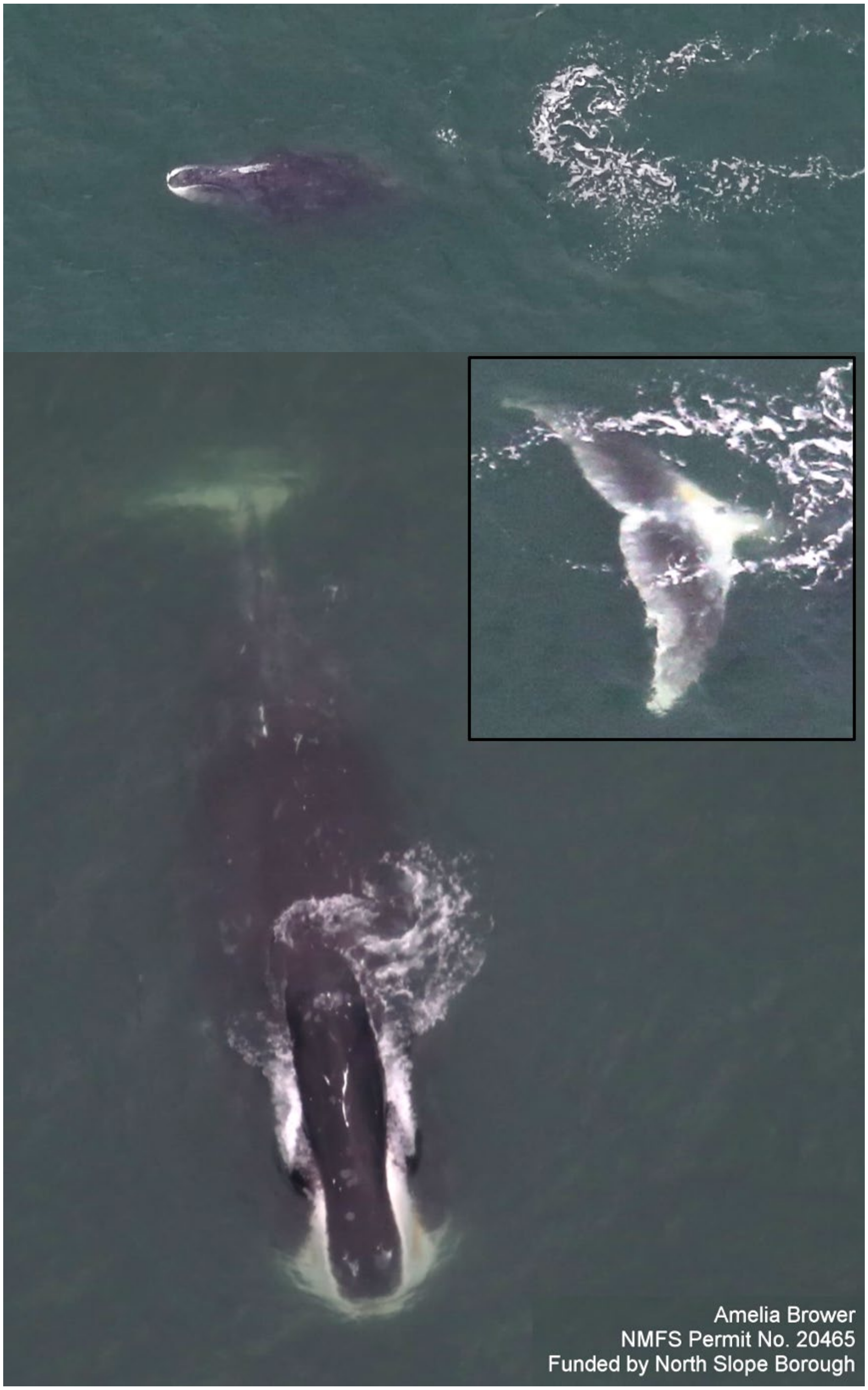
Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
5	9/27/2021 13:22	71.223	149.517	beluga	swim	1	0	2
5	9/27/2021 13:23	71.228	149.512	beluga	swim	2	0	2
5	9/27/2021 13:23	71.232	149.522	beluga	swim	1	0	2
5	9/27/2021 13:23	71.237	149.501	beluga	swim	1	0	2
5	9/27/2021 13:34	71.231	149.014	beluga	rest	1	0	2
5	9/27/2021 13:34	71.213	149.007	beluga	swim	3	0	2
5	9/27/2021 13:49	70.716	149.031	bowhead whale	swim	1	0	1
5	9/27/2021 13:56	70.718	149.031	bowhead whale	swim	2	1	1
5	9/27/2021 14:18	70.551	148.510	bowhead whale	mill	2	0	1
5	9/27/2021 14:18	70.560	148.509	bowhead whale	swim	1	0	1
5	9/27/2021 14:23	70.570	148.512	bowhead whale	mill	4	0	1
5	9/27/2021 14:23	70.571	148.521	bowhead whale	swim	3	1	1
5	9/27/2021 14:23	70.572	148.491	bowhead whale	swim	2	0	1
5	9/27/2021 14:46	70.892	148.499	beluga	rest	2	0	1
5	9/27/2021 14:55	71.186	148.514	beluga	swim	15	0	2
5	9/27/2021 14:55	71.187	148.516	beluga	swim	1	0	2
5	9/27/2021 14:55	71.188	148.510	beluga	swim	1	0	2
5	9/27/2021 14:55	71.191	148.499	beluga	swim	2	0	2
5	9/27/2021 14:55	71.194	148.499	beluga	swim	1	0	2
5	9/27/2021 14:55	71.202	148.527	beluga	swim	17	0	2
5	9/27/2021 14:55	71.203	148.501	beluga	swim	2	0	2
5	9/27/2021 14:56	71.217	148.541	beluga	swim	1	0	2
5	9/27/2021 15:11	71.139	148.025	beluga	rest	2	0	2
5	9/27/2021 15:37	70.443	147.515	bowhead whale	swim	1	0	1
5	9/27/2021 15:51	70.871	147.511	beluga	swim	5	0	2
5	9/27/2021 16:02	70.981	147.000	beluga	swim	1	0	2
5	9/27/2021 16:02	70.977	147.021	beluga	swim	1	0	2
5	9/27/2021 16:02	70.975	147.015	beluga	swim	1	0	2
5	9/27/2021 18:00	71.052	150.009	bowhead whale	swim	2	1	3
5	9/27/2021 18:12	71.256	149.997	beluga	rest	1	0	2
5	9/27/2021 18:12	71.259	150.011	beluga	swim	3	0	3
5	9/27/2021 18:12	71.260	149.999	beluga	rest	1	0	2

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
5	9/27/2021 18:13	71.265	149.995	beluga	swim	1	0	2
5	9/27/2021 18:30	71.816	150.009	beluga	swim	1	0	11
5	9/27/2021 18:32	71.880	149.997	beluga	rest	1	0	10
5	9/27/2021 19:00	71.321	150.508	beluga	swim	5	0	3
5	9/27/2021 19:00	71.319	150.480	beluga	swim	1	0	3
5	9/27/2021 19:00	71.316	150.519	beluga	swim	1	0	3
5	9/27/2021 19:07	71.082	150.508	bowhead whale	swim	1	0	3
5	9/27/2021 19:11	71.016	150.522	bowhead whale	swim	1	0	3
5	9/27/2021 19:14	70.949	150.506	bowhead whale	swim	2	1	3
5	9/27/2021 19:16	70.949	150.562	bowhead whale	swim	1	0	3



Appendix Figure E5. -- Flight 5 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.



Bowhead whale mom-calf pair, sighted approximately 50 km northwest of Cross Island, Alaska, on Flight 5, 27 September 2021. The calf is in the top photo, and the mom is in the bottom photo. This calving female was matched by Barbara Tudor to a sighting in 1985 making this 36-year inter-annual match the longest recapture known to date (match was confirmed by D. Rugh and B. Koski; Pers. comm., Craig George, 2 October 2021).

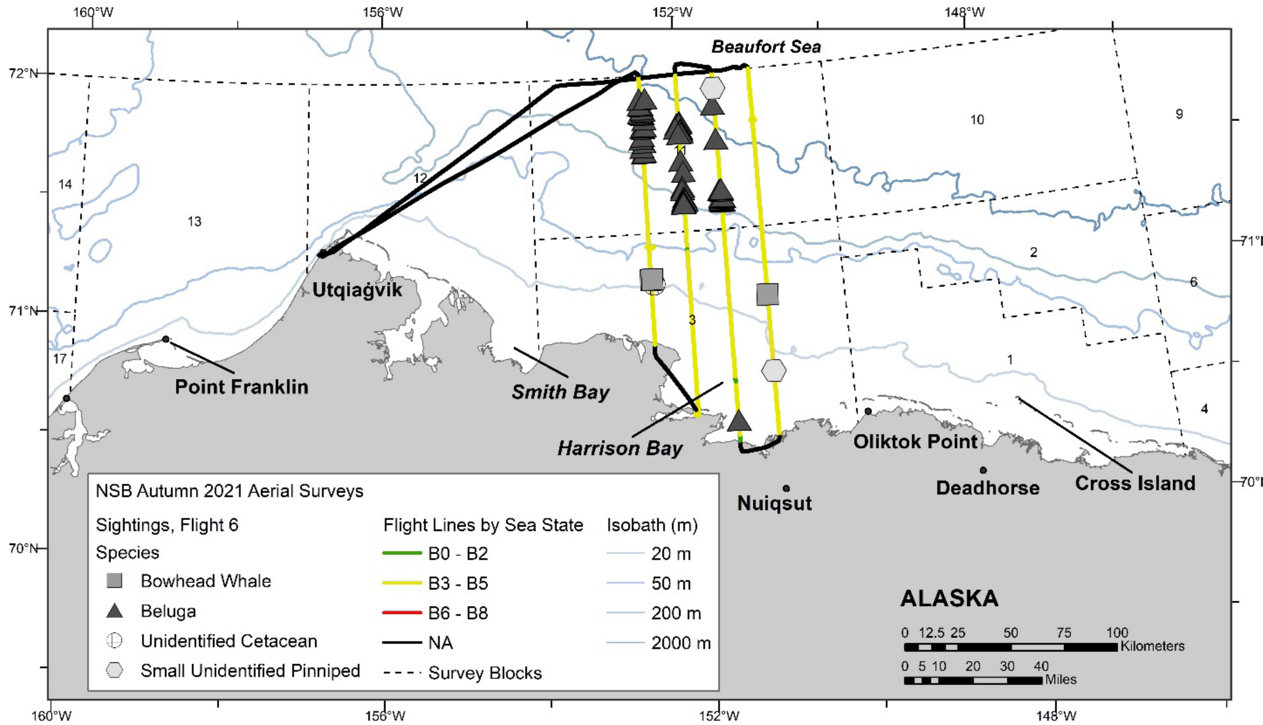
28 September 2021, Flight 6

Flight was a complete survey of transects 123, 124, 125, and 126. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, ice on the window, low ceilings, and precipitation, and Beaufort 1-5 sea states. Sea ice was 0-50% grease/new ice in the area surveyed. Sightings included bowhead whales (including two calves), belugas (including three calves and one carcass), unidentified cetaceans (including one carcass) and small unidentified pinnipeds. The beluga carcass was sighted approximately 155 km north of Harrison Bay, Alaska. The unidentified cetacean carcass was sighted approximately 80 km northeast of Smith Bay, Alaska.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude °N	Longitude °W	Species	Behavior	Group Size	Calf No.	Block
6	9/28/2021 13:58	71.782	151.011	beluga	dead	1	0	11
6	9/28/2021 14:22	71.042	151.004	bowhead whale	swim	2	1	3
6	9/28/2021 14:54	70.524	151.501	beluga	swim	1	0	3
6	9/28/2021 15:23	71.450	151.486	beluga	swim	1	0	11
6	9/28/2021 15:23	71.451	151.493	beluga	swim	1	1	11
6	9/28/2021 15:23	71.453	151.504	beluga	swim	1	0	11
6	9/28/2021 15:23	71.454	151.490	beluga	swim	3	0	11
6	9/28/2021 15:23	71.457	151.512	beluga	swim	1	0	11
6	9/28/2021 15:23	71.459	151.511	beluga	swim	1	0	11
6	9/28/2021 15:23	71.464	151.512	beluga	swim	1	0	11
6	9/28/2021 15:23	71.464	151.473	beluga	swim	1	0	11
6	9/28/2021 15:23	71.469	151.517	beluga	swim	1	0	11
6	9/28/2021 15:24	71.471	151.487	beluga	swim	1	0	11
6	9/28/2021 15:24	71.494	151.494	beluga	swim	1	0	11
6	9/28/2021 15:24	71.500	151.522	beluga	swim	2	0	11
6	9/28/2021 15:25	71.502	151.498	beluga	swim	1	0	11
6	9/28/2021 15:31	71.716	151.519	beluga	swim	1	0	11
6	9/28/2021 15:36	71.862	151.528	beluga	swim	1	0	11
6	9/28/2021 15:51	71.797	151.989	beluga	swim	1	0	11
6	9/28/2021 15:51	71.793	151.986	beluga	swim	1	0	11
6	9/28/2021 15:51	71.788	152.028	beluga	swim	1	0	11
6	9/28/2021 15:51	71.788	152.016	beluga	swim	1	0	11
6	9/28/2021 15:51	71.787	151.997	beluga	swim	1	0	11
6	9/28/2021 15:51	71.772	152.049	beluga	swim	1	0	11
6	9/28/2021 15:52	71.765	151.980	beluga	swim	1	0	11
6	9/28/2021 15:52	71.760	151.983	beluga	swim	1	0	11
6	9/28/2021 15:52	71.749	151.977	beluga	swim	1	0	11
6	9/28/2021 15:52	71.749	152.012	beluga	swim	1	0	11
6	9/28/2021 15:55	71.634	152.009	beluga	swim	1	0	11
6	9/28/2021 15:57	71.587	151.985	beluga	swim	1	0	11

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
6	9/28/2021 15:59	71.522	152.008	beluga	swim	1	0	11
6	9/28/2021 15:59	71.511	152.013	beluga	swim	2	1	11
6	9/28/2021 16:00	71.479	151.995	beluga	swim	1	0	11
6	9/28/2021 16:00	71.472	151.986	beluga	swim	1	0	11
6	9/28/2021 16:00	71.470	152.001	beluga	swim	1	0	11
6	9/28/2021 16:00	71.462	151.977	beluga	swim	1	0	11
6	9/28/2021 16:00	71.462	152.011	beluga	swim	1	0	11
6	9/28/2021 16:00	71.462	152.003	beluga	swim	1	0	11
6	9/28/2021 16:01	71.457	151.997	beluga	swim	4	0	11
6	9/28/2021 16:01	71.456	152.003	beluga	swim	1	0	11
6	9/28/2021 16:01	71.455	152.015	beluga	swim	2	0	11
6	9/28/2021 16:01	71.453	152.008	beluga	swim	3	0	11
6	9/28/2021 16:45	71.120	152.465	unid cetacean	swim	1	0	3
6	9/28/2021 16:49	71.140	152.504	bowhead whale	swim	2	1	3
6	9/28/2021 16:49	71.141	152.486	bowhead whale	swim	1	0	3
6	9/28/2021 17:00	71.272	152.448	unid cetacean	dead	1	0	3
6	9/28/2021 17:16	71.676	152.505	beluga	swim	2	1	11
6	9/28/2021 17:17	71.679	152.488	beluga	swim	3	0	11
6	9/28/2021 17:17	71.700	152.519	beluga	swim	1	0	11
6	9/28/2021 17:18	71.720	152.485	beluga	swim	1	0	11
6	9/28/2021 17:18	71.736	152.521	beluga	swim	1	0	11
6	9/28/2021 17:19	71.747	152.502	beluga	swim	1	0	11
6	9/28/2021 17:20	71.779	152.487	beluga	swim	1	0	11
6	9/28/2021 17:20	71.785	152.501	beluga	swim	1	0	11
6	9/28/2021 17:20	71.788	152.471	beluga	swim	1	0	11
6	9/28/2021 17:21	71.818	152.468	beluga	swim	1	0	11
6	9/28/2021 17:22	71.838	152.485	beluga	swim	1	0	11
6	9/28/2021 17:22	71.842	152.502	beluga	swim	1	0	11
6	9/28/2021 17:22	71.842	152.502	beluga	swim	1	0	11
6	9/28/2021 17:22	71.848	152.521	beluga	swim	1	0	11
6	9/28/2021 17:22	71.853	152.472	beluga	swim	3	0	11
6	9/28/2021 17:22	71.861	152.491	beluga	swim	1	0	11
6	9/28/2021 17:23	71.875	152.493	beluga	swim	1	0	11
6	9/28/2021 17:23	71.879	152.519	beluga	swim	1	0	11
6	9/28/2021 17:24	71.903	152.516	beluga	swim	1	0	11
6	9/28/2021 17:24	71.904	152.437	beluga	swim	3	0	11



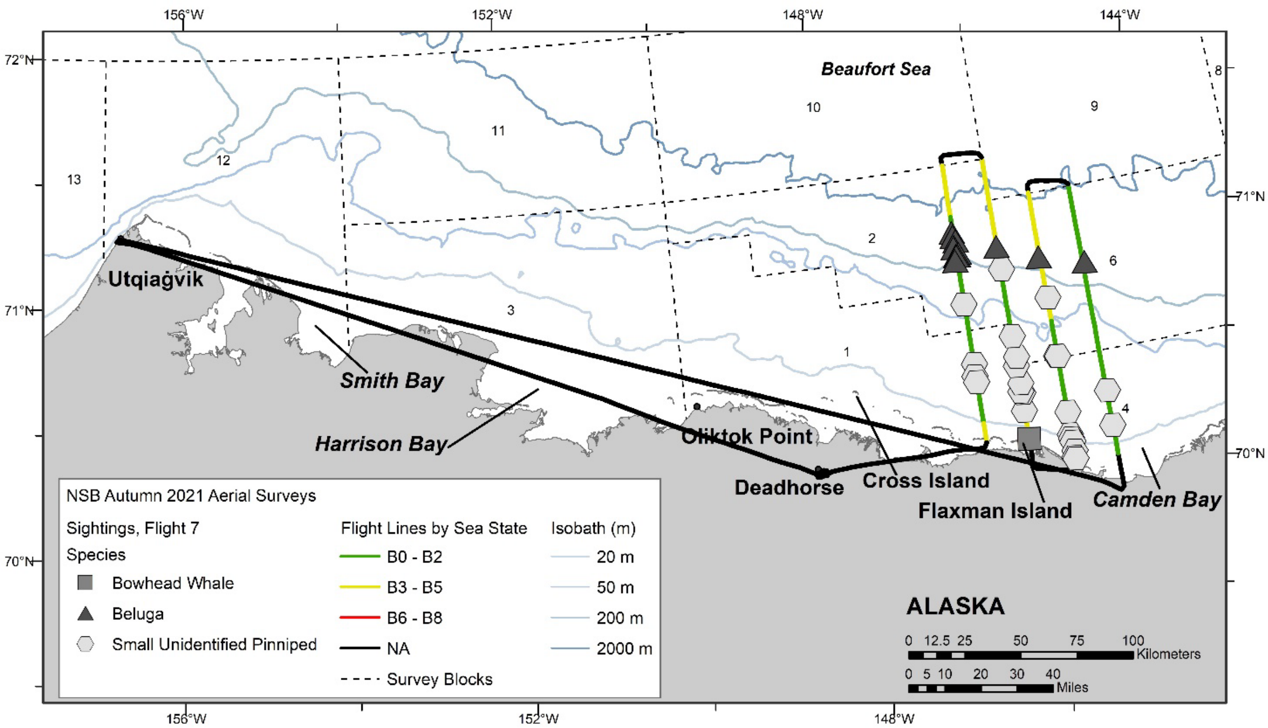
Appendix Figure E6. -- Flight 6 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

30 September 2021, Flight 7

Flight was a complete survey of transects 111, 112, 113, and 114. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, ice on window, low ceilings, and precipitation, and Beaufort 1-3 sea states. Sea ice was 0-80% new and broken floe ice in the area surveyed. Sightings included one bowhead whale, belugas, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude °N	Longitude °W	Species	Behavior	Group Size	Calf No.	Block
7	9/30/2021 13:55	70.859	144.981	beluga	swim	1	0	6
7	9/30/2021 14:17	70.910	145.522	beluga	swim	1	0	6
7	9/30/2021 14:48	70.202	146.003	bowhead whale	swim	1	0	1
7	9/30/2021 15:14	70.980	146.007	beluga	swim	1	0	2
7	9/30/2021 15:38	71.064	146.520	beluga	swim	1	0	2
7	9/30/2021 15:39	71.048	146.515	beluga	swim	4	0	2
7	9/30/2021 15:39	71.029	146.490	beluga	swim	1	0	2
7	9/30/2021 15:40	71.006	146.516	beluga	swim	1	0	2
7	9/30/2021 15:40	71.002	146.527	beluga	swim	1	0	2
7	9/30/2021 15:41	70.977	146.478	beluga	swim	1	0	2
7	9/30/2021 15:41	70.971	146.512	beluga	swim	1	0	2
7	9/30/2021 15:41	70.969	146.492	beluga	swim	1	0	2
7	9/30/2021 15:41	70.967	146.508	beluga	swim	1	0	2
7	9/30/2021 15:42	70.950	146.532	beluga	swim	1	0	2



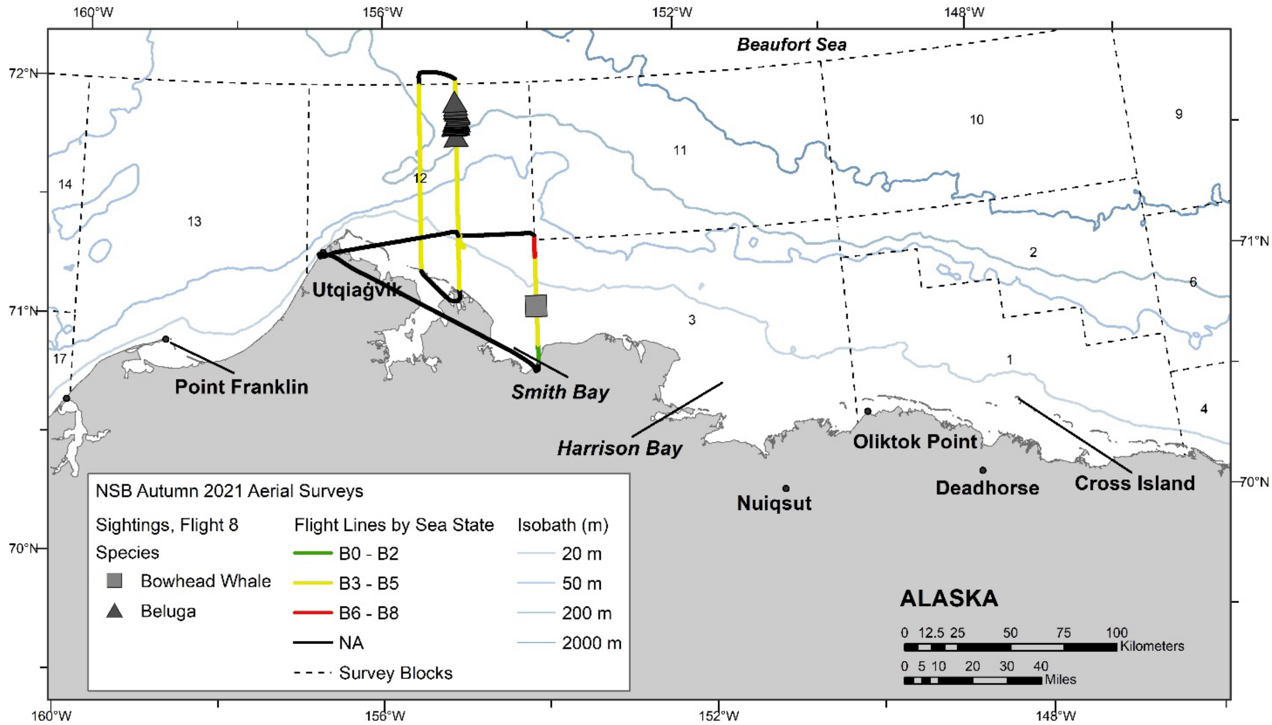
Appendix Figure E7. -- Flight 7 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

3 October 2021, Flight 8

Flight was a complete survey of transects 131 and 132 and a partial survey of transect 129. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with glare, ice on the window, low ceilings, and precipitation, and Beaufort 1-6 sea states. Sea ice was 0-15% grease/new ice in the area surveyed. Sightings included bowhead whales (including one carcass) and belugas (including three calves). The bowhead whale carcass was approximately 50 km east of Point Barrow, Alaska.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
8	10/3/2021 16:04	71.053	154.013	bowhead whale	swim	1	0	12
8	10/3/2021 16:23	71.353	155.007	bowhead whale	dead	1	0	12
8	10/3/2021 16:43	71.780	155.012	beluga	swim	1	0	12
8	10/3/2021 16:44	71.825	155.028	beluga	swim	1	0	12
8	10/3/2021 16:44	71.826	155.043	beluga	swim	1	0	12
8	10/3/2021 16:44	71.828	154.989	beluga	swim	1	0	12
8	10/3/2021 16:44	71.830	155.010	beluga	swim	1	0	12
8	10/3/2021 16:44	71.834	154.991	beluga	swim	1	0	12
8	10/3/2021 16:44	71.834	155.018	beluga	swim	2	0	12
8	10/3/2021 16:44	71.840	154.999	beluga	swim	1	0	12
8	10/3/2021 16:45	71.842	155.016	beluga	swim	3	0	12
8	10/3/2021 16:45	71.843	154.979	beluga	mill	9	2	12
8	10/3/2021 16:45	71.846	155.023	beluga	swim	1	0	12
8	10/3/2021 16:45	71.847	154.995	beluga	swim	1	0	12
8	10/3/2021 16:45	71.849	154.999	beluga	swim	2	1	12
8	10/3/2021 16:45	71.851	155.016	beluga	swim	9	0	12
8	10/3/2021 16:45	71.852	154.985	beluga	swim	1	0	12
8	10/3/2021 16:45	71.853	154.991	beluga	swim	1	0	12
8	10/3/2021 16:45	71.855	154.994	beluga	swim	1	0	12
8	10/3/2021 16:45	71.860	155.001	beluga	swim	3	0	12
8	10/3/2021 16:45	71.862	155.001	beluga	swim	1	0	12
8	10/3/2021 16:45	71.871	154.979	beluga	swim	1	0	12
8	10/3/2021 16:46	71.880	154.979	beluga	swim	1	0	12
8	10/3/2021 16:46	71.889	154.998	beluga	swim	1	0	12
8	10/3/2021 16:46	71.895	155.007	beluga	swim	1	0	12
8	10/3/2021 16:46	71.899	155.012	beluga	swim	2	0	12
8	10/3/2021 16:47	71.912	155.009	beluga	swim	1	0	12
8	10/3/2021 16:47	71.926	155.020	beluga	swim	2	0	12



Appendix Figure E8. -- Flight 8 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

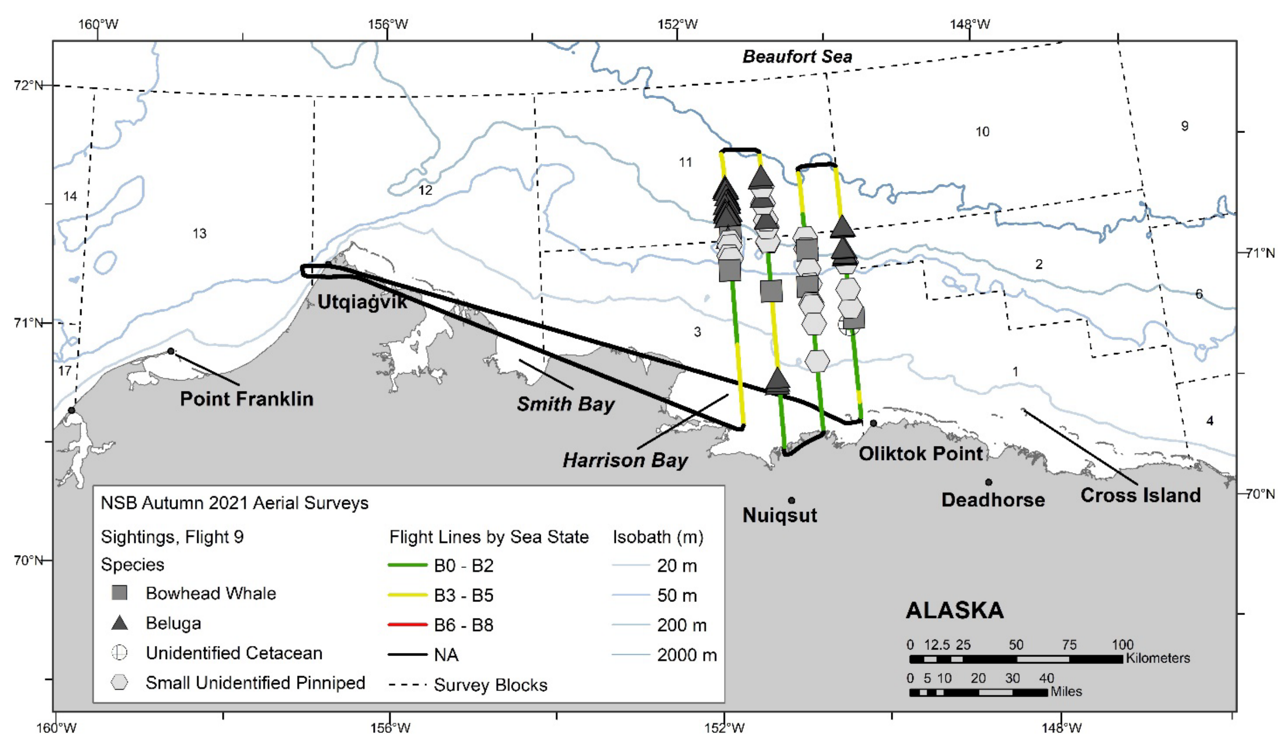
6 October 2021, Flight 9

Flight was a partial survey of transects 121, 122, 123, and 124. Survey conditions included partly cloudy to overcast skies, 1 km to unlimited visibility, with glare and low ceilings, and Beaufort 0-4 sea states. Sea ice was 0-95% grease/new ice in the area surveyed. Sightings included bowhead whales (including two calves), belugas, one unidentified cetacean, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude °N	Longitude °W	Species	Behavior	Group Size	Calf No.	Block
9	10/6/2021 14:38	70.935	150.036	unid cetacean	unknown	1	0	3
9	10/6/2021 14:44	70.962	149.973	bowhead whale	swim	1	0	1
9	10/6/2021 14:55	71.231	150.010	beluga	swim	1	0	3
9	10/6/2021 14:55	71.231	150.012	beluga	swim	1	0	3
9	10/6/2021 14:56	71.235	150.001	beluga	swim	2	0	3
9	10/6/2021 14:56	71.239	150.001	beluga	swim	3	0	3
9	10/6/2021 14:56	71.239	150.008	beluga	swim	1	0	3
9	10/6/2021 14:56	71.259	150.010	beluga	swim	1	0	3
9	10/6/2021 14:56	71.259	149.996	beluga	swim	1	0	2
9	10/6/2021 14:56	71.264	150.019	beluga	swim	1	0	3
9	10/6/2021 14:59	71.348	150.005	beluga	swim	2	0	11
9	10/6/2021 14:59	71.352	149.986	beluga	swim	1	0	10
9	10/6/2021 14:59	71.356	149.996	beluga	swim	1	0	10
9	10/6/2021 15:20	71.265	150.490	bowhead whale	mill	2	1	3
9	10/6/2021 15:36	71.111	150.531	bowhead whale	swim	1	0	3
9	10/6/2021 16:10	70.715	151.033	beluga	swim	1	0	3
9	10/6/2021 16:10	70.726	151.025	beluga	swim	1	0	3
9	10/6/2021 16:10	70.742	151.019	beluga	swim	1	0	3
9	10/6/2021 16:22	71.106	151.005	bowhead whale	mill	2	0	3
9	10/6/2021 16:38	71.416	150.991	beluga	swim	3	0	11
9	10/6/2021 16:41	71.508	151.023	beluga	swim	3	0	11
9	10/6/2021 16:43	71.587	151.024	beluga	swim	1	0	11
9	10/6/2021 16:43	71.598	151.006	beluga	swim	1	0	11
9	10/6/2021 16:54	71.566	151.499	beluga	swim	1	0	11
9	10/6/2021 16:54	71.560	151.493	beluga	swim	1	0	11
9	10/6/2021 16:54	71.560	151.506	beluga	swim	2	0	11
9	10/6/2021 16:54	71.557	151.492	beluga	swim	1	0	11
9	10/6/2021 16:54	71.554	151.488	beluga	swim	1	0	11
9	10/6/2021 16:55	71.552	151.482	beluga	swim	1	0	11
9	10/6/2021 16:55	71.550	151.499	beluga	swim	1	0	11
9	10/6/2021 16:55	71.529	151.490	beluga	swim	1	0	11
9	10/6/2021 16:56	71.508	151.470	beluga	swim	1	0	11

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
9	10/6/2021 16:56	71.507	151.477	beluga	swim	1	0	11
9	10/6/2021 16:56	71.505	151.493	beluga	swim	1	0	11
9	10/6/2021 16:56	71.493	151.473	beluga	swim	1	0	11
9	10/6/2021 16:56	71.492	151.480	beluga	swim	1	0	11
9	10/6/2021 16:56	71.491	151.520	beluga	swim	1	0	11
9	10/6/2021 16:57	71.468	151.523	beluga	swim	1	0	11
9	10/6/2021 16:57	71.463	151.515	beluga	swim	1	0	11
9	10/6/2021 16:57	71.459	151.474	beluga	swim	1	0	11
9	10/6/2021 16:57	71.457	151.460	beluga	swim	1	0	11
9	10/6/2021 16:58	71.456	151.483	beluga	swim	1	0	11
9	10/6/2021 16:58	71.455	151.520	beluga	swim	1	0	11
9	10/6/2021 16:58	71.453	151.483	beluga	swim	1	0	11
9	10/6/2021 16:58	71.451	151.494	beluga	swim	1	0	11
9	10/6/2021 16:58	71.444	151.477	beluga	swim	1	0	11
9	10/6/2021 16:58	71.435	151.516	beluga	swim	1	0	11
9	10/6/2021 17:01	71.357	151.504	beluga	swim	1	0	11
9	10/6/2021 17:01	71.350	151.481	bowhead whale	unknown	1	0	11
9	10/6/2021 17:03	71.348	151.511	beluga	swim	1	0	11
9	10/6/2021 17:12	71.209	151.523	bowhead whale	rest	2	1	3



Appendix Figure E9. -- Flight 9 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Bowhead whale mom-calf pair sighted approximately 80 km north of Harrison Bay, Alaska, on Flight 9, 6 October 2021. In this image, water swashes over the cow's back as she rests at the surface and the calf with the bowhead whales' classic V-shaped blow is swimming towards her.

Bowhead whale mom-calf pair sighted approximately 80 km north of Harrison Bay, Alaska, on Flight 9, 6 October 2021. The calf, having rejoined mom, is resting its chin on her back.

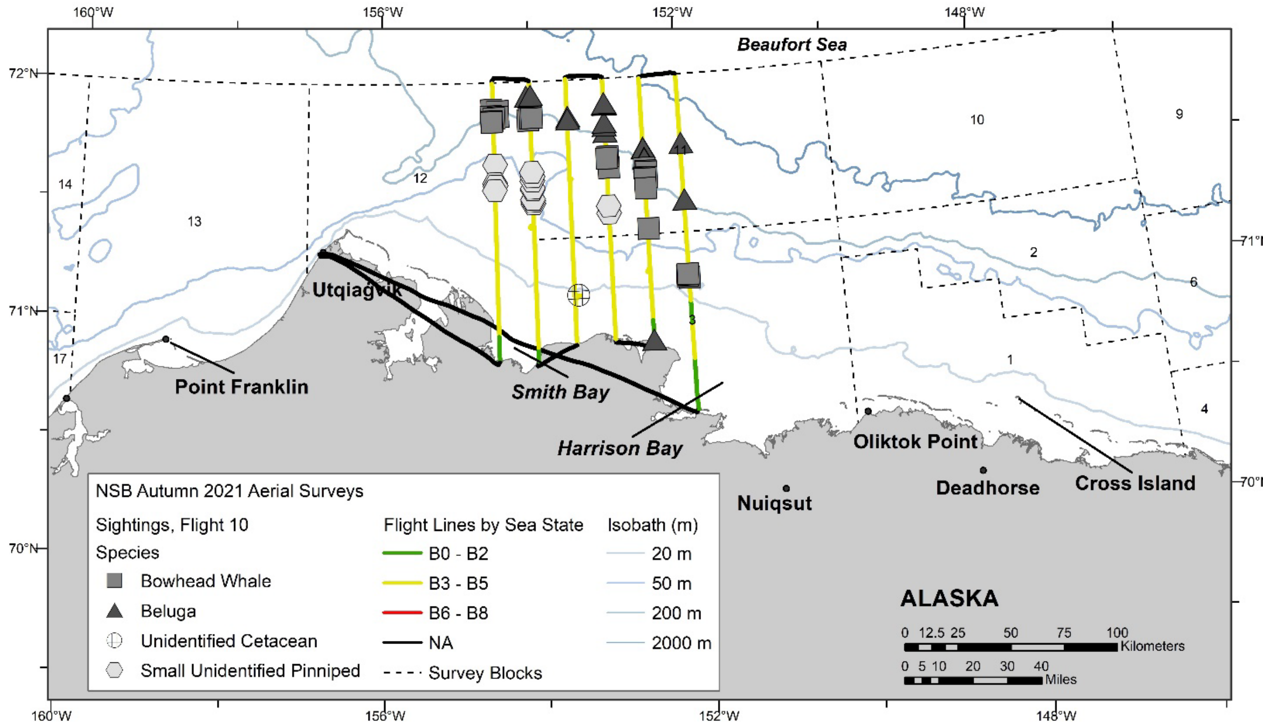
9 October 2021, Flight 10

Flight was a complete survey of transects 125, 126, 127, 128, 129, and 130. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with ice on window, low ceilings, and precipitation, and Beaufort 0-4 sea states. Sea ice was 0-95% grease/new in the area surveyed. Sightings included bowhead whales (including one calf and one carcass), belugas (including one carcass), unidentified cetaceans (including two carcasses), and small unidentified pinnipeds. The bowhead whale carcass was approximately 90 km east of Point Barrow, Alaska. The beluga carcass was approximately 110 km northeast of Point Barrow, Alaska. One unidentified cetacean carcass was approximately 100 km north of Harrison Bay, Alaska and the other was approximately 140 km southeast of Point Barrow, Alaska.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude °N	Longitude °W	Species	Behavior	Group Size	Calf No.	Block
10	10/9/2021 12:35	71.139	151.999	bowhead whale	swim	1	0	3
10	10/9/2021 12:35	71.147	152.027	bowhead whale	swim	1	0	3
10	10/9/2021 12:35	71.153	152.017	bowhead whale	swim	1	0	3
10	10/9/2021 12:36	71.155	152.016	bowhead whale	feed	2	0	3
10	10/9/2021 12:49	71.467	152.026	unid cetacean	dead	1	0	11
10	10/9/2021 12:49	71.471	151.990	beluga	swim	2	0	11
10	10/9/2021 12:58	71.709	151.990	beluga	swim	1	0	11
10	10/9/2021 13:18	71.699	152.501	beluga	swim	1	0	11
10	10/9/2021 13:18	71.697	152.502	beluga	swim	1	0	11
10	10/9/2021 13:19	71.657	152.491	beluga	swim	1	0	11
10	10/9/2021 13:20	71.653	152.493	beluga	swim	1	0	11
10	10/9/2021 13:21	71.613	152.499	bowhead whale	swim	1	0	11
10	10/9/2021 13:24	71.601	152.480	bowhead whale	swim	1	0	11
10	10/9/2021 13:24	71.596	152.477	bowhead whale	swim	1	0	11
10	10/9/2021 13:24	71.574	152.491	bowhead whale	swim	1	0	11
10	10/9/2021 13:24	71.572	152.476	bowhead whale	swim	1	0	11
10	10/9/2021 13:25	71.567	152.498	bowhead whale	swim	1	0	11
10	10/9/2021 13:26	71.527	152.500	bowhead whale	swim	1	0	11
10	10/9/2021 13:30	71.357	152.491	bowhead whale	swim	1	0	11
10	10/9/2021 13:35	71.184	152.520	unid cetacean	dead	1	0	3
10	10/9/2021 13:44	70.888	152.504	beluga	swim	1	0	3
10	10/9/2021 14:12	71.623	152.976	bowhead whale	breach	1	0	11
10	10/9/2021 14:17	71.670	152.981	bowhead whale	swim	1	0	11
10	10/9/2021 14:18	71.663	152.998	bowhead whale	swim	1	0	11
10	10/9/2021 14:23	71.776	153.002	beluga	swim	1	0	11
10	10/9/2021 14:24	71.802	153.011	beluga	swim	1	0	11
10	10/9/2021 14:24	71.816	153.009	beluga	swim	1	0	11
10	10/9/2021 14:26	71.890	152.989	beluga	swim	1	0	11

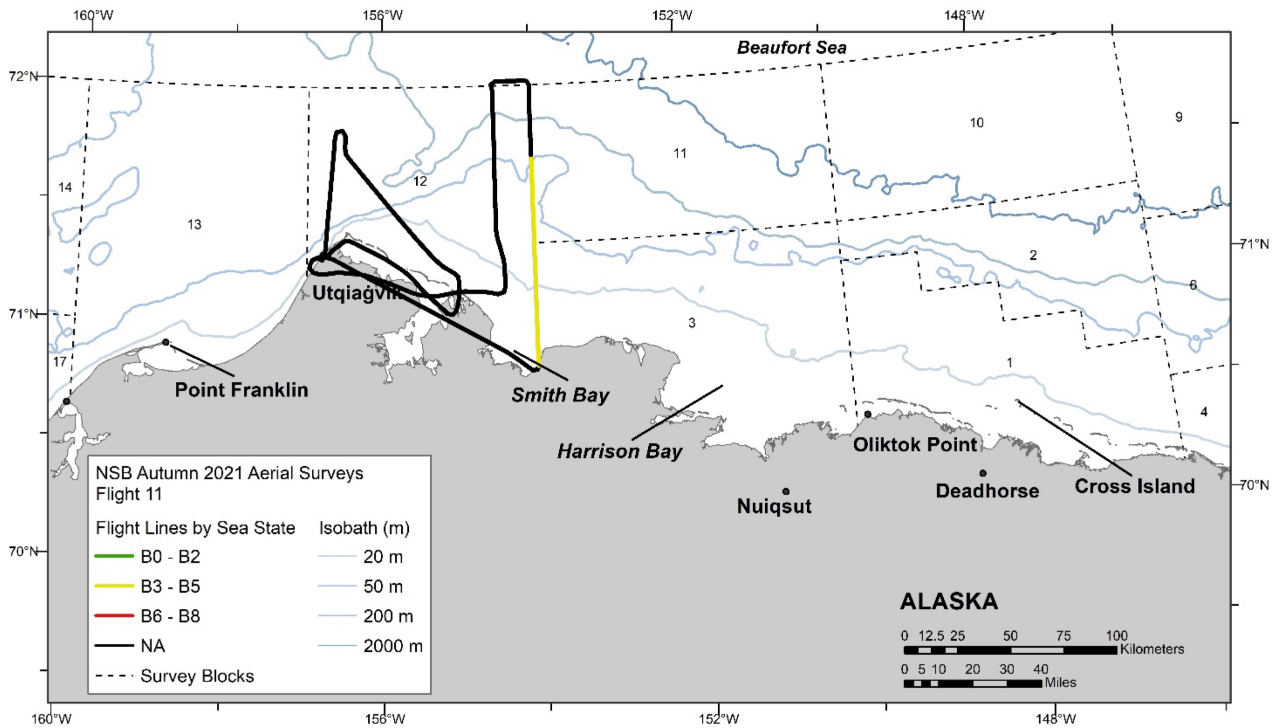
Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
10	10/9/2021 14:26	71.893	153.001	beluga	swim	1	0	11
10	10/9/2021 14:27	71.897	152.998	beluga	swim	1	0	11
10	10/9/2021 14:38	71.846	153.496	beluga	swim	1	0	11
10	10/9/2021 14:38	71.836	153.500	beluga	swim	1	0	11
10	10/9/2021 14:45	71.584	153.502	beluga	dead	1	0	11
10	10/9/2021 15:01	71.092	153.453	unid cetacean	swim	1	0	3
10	10/9/2021 15:32	71.384	154.027	bowhead whale	dead	1	0	12
10	10/9/2021 15:49	71.838	154.037	bowhead whale	swim	1	0	12
10	10/9/2021 15:50	71.848	154.005	bowhead whale	rest	2	1	12
10	10/9/2021 15:50	71.848	153.983	bowhead whale	mill	2	0	11
10	10/9/2021 15:55	71.935	153.998	beluga	swim	1	0	11
10	10/9/2021 15:55	71.939	154.047	beluga	swim	1	0	12
10	10/9/2021 15:56	71.942	153.988	beluga	swim	1	0	11
10	10/9/2021 16:05	71.886	154.522	bowhead whale	swim	1	0	12
10	10/9/2021 16:06	71.879	154.438	bowhead whale	swim	1	0	12
10	10/9/2021 16:10	71.859	154.533	bowhead whale	swim	1	0	12
10	10/9/2021 16:11	71.855	154.439	bowhead whale	swim	1	0	12
10	10/9/2021 16:12	71.851	154.490	bowhead whale	swim	1	0	12
10	10/9/2021 16:12	71.838	154.521	bowhead whale	swim	1	0	12
10	10/9/2021 16:12	71.834	154.527	bowhead whale	swim	1	0	12



Appendix Figure E10. -- Flight 10 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

10 October 2021, Flight 11

Flight was a partial survey of transect 129. Survey conditions included overcast skies, 0 km to unlimited visibility, with precipitation, and Beaufort 3-4 sea states. There was no sea ice observed in the area surveyed. Snow and low ceilings caused icing conditions in the eastern portion of block 12. The survey team landed to deice the plane and launched again to assess conditions near shore and in the western half of block 12; however, low ceilings and precipitation precluded further survey effort. There were no marine mammal sightings.



Appendix Figure E11. -- Flight 11 survey track, depicted by sea state.

The survey plane being moved into a hanger to remove accumulated ice so the team could get back in the air to look for surveyable areas. Knowing this day was the last possible flight day of the season due to few remaining flight hours and approaching bad weather, the crew gave it their all.

Despite the team's best efforts, widespread low ceilings hung over the water right at survey altitude with blue skies just above precluding further survey effort, Flight 11, 10 October 2021.

APPENDIX F: Bowhead Whale Calves in 2020-21 Compared to 2009-19

Bering-Chukchi-Beaufort seas bowhead whale calf sightings from the North Slope Borough Autumn Aerial Survey project, 2020–2021 with a comparison to the Aerial Surveys of Arctic Marine Mammals project, 2009–2019

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ABSTRACT

The North Slope Borough (NSB) Autumn Aerial Surveys project collected bowhead whale calf data during line-transect surveys in the western Beaufort and northeastern Chukchi seas (140°W–169°W). Surveys were conducted from mid-September to mid-October 2020 and 2021. Data for the same autumn period from 2009 to 2019 were isolated from the Aerial Surveys of Arctic Marine Mammals (ASAMM) project dataset. ASAMM data provide context for assessing 2020 and 2021 bowhead whale calf ratios (number of calves relative to total bowhead whales) and calf sighting rates (calves per 1,000 km of survey effort). For consistency between projects, analyses are limited to the area from 140°W to 160°W. From 15 September to 15 October 2009–2021, 2,310 bowhead whales, including 148 calves were sighted in the analytical area. Thirty-three of the calves were sighted during NSB Autumn Aerial Surveys in 2020 (22 calves) and 2021 (11 calves). Across all years, calves were most commonly encountered over the continental shelf and Barrow Canyon and most (88 calves, 77%) were in water ≤50m deep. The highest calf ratio was in 2019 (0.247), followed by 2016 (0.137) and 2013 (0.105). The highest calf sighting rate was 2020 (5.1 calves per 1,000km), followed by 2017 and 2016 (2.7 and 2.3 calves per 1,000km, respectively).

BACKGROUND AND METHODS

In 2020 and 2021, the North Slope Borough (NSB) funded aerial surveys of the bowhead whale autumn migration across the western Beaufort Sea. These surveys began the year after the Aerial Surveys of Arctic Marine Mammals (ASAMM) project concluded. The objectives of the NSB Autumn Aerial Surveys were to:

- Conduct line-transect aerial surveys in the western Beaufort Sea to collect data on bowhead whale density, distribution, activities, and calves using survey methods consistent with the existing 41-year ASAMM time series.
- Analyze the autumn aerial survey data with the ASAMM historical database to investigate spatial and temporal patterns, variability, and trends in bowhead whale density and habitat use in the western Alaskan Beaufort Sea.

The NSB Autumn Aerial Surveys project conducted line-transect surveys in the western Beaufort and northeastern Chukchi seas from mid-September to mid-October 2020 and 2021. Like ASAMM, the NSB Autumn Aerial Surveys study area encompassed the area from 67°N to 72°N and 140°W to 169°W; however, in 2020 and 2021 the western Beaufort Sea (140°W–157°W) was the priority study area (Appendix Fig. F1). Specifically, the area from Utqiaġvik to Prudhoe Bay was the highest priority for documenting bowhead whale migration. Prudhoe Bay to the US-Canada border was the second priority area. The northeastern Chukchi Sea, from Utqiaġvik to Wainwright, was third in priority. The remaining Chukchi Sea study area was the lowest priority, but it was significant for documenting the presence of other large cetaceans, including gray, humpback, fin, minke, and killer whales. From 2009 to 2019, ASAMM flights were planned to cover the entire study area uniformly, weather permitting. Here, we refer to the area from 140°W to160°W (corresponding to survey blocks 1–13) as the bowhead whale calf analysis area (Appendix Fig. F1).

For the NSB Autumn Aerial Surveys, transect lines spaced 18km apart were oriented perpendicular to the coastline to cross isobaths, from the shore to the Beaufort Sea basin (> 2,000m). Surveys were conducted in high-wing Turbo Commander (2009–2021) and Twin Otter (2009–2010) aircraft at altitudes of 305–460 m and targeted survey speed of 213 km/hr. Survey aircraft were equipped with left- and right-side bubble windows that enabled a complete view of the survey trackline. Survey teams consisted of two primary marine mammal observers (one stationed at each bubble window), one dedicated data recorder who entered data into a laptop connected to a GPS and running specialized data collection software, and two pilots. The data recorder and pilots served as secondary observers. Time and position data (altitude, heading, latitude, longitude) were automatically recorded every 30 seconds or when manual entries (survey mode change, sighting, and environmental updates) were recorded.

Environmental conditions recorded included a consensus by the left and right observers for Beaufort Sea State, sky condition, and type of sea ice. Unique environmental information recorded for the left and right observer included perpendicular visibility (km), impediment to visibility, and sea ice cover (as a percent of the field of view); these conditions were recorded every five minutes or whenever changes occurred. Primary observers scanned for sightings, using binoculars only rarely. Declination angles from the horizon to each sighting were measured when the sighting was abeam the observer. Once the data recorder had input the angle, most sightings of large cetaceans (larger than a beluga, *Delphinapterus leucas*) were circled to confirm species, determine a final group size and behavior and to look for calves.

Circling is an important component of calf detection. Clarke *et al.* (2022) found that from 2012 to 2019, less than half of the bowhead whale calves documented during ASAMM were sighted from the transect line; without diverting to circle sightings, ~60% of calves would likely have gone undetected. Circling all sightings of large cetaceans, when time, fuel, weather and survey location relative to sensitive wildlife and subsistence activities allowed, was initiated and consistently recorded beginning in 2009.

Each survey flight included up to seven different survey modes characterized by specific survey protocols and objectives:

1. Transect effort – Flat and level systematic survey effort along a prescribed transect line; sightings not limited to species or distance from the transect line; on effort.
2. Circling from transect – Brief (< 10 min) diversion from transect to circle over a localized area; sightings limited to the area within the circle; off effort.
3. Search - Flat and level non-systematic survey effort during transits; off effort.
4. Circling from search – Brief (< 10 min) diversion from search effort to circle over a localized area; off effort.
5. Cetacean Aggregation Protocols (CAPs) passing – Flat, level, and continuous systematic survey effort along a prescribed transect line to collect accurate encounter rate data for areas with dense aggregations of large cetaceans; sightings limited to large cetaceans within3 km of the transect line; must be followed immediately by CAPs circling; on effort.
6. CAPs circling – Departure from CAPs passing to search for sightings within the strip surveyed during CAPs passing; immediately follows CAPs passing; sightings limited to within 3km of the transect line; off effort.
7. Deadhead – No sighting or environmental data collected; used during transits to and from the study areas, to mitigate observer fatigue, and during times when survey parameters were not met; off effort.

During all non-deadhead survey modes, observers were actively surveying, and marine mammal sightings and effort data were collected. Statistics for Cetacean Aggregation Protocols (CAPs) passing mode that are inferred from CAPs circling data (e.g., group size, number of calves and feeding or milling behavior) are referred to as CAPs-adjusted statistics. The surveys in 2020 and 2021 followed the same protocols as were implemented during ASAMM surveys in 2019; more details about the survey design and methods can be found in Clarke et al. 2020.

Two summary statistics, bowhead whale calf ratios and sighting rates, were calculated to evaluate annual calf presence and relative density. All analyses were limited to sightings by primary observers during transect and adjusted CAPs-passing modes, herein referred to as Transect and CAPs-adjusted, respectively, and collectively as "on effort". Calf ratio is the proportion of observed bowhead whales that were calves. Calf ratios provide an index of calf production and were calculated using the number of calves sighted on effort, relative to the number of total bowhead whales sighted on effort (calves/total whales). Calf sighting rates normalize the number of observed calves by the amount of survey effort, providing an index of relative density. Calf sighting rates were calculated using the number of on-effort calves per 1,000 km flown on effort.

OBSERVED BOWHEAD WHALE CALF RATIOS AND SIGHTING RATES

From 15 September to 15 October, 2009 to 2021, 148 bowhead whale calves were sighted on effort out of a total of 2,310 bowhead whales in the analysis area (Clarke *et al*. 2011a, 2011b, 2012, 2013, 2014, 2015, 2017a, 2017b, 2018, 2019, 2020; Brower *et al.* in review, in prep) (Appendix Table F1). Calves were distributed across the analysis area from 140°W to 160°W (Appendix Fig. F1). Across all years, calves were most commonly encountered over the continental shelf and Barrow Canyon, and most (88 calves, 77%) were in water ≤50m deep (Appendix Fig. F1). Most calves (101 calves, 68%) were sighted after circling was initiated. Of the 148 calves sighted since 2009, 33 (22%) were sighted during NSB Autumn Aerial Surveys in 2020 (22 calves) and 2021 (11 calves) (Appendix Table F1).

The 2020 bowhead whale calf ratio was 0.038 (22 calves/589 whales). In 2021, the calf ratio was 0.083 (11 calves/131 whales), more than twice as high as 2020 (Appendix Table F1, Appendix Fig. F2). Annual bowhead whale calf ratios for the analysis area (140°W–160°W) varied. Using data collected since 2009, calf ratios were highest in 2019, followed by 2016, 2013, 2017, and 2021 (Appendix Table F1, Appendix Fig. F2).

The 2020 calf sighting rate was 5.1 calves per 1,000 km flown on effort and almost three times more than 2021 (Appendix Table F1, Appendix Fig. F2). Annual bowhead whale calf sighting rates for the analysis area (140°W–160°W) varied. Using data collected since 2009, calf sighting rates were highest in 2020, followed by 2017, 2016, 2021, and 2009.

DISCUSSION

Autumn (15 September through 15 October) calf distribution in 2020 was largely west of 152°W, overlapping a well-documented bowhead whale feeding area (~152°W–157°W) (e.g., Clarke *et al*. 2017a; Moore and Reeves 1993; Mocklin *et al*. 2011; Shelden *et al*. 2017) and where extremely large and dense aggregations of feeding bowhead whales were sighted in 2020 (Brower *et al*. in review) (Appendix Fig. F1). Calves in 2020 were closer to shore and in shallower water compared to calves in 2019, when the bowhead whale migration was unprecedented with whales sighted farther offshore and in deeper water than previous years with light sea ice cover in autumn (i.e., 1989, 1990, 1993–2018; Clarke *et al*. 2020; Brower *et al*. in review) (Appendix Fig. F1). Calf distribution in 2021 was similar to previous years, 2009–2018 and 2020 (Brower *et al*. in prep) (Appendix Fig. F1).

Beginning in 2016, annual autumn calf ratios were generally higher than 2009–2015, with a few exceptions: the 2013 calf ratio was high (0.105) and 2018 and 2020 were low (0.045 and 0.038, respectively) (Appendix Table F1,

Appendix Fig. F2). The calf ratio in 2020 was the second lowest (Appendix Table F1, Appendix Fig. F2); however, the calf sighting rate in 2020 (5.1 calves per 1,000 km) was nearly twice as high as the second highest year, 2017 (Appendix Table F1, Appendix Fig. F2). Although the proportion of surveyed bowhead whales that were calves was low in 2020, the relative density of calves was high. This is likely because an extraordinary number of bowhead whales were encountered in 2020, and by many accounts are the densest aggregations of bowhead whales recorded in the history of the annual ASAMM and preceding (1982–2019) aerial surveys in the western Beaufort Sea (Brower *et al*. in review, in prep) (Appendix Table F1, Appendix Fig. F2).

Solo calves were observed on 10 occasions since 2009 (15 September to 15 October); there were adults in the vicinity of one of these calves. It is likely that most solo calves were encountered while the mom was below the surface. Observations of dive sequences for one bowhead whale mom-calf pair in 2019 found that during the observation period (103 min), the calf spent most (94%) of its time at or near the surface, while the mom was visible only 19% of the time (Clarke *et al*. 2022). An adult with two calves was also observed on two occasions (once in 2017 and once in 2019). In both cases, other adults were in the vicinity.

Sightings and images of calves associated with adult bowhead whales with white peduncle and flukes provide evidence of a long period of reproductive success during a female bowhead whale's lifespan, as is the case with two recent sightings described below. Subadult bowhead whales ~10–11m in body length may begin losing pigmentation on their peduncle and most have distinctly white peduncles by ~14.5m in length (George *et al*. 2020). With age, the loss of pigmentation can progress beyond the peduncle to include the flukes (George *et al*. 2020). White pigmented flukes are an indication of advanced age (George *et al*. 2020). A calf documented on 15 October 2020 was photographed with an adult, presumed to be its mother, who had extensive white pigmentation from the caudal peduncle through the flukes (Appendix Fig. F3). On 27 September 2021, the mom from a photographed mom-calf pair was matched by Barbra Tudor and confirmed by Dave Rugh and Bill Koski to an image of the female taken in 1985 and represents the longest (36 year) recapture of a bowhead whale (J.C. George, Pers. comm., October 2021). In 1985, the whale had a white peduncle and by 2021 loss of pigmentation extended onto the flukes.

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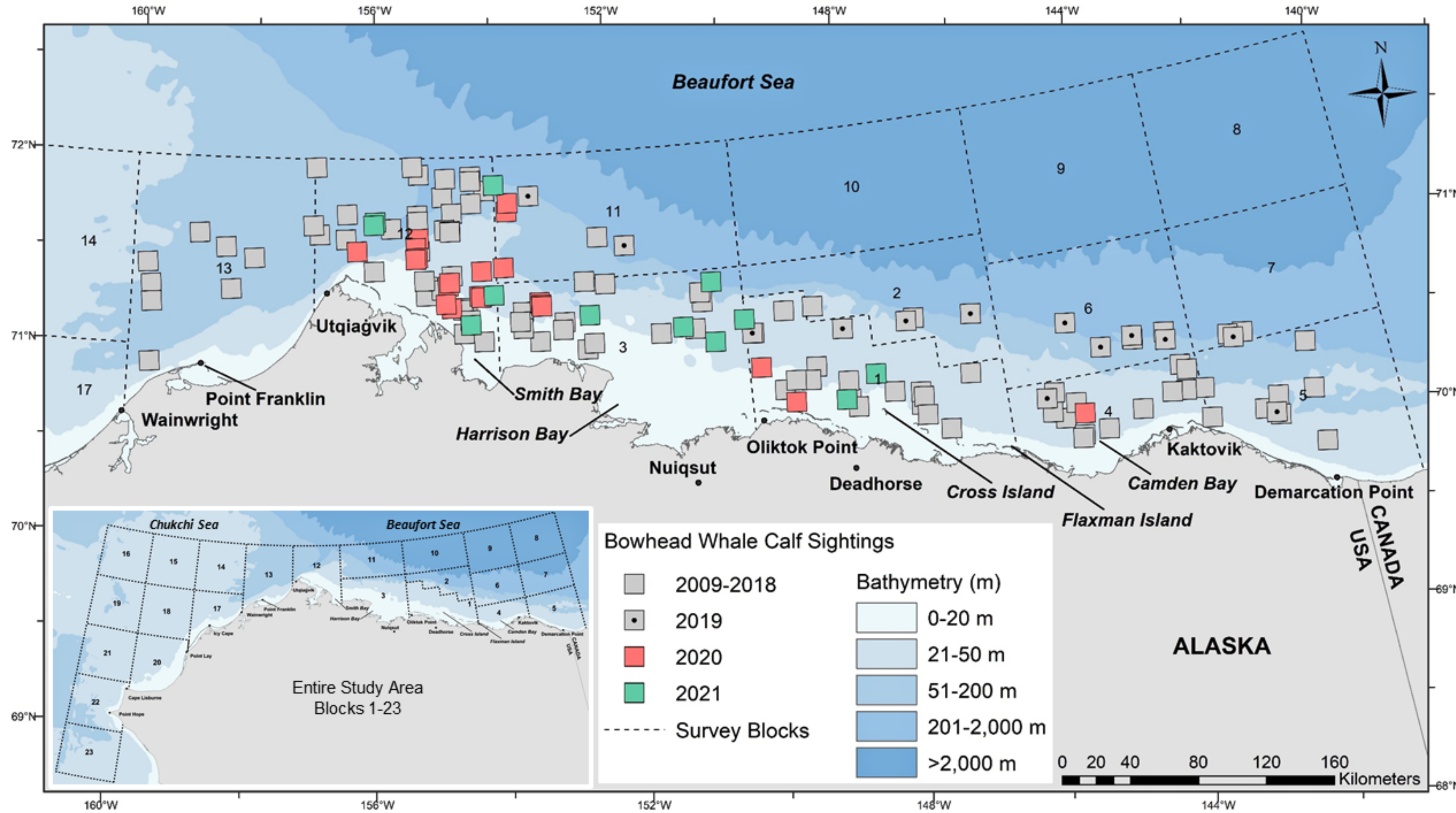
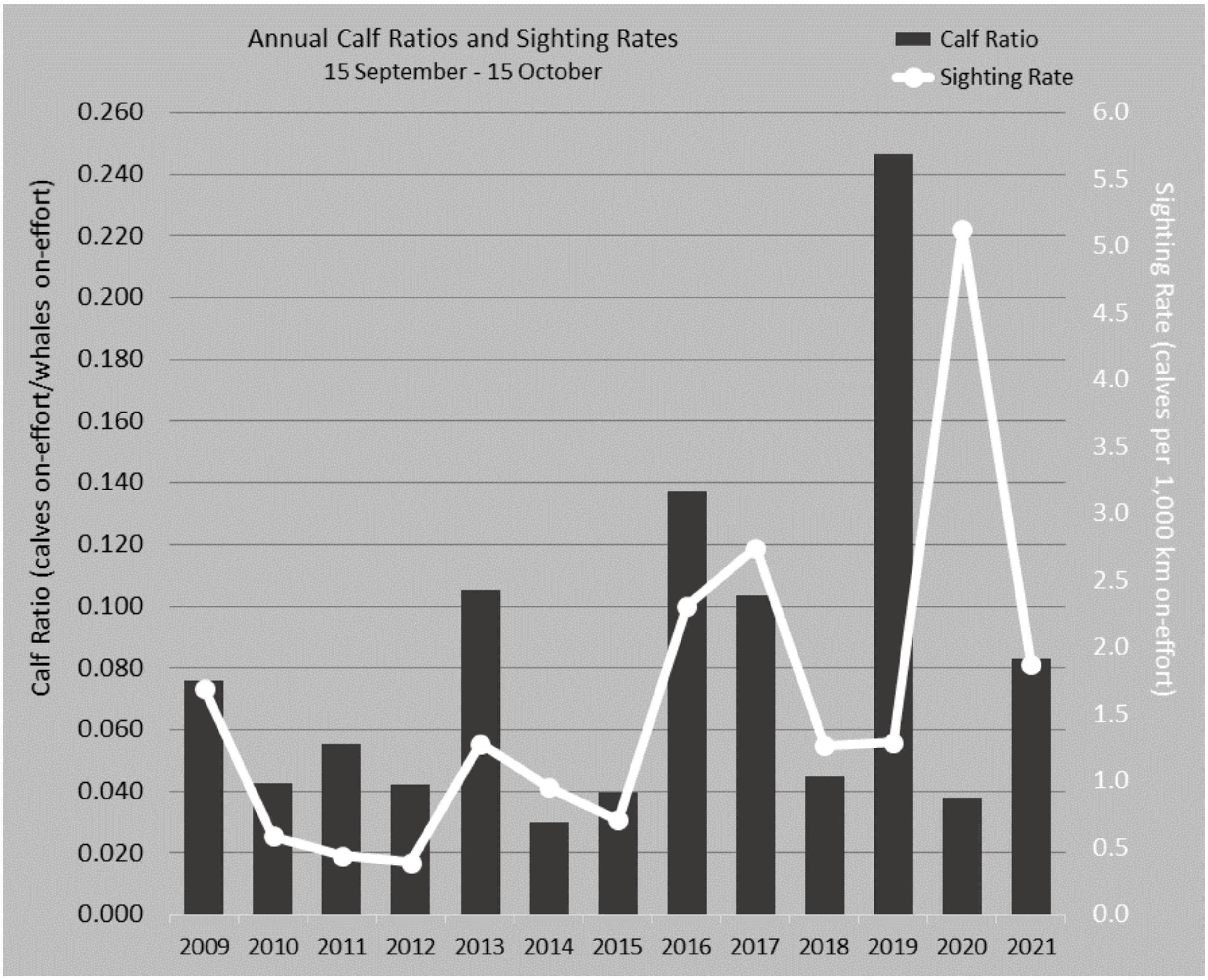


Appendix Figure F1. Bowhead whale calf sightings, during transect and CAPs-passing survey modes, by primary observers, from 15 September to 15 October 2009–2021, in the bowhead whale calf analysis area (140°W–160°W). The inset shows the entire study area and survey blocks 1–23.

Appendix Table F1. Annual bowhead whale calf ratios (CR, on-effort calves/whales) and sighting rates (SR, on-effort calves per 1,000 km), in the bowhead whale calf analysis area (140°W–160°W), from 15 September to 15 October 2009–2021.

Year	Whales	Calves	CR	1,000 km	Calves	SR
2009	145	11	0.076	6.5	11	1.7
2010	94	4	0.043	6.8	4	0.6
2011	54	3	0.056	6.8	3	0.4
2012	95	4	0.042	10.2	4	0.4
2013	57	6	0.105	4.7	6	1.3
2014	232	7	0.030	7.4	7	1.0
2015	253	10	0.040	14.1	10	0.7
2016	153	21	0.137	9.1	21	2.3
2017	174	18	0.103	6.6	18	2.7
2018	256	12	0.045	9.1	12	1.3
2019	77	19	0.247	14.7	19	1.3
2020	589	22	0.038	4.3	22	5.1
2021	131	11	0.083	5.8	11	1.9
Total	2,310	148		106.0	148	



Appendix Figure F2. Annual bowhead whale calf ratios (on-effort calves/total whales), in the bowhead whale calf analysis area (140°W–160°W), from 15 September to15 October (left y-axis). Annual bowhead whale calf sighting rates (on-effort calves per 1,000 km) are depicted by the white trend line with markers, for the bowhead whale calf analysis area (140°W–160°W), from 15 September to 15 October (right y-axis).

Appendix Figure F3. Images show extensive whitening on the posterior end of a female bowhead whale sighted with her calf on 15 October 2020. Note the calf is not visible in these particular images.

APPENDIX G: 43 Years of Scientific Accomplishments in the Arctic

The Aerial Surveys of Arctic Marine Mammals and North Slope Borough Autumn Aerial Surveys Projects List of Accomplishments

Critical to understanding the Arctic ecosystem and managing Arctic natural resources in the present and future.

Aerial Surveys of Arctic Marine Mammals (ASAMM)

1. ASAMM is the only long-term broad-scale time series of data on marine mammal distribution, relative abundance, and behavior that exists for the Alaskan Arctic (140°-169°W, 68°-72°N, with surveys in adjoining regions in some years). The surveys were conducted every year from 1979 to 2019, with remarkably consistent data collection protocols from 1982 to 2019.
2. Information on marine mammal distribution and relative abundance in the western Beaufort and eastern Chukchi seas during summer (July-August) and autumn (September-October) can be reliably obtained only through aerial surveys conducted in these regions during the relevant seasons. This information is needed to generate species-specific estimates of the number of animals that are likely to be affected by future anthropogenic activities that are proposed to occur in the ASAMM study area during summer and autumn. This information is required by BOEM, NOAA, USFWS, and DoD to fulfill the agencies' obligations under the National Environmental Policy Act, Marine Mammal Protection Act, and Endangered Species Act. Without current, reliable data, the agencies will be vulnerable to litigation and their ability to make management decisions about future anthropogenic activities in this region during summer and autumn will likely be delayed.
3. Colleagues at multiple federal and state agencies, academic institutions, and private companies rely on the data in the ASAMM historical database to make decisions regarding marine mammal conservation and management, and to better understand marine mammal roles in the Arctic ecosystem. Results from ASAMM have also been of interest to the general public, and have been communicated through newspaper articles, online blogs, and radio interviews. Additional details are provided in the matrix and summary sections below.
4. There was minimal time lag between when ASAMM data were collected and when they could be used to inform management decisions. The survey aircraft could use the satellite telephone to convey critical information to contacts on the ground without any delay. That information proved valuable in reporting walrus distributions and numbers to research vessels searching for walruses to tag and in relaying the exact location and approximate size of mass coastal walrus haulouts to USFWS to implement additional protective measures. Furthermore, the first draft of the entire database for each ASAMM flight was available within hours of the end of the survey and provided near real-time information to BOEM

and NOAA for use in offshore oil exploration mitigation and oil-spill response drills. The final database was made available a few months after of the end of the field season, and that rapid turn-around time proved valuable in generating abundance estimates for Eastern Chukchi Sea belugas and Western Arctic bowhead whales, which resulted in cost savings to the Federal government.

5. Due to the inter-annual variability in the Arctic ecosystem and observed and expected changes to the ecosystem due to the changing climate, annual surveys of this region are critical to capture the range of ecosystem dynamics.
6. The phenology of the Arctic ecosystem is changing, with sea ice melt occurring earlier and freeze-up occurring later in the year. One result of the lengthened open water season is a greater period of time during which the Arctic marine ecosystem is accessible to human activities with the potential to affect Arctic resources, such as vessel traffic and oil and natural gas exploration, development, and production. To implement effective marine mammal conservation and management practices, it is important to conduct broad-scale surveys for marine mammals throughout the entire seasonal range in which anthropogenic activities are likely to occur. ASAMM captured this critical time period from the begging of July through the end of October.
7. Weather in the Arctic can be extreme and is highly dynamic in space and time. There was no way to predict when the good weather would occur during the open water season within the ASAMM study area. To maximize the chances of obtaining useful data and be most efficient with limited government resources, best practice was to have ASAMM field teams maintain a constant presence in the study area throughout the open water season. Transits between the study area and home bases in lower latitudes was not economical due to expenses associated with increased flight time for the survey aircraft and travel expenses for the aerial observers.
8. The U.S. is a member of the Arctic Council, a high-level intergovernmental forum providing a means for promoting cooperation, coordination, and interaction on common issues among the Arctic States, with the involvement of Arctic Indigenous communities and other Arctic inhabitants. Sustainable development and environmental protection are particular issues of concern. Other member nations of the Arctic Council include Canada, Denmark, Finland, Iceland, Norway, Russia, and Sweden, in addition to six Permanent Participants representing Indigenous peoples. ASAMM represents the most extensive marine mammal dataset from any Arctic Council nation, and remains an example of the usefulness of a multi-decadal time series.

North Slope Borough (NSB) Autumn 2020-2021 Aerial Surveys

In 2020 and 2021, the North Slope Borough (NSB) funded an aerial survey of the bowhead whale autumn migration across the western Beaufort Sea. The surveys were conducted in the absence of the ASAMM project, which concluded after the 2019 field season. The NSB surveys in 2020 and

2021 were conducted to maintain consistency with ASAMM's 41-year dataset. The objectives of NSB Autumn Aerial Surveys were to:

1. Conduct line-transect aerial surveys in the western Beaufort Sea to collect data on bowhead whale density, distribution, activities, and calves using survey methods consistent with the existing 41-year ASAMM time series.
2. Analyze the autumn 2020 aerial survey data with the ASAMM historical database to investigate spatial and temporal patterns, variability, and trends in bowhead whale density and habitat use in the western Alaskan Beaufort Sea.

Matrix Summarizing ASAMM and NSB Autumn Survey Products Distributed to Institutions and Agencies, 2008-2021

	Daily Reports	Biweekly Maps & Reports	Annual Reports	Maps	Shape-files	Carcass Data	Sea Ice Photos	Sighting & Effort Data	Expert Input into Manage-ment Decisions	Aerial Recon
USCG				x			x			
BOEM	x	x	x	x	x		x	x	x	
USGS	x	x	x	x			x	x		x
NOAA/NMFS	x	x	x	x	x	x	x	x	x	
USFWS	x	x	x	x		x	x	x		x
ADF&G		x								
U.S. Marine Mammal Commission			x						x	
AOOS					x			x		
Arctic ERMA					x			x		
NPRB		x								
NSB	x	x	x	x		x		x		
Oil & Gas Industry	x	x	x	x			x	x		
OBIS-SEAMAP								x		
NGOs	x		x					x	x	
Other Researchers	x	x	x	x	x		x	x		x

Contributions to the Scientific Community, 2008-Present

1. **Published papers using ASAMM/BWASP/COMIDA and NSB 2020-2021 data (alphabetized)**

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xlviii. National Marine Mammal Laboratory. 2017. Annual Report for Permit No. 14245: 1 May 2016 to 30 April 2017. Submitted to the National Marine Fisheries Service Office of Protected Resources.

xlix. Marine Mammal Laboratory. 2018. Annual Report for Permit No. 20465: 1 June 2017 to 31 May 2018. Submitted to the National Marine Fisheries Service Office of Protected Resources.

l. Marine Mammal Laboratory. 2019. Annual Report for Permit No. 20465: 1 June 2018 to 31 May 2019. Submitted to the National Marine Fisheries Service Office of Protected Resources.

li. Stimmelmayr, R., J. Citta, K. Scheimreif, M. Ferguson, G. Givens, A. Willoughby, A. Brower, A. Von Duyke, G. Sheffield, B. Person, T. Sformo, L. de Sousa, and R. Suydam. 2022. 2020-2021 Health Report for the Bering-Chukchi-Beaufort seas bowhead whales – Preliminary Findings. Paper Sc/68D/ASW/03 presented to the International Whaling Commission Scientific Committee, virtual event, 2022.

lii. Stimmelmayr, R., J. Craig George, J. Clarke, M. Ferguson, A. Willoughby, A. Brower, G. Sheffield, K. Staffort, G. Givens, A. Von Duyke, T. Sformo, B. Person, L. de Sousa, and R. Suydam. 2020. 2018–2019 Health report for the Bearing-Chukchi-Beaufort seas bowhead whale – preliminary finding. SC/68b/ASW/03 presented at the International Whaling Commission Scientific Committee Meetings, virtual meetings 2020.

liii. Stimmelmayr, R., J.C. George, A. Willoughby, A. Brower, J. Clarke, M. Ferguson, G. Sheffield, K. Staffort, A. Von Duyke, T. Sformo, B. Person, L. Sousa, and R. Suydam. 2018. 2017 health report for the Bering-Chukchi-Beaufort Seas bowhead whales – preliminary findings. SC/67b/AWMP8 presented at the International Whaling Commission Scientific Committee Meetings, Slovenia, April 2018. 25 pp.

liv. Willoughby, A. and A. Brower. 2020. Marine Mammal Laboratory. Annual Report for NMFS Permit No. 20465: 1 June 2019 to 31 May 2020. Submitted to the National Marine Fisheries Service Office of Protected Resources.

lv. Willoughby, A. and A. Brower. 2021. Marine Mammal Laboratory. Annual Report for NMFS Permit No. 20465: 1 June 2020 to 31 May 2021. Submitted to the National Marine Fisheries Service Office of Protected Resources.

lvi. Willoughby, A. and A. Brower. 2022. Marine Mammal Laboratory. Annual Report and Final Report for NMFS Permit No. 20465: 1 June 2021 to 31 Nov 2021 and 2017-2021. Submitted to the National Marine Fisheries Service Office of Protected Resources.

lvii. Willoughby, A.L., J.T. Clarke, M.C. Ferguson, R. Stimmelmayr, and A.A. Brower. 2018. Bowhead whale carcasses in the eastern Chukchi and western Beaufort seas, 2009-2017. SC/67b/AWMP2 presented at the International Whaling Commission Scientific Committee Meetings, Slovenia, April 2018. 10 pp.

lviii. Willoughby, A. L., R. Stimmelmayr, A.A. Brower, J.T. Clarke, and M.C. Ferguson. 2020. Gray whale carcasses in the Eastern Chukchi Sea, 2009-2019. SC/68b/IST/02 presented to the International Whaling Commission, Cambridge.

lix. Willoughby, A.L., R. Stimmelmayr, A.A. Brower, J.T. Clarke, and M.C. Ferguson. 2020. Bowhead whale carcasses in the eastern Chukchi and western Beaufort seas, 2009-2019. SC/68B/ASW/02 Rev1 presented to the International Whaling Commission Scientific Committee, virtual meeting May 2020.

3. Venues where ASAMM and NSB 2020-2021 results were presented (alphabetized)

i. Alaska Beluga Whale Committee Workshop, Anchorage, AK. 2012, 2016, 2017, 2019. Presentations (4).

ii. Alaska Eskimo Whaling Commission, Anchorage, AK. 2019, 2021. Presentations (2).

iii. Alaska Marine Science Symposium, Anchorage, AK. 2009-2020. Presentations (2), posters (50).

iv. American Cetacean Society, Monterey, CA. 2008. Poster (1).

v. Applied Physics Lab, Polar Science Center, Seattle, WA. 2016. Presentation (1).

vi. Arctic Cetacean Listening Session, Utqiaġvik, AK. 2020. Presentation (1).

vii. Arctic Council/PAME Workshop, Science and tools for developing Arctic MPA Networks, Washington, DC, 2016. Presentation (1).

viii. Arctic Open Water Meetings, Anchorage, AK. 2009-2013. Presentations (2).

ix. Bering Sea Open Science Meeting, Honolulu, HI. 2014. Poster (1).

x. Bowhead Whale Feeding Ecology Study Workshop, Anchorage, AK. 2009. Presentation (1).

xi. Camden Bay Collaborative Study Workshop, Fairbanks, AK, 2014 and Anchorage, AK, 2016, 2018, and 2020. Presentations (4).

xii. Distributed Biological Observatory Workshops, Seattle, WA. 2014, 2016, 2107, 2020. Presentations (4).

xiii. Duke University, Marine Geospatial Ecology Lab, Durham, NC. 2017. Presentation (1).

xiv. International Whaling Commission Scientific Committee Meeting, Morocco. 2010. Reports (2).

xv. International Whaling Commission Scientific Committee Meeting, Slovenia. 2018. Reports (4).

xvi. Inter-American Tropical Tuna Commission Workshop, La Jolla, CA, 2016. Presentation (1).

xvii. Minerals Management Service Information Transfer Meeting, Anchorage, AK. 2008. Presentations (2).

xviii. North Slope Borough Marine Mammal Observer training, Barrow, AK. 2009. Presentation (1).

xix. NOYO Center for Marine Science, virtual event, March 2021. Presentation (1).

xx. Ocean Sciences Meeting. 2014 and 2016. Presentations (2), poster (1).

xxi. Preview of Ecosystem and Economic Conditions 2020, 2021. Presentation (2)

xxii. Society for Marine Mammalogy, 2009, 2011, 2015. Presentation (1), posters (2).

xxiii. Sitka Sound Science Center's Whale Fest 2021, virtual event, Nov 2021. Presentation (1).

xxiv. United States-Canada North Oil and Gas Forum, Anchorage, AK. 2012. Presentation (1).

xxv. US-Russia Area V Marine Mammal Meetings, Anchorage, AK. 2020. Presentation (1).

xxvi. USFWS Workshop on Assessing Pacific Walrus Population Attributes from Coastal Haul-outs, Anchorage, AK. 2012. Presentation (1).

xxvii. World Marine Mammal Conference, Barcelona, Spain, 2019. Posters (2).

4. Timeline of ASAMM and NSB 2020-2021 marine mammal data requests (all granted) and uses (chronological)

i. Feb 2010: Conoco-Phillips requested ASAMM 2008 aerial survey data for use in an Environmental Impact Study.

ii. Mar 2010: Greg Balogh (USFWS) requested an ASAMM 2009 Icy Cape walrus haulout photograph for use in a USFWS Landscape Conservation Cooperative planning document.

iii. Apr 2010: Bill Lorand (SFSU GIS student) requested the ASAMM 2008-2009 walrus sighting data for use in a Coastal & Marine Applications GIS course project.

iv. May 2010: Lisa Rotterman (NMFS) requested maps of ASAMM data for potential use in Arctic Incidental Harassment Authorization Biological Opinion.

v. June 2010: Dave Rugh (NMML) requested maps of ASAMM 2009 effort for use in an informal discussion about NMML Arctic surveys with a Naval Officer.

vi. 2010: Dan Pendleton (NOAA) requested 1982-2010 ASAMM bowhead whale data for a research project funded by NASA entitled "Forecasting Changes in Habitat Use by Bowhead Whales in Response to Arctic Climate Change: Integration of Physical-Biological Models with Satellite, Biological Survey and Oceanographic Data."

vii. April 2011: Lisanne Aerts (OASIS Environmental) requested ASAMM 1982-2010 sightings within the Olgoonik-Fairweather study area for use in a comparison of aerial sightings with shipboard sightings.

viii. Oct 2011: Joel Kasser and Jeadiz Wiedmer (Van Hall Larenstein, Netherlands BSc students) requested ASAMM walrus sightings from 2008-2010 for use in a thesis project for the Dutch WWF.

ix. 2011: Ken Dunton and Susan Schonberg (UT) requested shapefiles of ASAMM 2008-2010 bowhead whale, gray whale, and walrus sightings for comparison with benthic data.

x. 2011: Provided the ASAMM 1979-2010 historical data and associated metadata to OBIS-SEAMAP, a spatially referenced online database, aggregating marine mammal, seabird and sea turtle observation data from across the globe.

xi. 2011: NMFS Cetacean Density and Distribution Mapping (CetMap) Working Group requested ASAMM data to conduct a "gap analysis" of cetacean data within the US EEZ.

xii. 2012-present: Hajo Eicken and Olivia Lee (UAF) requested ASAMM walrus and sea ice data to investigate walrus use of sparse sea ice habitat and to calibrate remotely sensed sea ice data.

xiii. 2012: NSB requested data collected during ASAMM surveys conducted in the Alaskan Beaufort Sea in July and August 2012 to calculate a population estimate for the Eastern Chukchi Sea beluga stock.

xiv. 2012: Alyson Azzara (Committee on the Marine Transportation System) requested use of ASAMM data for an analysis of ship traffic in the Arctic.

- Azzara, A., H Wang, and D. Rutherford. 2015. A 10-year projection of maritime activity in the U.S. Arctic Region. Prepared by The International Council on Clean Transportation for the U.S. Committee on the Marine Transportation System.

xv. 2012: Amy Merten (NOAA) requested the ASAMM 1979-2012 database and tracklines for use in Arctic ERMA.

xvi. 2012: Sadie Wright (NOAA) requested the ASAMM bowhead whale sightings from summer 2012 for use in Noise Exposure Analysis section of the 2013 Arctic Biological Opinion.

xvii. 2013: Lucy Romeo (OSU graduate student) requested ASAMM beluga data to investigate the association between beluga and Arctic cod.

- Romeo, L.F. "Spatial distribution and the probability of occurrence of beluga whales (*Delphinapterus leucas*) in Alaskan Arctic." Master's thesis, Oregon State University, 2014.

xviii. 2013: Peter Winsor (UAF) requested near real-time ASAMM marine mammal data to inform decisions on deploying an underwater glider equipped with a passive acoustic monitoring device for recording cetacean vocalizations.

xix. 2013: John Brandon (Greeneridge Sciences, Inc.) requested ASAMM bowhead whale sighting data for the Point Franklin-Peard Bay region in summer 2009-2012.

xx. 2011, 2012, 2013: Sue Moore (NOAA) requested map of ASAMM gray whale and walrus sighting data from 1982-2013 overlying areas covered by the Distributed Biological Observatory.

xxi. April 2014: Craig George (NSB) requested map of ASAMM 2013 bowhead whale calf sighting data.

xxii. April 2014: Sue Moore (NOAA) requested map of gray whale data (sightings, calves, feeding) to include in discussions at the IWC Workshop "Range wide review of the population structure and status of North Pacific gray whale."

xxiii. 2014: Ying-Chih Fang (UAF) requested ASAMM 2010 bowhead and gray whale sighting data for comparison with surface current data in the Chukchi Sea, obtained from high-frequency radar.

xxiv. 2014: Elizabeth Edwards (NOAA) requested ASAMM fin whale sightings for a summary analysis of fin whale global distribution.

xxv. October 2014: Craig George (NSB) requested map of ASAMM 2014 bowhead whale Beaufort Sea sighting data to present at quarterly AEWC meeting.

xxvi. November 2014: Sue Moore (PMEL) requested map of ASAMM 2014 feeding bowhead whale sightings for presentation at SOAR workshop.

xxvii. November 2014: Chris Krenz (Oceana) and Nathan Walker (Audubon) requested ASAMM 2013 data.

xxviii. December 2014: Alicia Bishop (NMFS Alaska Regional Office) requested estimates of densities, representing the best available science, for ESA-listed species in the northeastern Chukchi Sea. This information is to be used in NMFS AKRO's consultation with BOEM over a proposed action on Lease Sale 193.

xxix. 2014-2015: ASAMM historical database was used to determine the best study area for the Arctic Aerial Calibration Experiments (Arctic ACEs), a collaboration among BOEM, US Navy, NOAA, Shell, and NSB.

xxx. March 2015: Guy Fleischer (AFSC, RACE division) requested the best available estimates of cetacean densities in the Arctic Large Marine Ecosystem for use in an Environmental Assessment.

xxxi. May 2015: Craig George (NSB) requested information on historical bowhead whale calf ratios and Sue Moore (NOAA) requested 2014 gray whale sighting and abundance information for presentation at International Whaling Commission Scientific Committee meetings.

xxxii. July-October 2015: Cetacean, walrus and polar bears sightings shared with BOEM and Shell for discussion during weekly PSO conference.

xxxiii. September 2015: Craig George (NSB) requested near real-time bowhead sighting information to directly assist with satellite tagging project. Three bowhead whales were tagged northwest of Point Barrow on 2 September using information provided by ASAMM for bowhead locations on 1 September.

xxxiv. October 2015: Kate Stafford (PMEL) requested ASAMM 2015 beluga sighting data for presentation at ABWC meetings to be held in November 2015.

xxxv. October 2015: Craig George (NSB) requested ASAMM 2015 bowhead whale carcass sighting data. More bowhead whale carcasses were seen in 2015 than in any prior year of ASAMM surveys; speculation is increased killer whale predation.

xxxvi. January 2016: Beth Sharp (Hilcorp Alaska) requested information about the potential of bowhead whales occurring between the mainland and barrier islands in the Alaskan Beaufort Sea.

xxxvii. March 2016: Steve Okkonen (UAF) and Craig George (NSB) requested information on survey effort and bowhead whale sightings at <50 m and >50 depths in the Barrow area.

xxxviii. July 2016: Raphaela Stimmelmayr (NSB) requested polar bear and brown bear sighting records from the ASAMM database, July-October, 1979-2016.

xxxix. July 2016: Carin Ashjian (WHOI) and Craig George (NSB) requested maps of bowhead and gray whale transect sightings in the Barrow region for inclusion in an NSF proposal for Long Term Ecological Research.

xl. August 2016: Sadie Wright (NMFS) requested near real-time data on marine mammal occurrence in the area of an oil spill drill near Oliktok Point, Beaufort Sea, AK.

xli. May 2017: Don Dragoo (Chukchi Sea area biologist) and Jeff Williams (Alaska Maritime National Wildlife Refuge Manager) requested photos of Cape Lisburne for use in managing the refuge.

xlii. May 2017: Martin Robards (Director, Arctic Beringia Program, Wildlife Conservation Society) requested marine mammal photos to be used in an op-ed in Scientific American highlighting the abundance of marine mammals north of Bering Strait during fall.

xliii. June 2017: Lori Quakenbush (ADFG) requested photos of belugas for use in an education and outreach presentation about aerial surveys.

xliv. July 2017: Sue Moore (NOAA PMEL) requested photos and flight track from ASAMM-Beaufort Flight 2, 21 July 2017, to be included in a presentation on the "krill trap" that she will present to vessel operators and participants conducting the fall 2017 Arctic Ecosystem Integrated Survey cruise.

xlv. July 2017: Raphaela Stimmelmayr (NSB) requested information about unid shark sightings in 2012 and 2017.

xlvi. July 2017: Sadie Wright (NMFS AKRO) requested recent data on ASAMM sightings near Northstar Island in the Beaufort Sea, for use in a hypothetical oil spill response drill.

xlvii. August 2017: Cleridy Lennert-Cody (Inter-American Tropical Tuna Commission) requested an estimate of the cost of conducting ASAMM surveys to be included in: Lennert-Cody, C.E., S.T Buckland, T. Gerrodette, A. Webb, J. Barlow, P.T. Fretwell, et al. (2018). Review of potential line-transect methodologies for estimating abundance of dolphin stocks in the eastern tropical Pacific. *Journal of Cetacean Research and Management* 19: 9–21.

xlviii. September 2017: Willow Hetrick (Fairweather Science) requested gray whale range data for use in an Incidental Harassment Authorization.

xlix. April 2018: NMFS AKRO requested ASAMM data and shapefiles for survey blocks 1 and 1a, for use in an ESA section 7 consultation for the Liberty development project.

l. April 2018: Sue Moore (NOAA PMEL) requested data on gray whale sightings in the Beaufort Sea for background information in response to a letter from the U.S. Marine Mammal Commission.

li. May 2018: Amy Fowler (NOAA OPR) requested input on "Request for Incidental Harassment Authorization for the Incidental Harassment of Marine Mammals Resulting from the Office of Naval Research Arctic Research Activities 2018-2019"

lii. July 2018: Sue Moore (PMEL) requested use of a figure showing all baleen whales sighted in 2017 to be included in a baleen whale occurrence review paper she is co-authoring.

liii. August 2018: Alicia Bishop (NOAA) requested information on species expected to occur in the Point Thomson area in response to an oil spill drill

liv. January 2019: Robyn McPhee (ConocoPhillips) requested ASAMM historical database 1979-2018 and information specific to the Coastal Harrison Bay transect surveyed in 2018.

lv. April 2019: Stephanie Grassia (JISAO) requested minke sightings, 2010-2018, for inclusion in a manuscript on minke whale acoustic detections.

lvi. October 2019: Ben Sullender (Audubon Alaska) requested 2015-2017 flightlines for use in comments provided to the USCG related to the Arctic Port Access Route Study.

lvii. October 2019: Alan Springer requested a bowhead whale distribution map that had been published in newspaper article.

lviii. October 2019: Kate Savage (Gray Whale UME team) requested map of gray whale sightings from 2019, 2009-2015, and 2016-2018.

lix. 2008-2019: Marine mammal photos taken during ASAMM were shared with numerous entities, including WWF, DFO, NOAA HQ, NSB, APR, and Arctic Sounder.

lx. 2010-2019: Biweekly maps of ASAMM bowhead whale sightings were sent to BOEM, NMFS, NSB, USFWS, USGS, ADFG, USCG.

lxi. November 2019: Steve Okkonen (UAF) requested bowhead whale sighting data from 2015-2019 to supplement data share previously.

lxii. January 2020: Vicki Cornish (MMC) requested map showing bowhead whale sightings in relation to proposed location of Qilak liquefied natural gas (LNG) north of Point Thomson, AK.

lxiii. February 2020: Vicki Cornish & Merra Howe (MMC) requested 2019 ASAMM transects & data to create heat maps that will display the last ten years of ASAMM sightings in the Arctic, to inform their recommendations about which areas should be excluded from shipping lanes in the Arctic. This will be a public letter ("MMC letter to AACPARS_10Nov2020.pfd") in response to Federal Register notice (83 Fed. Reg. 65701), which seeks public comment on the Arctic Coast Port Access Route Study.

lxiv. 2008-present: Level A stranding reports and photos (ASAMM through 2019 and NBS funded surveys 2020-2021) were sent to NSB, NMFS, and USFWS.

lxv. February 2020: Belly Port Camera imagery was shared with Natalie Kelly, Australian Antarctic Division, Southern Ocean Ecosystems for use in AI detection software.

lxvi. April 2020: Alexandra Mayette and Marianne Marcoux with Canada Fisheries and Ocean requested beluga sightings, between 118-141W and link to data and metadata.

lxvii. October 2020: Olivia Lee with UAF requested North Slope Borough funded aerial survey data for 2020 walrus sightings.

lxviii. November 2020: Marilyn Mayers, NMFS AKRO, requested bowhead whale distance from shore data. Info on bowhead whale distance from shore in Block 12. Sent central tendency analysis methods and results in the ASAMM reports, filtered data from NSB funded 2020 surveys for non-dead bowheads in block 12, and shared draft copies of the bowhead 2020 sighting, bowhead feed/mill, and 2020 plus light ice years figures from the 2020 survey report.

lxix. January 2021: Leigh Torres with Oregon Sea Grant and Geospatial Ecology of Marine Megafauna Lab, Marine Mammal Institute, Oregon State University and Carla Bird requested gray whale images for body condition analysis. Results used in Baja-Oregon gray whale body condition manuscript (Torres et al. 2022). A presentation of results is planned for the August 2022 World Marine Mammal Conference in Florida.

5. Non-marine mammal data collected, requested (all granted), and uses (chronological)

i. April 2012: Provided ASAMM sea ice observations made in September and October from 2007-2011 to Warren Horowitz (BOEM) to compare and ground-truth remotely sensed sea ice data. Extracted data, created feature classes for import into GIS, and stored in a file geo-database.

ii. Distributed sea ice photos and data from 2011-2019 to the following:
   - NOAA, National Weather Service and Pacific Marine Environmental Laboratory: Ground-truth remotely sensed data, train staff, and include in presentations
   - UAF: Examine sparse sea ice habitat for walruses
   - BOEM: Manage and plan open water season activities
   - USCG: Navigation
   - USFWS: Investigate walrus habitat
   - USGS: Sea ice reconnaissance during walrus tagging events
   - Alaska Center for Climate Assessment and Policy
   - Shell: Develop sea ice predictions for ice management during offshore operations

iii. Sea ice data sent to Tom Weingartner (UAF) in September 2013 to provide information about sea ice coverage in offshore areas where a sea glider were to be launched.

iv. Several meteorological instruments were located on shore and locations relayed to project owners for retrieval.

v. December 2014: Marine debris sightings sent to Peter Murphy, Regional Coordinator of NOAA Marine Debris Program, Office of Response and Restoration.

vi. February 2017: Provided ASAMM sea ice imagery from 2014-2015 to Victoria Hill (Old Dominion University, Department of Ocean, Earth and Atmospheric Sciences) to provide visual information about surface sea ice conditions in locations where buoy data overlap.

vii. August 2018: Aerial photos of PMEL sail drones provided to Heather Tabisola, Research Coordinator, EcoFoci and ITAE.

viii. February 2020: Aerial images and sighting data for jellyfish shared with NOAA's Carol Ladd, Ed Farley, and Kristen Cieciel.

ix. September-October 2020 and 2021 NSB funded aerial surveys: Recorded sightings of marine debris (notable debris only in 2020; all sightings of debris in 2021.

6. Walrus and polar bear collaborations with USFWS and USGS (chronological)

i. 2009-2019: Detailed information on ASAMM walrus and polar bear sightings were provided to USFWS to comply with research permit requirements. These data provide USFWS with information useful in Section 7 consultations required under the US Endangered Species Act.

ii. 2009-2019: Provided USGS and USFWS with the earliest and most comprehensive information about mass walrus haulouts located on the northeastern Chukchi Sea coast. USFWS used these data to implement management decisions affecting air traffic near the haulouts. USFWS and USGS use these data to study walrus haulout dynamics over time.

iii. 2010-2012: Provided ASAMM walrus sighting data, 1982-2011, to USFWS to investigate its utility in estimating walrus population size.

iv. 2011-2015: Multiple reconnaissance flights in July to locate walrus haulouts on offshore sea ice to assist USGS in satellite tagging efforts. Positions of large, small-boat-accessible walrus groups and surrounding ice conditions were relayed to biologists onboard the surface ship, resulting in a considerable cost savings to the government and an efficient use of uniquely qualified field personnel.

v. 2014: Coordinated survey time with Brian Battaile and Chad Jay (USGS) to allow for dedicated overflights of walrus haulout at Point Lay and coastal surveys between Point Barrow and Cape Lisburne specifically for photography of haulouts.

vi. 2014: Special Agent Ryan Cote (USFWS Office of Law Enforcement) requested ASAMM archived and future Level As for walrus and polar bears to help investigations into potential criminal matters.

vii. 2015: Provided USGS updated information on walrus haulout near Point Lay to assist with their planning for overflights of the haulout using a small drone. The haulout needed to be a minimum of 3 nmi from the airport in order for the drone to fly.

viii. 2015-2019: Incorporated searches of western Beaufort Sea coastline and barrier islands into flight plans, where possible, to search for polar bears; response to USFWS not conducting their biweekly coastal searches as they have in most recent past years.

ix. March 2017: Michelle St. Martin (USFWS) requested data on all polar bear sightings from 2008-2016. Also provided all polar bear photographs in the ASAMM photo archive.

x. August 2017: James MacCracken and Jonathan Snyder (USFWS), and Anthony Fischbach and Chad Jay (USGS) requested recent photos of the coastal walrus haulout at Point Lay, Alaska.

xi. August 2018: Sent summary of polar bear reactions, 2012-2017, from ASAMM database, to Michelle St. Martin and Kimberly Klein, USFWS.

xii. August 2018: Shared ASAMM database 1979-2017, metadata, flightlines, version histories, etc., to Kristin Laidre, Eric Regehr, Harry Stern and Ben Cohen (UW Applied Physics Lab, Polar Science Center.

xiii. August 2018: Photo of walrus haulout at Point Lay and daily walrus sightings shared with James MacCracken and Jonathan Snyder (USFWS), and Anthony Fischbach and Chad Jay (USGS).

7. Incidental Harassment Authorizations using ASAMM sighting and effort data for marine mammal density calculations and take estimates (list taken from IHAs on NMFS OPR website in November 2016) and Environmental Impact Statements/Environmental Assessments citing ASAMM (list taken from BOEM EIS and Major EA website in November 2016) (chronological)

i. Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed open water seismic program in the Chukchi and Beaufort Seas, Alaska, during 2007.

ii. ASRC Energy Services: Revised request for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed marine survey program in the Chukchi Sea, Alaska.

iii. BP Exploration: Request for an Incidental Harassment Authorization pursuant to section 101(A)(5) of the Marine Mammal Protection Action covering incidental harassment of marine mammals during and OBC seismic survey in the Liberty Prospect, Beaufort Sea, Alaska in 2008.

iv. Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed open water seismic and marine survey program in the Chukchi and Beaufort Seas, Alaska, during 2008-2009.

v. Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed open water marine survey program in the Chukchi and Beaufort Seas, Alaska, during 2009-2010.

vi. Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with planned 2010 exploration drilling program near Camden Bay in the Beaufort Sea, Alaska.

vii. Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with planned 2010 exploration drilling program, Chukchi Sea, Alaska.

viii. Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed open water marine survey program in the Beaufort and Chukchi Seas, Alaska, during 2010.

ix. Statoil: Request for an Incidental Harassment Authorization by Statoil to allow incidental harassment of marine mammals during a 3D marine seismic survey in the Chukchi Sea, Alaska, 2010.

x. US Geological Survey: Request by US Geological Survey for an Incidental Harassment Authorization to allow the incidental take of marine mammals during a marine seismic survey of the Arctic Ocean, August-September 2010.

xi. Statoil: Request by Statoil for an Incidental Harassment Authorization to allow the incidental take of marine mammals during a shallow hazards survey in the Chukchi Sea, Alaska, 2011.

xii. University of Alaska Geophysics Institute: Request by the University of Alaska Geophysics Institute for an Incidental Harassment Authorization to allow the incidental take of marine mammals during a marine geophysical survey by the R/V Marcus G. Langseth in the Arctic Ocean, September-October 2011.

xiii. BOEM, Alaska OCS Region: Chukchi Sea Planning Area, Shell Gulf of Mexico, Inc., Shell Revised Chukchi Sea Exploration Plan, Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915, Chukchi Seal 193, 2011.

xiv. BOEM, Office of Leasing and Environment, Alaska OCS Region: Beaufort Sea Planning Area, Shell Offshore, Inc., 2012 Revised Outer Continental Shelf Lease Exploration Plan, Camden Bay, Beaufort Sea, Alaska, Flaxman Island Blocks 6559, 6610 and 6658, Beaufort Lease Sales 195 and 202, 2011.

xv. BP Exploration: Incidental Harassment Authorization request for the non-lethal harassment of whales and seals during the Simpson Lagoon OBC seismic survey, Beaufort Sea, Alaska, 2012.

xvi. Ion Geophysical: Request by ION Geophysical for an Incidental Harassment Authorization to allow the incidental take of marine mammals during a marine seismic survey in the Arctic Ocean, October-December 2012.

xvii. ConocoPhillips: Application for Incidental Harassment Authorization for the non-lethal harassment of cetaceans and seals during exploration drilling activities in the Devil's Paw Prospect, Chukchi Sea, Alaska.

xviii. Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with planned exploration drilling program during 2012 near Camden Bay in the Beaufort Sea, Alaska.

xix. Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with planned exploration drilling program during 2012 in the Chukchi Sea, Alaska.

xx. Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed open water marine surveys program in the Chukchi Sea, Alaska, during 2013.

xxi. SAExploration: Application for the Incidental Harassment Authorization for the Taking of Whales and Seals in Conjunction with the SAE Proposed 3D Seismic Survey in the Beaufort Sea, Alaska, Summer 2013.

xxii. SAExploration: Application for the Incidental Harassment Authorization for the Taking of Whales and Seals in Conjunction with the SAE Proposed 3D Seismic Survey in the Beaufort Sea, Alaska, Summer 2014.

xxiii. BOEM, Office of Environment, Alaska OCS Region: SAExploration Inc., Colville River Delta 2014, 3D Geophysical Seismic Survey, Beaufort Sea, Alaska, 2014.
xxiv. BOEM, Office of Environment, Alaska OCS Region: BP Exploration (Alaska) Inc., 2014 Liberty Ancillary Activities, Shallow Geohazard Seismic Survey, Beaufort Sea, Alaska, 2014.
xxv. BOEM, Office of Environment, Alaska OCS Region: BP Exploration (Alaska) Inc., North Prudhoe Bay 2014 OBS, Geophysical Seismic Survey, Beaufort Sea, Alaska, 2014.
xxvi. BOEM, Office of Environment, Alaska OCS Region: SAExploration 2014 Geophysical Seismic Survey, Beaufort Sea, Alaska, 2014.
xxvii. BP Exploration: Incidental Harassment Authorization request for the non-lethal harassment of marine mammals during the Prudhoe Bay OBS Seismic Survey, Beaufort Sea, Alaska, 2014.
xxviii. BP Exploration: Incidental Harassment Authorization request for the non-lethal harassment of marine mammals during the Liberty Geohazard survey, Beaufort Sea, Alaska, 2014.
xxix. SAExploration: Application for the Incidental Harassment Authorization for the Taking of Marine Mammals in Conjunction with the SAE's Proposed 3D Seismic Survey in the Beaufort Sea, Alaska, 2015.
xxx. Shell Gulf of Mexico, Inc.: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with planned exploration drilling activities during 2015, Chukchi Sea, Alaska.
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APPENDIX H: Abbreviations and Acronyms

AACPARS	Alaskan Arctic Coast Port Access Route Study
ADFG	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
AFF	Automated Flight Following
AFSC	Alaska Fisheries Science Center
AKRO	Alaska Regional Office
AOOS	Arctic Ocean Observing System
APR	Alaska Public Radio
APRN	Alaska Public Radio News
Arctic ERMA	Arctic Environmental Response Management Application
ASAMM	Aerial Surveys of Arctic Marine Mammals
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BP	British Petroleum
BS	Beaufort Sea (specific to beluga population)
BWASP	Bowhead Whale Aerial Survey Project
BWCA	Barrow Whaling Captains' Association
CAPs	Cetacean Aggregation Protocols
CICOES	Cooperative Institute for Climate, Ocean, and Ecosystem Studies
COMIDA	Chukchi Offshore Monitoring in Drilling Area
DFO	Fisheries and Oceans Canada
DoD	Department of Defense
DOI	Digital Object Identifier
e.g.	for example
ECS	Eastern Chukchi Sea (specific to beluga population)
EE	Exclusive Economic Zone
ELT	emergency locator transmitter
ERMA	Environmental Response Management Application
ESA	Endangered Species Act
etc.	et cetera
ft	feet
GIS	Geographic Information System
GPS	Global Positioning System
HQ	Headquarters
hr	hour
HUA	high-use area
i.e.	that is
IHA	Incidental Harassment Authorization
IWC	International Whaling Commission
JISAO	Joint Institute for the Study of the Atmosphere and Ocean
km	kilometer

LNG	Liquid Natural Gas
m	meter
MCC	Main Construction Camp
mi	mile
min	minute
MMC	Marine Mammal Commission
MML	Marine Mammal Laboratory
MPA	Marine Protected Areas
NASA	National Aeronautics and Space Administration
NGO	Non-governmental Organization
NMFS	National Marine Fisheries Service
nmi	nautical mile
NMML	National Marine Mammal Laboratory
No.	number
NOAA	National Oceanic and Atmospheric Administration
NPRB	North Pacific Research Board
NSB	North Slope Borough
NSB DWM	North Slope Borough Department of Wildlife Management
NSB SAR	North Slope Borough Search and Rescue
NSF	National Science Foundation
OBIS-SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
OCS	Outer Continental Shelf
OE-Si	on-effort sightings
OPR	Office of Protected Resources
OSU	Oregon State University
P	probability
PAME	Protection of the Arctic Marine Environment
PIC	pilot in command
PLB	personal locator beacon
PMEL	Pacific Marine Environmental Laboratory
RACE	Resource Assessment and Conservation Engineering
SAE	SAExploration, Inc.
SD	standard deviation
sec	second
SFSU	San Francisco State University
SOAR	Synthesis of Arctic Research
SST	sea surface temperatures
Tr	transect
UAF	University of Alaska Fairbanks
UME	Unusual Mortality Event
USCG	US Coast Guard
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey

UT	University of Texas
UTM	Universal Transverse Mercator
UW	University of Washington
WHOI	Woods Hole Oceanographic Institution
WPUE	whales or walruses per unit effort (index of relative abundance or occurrence)
WWF	World Wildlife Fund
Z	standard normal variable

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