PEBBLE PROJECT
ENVIRONMENTAL BASELINE DOCUMENT
2004 through 2008

CHAPTER 43.
NEARSHORE FISH AND INVERTEBRATES
Cook Inlet Drainages

PREPARED BY:
PENTEC ENVIRONMENTAL/HART CROWSER, INC.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

ADF&G	Alaska Department of Fish and Game
CPUE	catch-per-unit-effort
GIS	geographic information system
GPS	global positioning system
IIE	Iniskin and Iliamna Estuary
IRI	Index of Relative Importance
MLLW	mean lower low water

43. NEARSHORE FISH AND INVERTEBRATES

43.1 Introduction

Littoral and subtidal habitats in lower Cook Inlet support diverse populations of numerous species of finfish and macroinvertebrates. These habitats are used as rearing areas, migration corridors, spawning areas, and places of refuge from deepwater predators.

This chapter of the Environmental Baseline Document describes fish and macroinvertebrate fauna in Iniskin and Iliamna bays based on existing literature and on field investigations conducted over a 5-year period from 2004 through 2008. Iniskin and Iliamna bays (Figure 43-1) comprise one of several estuarine complexes and embayments along the west side of lower Cook Inlet and, for this report, are collectively termed the Iniskin and Iliamna Estuary, or IIE.

43.2 Study Objectives

The goal of this study was to characterize nearshore fish and invertebrate populations in the IIE. This section builds on historic information and presents the results of field work conducted from 2004 through 2008. Specific objectives of field work included:

- Build upon the limited knowledge available from past studies to gain a broader understanding of the nearshore and demersal ecology of the IIE, to provide a baseline that includes seasonal, annual, and tidal variations.
- Identify and describe the specific habitats of each sampling station.
- Document the food web and ecological relationships among key species of fish and invertebrates.
- Investigate local spawning by Pacific herring (*Clupea pallasii*).

43.3 Study Area

The nearshore fish and invertebrate study area included all marine waters and shorelines of the IIE, except inner Cottonwood Bay and inner Iniskin Bay, from the east side of the entrance to Iniskin Bay and Scott Island to the south side of the entrance to Iliamna Bay at South Head (Figure 43-2). The sampling effort focused on nearshore habitats. Key geographic features in the IIE considered in this study are shown on Figure 43-2.

Sample sites are shown on Figure 43-2 and included beach seine, gill net, and trammel net stations along the southeast shore of Knoll Head, the east and west shores of Iliamna Bay (including the entrance to Cottonwood Bay), and Blackie Beach on the east side of Iniskin Bay. Trawl stations were located at various depths in both Iniskin and Iliamna bays and at one location in deeper water off Knoll Head (Figure 43-2).

43.4 Previous Studies

Few scientific studies of the west side of lower Cook Inlet or in the IIE area had occurred prior to the initiation of the National Oceanic and Atmospheric Administration's Outer Continental Shelf Environmental Assessment Program in the mid-1970s. The following discussion of the food web supporting lower Cook Inlet nearshore fish and invertebrates is drawn mainly from that research.

43.4.1 Primary Productivity

The timing of the spring phytoplankton bloom in lower Cook Inlet coincides with stabilization of the water column and increased incident light; this usually occurs in May (Larrance et al., 1977). From late August through April, unidentified microflagellates were dominant but not abundant in most areas of the lower inlet. Diatom blooms occurred during summer months, and the diatom *Melosira sulcata* always dominated the northern part of lower Cook Inlet in summer, particularly in August. Diatoms of the genus *Thalassiosira* began to increase in abundance in early May in Kachemak Bay (Figure 43-1) and later in May in areas to the west. However, data from a station northeast of Augustine Island, indicate that *Thalassiosira* was slightly more abundant than microflagellates in parts of southern Cook Inlet as early as April. The *Thalassiosira* bloom subsided by July, when the diatom *Chaetoceros* became dominant. This bloom was over by August, when microflagellates again prevailed but in low numbers (Larrance et al., 1977).

Nitrate concentrations decreased sharply in Kamishak Bay between late May and early July, during the diatom blooms, and increased rapidly in late August. Primary productivity peaked in late May. Chlorophyll *a* increased steadily through mid-July. Primary productivity in Kamishak Bay was only 10 to 50 percent that of Kachemak Bay, and chlorophyll *a* concentrations were only 10 percent of those in Kachemak Bay (Larrance et al., 1977). Differences in nutrient and chlorophyll concentrations of Kamishak and Kachemak bays may be due to the greater water circulation in Kamishak Bay, which continues to be well mixed into the spring bloom season.

43.4.2 Secondary Productivity

Copepods numerically dominate the zooplankton community in lower Cook Inlet (Damkaer, 1977). Overall zooplankton abundance outside Kachemak Bay paralleled that of the Gulf of Alaska. While zooplankton abundance reached a maximum in Kachemak Bay in May, it did not peak in other areas of lower Cook Inlet until July (Damkaer, 1977).

43.4.3 Fish

43.4.3.1 Salmon

Chum, pink, and coho salmon (*Oncorhynchus keta, O. gorbuscha,* and *O. kisutch*) are reported to spawn in the streams discharging to Iniskin and Cottonwood bays. According to the Alaska Anadromous Stream Catalog GIS database, adult salmon spawn in seven streams discharging to Iniskin Bay and two streams discharging to Cottonwood Bay (Figure 43-2). In addition, adult chum salmon showing spawning colors were observed by field teams in Williams Creek, which discharges to inner Iliamna Bay. Most of these are small streams, less than 7 miles in length. Chum and pink salmon spawn in most of the streams, while small populations of coho salmon spawn in some larger streams such as the Iniskin River. Chinook and sockeye salmon (*O. tshawytscha* and *O. nerka*) have been documented in Y Valley Creek; run sizes are not known but considered small.

Chum salmon are reported to be the most abundant salmonid within the IIE (Blackburn et al., 1981; ADF&G, 2009). From 1988 to 2008, chum salmon escapement in Cottonwood Bay ranged from a low of 2,300 in 1998 to a high of 72,800 in 2003, with an average of 16,500 fish. Most of these fish were destined for Cottonwood Creek. Similar run sizes have been found in Iniskin Bay with escapements averaging 14,700 fish and ranging from 3,400 in 1992 to 28,500 in 2002. Most of these fish returned to the Iniskin River, but chum also spawn in several other streams that discharge to the bay. Escapement has exceeded the 20-year average in 3 of the last 5 years (ADF&G, 2009). Pink salmon escapements have been on the order of 5,000 in Y Valley Creek between Knoll Head and North Head, 1,000 in Cottonwood Creek and in the Iniskin River, and somewhat less in other streams in those bays. Coho spawn in Cottonwood Creek (~2,000) and in the Iniskin River (no numbers given by Blackburn et al., 1981).

In southcentral Alaska, including Iniskin, Iliamna, and Cottonwood bays, pink and chum salmon spawn in lower reaches of streams, often in areas that experience some tidal influence. Blackburn et al. (1981) note that these habitats can be especially productive since extremes of weather, which can cause mortality, are ameliorated by proximity to tidal waters.

Blackburn et al. (1981) also found that juvenile chum and pink salmon were predominant in the nearshore during spring. Both species were present when sampling began in May and increased in abundance through early summer. In addition, these two species were commonly observed in deeper water habitats sampled by tow net along with smaller numbers of juvenile sockeye and Chinook salmon. Juvenile pink, chum, and Chinook were relatively common offshore during July and August while juvenile sockeye were common during June and early July.

43.4.3.2 Pacific Herring

The Kamishak Bay herring fishery began in 1973 (Blackburn et al., 1981) and was primarily a roe fishery which began in late April, when larger fish typically spawned. Younger fish began spawning after the first week of May and continued into early June. For example, in 1997, 41 percent of the harvest biomass was spawned before May 8 and 59 percent after May 8. Spawning can peak even before schools are observed (April 20), as happened in 1990 (Otis et al., 1998).

To model herring abundance, the Alaska Department of Fish and Game (ADF&G) conducts aerial surveys of herring schools in Iniskin, Cottonwood, and Iliamna bays and in Ursus Cove as well as other Kamishak Bay locations (Otis et al., 1998). Model inputs for 1-year forecasts include commercial harvests, catch-age compositions, total run-age compositions, weights-at-age, and aerial survey biomass estimates; also initial cohort abundance, age-specific maturity, and fishery selectivity.

The Kamishak Bay herring fishery has been closed since 1999 (the last harvest was in 1998) due to low abundance (ADF&G, 2009). Current regulations allow for the harvest of 15 percent of a threshold biomass of 6,000 [short] tons. Since the fishery has been closed, biomass has ranged from 1,775 tons to 3,921 tons, well below regulatory thresholds. From 1999 through 2007, biomass has steadily declined with a slight increase in 2007. No estimate of abundance was generated in 2008, but aerial surveys resulted in a cumulative total of 2,098 tons, still well below regulatory thresholds (ADF&G, 2009). A very strong 1988 cohort (age class) is thought to have supported the commercial herring fishery in Kamishak Bay through most of the 1990s (Iniskin, Iliamna, and Cottonwood bays fall within Area 9 of the Kamishak Bay district; ADF&G, 2004).

Young-of-the-year herring grow from about 20 millimeters in late May to 40 to 50 millimeters in late September; one-year old herring are about 80 to 90 millimeters in late June and 90 to 120 millimeters by early August. Blackburn et al. (1981), who sampled extensively in Kamishak and Kachemak bays using a variety of nearshore and pelagic gear types, did not capture herring more than one year old.

The ADF&G Division of Commercial Fisheries has developed a GIS-based synthesis of Kamishak Bay herring data (ADF&G, 2002; ADF&G, unpublished data). The synthesis database includes adult herring and spawning data collected by both aerial and vessel-based surveys throughout Iniskin, Iliamna, and Cottonwood bays, 1978 through 2005. Figures 43-3 through 43-5 summarize the spatial distribution of adult herring schools and spawning areas found within the bays during this period.

Aerial survey data show that pre-spawning adult herring stage in offshore areas of all three study area bays (Iniskin, Iliamna, Cottonwood) with somewhat larger concentrations on the eastern half of Iniskin Bay (Figure 43-3) and lesser numbers along the reach between Knoll Head and North Head. This distribution did not change substantially over the 1978 to 2002 period (ADF&G, 2002; ADF&G, unpublished data). The general abundance of herring was corroborated in 1978 by their predominance in tow net hauls of habitats farther from shore in Kamishak Bay and the IIE (Blackburn et al., 1981).

In contrast to the distribution of adults, the distribution and volume of herring spawn changed substantially over the 1978 to 2002 time period. From 1978 to 1989 herring spawn was concentrated along the eastern shore of Iniskin Bay from the inner bay to the head of the bay including reefs along the western and northern shores of Scott Island (Figure 43-4). Spawning was also found along most of the shore along Knoll and North heads to outer portions of Iliamna Bay, as well as the southern shore of outer Cottonwood Bay. Just outside of Iniskin Bay, spawning herring used reefs between Iniskin and Pomeroy islands (Figure 43-4). A substantial degree of spawning occurred during the 1980s; aerial surveys detected spawning in all but two years during this period. The geographical extent of spawning in the study area appeared to increase through the period, particularly from 1985 through 1989 (ADF&G, 2002).

Substantially lower levels of spawning occurred in the IIE during the 1990 to 2002 period (Figure 43-5). Spawning during this period was limited to reefs along the eastern shore of middle Iniskin Bay, outer Scott Island, and Knoll Head near the mouth of Y Valley Creek. Spawning was also found in headland areas and islands between Oil Bay and Iniskin Bay, largely outside of the study area (Figure 43-5). Between 1990 and 2002, spawning fish were detected in the study area only in 1990, 1991, and 1994 (ADF&G, 2002).

No spawning was observed during aerial surveys in the study area during the 2003 to 2005 period (ADF&G, unpublished data).

43.4.3.3 Other Nearshore Species

From May through September 1978, Blackburn et al. (1981) sampled extensively in Kamishak Bay (Figure 43-1) and areas farther north, including the IIE, with beach seines, gill nets, trammel nets, and tow nets. The dominant species in the beach seine hauls in those bays were, in order of numerical abundance:

Pacific sand lance (*Ammodytes hexapterus*), Pacific herring, juvenile chum salmon, Dolly Varden char (*Salvelinus malma*), and juvenile whitespotted greenling (*Hexagrammos stelleri*). Pacific sand lance and Pacific herring were the most abundant species caught in tow net hauls in deeper portions of the bays. Sand lance were caught in largest numbers in early summer (mean of 18.9 ± 18.7 fish per beach seine haul, May 16 to 31) and early fall (mean of 88.3 ± 82.4 fish, September 1 to 15) in Kamishak Bay, south of the IIE. The largest haul was at a station at the mouth of Iliamna Bay. Within Cottonwood, Iliamna, and Iniskin bays, sand lance were infrequent. Juvenile chum salmon were less abundant in the tow net catches than other salmon species, probably because juvenile chum tend to hug the shore more than other juvenile salmon. Juvenile chum also tended to remain in this environment later than pinks (through mid-September versus mid-July). Abundances varied seasonally and by site. Adult Dolly Varden were less abundant in Cottonwood, Iliamna, and Iniskin bays relative to Kamishak area bays, and catches of longfin smelt (*Spirinchus thaleichthys*) were inversely correlated with water clarity at time of sampling. Reproductively mature capelin (*Mallotus villosus*) were caught only in late May in the mouth of Iniskin Bay in both the tow net and a small otter trawl. Blackburn et al. (1981) also reported on the dietary habits of the fish they sampled. Demersal sampling with the otter trawl yielded primarily flatfish and crab (Blackburn et al., 1981). However, the authors did not report trawl data by area, and it is not possible to compare catch among locations.

Kachemak Bay, on the east side of lower Cook Inlet (Figure 43-1), was sampled in 1976 by Blackburn et al. (1981). To make historical and inter-area comparisons, in 1995 and 1996, Robards et al. (1999) resampled Kachemak Bay (one of the areas sampled by Blackburn et al., 1981), and also sampled the Barren Islands (Figure 43-1) and Chisik Island, along the west side of Cook Inlet north of Kamishak Bay. Fish were captured with beach seines and midwater trawls. Compared to 1976, the fish community of Kachemak Bay in 1995 and 1996 showed a similar pattern of numerical dominance by Pacific sand lance, Pacific herring, Dolly Varden, and pink salmon, but it also showed a substantial increase in gadids (Pacific cod, *Gadus macrocephalus*; saffron cod, *Eleginus gracilis*; Pacific tomcod, *Microgadus proximus*; and walleye pollock, *Theragra chalcogramma*); sockeye and chum salmon; sculpins (silverspotted sculpin, *Blepsias cirrhosus*; buffalo sculpin, *Enophrys bison*; and warty sculpin, *Myoxyocephalus verrucosus*); Pacific sandfish, *Trichodon trichodon*; pricklebacks (slender eelblenny, *Lumpenus fabricii*, and daubed shanny, *Leptoclinus maculatus*); lobefin snailfish, *Liparis greeni*; sablefish, *Anoplopoma fimbria*; and flathead sole, *Hippoglossoides elassodon*. The only notable declines were in numbers of masked greenling, *Hexagrammos octogrammus*; coho salmon; and longsnout prickleback, *Lumpenella longirostris*. Gadids and flatfish were identified as species favored by periods with a strong Aleutian Low and warm coastal waters, as has occurred in the northern Gulf of Alaska from the late 1970s to late 1990s (Anderson and Piatt, 1999).

Among the sites sampled in 1995 and 1996, catch-per-unit-effort (CPUE) for all species was highest (an order of magnitude above that in Kachemak Bay) in the Barren Islands (well southwest of the IIE), but average species diversity, evenness, and richness were lowest there (Robards et al., 1999). CPUE was lowest (an order of magnitude lower than in Kachemak Bay) at Chisik Island (well northeast of the IIE), but average species diversity, evenness, and richness were highest there. (These statistics may be somewhat misleading, however, because of the comparatively small sample size at Chisik Island: 24 species in 30 seine sets at Chisik Island compared to 50 species in 305 sets in Kachemak Bay). Kachemak Bay was sampled every month except January and November. Almost no fish were caught during winter months (December through March). CPUE was highest for all species from June to mid-July. Adult sand lance moved away from the shore in late July, returning in October to spawn. Sand lance caught in August and September were young-of-the-year. Robards et al. (1999) also noted differences between high tide sets, when juvenile sand lance and Dolly Varden were more abundant, and low tide sets, when pricklebacks, gunnels, and sculpin appeared in catches. Cod, greenling, and flatfish were also less abundant during high tide sets.

Abookire et al. (2000) compared the distribution and abundance of nearshore species in outer and inner Kachemak Bay from June to August 1996 and 1998 using beach seines and small-meshed beam trawls (a type of trawl net with a beam across its mouth to maintain lateral spread during trawling>). There was a significant difference in fish communities between the outer and inner bay. The seine catch in the inner bay, which is characterized by lower salinity and warmer temperatures than the outer bay, was 48 percent adult Pacific sand lance, 29 percent Pacific herring, and 15 percent juvenile sand lance. Although the percentage of sand lance was similar between outer and inner bay catches, the total abundance was five times higher in the inner bay. Herring were 40 times more abundant in the inner bay. The authors attributed the higher abundance of these species in the inner bay to stratification that occurs there. Stratification is believed to enhance primary production by increasing the stability of surface waters, assuming adequate nutrients can be obtained from river runoff and upwelled water (Harrison et al., 1991). Both juvenile sand lance and herring are known to concentrate and feed on zooplankton in stratified estuarine environments. Moreover, juvenile herring are known to feed at a higher rate when there is a moderate suspension of fine-grained sediment, which may help provide a visual contrast in prey items while reducing predation on the herring (references cited in Abookire et al., 2000). The reduced salinity of the estuarine environment may ameliorate stress on juvenile salmonids as they acclimatize to the marine environment in addition to providing enhanced feeding opportunities (Simenstad et al., 1982).

Abookire et al. (2000) emphasized the importance of habitat (namely depth, temperature and salinity) in relation to the distribution and abundance of juvenile groundfish in outer Kachemak Bay. They sampled depths from 10 to 70 meters at 10-meter intervals using a small-meshed beam trawl in August and September 1994 to 1999. Juveniles mostly concentrated in either shallow (<20 meter) or deep (50 to 70 meter) water. Shallow species included rock sole, *Lepidopsetta bilineata*; Pacific halibut, *Hippoglossus stenolepis*; great sculpin, *Myoxocephalus polyacanthocephalus*; and Pacific cod. Deep species were flathead sole; slim sculpin, *Radulinus asprellus*; spinycheek starsnout, *Bathyagonus infraspinatus*; rex sole, *Glyptocephalus zachirus*; tadpole sculpin, *Psychrolutes paradoxus*; and whitebarred prickleback, *Poroclinus rothrocki*. Overall, rock sole was the most abundant species. Although most strongly correlated with depth, species also showed a preference for bottom type, which was in turn correlated with depth and may be the factor responsible for the depth preference. Shallow stations were at least 95 percent sand whereas deeper stations were a mixture of sand (77 to 83 percent) and mud (17 to 23 percent). The authors observed no direct link between fish distribution and temperature although they noted that CPUE was lower overall in 1998 following a winter with unusually warm water temperatures due to the strong 1997 and 1998 El Niño. There was also no link with salinity.

43.5 Scope of Work

The scope of work for this study was to repeatedly sample nearshore and offshore demersal habitats using several types of gear that are well-suited to characterizing fish and invertebrates in those habitats. Two beach seine types were used to sample pelagic and demersal species within 100 feet of shorelines with sandy to cobble substrates and within tidal lagoons of the IIE. Floating gill and sinking trammel nets were used to sample the nearshore water column and demersal rocky habitats. A small otter trawl was used to sample demersal fish and invertebrates in waters from approximately 10 to 70 feet deep. An initial reconnaissance sampling was conducted in late August 2004. In 2005, prolonged sampling efforts were conducted from spring through fall. In 2006 and 2007, sampling occurred during April/May and September/October, respectively, to supplement data sets that are typically smaller during these periods when inclement weather can hamper sampling efforts. In 2008, sampling was conducted monthly from late winter (March) to early winter (November). In addition, herring spawning surveys were conducted during spring in 2006 and 2008.

Specific fishery investigations were performed in the intertidal and subtidal habitats to meet the overall study objectives. Pentec Environmental, the natural resources arm of Hart Crowser, Inc., conducted the studies over a 5-year field effort. Field work was conducted under the direction of Dr. Jon Houghton and/or Mr. Jim Starkes.

Work over the 2004 to 2008 study period was conducted in accordance with yearly study and field sampling plans (Appendix E) and quality assurance project plans (QAPP; Appendix G). Detailed methods are described in these documents and are summarized in the following section only when methods used differed from those identified in study plans and QAPPs.

43.6 Methods

43.6.1 Literature Synthesis

Senior biologists with Pentec, University of Alaska Fairbanks, and RWJ Consulting prepared a synthesis of literature relevant to the project. Resources searched included online searches, academic libraries in the area, ADF&G archives, and discussions with area researchers. The synthesis developed general descriptions of the geologic, hydrodynamic, climatological, and biological conditions that are provided in Section 43.4 and in other chapters (e.g., Chapters 27, 30, and 34).

43.6.2 Field Surveys and Collections

43.6.2.1 Timing

Field surveys were conducted over a 5-year period between 2004 and 2008; dates and types of equipment used during each survey are presented in Table 43-1. Multiple sampling events for fish, macroinvertebrates, and herring spawn were conducted over this period. In 2005 and 2008, fish samples also were collected periodically for stomach content analysis. Additional benthic sampling (including intertidal transects and subtidal dive surveys), and baseline environmental chemistry sampling also were conducted. The results of intertidal and subtidal surveys are presented in Chapter 42. Baseline chemistry results are presented in Chapters 34 and 35.

43.6.2.2 120-foot Beach Seine

The methods used in these studies were used in recent work in Knik Arm and in the Aleutian Islands where they have demonstrated a substantial presence of fish in shallow waters along shorelines of embayment and estuaries well into summer and fall. To sample this important component of the IIE system, beach seining was conducted using a standard 120-foot, fine-mesh seine (0.375-inch bar mesh wings and 0.125-inch bar mesh codend). Fifteen locations were sampled in the IIE (Figure 43-2). Seining was conducted along low-gradient, fine-sediment beaches in Iniskin, Iliamna, and Cottonwood bays at higher tidal elevations. The beach seine was deployed by skiff, 100 feet out and parallel to shore, and was slowly retrieved to shore by the field team. When approximately three quarters of the way to shore, the wings of the net were pursed toward one another forcing fish into the codend situated at the center of the net. When pursing was completed and the net brought completely to shore, fish were collected from the codend and placed into buckets of ambient water for identification, enumeration, and measurement. This sampling method is widely used in the scientific community and is considered to provide a high CPUE for fish between about 50 and 200 millimeters with lesser efficiencies for smaller and larger fish. Catch efficiency is reduced where cobbles or beach obstructions interfere with smooth net retrieval.

Sampling by 120-foot beach seine was conducted during 21 sampling events between August 2004 and November 2008, for a total of 237 individual sets. Sampling events occurred in March through November; winter weather and ice conditions prevented sampling in other months. Catch was identified to species in the field and a representative number (e.g., 20 or more) of each cohort was measured to identify the dominant size classes in shallow-water habitats at each sampling. Fish and invertebrates that could not be identified in the field were retained for later identification onboard the larger vessel or in the Pentec laboratory.

43.6.2.3 30-foot Beach Seine

A smaller 30-foot beach seine was used to sample fish and macroinvertebrates at three small, shallow, intertidal lagoons within Iliamna Bay—one site located near AC Point, and two sites located near the head of Cottonwood Bay on the north and south shores. The seine was also used on a few occasions to sample extensive mudflat habitats in the inner reaches of Iliamna and Iniskin bays that were too shallow for the 120-foot seine (Figure 43-2). With this smaller seine, a 100-foot transect was measured along the shore and the seine was deployed perpendicular to the waterline and dragged the length of the transect before pursing to the waters edge. Intertidal sampling by 30-foot beach seine was conducted during nine sampling events between September 2007 and October 2008 for a total of 18 individual sets. Catch was processed in the same manner as for the 120-foot beach seine.

43.6.2.4 Gill and Trammel Net

To sample nearshore rocky habitats, gill and trammel nets were set near rocky outcrops at six locations in Iliamna and Iniskin bays. The gill net was a 100-foot, multi-panel, floating net with each panel having a different mesh size (1.0-, 1.5-, 2.0-, and 2.5-inch mesh). The trammel net was a 100-foot sinking net constructed of three adjacent panels (outer panels at 20-inch mesh and an inner panel with 2-inch mesh).

Sampling by gill and trammel nets was conducted during nine sampling events: once in September 2007 and eight times in 2008, between the months of April and November, for a total of 36 individual sets. Catch was identified to species, and a representative number of each cohort (e.g., 20 or more) was measured to identify dominant size classes using this habitat. Fish and invertebrates that could not be identified in the field were retained for later identification on board the larger vessel or in the Pentec laboratory.

43.6.2.5 Otter Trawl

To sample demersal fish and large invertebrates in subtidal waters, a 10-foot research bottom trawl (“try net”) was used at eight stations in soft-bottom areas in Iniskin and Iliamna bays. Five-minute tows were made at each station. This sampling method is widely used in the scientific community and is considered to provide a high catch efficiency for fish and invertebrates between approximately 50 and 200 millimeters. Lesser efficiencies are expected for smaller and larger animals and for those with strong escape responses. Catch efficiency is reduced where cobbles or beach obstructions interfere with smooth net retrieval. Because most trawling was conducted from a small (14-foot) skiff, to maintain net movement across the bottom, tows were made with the current whenever substantial current was flowing.

Sampling by otter trawl was conducted in conjunction with beach seine sampling during 21 sampling events between August 2004 and November 2008, for a total of 143 individual sets. Catch was identified to species, and a representative number of each cohort (e.g., 20 or more) was measured to identify dominant size classes using this habitat. Macroinvertebrates were retained for laboratory identification and enumeration. Fish and invertebrates that could not be identified in the field were retained for later identification onboard the larger vessel or in the Pentec laboratory.

43.6.2.6 Herring Spawn Surveys

Herring spawn surveys were conducted in the IIE from late April to mid-June 2006 and 2008, during the general herring spawn period within Cook Inlet (Figure 43-6). Survey crews cruised and walked shorelines during minus tides, looking for signs of herring spawn (e.g., spawn on algae, wrack, in the water, or bird activity) along rocky outcrops and reefs inside the outer western shore of Iniskin Bay and outer eastern shore of Iliamna Bay. Surveys were also conducted along a shallow shelf in the vicinity of Scott, Vert, and Iniskin islands, as well as reefs along the eastern shore of outer Iniskin Bay. Crews stopped frequently to walk selected reaches of shore and to closely examine attached and drifting vegetation for eggs. GPS (Global Positioning System) coordinates of areas surveyed and any areas of spawn deposition were recorded. Where spawn was found it was classified as “trace” (1 to 50 eggs per square inch), “low” (50 to 150 eggs per square inch), “low moderate” (150 to 250 eggs per square inch), “moderate” (250 to 450 eggs per square inch), “moderate high” (450 to 650 eggs per square inch), “high” (650 to 1,150 eggs per square inch), and “very high” (>1,150 eggs per square inch), using standardized guidelines, as presented by Stick (1994). Mapping included documentation, with GPS coordinates, of areas and habitats surveyed and locations where eggs were detected for later incorporation into a project GIS database.

43.6.2.7 Food Habits Study

In 2005 and 2008, fish samples were collected periodically for stomach content analysis from beach seine and trawl sets (Table 43-1). Several fish species were collected based on their overall importance and ecological niche occupied within the IIE. Importance was defined by the general abundance, geographical distribution, and seasonal distribution of species within the IIE. Species were also selected for their different positions within the marine food web; for example, pelagic forage species (Pacific herring and juvenile salmon), pelagic predators (Dolly Varden char), demersal predators (whitespot greenling; Pacific halibut), and demersal benthic feeders (yellowfin sole and starry flounder).

Fish selected for stomach content analysis were immediately preserved in 10 percent formalin in the field to stop digestive processes. On larger fish specimens (over approximately 250 millimeters), the abdominal cavity was cut to facilitate penetration of the preservative. In the Pentec Laboratory, the stomach was removed from the fish, cut open, and prey contents removed for identification and quantification. Prey contents were identified to the lowest possible taxa and enumerated. Taxa groups from each specimen were placed into individual containers for drying. The only exception to this was Pacific herring—a number of specimens had very few prey items in their stomach, so taxa groups from multiple fish of the same size class were combined for drying to increase the accuracy of the dry weight measurement. Specimens were dried at 70 degrees Celsius for 24 hours and weighed. This dry weight was used to determine individual prey weights used in analyzing the diet of ecologically important fish species within the IIE.

43.6.2.8 Data Management and Analysis

Field and laboratory data were entered into Excel spreadsheets for calculation of catch statistics. Data entry by a Pentec staff member was initially 100 percent checked by two other Pentec staff, one reading from the field/lab sheet and one following along on a print-out of the data file. If 200 records were checked error free, then subsequent checking was limited to 30 percent of all additional records. Fish data were further assessed for errors (outliers) during analysis by setting limits on data fields; if a field was left blank, or exceeded the maximum or minimum values, data were compared to the original data sheets. When errors were identified, all data entered by the staff member responsible were compared with the original data sheets to resolve discrepancies.

Excel was used to consolidate and sort data and to create charts and tables of fish and invertebrate catch by date, location, and tidal condition. CPUE of fish captured by beach seine and otter trawl was calculated for each station, date, and tide status by dividing the total number of each species caught by the number of sets made during the specified sampling effort.

To evaluate the seasonality and distribution of each species among sampling locations, a single-factor analysis-of-variance was used to test for differences in average CPUE among sample locations and seasons and a subsequent P-value was generated (P-value is the probability of obtaining a test statistic at least as extreme as the one that was actually observed). To assess the relative efficiency of the otter trawl while towing with or against the current, average CPUEs were compared using a paired t-test.

To evaluate the diets of selected fish species, the Index of Relative Importance (IRI; from Cailiet, 1976) of each prey item in the diets of each fish species was calculated as follows:

$$IRI = (\%N + \%W)(\%FO)$$

where N is the proportion of a particular prey item relative to the total number of prey items; W is the percent biomass that each prey item comprised; and FO, or frequency of occurrence, is the proportion of stomachs in which the prey type was identified. IRI was calculated only for specimens collected in 2008 because individual prey weights were not measured in 2005.

Following internal Quality Assurance/Quality Control procedures, all data were transmitted to Resource Data, Inc., for incorporation into the master Pebble database.

43.7 Results and Discussion

Between 2004 and 2008, 255 beach seine sets were conducted with 120- and 30-foot seines at 21 stations on sandy/cobble beaches and soft-bottom lagoons within Iniskin and Iliamna bays (Table 43-2). In addition, 36 sets of gill and trammel nets were conducted (mostly in 2008) in nearshore rocky habitats at six stations within the bays and 143 bottom trawl tows were conducted in demersal habitats farther from the beach at seven stations within the two bays.

Collectively, over 88,500 fish were processed during the 5-year sampling program. The following is a detailed presentation of the results and an assessment of the fish and macroinvertebrate assemblages within the IIE.

43.7.1 Fish Community Assemblages

43.7.1.1 120-foot Beach Seine

Within the nearshore sandy/cobble habitats of the IIE over 71,000 fish were captured with the 120-foot beach seine, comprising 81 percent of total catch by all sampling gear types. Over all sampling locations, 41 species of fish were captured by 120-foot beach seine. Total CPUE was 300.7 fish per set for the 5-year period and 88.3 percent of all fish were Pacific herring and juvenile salmon. Several other species were frequently observed, but none comprised more than 5 percent of total catch. Results of beach seining from 2004 to 2008 are presented in Tables 43-3 and 43-4 and are discussed in greater detail below. Except as noted below, monthly data referenced in this section are pooled over all years in which that month was sampled (e.g., Table 43-4).

Pacific Herring

Beach seine data from the IIE indicate that nearshore habitats are heavily used by rearing juvenile Pacific herring. By far, juvenile herring were the most abundant species/age class, comprising 77.4 percent of total catch by 120-foot beach seine with an average CPUE of 233.1 fish per set (Table 43-3). During the March through November sampling periods, herring occurred during every month except April. Herring were most abundant from late spring (June) through late summer (September), peaking in June at nearly 1,000 fish per set and declining substantially in October and November. The high peak in June was due to very high catches observed in June 2008, especially along the west side of Iliamna Bay. Catch rates between 136.5 and 202.4 fish per set were observed from July through September (Table 43-4). The relatively high catch rate in March may be due to small sample sizes, because weather and ice conditions prevented sampling, and because one of the sets captured a relatively large number of herring. Similarly, poor weather and nearshore ice also were encountered during April 2007 and 2008, resulting in no herring captured. Catch rates increased in May, during consistently good sampling conditions in 2005, 2007, and 2008, but were still well below levels found during summer months.

Length frequency data confirm that the nearshore IIE is used by large numbers of juvenile herring, most notably by Age 1 fish, and mostly early in the season (through June); young-of-the-year are also abundant during the summer, fall, and early winter (Figure 43-7). During spring, the beach seine catch is dominated by herring that are likely the progeny from the previous years' spawning (Age1), most between 60 and 100 millimeters. A much smaller percentage of herring, likely Age 2 or older fish between 126 and 200 millimeters, was also observed. By July, young-of-the-year fish, most under 40 millimeters, were captured and remained the dominant cohort through the late summer and fall. These fish were characterized by typical transparent and elongated larval morphology in July. In August, young-of-the-year with both larval characteristics (under 40 millimeters) and with typical adult morphology (over 50 millimeters) were present. In October and November, few larval herring were captured relative to summer catch rates, and the length frequency data show a large proportion of fish between 51 and 75 millimeters in length. The season-long data show that most young-of-the-year fish likely move farther from shore by the time they reach about 100 millimeters in length. Very few adult herring (<30) were captured in beach seine sets, and the few adults over 175 millimeters were taken only in May and June. These may have been pre-spawn adults staging in the area. As discussed further in Section 43.7.1.3, large gravid adults were captured in gill net sets in May 2008, but none were taken during beach seine sampling.

Juvenile Salmon

Beach seine data indicate that juvenile salmon use the nearshore IIE primarily during the spring and summer outmigration period. As a group, juvenile salmon were second in abundance to herring, comprising 10.9 percent of fish captured by the 120-foot beach seine. The total CPUE for juvenile salmon was 32.7 fish per set. Juvenile chum and pink salmon were the dominant species and were captured in nearly equal numbers in the IIE with CPUEs of 14.4 and 15.9 fish per set, respectively (Table 43-3). Substantially fewer sockeye salmon were captured (2.2 fish per set). Coho and Chinook salmon juveniles were rare in the IIE (Table 43-4).

The outmigration period for juvenile salmon occurred during spring and summer, beginning in April, peaking from May through July and declining sharply by August (Table 43-4). Although juvenile chum and pink salmon were found in near equal numbers within the IIE, the two species had distinctly different outmigration patterns and embayment preferences. The juvenile chum salmon outmigration occurred over a relatively short period during spring. Chum were not found in March, but were moderately abundant during the April sampling events in 2006 and 2008. Chum presence in beach seine catches peaked in May at nearly 50 fish per set, followed by a sharp decline in June and again in July, to less than 1 fish per set in August. Juvenile chum salmon were found at all beach seine stations within both bays, but were significantly more abundant in Iliamna Bay ($P < 0.08$). CPUE of chum salmon in Iliamna Bay was 20 fish per set, compared with 5.7 fish per set in Iniskin Bay. Length frequency data for juvenile chum salmon showed a typical size and growth pattern of young-of-the-year outmigrants during spring (Figure 43-8). In April, almost all juvenile chum were between 36 and 45 millimeters with progressively larger fish appearing in beach seines through the outmigration period. By July, about half of the fish measured between 46 and 60 millimeters, with nearly 30 percent of fish between 61 and 90 millimeters.

The outmigration period for juvenile pink salmon within the IIE was more prolonged than that of chum salmon. Low numbers of pink salmon were first observed in April (1.7 fish per set), followed by a rapid and extended peak between May and July, during which CPUEs ranged from 27.1 to 34.8 fish per set (Table 43-4). Catch rates dropped substantially in August and were below 1 fish per set in September. Juvenile pink salmon were found at all stations within both bays, but unlike chum, juvenile pink were significantly more abundant in Iniskin Bay ($P = 0.03$). Mean CPUE for pink salmon in Iniskin Bay was 30.4 fish per set compared with 6.8 fish per set in Iliamna Bay (Table 43-3). Length frequency data for juvenile pink salmon again showed a typical size and growth pattern of young-of-the-year outmigrants during spring. Substantial growth within the IIE was apparent. In April, all fish measured were under 40 millimeters in length, increasing steadily to between 81 and 120 millimeters by August and September (Figure 43-9).

As reported, substantially fewer juvenile sockeye salmon were captured in beach seine sets relative to chum and pink salmon, but moderate numbers of juvenile sockeye were taken over the course of the 5-year sampling period. Juvenile sockeye salmon arrived later in the IIE than chum and pink salmon, reflecting the lack of local spawning populations. Few sockeye were taken in May, moderate numbers were present in June and July (8.3 and 7.0 fish per set, respectively), and catch declined to well below one fish per set by August (Table 43-4). Juvenile sockeye were found at most stations in both bays with slightly higher catch rates observed in Iniskin Bay (Table 43-3). Higher numbers of juvenile sockeye were also observed at the eastern Iniskin reference station (MBB) relative to most other IIE stations. Length frequency data for juvenile sockeye salmon show two or more possible cohorts within the IIE (Figure 43-10). The most abundant cohort was in the 61 to 75 millimeters range, found throughout spring and summer. A less abundant cohort of larger fish, between 91 and 105 millimeters, was also observed, along with a few smaller young-of-the-year.

Very few juvenile coho or Chinook salmon were observed in the IIE (6 Chinook and 43 coho). Over 80 percent of juvenile coho were taken at the outermost stations in Iniskin Bay (MPS1 and MPS1A) and at MVYCM, near the mouth of Y Valley Creek, suggesting that this is the natal stream of origin for these fish.

Adult Salmon

Adult chum and pink salmon were occasionally captured by beach seine in the IIE, almost all during July and August while staging in the nearshore before beginning their spawning runs. Most adult chum were captured at Station MPS3 in outer Cottonwood Bay and most adult pink salmon were captured at Station MPS1C in outer Iniskin Bay.

Surf Smelt

Surf smelt (*Hypomesus pretiosus*), another forage fish species, were captured in moderate numbers in the IIE, comprising 4.6 percent of total catch over the 5-year sampling program. Both adult and larval young-of-the-year were captured. Surf smelt maintained a prolonged presence in the IIE, and were found during all months sampled (Table 43-4). Abundance was low during spring with catch rates of under 1 fish per set, but increased through the summer and fall months (6.7 to 65.0 fish per set), before declining in November. Although found at most stations, the species was relatively abundant within Iliamna Bay with catch rates of 67 fish per set at MBSA1 and over 20 fish per set at Stations MBS4 (Williamsport) and MPSE (Table 43-3).

Length frequency data showed a number of cohorts of surf smelt within the IIE, mostly young-of-the-year and juveniles (Figure 43-11). Juvenile fish maintained a presence during the entire March to November sampling season while adult and young-of-the-year fish had a distinct seasonal presence. Adult fish over 126 millimeters were found principally in May and June and may represent a spawning population within the IIE. Elongate and transparent young-of-the-year between 26 and 50 millimeters were abundant in the IIE during the fall. Catch rates of young-of-the-year ranged from 25.9 to 65.0 fish per set in September and October, declining to 8.3 fish per set in November. Young-of-the-year were found in the greatest abundances within inner and central Iliamna Bay (Stations MBS1 and MBS1A).

Pacific Sand Lance

Pacific sand lance was another pelagic forage fish species commonly found in the IIE, comprising 2.3 percent of total beach seine catch. Like herring and surf smelt, sand lance were observed over the majority of the sampling season at most stations in both bays (Table 43-4). Pacific sand lance were present sporadically, perhaps because they travel in large but discrete schools. Catch rates of between 14.0 and 42.8 fish per set were observed at two stations in Iniskin Bay and one station in Iliamna Bay, with substantially lower abundances at the remaining stations. Length frequency data show two or more cohorts of juvenile and adult fish (Figure 43-12). Adult fish over 105 millimeters were observed only during the late spring and summer while a juvenile cohort mostly between 60 and 90 millimeters was captured and increased in length through spring and summer. A young-of-the-year cohort with most fish under 60 millimeters, appeared in August.

Dolly Varden Char

Dolly Varden char are an anadromous salmonid commonly found in the IIE during spring and summer months; they comprised 1.5 percent of the total catch by beach seine. Dolly Varden began to appear in beach seines in May, peaking in June (20.8 fish per set), but maintaining a relatively moderate abundance through August (Table 43-4). The species was found at all stations within the IIE, but was significantly more abundant (P = 0.05) in Iniskin Bay (Table 43-3). A catch rate of over 20 fish per set was observed at Station MPS1 and rates between 9.3 and 13.0 fish per set were seen at Stations MPS1C, MYVCM, and MBB (east Iniskin reference). The greatest number of large adults was captured at MYVCM near the mouth of Y Valley Creek in 2008.

Length frequency data show a number of subadult and adult cohorts in the IIE (Figure 43-13). Most anadromous Dolly Varden in the region outmigrate annually, beginning at Age 2, spending the spring and summer in the nearshore before emigrating back to stream environments in late summer. Immature fish overwinter in downstream areas, while reproductively mature adults migrate to spawning grounds and spawn during the fall. A dominant cohort of likely 2-year old subadult fish between 135 and 200 millimeters was common in the nearshore IIE, showing growth over the spring and summer months. Several cohorts of adult fish over 250 millimeters also were captured, primarily in May but with a few fish present into October.

Pacific Staghorn Sculpin

Pacific staghorn sculpin (*Leptocottus armatus*) was a common demersal species of the IIE found in both the beach seine and trawl nets, comprising 1.1 percent of total beach seine catch. The species was found at nearly all stations within the IIE, but CPUE was relatively high at Stations MPSE and MPSE1 in inner Iliamna Bay (26.1 and 14.3 fish per set, respectively; Table 43-3). Staghorn sculpin were first captured in beach seines in May, increasing in abundance and peaking by July, and declining steadily through November (Table 43-4). Length frequency data show several cohorts of young-of-the-year, juveniles, and adults (Figure 43-14). Young-of-the-year began to appear in July, most under 30 millimeters, showing steady growth through the summer and fall. This was likely the cohort that appeared again in May as Age 1 fish between 80 and 100 millimeters. Subadult and adult cohorts over 150 millimeters were present through late fall.

Starry Flounder

Starry flounder (*Platichthys stellatus)* was the most common flatfish species observed within the IIE, found in beach seine sets and also in trawl sets. The species comprised 1.0 percent of total beach seine catch. In areas sampled by the beach seine, starry flounders were almost exclusively found in Iliamna Bay and were captured at all stations within the bay (Table 43-3). The highest catch rate was observed at Station MPSE (22.8 fish per set) within inner Iliamna Bay; relatively moderate to high abundances were also captured at other inner Iliamna stations. Starry flounder were first captured in the beach seines in May; numbers peaked in July and maintained moderate abundances through September, before declining later in the fall (Table 43-4). Length frequency data show multiple cohorts from post settlement young-of-the-year under 40 millimeters to large adults over 400 millimeters (Figure 43-15). Young-of-the-year began to appear in beach seine catches in August, but the remaining cohorts were commonly found in Iliamna Bay from May through September.

Longfin Smelt

Longfin smelt is a pelagic forage species not widely collected in the IIE, but large numbers were captured at Station MPSE (19.7 fish per set), within inner Iliamna Bay, especially during the September sampling event. Over 80 percent of all longfin smelt were captured at MPSE in September (8.9 fish per set; Table 43-4); catch rates during the remaining months were less than 1.7 fish per set. Adult and subadult cohorts were observed during the entire sampling period with a likely young-of-the-year cohort appearing in July (Figure 43-16).

Other Fishes

Twenty-six additional fish species were identified in beach seine sets over the 5-year sampling program within the IIE. These remaining species were uncommon and none of these species comprised more than 0.1 percent of the total beach seine catch.

43.7.1.2 30-foot Beach Seine

Three tidal lagoons in Iliamna and Cottonwood bays were sampled with the 30-foot seine during the 2008 sampling season. One lagoon (MACL) is located at AC Point and the other two are near the head of Cottonwood Bay on the north (Cottonwood Lagoon; MCWL) and south shores (Cottonwood Slough; MCWSL; Figure 43-2). (Three additional stations within inner Iniskin and Iliamna bays were also sampled infrequently and were eventually abandoned because they could be reached only infrequently). Lagoons were generally less than 3-feet deep at higher tidal elevations and from several inches to dry at lower tidal elevations. Sampling in one or more lagoons occurred in October 2007 (AC Point only) and in April through October 2008. Over 14,000 fish were captured by 30-foot beach seine in the three lagoons during the 2008 sampling season. By far, threespine stickleback (*Gasterosteus aculeatus*) was the most abundant fish species observed in the three lagoons (Table 43-5); however, juvenile chum, pink, and sockeye salmon were also abundant during spring and early summer. Several other species including juvenile starry flounder, Pacific staghorn sculpin, Pacific herring, surf smelt, and coho salmon were also captured in low numbers.

Threespine Stickleback

Over 13,000 threespine stickleback, comprising over 95 percent of the total catch were captured by the 30-foot seine in tidal lagoon habitats (Table 43-5). The species was most abundant at the AC Point Lagoon (Station MACL) with a mean CPUE of over 3,000 fish per set (Table 43-6). Lower abundances were found at the lagoon located on the north shore of Cottonwood Bay (Station MCWL) and no threespine stickleback were captured at the lagoon located on the south shore of Cottonwood Bay (Station MCWSL). Stickleback were present in AC Point Lagoon from May through October and at Cottonwood Lagoon (MCWL) in June and July. Adults from 65 to 80 millimeters were observed through the entire period, with young-of-the-year appearing at AC Point Lagoon beginning in July.

Juvenile Salmon

Over 400 juvenile chum and 200 juvenile pink salmon were captured in the three lagoons with mean catch rates during spring and summer of 29.5 and 17.7 fish per set, respectively (Tables 43-5 and 43-6). Juvenile salmon were present in the lagoons for a shorter period than they were in the sandy/cobble habitats sampled by 120-foot beach seines along shorelines of the IIE, probably as the result of higher summer temperatures in the shallow lagoons starting in July (Figure 43-17). In addition to juvenile chum and pink salmon, over 40 juvenile sockeye salmon were captured in the Cottonwood Lagoon and AC Point Lagoon with catch rates of 6.1 and 0.4 fish per set, respectively, during spring. No significant differences were found between the sizes of juvenile salmon in lagoons and their counterparts in adjacent nearshore areas. An interesting anomaly was the capture of 4 juvenile coho (mean size 80 mm) in AC Point Lagoon during September 2007 sampling; none was taken in the lagoon in fall sampling in 2008.

Other Fishes

Almost all staghorn sculpin and starry flounder collected by beach seine in lagoons were juveniles.

43.7.1.3 Gill and Trammel Net

In 2008, nearshore rocky subtidal habitats were sampled with floating gill nets and sinking trammel nets at six locations: four stations in Iniskin Bay and two stations in Iliamna Bay. A summary of catch is presented in Tables 43-7 through 43-10. The gill and trammel nets captured different fish assemblages than the beach seines and trawls did.

In gill nets, which sampled the water surface and the upper water column, catch during the spring and summer was dominated by Pacific herring, comprising over 90 percent of all fish captured (Table 43-7 and 43-8). Herring were abundant during the May 2008 sampling event and most all were gravid pre-spawn adults over 180 millimeters (Figure 43-18). Adult herring were found at five of the six gill net stations in both bays. The only station where herring were absent was at Station MBR, which is located farther from shore, just inside Black Reef. A lower number of herring were also observed during August sampling; these belonged to a subadult cohort between 120 and 140 millimeters (Figure 43-18). Several subadult and adult Dolly Varden char between 179 and 390 millimeters also were captured in gill nets, but they comprised only 4.4 percent of catch. Several demersal species including Pacific staghorn, calico sculpin (*Clinocottus embryum*), yellowfin sole, starry flounder, and sturgeon poacher (*Podothecus accipenserinus*) were found at relatively low abundances. Only seven species of fish were captured in gill nets.

In trammel nets, which sampled rocky demersal habitats, 13 species were captured and whitespotted greenling, starry flounder, and adult spiny dogfish (*Squalus acanthias)* were the most abundant species (Tables 43-9 and 43-10). Abundance varied seasonally; for example, nearly 90 percent of all whitespotted greenling were observed in August and most were gravid adults between 250 and 300 millimeters. The species was most abundant at Stations MPS1A and MPS4, both of which are located at outer bay areas south of Knoll Head and west of North Head. Interestingly, the highest abundances of spiny dogfish also were observed at these two stations in August, suggesting that dogfish may have been feeding on pre-spawning greenling staging in the area. A strong seasonal abundance was also observed with starry flounder, of which over 90 percent were captured in June; most of these were at Station MPS1A near Knoll Head. Several other demersal species were captured at relatively low abundances including Pacific staghorn sculpin, calico sculpin, yellowfin sole, rock sole, sand sole (*Psettichthys melanostictus*), Pacific halibut, Pacific cod, and kelp greenling (*Hexagrammos decagrammus*). Two pelagic species ubiquitous within the IIE, Dolly Varden and Pacific herring were also captured in low numbers in the trammel net.

43.7.1.4 Otter Trawl

Over 2,600 fish were captured in 143 otter trawl sets within the IIE during the 5-year sampling program. Forty-one species of fish were captured with a CPUE of 19.5 fish per haul (Tables 43-11 and 43-12). As expected, the demersal fish assemblage farther from the beach was quite different from that found in beach seine sets. The trawl catch was dominated by demersal species like snake prickleback (*Lumpenus sagitta)*, flatfish, and sculpin. Pacific herring, the most abundant species found in all IIE sampling, were also found in relatively high abundances, but with a very strong seasonality. In contrast to the beach seine results, the demersal fish assemblage sampled by otter trawl was less dominated by a single species. Snake prickleback and yellowfin sole (*Limanda aspera*) were common and widespread in trawl sets, together comprising 58.6 percent of total trawl catch. Several other species, including Pacific herring, starry flounder, walleye pollock, great sculpin, whitespotted greenling, Pacific staghorn sculpin, juvenile Pacific halibut, and variegated snailfish (*Liparis gibbus*) were also commonly taken, each comprising between 3 and 6 percent of total trawl catch.

In 2004 through 2007, CPUE was calculated as catch per trawl set. In 2008, at the request of ADF&G, catch rates were further refined by collecting GPS data at the beginning and end of each trawl haul, and calculating the number of fish per area trawled (Tables 43-13 and 43-14). Comparing both methods with the 2008 data yielded consistent results.

In 2008, also at the request of agency personnel, the efficiency of trawl tows was tested by running one tow in the direction of the current and setting another immediately afterward against the current at the same station. This testing was conducted at trawl stations MPS1T, MPS2T, MPS2TA, MPS2TB, MTR1, MTR2 and MTR3. A paired t-test was used to compare mean abundances of each species and to identify significant differences in efficiency with or against the current. The only station at which CPUE differed between the two set directions was MTR2 ($P = 0.04$). The first tow at this station yielded 30 fish of six species, compared with no fish caught in the second set. There were no fish caught in either set at MPS2TB, though numerous invertebrates were captured. For MTR3, there was no statistically significant difference between catches ($P = 0.89$); nine fish of one species were captured in the first set (starry flounder) and eight fish of four species were captured in the second set (half were starry flounder). For the remaining four stations, catch rate was slightly greater in one set, but the results were not significantly different ($0.20 < P < 0.37$). Overall, towing with or against the prevailing current did not appear to have a significant effect on catch rates. The results of demersal otter trawl sampling are presented in further detail below.

Snake Prickleback

Snake prickleback was the most abundant fish species found in demersal habitats sampled by trawl, comprising nearly 30 percent of total catch (Tables 43-11 and 43-12). The species was ubiquitous within the IIE, and had similar catch rates at all stations within both bays. Snake pricklebacks were also found during all months sampled, with moderate to high abundances during all months except March. Abundance was high during April and May (8.3 to 10.3 fish per set), lower during June and July (2.8 and 2.2 fish per set), and steadily increased again from August through October (6.1 to 7.5 fish per set). Catch rates declined in November. A similar pattern was observed in the 2008 data, when catch rates were calculated as fish per area trawled. Using that method, catch rates steadily increased through the year but with a slight decrease in July and peaking in October (Table 43-13). Length frequency data show a dominant juvenile cohort between 76 and 100 millimeters throughout the entire sampling period. Adult prickleback were taken in May and June, with young-of-the-year under 50 millimeters appearing in July, suggesting a spring spawning period (Figure 43-19).

Pacific Herring

Pacific herring were second in abundance in trawl sets and were taken at most trawl stations with mean catch rates of 2.9 fish per set (2004 through 2007; Table 43-11) or 6.0 fish per 10,000 square feet (2008; Table 43-13). The seasonal distribution of herring in demersal trawl sets differed from that in beach seines with a relatively strong presence during the fall and winter months. Catch rates were relatively high in March, dropping sharply to zero by May, and remaining near zero through late summer. In August, herring began appearing in trawl catches in low numbers with catch rates increasing in the fall. In 2008, the number of herring per 10,000 square feet steadily increased from late summer to November, until abundances in October and November were near those found in March. No sampling occurred from December through February because of inclement weather and ice.

Length frequency data show that in March and April, most herring were Age 1, between 41 and 80 millimeters (Figure 43-20). In August, when herring reappeared in trawl catches, the young-of-the-year cohort was dominant, ranging from 21 to 40 millimeters in August and steadily increasing in size through November. By November, the young-of-the-year cohort was very similar in size to the Age 1 juveniles found in March, indicating little growth over the winter.

Yellowfin Sole

Yellowfin sole were third in abundance, comprising 14.4 percent of fish captured in trawl sets. Data indicate that the species appears to have a preference within the IIE for Iniskin Bay, with mean catch rates three times higher in Iniskin than in Iliamna Bay (Table 43-11). CPUE calculated as catch per set (all years) as well as catch per area trawled show the highest catch rates at Stations MPS2T and MPS2TB in Iniskin Bay (Tables 43-12 and 43-14). Yellowfin sole were captured during all months sampled with peak occurrences in May, moderate abundances through the summer, and declines from September through the fall. Length frequency data show that yellowfin sole are a year-round resident, with several cohorts ranging from young-of-the-year under 60 millimeters to adults over 200 millimeters (Figure 43-21).

The dominant cohorts appear to be juveniles between 90 and 150 millimeters. The largest adults (>210 millimeters) were found only during May and June.

Other Fishes

No other fish species comprised more than 5.5 percent of total catch by trawl, but several were commonly observed at most trawl stations. Starry flounder, one of the more abundant species found in beach seine sets in Iliamna Bay, were also commonly found in trawl sets. Within the IIE, this species was consistently found at higher abundances in Iliamna Bay, with over half of all individuals found at Station MTR3, the shallowest, innermost trawl station in Iliamna Bay. Juvenile Pacific halibut were common in trawl sets within the IIE and were found at all stations from May through November (Tables 43-11 and 43-12). Most halibut were under 200 millimeters in length.

Two sculpin species—great sculpin and Pacific staghorn sculpin—were commonly taken in trawl sets, and were found at all trawl stations during all months of the sampling period (Tables 43-11 and 43-12). Almost all great sculpin were within one or two cohorts of juvenile fish, while there were several cohorts of staghorn sculpin, ranging from young-of-the-year to adults.

Whitespotted greenling were commonly captured in trawls, with an apparent preference for Iliamna Bay. Sixty-five percent of whitespotted greenling were found at Stations MTR1 and MTR2, in central and outer portions of the bay (Tables 43-11 and 43-12). Length frequency data indicate that a dominant juvenile cohort first appeared in July at 61 to 90 millimeters, gradually increasing in size to between 91 and 150 millimeters by fall. Adults over 180 millimeters were observed occasionally during most months, with higher abundances in June and July.

Juvenile walleye pollock were the most commonly captured gadid in IIE trawls, and most were taken in Iniskin Bay during the cooler months (Tables 43-11 and 43-12). The highest abundances were observed during March, and some were present through June and again from September through November. Almost all pollock were from one or two juvenile cohorts between 82 and 184 millimeters.

43.7.1.5 Herring Spawn Surveys

At the request of ADF&G, herring spawn surveys were conducted within the IIE during spring 2006 and 2008. Areas selected for surveys were based on historical spawning locations documented by ADF&G, as presented in Section 43.4.3.2 and Figures 43-4 and 43-5. No herring spawn was observed during 2006 surveys on April 26 or on May 17 and 18, but staging herring were present during the May surveys. In contrast, substantial herring spawn was observed along approximately 3.1 miles of shorelines and reefs during the 2008 surveys on May 24 and 25, June 5 and 6, and June 17 and 18 (Figure 43-22). Details are provided below.

April/May 2006

On April 26 and May 17 and 18, 2006, researchers conducted herring spawn surveys at elevations between 0 and –3.0 feet mean lower low water (MLLW) on several intertidal reefs and shorelines in the IIE (Figure 43-6). Areas investigated included North Head, Knoll Head, areas north of MPS1C, the western shore of Scott Island, the entire shoreline of Vert Island (including several reefs), the eastern shore and reefs of Iniskin Island, and a reef on the eastern shore of Iniskin Bay. Herring spawn had been found at all of these areas prior to 1995 (Figures 43-4 and 43-5; see Section 43.4.3.2). No herring spawn was found during the 2006 surveys. However, in one trawl set at Station MTR1 in Iliamna Bay (Figure 43-2), an eelgrass blade with several herring eggs was found on May 18, 2006. It is not known if these eggs were spawned in the bay or whether they drifted in from other areas. During the May surveys, concentrated gull activity was observed in central Iniskin Bay suggesting the presence of staging herring and this was confirmed by ADF&G researchers conducting herring spawn surveys in the area (T. Otis, ADF&G, personal communication, May 16, 2006).

May 2008

One herring spawn survey was conducted over a 2-day period on May 24 and 25, 2008 (Figure 43-6 and 43-22). On May 24, field teams conducted herring spawn surveys on Scott Island and along the shoreline from north of MPS1C to south of MPS1. On May 25, field teams conducted surveys from north of MPS1C (Iniskin Bay) along the shoreline to MPS4 (Iliamna Bay). Two survey crews were deployed on each day of surveys. On May 24 and 25, the tide levels in Iliamna and Iniskin bays reached a maximum low elevation of 0 and +0.7 feet, respectively. Minus tides were not available during the late May survey.

On May 24, eelgrass (*Zostera marina*) wrack (i.e., free floating eelgrass blades and shoots adrift or washed up onshore) with low to moderate spawn deposition were observed and collected along the mainland from north of MPS1C to MPS1. The source of the eelgrass wrack is unknown. Approximately 0.4 miles north of MSP1, a trace amount of spawn deposition was observed on an attached rockweed (*Fucus distichus* subsp. *evanescens*) plant.

A survey of Scott and Vert islands was also conducted on May 24, between tidal range of 0 to +2 feet MLLW. On Scott Island, herring spawn deposition was observed on multiple species of algae and bedrock. Highest densities of herring eggs were observed on rockweed, and other branching algal species, such as the red algae *Palmaria callaphylloides* and *Cryptosiphonia woodii*, and the green alga *Acrosiphonia arcta*. Deposition was also observed on the red algae *Halosaccion firmum*, *H. glandiforme*, *Halosaccion* sp., *Mazzella phyllocarpa*, and *P. mollis*. Relatively high amounts of deposition were observed on drifting and cast-ashore upper subtidal vegetation including the kelps *(Palmaria* spp. and *Agarum clathratum)*, and the red alga *Odonthalia kamtschatica*. In general, herring spawn deposition was recorded at an overall low density on the northern and western shorelines of Scott Island and along a small portion of the island's southern shoreline (Figure 43-22); however, the density was locally moderate where appropriate substrate was observed. Trace amounts of deposition, mainly on *C. woodii*, were locally present on small portions of Vert Island and the adjacent islets, particularly on the islet north of Vert Island. Deposition attached to wrack was observed in considerable quantities on and around Vert Island.

On May 25, the survey covered the shoreline from MPS1 to MPS4 (Figure 43-6). One survey crew started at MPS4 and surveyed the area in an easterly direction towards the Y Valley, while the second crew surveyed to the west from MPS1 towards Y Valley. Neither survey crew observed herring spawn along the area of shoreline between MPS4 and MPS1.

June 2008

In June 2008, two herring spawn surveys were conducted over an approximately 2-week period. On June 5 and 6, 2008, researchers conducted herring spawn surveys on Scott Island, Black Reef, Fossil Reef, the

Mushroom Islets, White Gull Island, and along the shoreline from north of MPS1C to MPS4 (Figure 43-6). One survey crew was deployed on each day that spawning surveys were conducted. On June 5 and 6, Iliamna and Iniskin bays were at minus tides of –4.6 and –4.1 feet, respectively. On June 17 and 18, 2008, biologists conducted surveys from MPS4 to Y Valley, in the Scott Island area, and at Black Reef. Two survey crews were deployed on June 17 and one survey crew was deployed on June 18. On June 17 and 18, the tidal levels were at –0.7 and –1.1, respectively.

The June 5 survey was conducted by boat and by walking portions of the shoreline around MPS4, Y Valley, Black Reef, and White Gull Island and did not result in any observations of herring spawn. Eelgrass wrack with egg depositions was observed near Black Reef, but no deposition was observed on attached vegetation.

The June 6 survey along the shoreline from MPS1 to north of MPS1C, in the Scott Island area, and on Fossil Reef revealed eelgrass wrack containing spawn at and around Station MPS1C, but no spawn was observed on attached vegetation. On Scott Island, herring spawn was observed in trace to moderate densities on assemblages of rockweed and *Palmaria* spp. as well as directly attached to boulders and bedrock. High densities were observed in localized areas. This spawn was likely the same deposition observed during the late May survey. The small reef located north of Vert Island was surveyed on June 6 and trace to low densities of herring spawn were observed throughout the reef; low to moderate densities were observed in localized areas adjacent to the low tide line. Moderate to high densities of deposition were observed on *Odonthalia* wrack near the reef. Surveys conducted on the Mushroom Islets on a rising tide documented trace to low levels of herring spawn primarily on rockweed and *Palmaria* spp., and also deposited in lesser densities on *Acrosiphonia* sp. Again, localized areas contained low to moderate density deposition. The Blackie Beach reef also contained trace to low densities of herring spawn deposition. No deposition was observed on Iniskin Island and Fossil Reef. In summary, herring spawn deposition was recorded at trace to low densities on the reefs near Vert Island, and on Scott Island, the Mushroom Islets and Blackie Beach reef.

On June 17, two survey crews conducted herring spawn surveys at locations similar to those surveyed in late May and early June. One crew surveyed the shoreline from north of MPS1C to Y Valley by walking sections of the shoreline north of beach seine station MPS1B and by watercraft between MPS1B and Y Valley. North of and adjacent to MPS1, herring spawn deposition was observed in trace to low densities, primarily on rockweed (Figure 43-22). Trace amounts of deposition were observed on eelgrass wrack in the area. Rocky outcrops and boulders from north of MPS1C and MPS1B contained low to moderate deposition on rockweed and *Palmaria* spp. Continuing south to MPS1B, moderate to high deposition was observed on rockweed, *Palmaria* spp., *Odonthalia* sp., and on the bases of kelp plants. Deposition was found in lesser quantities (i.e., classified as low), south of MPS1B and extending just south of Entrance Rock, where seagulls were observed consuming herring eggs on exposed rocks. No herring spawn deposition was observed south and west of Entrance Rock to Y Valley. Eelgrass wrack with herring spawn ranging from trace to moderate deposition was also observed from beach seine stations MPS1C to MPS1B. In summary, trace, low, and moderate density herring spawn deposition was recorded from north of MPS1C to Entrance Rock on June 17.

The second survey crew investigated the Scott Island area on June 17 by watercraft and by walking sections of the shoreline. Trace amounts of herring spawn deposition were observed in this area with the exception of Blackie Beach reef and the reef south of Vert Island. It is surmised that the trace deposition observed in these areas was the remaining hatched and unhatched eggs that were initially observed in this area in May. Trace to moderate densities were observed on rockweed at Blackie Beach reef, whereas only trace amounts were observed at the base of *P. callaphylloides* at the Vert Island reef. Many of the herring eggs observed during the May and early June surveys appeared to have hatched or been consumed by birds, marine mammals, invertebrates, or fish. In summary, trace deposition was recorded at the Mushroom Islets and a substantial portion of the Scott Island shoreline. Low herring spawn deposition was recorded at Blackie Beach reef, again the reductions from the earlier densities likely resulting from hatching or predation.

On June 18, one crew surveyed the shoreline between MPS4 and Y Valley Creek, and Black Reef by watercraft. No herring spawn deposition was observed within these areas. Eelgrass wrack with herring spawn deposition ranging from trace to moderate was observed on and adjacent to Black Reef; however, no deposition was observed on attached algae.

43.7.2 Invertebrate Assemblages

Varying numbers of epibenthic macroinvertebrates were captured in 143 otter trawl sets during sampling events in 2004 through 2008 (Tables 43-15 and 43-16; Appendix 43A and 43B; Figure 43-23). However, because invertebrates were not fully enumerated in trawl catches during the 2004 reconnaissance work, a majority of data and analyses in this section are from trawls during the 2005 through 2008 field work.

Over 170 taxa were identified, but at most trawl stations macroinvertebrates were dominated by a few species of shrimp. Pandalid shrimp, represented principally by *Pandalus goniurus* and *P. danae;* mysid shrimp, primarily *Neomysis rayii;* and crangonid shrimp, mostly *Crangon alaskensis* comprised over 75 percent of all epibenthic macroinvertebrates caught.

P. goniurus, the coonstripe or humpy shrimp, was the most abundant shrimp overall with a CPUE of 200.3 shrimp per set. The species was commonly observed throughout the sampling period but was distinctly more abundant in fall especially in 2007; also, they were more abundant in the centers of each bay at sites MTR1 and MPS2TB (Table 43-15). *P. danae*, the dock shrimp, another pandalid, was also relatively abundant in total catch, exhibiting distribution and population fluctuations in Iniskin Bay similar to that of *P. goniurus* and also exhibiting high densities at the mouth of Iliamna Bay (MTR1). Other pandalids, including *P. tridens and P. eous,* were captured on rare occasions. See Appendices for the full list of macroinvertebrates captured with the otter trawl in the 2004 through 2008 sampling seasons.

The crangonid shrimp *C. alaskensis* was the second most abundant shrimp identified to species. It was found in relatively high numbers at all of the Iliamna and Iniskin bay stations with highest concentrations noted at MPS1T, where there was a large catch of *Crangon* sp. (likely *C. alaskensis*) in September 2007 (average CPUE of 193.3 per set). *C. alaskensis* was relatively abundant throughout the sampling period, especially early spring (March/April) and fall (September/October) when it was the most abundant species taken (Table 43-16).

The mysid shrimp *N. rayii* was third in abundance at study area trawl stations (CPUE 94.1 per set). The abundance of this species was relatively high (CPUE > 50 per set) across both bays with the exception of two trawl stations—MPS2T located at the mouth of Iniskin Bay and MTR4 located in the northern portion of Iliamna Bay (Table 43-15). Large numbers were observed at the other six trawl stations, with most of the catch occurring in April and October 2008. Other mysid species were found in relatively low abundance: *Acanthomysis pseudomacropsis* was found almost exclusively in 2005 at Station MPS1T in Iniskin Bay and *N. mercedis* was taken only rarely.

Hippolytid shrimp, *Heptacarpus* spp., were also a major component of the trawl catch, with nine different species totaling over 6,000 individuals. *H. brevirostris* and *H. tridens* were found most frequently (CPUE of 23.1 and 16.6 per set, respectively) in both bays and months (no *H. tridens* were caught in May sampling) (Tables 43-15 and 43-16; Appendix 43A and 43B).

Juvenile Dungeness crabs (*Cancer magister*) were found at more than half of the trawl stations; average CPUE was 0.26, with the highest frequency of occurrence in Iniskin Bay (Table 43-15). Carapace measurements were not taken, but all were juveniles estimated to have carapace widths of 75 millimeters or less. Juvenile crabs were observed between May and October in 2005 through 2007, but, none were caught in the 2008 season.

Nine species of hermit crab totaling 908 individuals were captured in trawl sets, with *Pagarus beringanus, P. kennerlyi,* and *Elassochirus tenuimanus* the most often observed. Hermit crabs were taken during all sampling months (Table 43-15; Appendix 43B).

43.7.2.1 Seasonal Differences

To build upon data gathered during 2005, efforts were made to round out sampling in the full ice-free season with sampling in spring 2006, fall 2007, and from March through November 2008. Numerous macroinvertebrates were captured by otter trawl during September (2006 through 2008), October (2007 through 2008), and November (2008) (Table 43-16; Appendix 43B). Over 90 species were captured in fall sampling, but as in 2005, macroinvertebrates were dominated by a few species of shrimp at most trawl stations. Two shrimp families, pandalids, again represented principally by *P. goniurus*, and crangonids, mostly *C. alaskensis*, dominated the catch comprising approximately 75 percent of all macroinvertebrates caught in fall/early winter samples. Invertebrate numbers were comparable or higher in some instances to summer catch rates and did not follow the end of year reduction of numbers recorded for demersal fish species.

In both 2007 and 2008, the average CPUE for all shrimp increased between September and October (Figure 43-24). November samples were collected only in 2008 and in that year the average CPUE decreased in November to near September values. The highest monthly CPUE for any macroinvertebrate was in March 2008 when an average of 923 *C. alaskensis* were captured per set, indicating abundant shrimp populations in the IIE early in the sampling season (Table 43-16). A large catch of 1,500 *Crangon* sp. during a single trawl at MTR4 in 2005 was responsible for the high *Crangon* CPUE in September (Table 43-16; Figure 43-25). Pandalid shrimp exhibited seasonal changes in abundance similar to other shrimp, with a marked increase in trawl catch between September and October in both 2007 and 2008 and a decrease in November 2008 (Table 43-16; Appendix 43B). This seasonal difference in pandalid catch resulted mainly from large catches at MTR1 and to a lesser extent MPS2TB (Figure 43-25).

Juvenile tanner crabs (*Chionoecetes bairdi*) were three times more abundant in trawl samples in September 2007 than they were in September 2006 (Figure 43-26). This relatively high abundance in September 2007 was followed by a sharp decrease in abundance of tanner crabs in October 2008. In contrast, numbers in 2008 increased slightly between September and October (CPUE 2.7 to 3.7 per set, respectively), followed by a three-fold decrease in November. These data, although variable between years, show relatively high use of the area by this species.

43.7.2.2 120-foot Beach Seine

Relatively few invertebrate species were captured using the 120-foot beach seine due to gear selectivity. Catches were highly variable and dominated by two species of mysid from the genus *Neomysis* with occasional gammarid amphipods. Two other invertebrates, the ctenophore *Pleurobranchia* sp. and the cnidarian *Polyorchis* sp., were often relatively abundant but unquantified in the beach seines. Invertebrate data from these observations should not be treated as quantitative, but they do reflect the presence of the organisms in the nearshore and their availability as prey organisms for juvenile salmonids, flatfish, and sculpins.

43.7.2.3 Stomach Content Analysis

In 2005 and 2008, researchers retained a subset of fish from the IIE for stomach content analysis. Representative specimens of juvenile chum salmon, juvenile pink salmon, Dolly Varden, yellowfin sole, starry flounder, Pacific staghorn sculpin, whitespotted greenling, Pacific herring, and surf smelt were collected to determine the composition of their diet.

The stomach contents of juvenile chum salmon collected by beach seine in 2005 contained a variety of epifauna, small zooplankters, terrestrial insects, and larval fish that are found within the nearshore area. Several species of copepods, including *Acartia clausi* and *Eurytemora* sp., and small marine aquatic snails (*Lacuna* spp.), were the most numerous items in juvenile chum diets (Figure 43-27). Fish, composed principally of juvenile sand lance, were third in importance and were often the dominant dietary component of larger juvenile chum (>70 millimeters). Terrestrial insects were nearly as numerous as fish, but were found in only a few of the stomachs, suggesting that numbers of terrestrial insects may fall sporadically into the marine nearshore. Crab zoea, polychaete worms, amphipods, and barnacles also were consumed in low numbers.

The diet of juvenile pink salmon collected by beach seine in 2008 was somewhat similar to that of juvenile chum salmon. The dietary composition, calculated as the percent IRI of dominant prey found in the stomach (Figure 43-28), shows that terrestrial insects (50 percent) and copepods (43 percent) were the most important foods of juvenile pinks. Although terrestrial insects were not the numerically dominant food item, they comprised much of the total prey weight and nearly 50 percent of the IRI for the ten individuals sampled. Copepods have been reported by other investigators as a relatively abundant food of pink salmon throughout both bays (Damkaer, 1977).

The stomach contents of yellowfin sole (2008 only, n = 8) collected by otter trawl contained a variety of polychaetes, molluscs, copepods, eggs, barnacles, and amphipods found in Iniskin and Iliamna bays. Polychaetes in the Family Sabellidae occurred most frequently and had the highest percent IRI (approximately 80 percent) in the diets of yellowfin sole (Figure 43-29), indicating a strong dependence on this one resource. Bivalves were the next most important prey item, but were only one eighth as important as polychaetes (IRI approximately 10 percent).

The stomach contents of starry flounder collected by 120-foot beach seine in 2008 contained mostly whole bivalves, *Macoma balthica*, and bivalve siphons, along with some polychaetes, unidentified fish eggs, and amphipods (Figure 43-30). In 2008, *M. balthica* was one of the most abundant infaunal species in Iliamna Bay based on intertidal core samples (Chapter 42). Also, starry flounder was the most abundant flatfish species encountered in Iliamna Bay in 2008.

The stomach contents of 12 subadult Dolly Varden (117 to 157 millimeters) collected in mid-June 2008 near MPS1 contained almost exclusively herring eggs (98 percent IRI), with terrestrial insects and cumaceans (hooded shrimp) accounting for most of the remaining 2 percent (Figure 43-31). Herring had been observed spawning in this location, so the eggs apparently were abundant and readily available for consumption.

Pacific herring were also exclusive feeders, with nearly 98 percent IRI composed of copepods (Figure 43-32).

Pacific staghorn sculpin, collected in 2005, fed primarily on several shrimp species including *C. alaskensis*, other *Crangon* shrimp species, and shrimp within the Family Hippolytidae. Amphipods, mostly *Anisogammarus pugettensis,* were second in importance. Unidentified fish were also a substantial part of the sculpin diet. In addition, a substantial amount of sediment was present in the stomachs of sculpin, indicating a demersal foraging behavior.

Surf smelt, a pelagic forage fish, were also collected in the IIE by beach seine in 2005. This species fed heavily on the copepod *Acartia clausi* and other calanoid copepods within the nearshore. Barnacle larvae were also consumed in appreciable numbers.

In September 2007, several fish were collected at various seine and trawl locations for stomach content analysis. Of those collected via 120-foot seine, Dolly Varden had the most varied diet that included both benthic and pelagic taxa as well as fish and invertebrate prey species. However, dietary exclusivity was also observed; in contrast to dietary focus on herring eggs during early summer (June) collections, some Dolly Varden in fall were found to feed almost exclusively on amphipods (>98 percent numerical dominance). Both Pacific herring and surf smelt consumed mainly pelagic prey species dominated by mysids and copepods.

Qualitative (2007) and quantitative (2008) observations on stomach parasite load showed a relatively high degree of parasites in Pacific herring and to a lesser degree, in Dolly Varden. The predominant parasite type in Pacific herring from both bays was a digenic trematode (*Brachyphallus* sp.) which also occurred in Dolly Varden when the diet included Pacific herring. Otherwise, Dolly Varden parasites were mostly round worms, present only as minor infestations. Of the 14 herring sampled in 2008, all had some level of parasite load. The young-of-the-year (average 53.3 millimeters) parasite load ranged from 30 to 304 parasites per individual, with a mean of 135.6 parasites. The Age 1+ (average 90.4 millimeters) load ranged from 10 to 59 parasites per individual, with a mean of 33.1 parasites (Figure 43-33).

The trematode *Brachyphallus* is found in many fish hosts, including herring and salmonids. They often use copepods (Køie, 1992) or chaetognaths (Prado-Rosas et al., 2005) as intermediate hosts, and consumption of these can cause infestation in fish. It has even been suggested that infested chaetognaths can experience physiological effects or behavioral changes (i.e., altered position in the water column), making them more susceptible to predation (Prado-Rosas et al., 2005). Previous studies have found *Brachyphallus* sp. in Pacific herring with the infestation rates ranging from 16 percent in British Columbia to 100 percent in Norton Sound, Alaska (Arthur and Arai, 1980; Moles and Heintz, 2007).

The prevalence of trematodes in young-of-the-year herring from the IIE was 100 percent, and prevalence has been reported elsewhere to be higher among younger fish (Marty et al., 1998). However, effects of trematode parasitism on the behavior, condition, or survival of herring are unknown.

Greenling (kelp and whitespotted) were collected opportunistically in both 2007 and 2008. The diets of these fish were much more varied than some other species and reflected the diversity of the demersal and benthic communities. Prey consisted of amphipods, mysids, several shrimp species (pandalid, spirontocarid, and heptacarpid shrimp), and Pacific herring and other fish eggs (Figure 43-34). The fish eggs observed in the 2007 samples resembled greenling eggs, were only present in the stomachs of adult female greenling, and were fertile with substantial development. As such, it was suspected that this could be facultative cannibalism where a gravid female preys upon an occupied nest and replaces the cannibalized eggs with her own. This behavior has been known to occur in other hexagrammids including the Atka mackerel, *Pleurogrammus monopterygius* (Yang, 1999). This result could point to possible limited availability of suitable nest sites and/or males within the region.

43.7.3 Synthesis

Collectively, data gathered from 2004 to 2008 covered the time period of late March through mid-November. This includes monthly sampling over this entire period in 2008 and sampling from May through August in 2005. To augment sampling during the late fall periods, additional sampling occurred in late September 2006 and mid-October 2007. To augment early spring sampling, additional sampling occurred in late April and mid-May 2006. Attempts to sample into mid- to late September 2005 were aborted because of poor weather conditions. Sampling in early April 2006 also could not be accomplished due to severe weather and ice conditions; substantial amounts of ice remained during the late April sampling period in 2006. In 2008, sampling occurred over 9 months, from late winter to early winter, and provided new information on biological communities present in the IIE. This section discusses both temporal and geographical trends of the nearshore demersal fish and invertebrate communities within the IIE study area from 2004 through 2008.

43.7.3.1 Nearshore Fish Community

As indicated by beach seine sampling, fish abundance in the nearshore IIE was high for most of the spring and summer sampling period. The number of species in the nearshore fish community increased substantially from between late March (2 species) and May (23 species) and remained high through September (21 species), declining substantially in October (11 species) and November (8 species; Figure 43-35; Table 43-4). Peak species richness occurred in July, when nearly 30 species were captured. Total catch rates with beach seines were moderate in March (<230 fish per set), low in April (22 fish per set), somewhat higher in May (~120 fish per set), and increased to a peak of more than 1,000 fish per set in June. Catch rates returned to moderate levels in late summer (between about 200 and 260 fish per set) and then, like species richness, steadily decreased from 202 fish per set in September to 24 fish per set in November.

More than 30 species of fish were captured in beach seine sets. Abundance data show that the nearshore IIE is an important nursery for juvenile herring and for three species of juvenile salmon. These two groups dominated catch in beach seine sets over the entire sampling period except in September, October, and November, when very few juvenile salmon were captured. The next most abundant species was subadult/adult Dolly Varden, which comprised less than 3 percent of total beach seine catch.

Pacific Herring

The fish community within the IIE is dominated by Pacific herring and they are a widely reported component of the diet of other species. Herring were the most abundant fish in beach seines and also in trawl and gill net catches. The IIE was used by spawning herring during the 1970s through 1994, and again in 2008. Although spawning herring were not observed during sampling from 2004 through 2007, juvenile herring from young-of-the-year through Age 1 were the most dominant fish in beach seine catches, and older sub-adult and adult herring also were seasonally abundant in gill nets and trawls.

Blackburn et al. (1981) found juvenile young-of-the-year herring averaging 20 millimeters in late May and growing to 40 to 50 millimeters by late September. In this study, young-of-the-year herring of that size were observed only in July and only in 2008. In July 2008, herring from 17 to 24 millimeters were observed, likely representing the cohort originating from IIE spawn observed in May and June 2008. In all other years, herring observed before July were mostly 51 to 90 millimeters in size and were likely an Age 1 cohort. During years when no spawn was observed in the IIE, young-of-the-year were first seen as a 30 to 50 millimeters cohort in June with the great majority in the 31 to 40 millimeter size range. In July, fish 30 to 40 millimeters long remained abundant, although this cohort showed considerable growth by August with most fish between 40 and 50 millimeters. Data from September and October 2006 and 2007 show a consistent growth pattern with most fish in the range of 41 to 70 millimeters (see Figure 43-7). These data suggest a prolonged recruitment of young-of-the-year fish from different spawning stocks into Iliamna and Iniskin bays. The lack of very small young-of-the-year except in 2008 is consistent with the limited local spawning in these bays during most years. The presence of larger young-of-the-year fish from June on, particularly over a prolonged period, is evidence for a continual recruitment of young fish to the bays from stocks that spawn over a wide area and/or period of time during spring. Herring spawning surveys conducted by ADF&G indicate that spawning occurs in lower Cook Inlet over a relatively long period between late April and early June (T. Otis, ADF&G, pers. comm., 2004), which likely accounts for the wide size distribution of young-of-the-year fish. Our 2008 herring spawn and early young-of-the year data show that the spawning period within the IIE is relatively late, ranging from mid-May to mid-June.

Blackburn et al. (1981) also reported Age 1 herring at 80 to 90 millimeters in June and 90 to 120 millimeters by August. The 2004 through 2008 data also showed this cohort of larger juveniles within the IIE, beginning in mid-May (see Figure 43-7). During May and June, larger juveniles were more abundant than young-of-the-year fish, but most had left the area by July and August. This suggests that the nearshore of the study area is widely used by juvenile herring until Age 1+, followed by an offshore movement as the fish exceed a size of about 100 millimeters. Results of trawl sampling provided some evidence for an offshore movement of larger juvenile herring. Herring were absent in bottom trawl catches during late spring and early summer but were present during the late winter/early spring (March and April) and from August on. During the late fall through early spring, trawl-caught herring were of the same general size range as those fish found in March beach seine catches, representing herring approaching Age 1 from the previous spring spawning. These findings are consistent with Blackburn et al. (1981), who found no subadult herring in greater Kamishak Bay older than Age 1 using a variety of nearshore and pelagic sampling gear. The present study found very few herring over 100 millimeters, except during spring 2008, when large gravid adults were captured in gill net sets. Herring in the IIE were found to feed almost exclusively on copepods (Figure 43-32), a group of zooplankton known to be numerically dominant within lower Cook Inlet (Damkaer, 1977).

Sampling data show a statistically significant preference of herring for Iliamna Bay ($P < 0.05$) relative to Iniskin Bay; note that all Iniskin stations were in the outer third of the Bay, while Iliamna sampling included stations throughout the bay. Over the 5-year sampling period, mean catch rates of herring were 358.9 fish per set in Iliamna Bay and 37.4 fish per set in Iniskin Bay. Catch rates of 72 fish per set were observed at the eastern Iniskin reference station (MBB; Figure 43-2). In Iliamna Bay, the highest catch rates were observed at inner bay stations such as MPSE1, MPSE2, MBS4, MBS3, and MPSE. Within the inner bay, CPUEs ranged from 276 to over 2,000 herring per set. The highest catch rates were for Age 1 fish during summer 2008. All outer Iliamna Bay stations (MBSA1, MBS1, MPS3, and MPS4) had catch rates below 150 herring per set. Still lower catch rates were observed at the Iniskin Bay stations most of which were clustered near MPS1 in the outer bay. No herring were taken at Station MYVCM, the outermost station located between Knoll Head and North Head. This preference for inner Iliamna Bay stations may be related to the protected nature of this portion of the study area relative to other areas of outer Iliamna and Iniskin bays. In 2005, sets were made on either side of a large rocky outcrop at Station MBS3. Beaches were similar at both substations. At the inner substation, protected from wind and swell by the outcrop, mean CPUE was 673.3 fish per set, while at the more exposed substation, mean CPUE was 49.5 fish per set, which was more typical of the other stations in the outer bay in 2005. The preference for this area was even more apparent during the fall 2007, when catch rates of over 1,100 fish per set (mostly age 0 fish) were found at MBS3, accounting for over half of the total catch of juvenile herring in 2007. Note that no sampling was conducted in the more sheltered areas of inner Iniskin Bay where conditions and juvenile herring use may more closely resemble those found in the inner Iliamna Bay stations sampled in this study.

Aerial surveys conducted by ADF&G show that adult herring use open waters of the IIE, with somewhat larger concentrations in the eastern half of Iniskin Bay. This distribution did not change substantially over the 1978 to 2005 period (ADF&G, 2002; ADF&G, 2005 unpublished data). In contrast, annual ADF&G spawning surveys have shown that the amount of herring spawn deposition has changed substantially over the 1978 to 2005 time period. From 1978 to 1989, herring spawn was widely distributed along much of the eastern shore of Iniskin Bay, within the IIE from MPS1 to north of MPS4 and along the southern shore of Cottonwood Bay. Spawning declined substantially from 1990 to 2002, when it was limited to some of the islands and reefs on the eastern shore of Iniskin Bay and in the Knoll Head reach within the IIE (Figures 43-4 and 43-5). Spawning was not reported directly within the IIE by ADF&G from 1994 to 2005, and field teams found no spawn on beaches surveyed in 2006.

In 2008, however, spawning surveys conducted by the field teams found a return of spawning herring to the IIE, with trace to moderate amounts of spawn deposition from north of MPS1C to Knoll Head and around islands and reefs of eastern Iniskin Bay (Figure 43-22). Two spawning periods were detected, one in late May to early June on the eastern islands and reefs, and another in mid-June along the western shore of Iniskin Bay. A total of approximately 3.1 miles of shoreline spawn deposition was observed in 2008. This is slightly lower than the amount found during a period of spawning abundance observed between 1985 and 1989 during which spawn was detected on 3.8 to 5.1 miles of shoreline within the IIE (ADF&G, 2002; ADF&G, 2005 unpublished data). All areas where spawn was observed in 2008 were areas used historically. Spawn was not detected in areas between MPS4 and North Head, where ADF&G data showed consistent spawning between 1985 and 1989. Marine macrovegetation appeared to be as abundant in this area as in areas where spawn was observed in 2008, so lack of spawning was likely due to annual variability in the size of the spawning population. These data on local spawning were corroborated by the collection of gravid adult herring in gill net sets in both Iniskin and Iliamna bays during May.

Historical data show that the IIE study area plays a relatively minor role in providing spawning habitat relative to Kamishak Bay and southwest Cook Inlet as a whole. Between one to nearly 50 miles of marine nearshore in Kamishak Bay have been used by spawning herring annually between 1978 and 2004 (Figure 43-36; ADF&G, 2002; ADF&G, unpublished data). The largest amount of spawn in the entire southwest Cook Inlet area (including Kamishak Bay and the IIE) occurred during the period between 1984 and 1989 during which over 25 miles of nearshore was used by spawning fish annually. Herring spawned in the IIE most consistently during that time period, but otherwise were absent or sporadically present in the IIE. From 1985 through 1991, the percentage of total southwest Cook Inlet herring spawn that was located within the IIE ranged from 8 to 21 percent annually (Figure 43-37). Substantially less herring spawn occurred in southwest Cook Inlet from 1992 through 2004, and herring spawn was observed within the IIE only once during that period.

Preliminary studies by Ware and Tovey (2004), investigating herring spawn disappearance and recolonization events in British Columbia, suggest that such events may be explained by dispersal and other natural mechanisms of a large metapopulation, and that vacant habitat will eventually be recolonized when suitable conditions return. Their analyses also showed that such metapopulations of herring in British Columbia appear to respond to events such as the Pacific Decadal Oscillation climatic regime changes in the North Pacific. The southwest Cook Inlet (greater Kamishak Bay, including the IIE) herring stock shows several consistencies with this metapopulation model. The southwest Cook Inlet herring population grew substantially during the Pacific Decadal Oscillation "warm" regime which lasted from 1977 to 1997 and fell during the subsequent "cool" regime that occurred after 1998. This population response is the opposite of that found in southern British Columbia (Ware and Tovey, 2004), where declines were observed during the warm regime and increases during the cool regime, but it is consistent with population responses found in the Gulf of Alaska and Prince William Sound (Brown, 2002). The period of disappearance of spawning herring within the IIE largely coincided with the regime shift in the late 1990s. Ware and Tovey (2004) also found that, among 82 disappearance events in British Columbia since 1943, the average length of vacant spawning habitat was 11 years (range of 5 to 35 years). If herring spawn observed in the IIE in 2008 represents an initial recolonization event (no foot surveys were done in the IIE in 2007), then the prior disappearance event lasted for 13 years.

The distribution of herring spawn in southwest Cook Inlet since 1978 show that most spawning occurs in the southern reaches of Kamishak Bay with prominent spawning areas on the flats and reefs off Katmai National Park, Chenik Head, Contact Point near Bruin Bay, and Rocky Cove south of Ursus Cove. These areas were used by spawning herring nearly every year during 1978 to 2005. Spawning occurred north of Ursus Cove and into the IIE during the high biomass years of the 1980s (ADF&G, 2002; ADF&G, unpublished data). Tagging studies of British Columbia herring suggest a high fidelity (85 percent on average) of repeat spawning at large spatial scales of stock assessment areas, but at smaller embayment scales fidelity rates are much lower, averaging only 17 percent (Hay et al., 2001). A high degree of interannual variability is present in the abundance of spawners, presumably due to large variation in the number of adult herring straying between nearby areas from one spawning season to the next (Ware and Tovey, 2004). These data suggest that areas of limited use for spawning, or areas used primarily during large biomass years, such as the IIE, would play a less prominent role in the maintenance of the herring stock as a whole.

Salmon

Use of the study area nearshore was high for juvenile pink and chum salmon, but substantially fewer sockeye were present and very few juvenile coho or Chinook use the nearshore of the IIE. Juvenile salmon were found in moderate numbers in April, but were absent during March. During March, moderate amounts of floating ice were present in both bays. Total juvenile salmon abundance peaked in May, but a substantial presence continued in June and July, before declining sharply by August. The three salmon species each had distinct temporal migration patterns through the nearshore study area. Juvenile chum salmon maintained the shortest residence in the bays; chum were most abundant in April and May, declining sharply to near zero from June on. Juvenile pink salmon did not arrive in substantial numbers until May and peaked in July, followed by a sharp decline in August. Juvenile sockeye were found at relatively low but consistent catch rates in June and July. Few juvenile salmonids were found in September and none were found in October. In contrast, Blackburn et al. (1981) found that juvenile chum salmon tended to remain in lower Cook Inlet longer than pink salmon, remaining in the area through mid-September, a pattern seen also in Knik Arm (Pentec, 2005a, 2005b).

Length frequency data for juvenile pink and chum salmon show a typical movement of a single young-of-the-year cohort into nearshore marine areas in spring. Size data indicate good growth, even as numbers decline sharply later in the summer. The chum outmigration was early and relatively short with catch dropping sharply after peaking in mid-May (Figure 43-39). This behavior pattern is typical of chum in North American estuaries and marine nearshore (e.g., Healey, 1982). Length frequency data did not show a substantial amount of growth during this relatively short period, but the few lingering chum found through the remainder of the summer were larger than those found in April and May (Figure 43-8). Juvenile chum fed heavily on copepods, which is consistent with numerous other reports (Kacyzinski et al., 1973; Simenstad et al., 1980; Sibert et al., 1977), but they also fed heavily on snails of the genus *Lacuna*, which has not previously been reported to be a substantial food.

The outmigration of juvenile pink salmon through the IIE was longer, as they extended their residence in the bays from May through much of July. This prolonged residency by pink salmon was in sharp contrast to their behavior in upper Cook Inlet (Knik Arm) and southern Kamishak Bay where they had the shortest estuarine residence of any salmon species (Blackburn et al., 1981; Pentec, 2005a, 2005b). While not typical, pink salmon have been found to occupy several zones of the nearshore during their early marine life history. Karpenko (1987) reported that juvenile pink salmon in the Bering Sea were found in one of three hydrological zones during the first three to four months of marine life: 1) the littoral zone, up to 150 meters from shore; 2) open parts of inlets and bays, from 150 meters to 3.2 kilometers from shore; and 3) offshore from 3.2 to 97 kilometers from shore. Pentec (2006) also found substantial numbers of juvenile pink salmon in the nearshore of False Pass on Unimak Island in September. Over their prolonged presence in the nearshore of the IIE, pink salmon showed steady growth increasing from 31 to 40 millimeters in May to 71 to 80 millimeters in July (see Figure 43-9), suggesting that fish were finding sufficient food resources within the nearshore of the two bays. Feeding by the species was concentrated on copepods and terrestrial insects (Figure 43-28).

The two dominant juvenile salmon within the IIE, chum and pink salmon, showed statistically distinct bay preferences during their outmigration—chum preferred Iliamna Bay ($P < 0.1$) and pink preferred

Iniskin Bay ($P < 0.05$; Figure 43-38). Note again that stations sampled in Iniskin Bay were all in the outer third of the bay whereas stations were sampled throughout Iliamna Bay. Given the different outmigration behavior of the two species, an interesting bimodal temporal outmigration pattern emerged. Beach seine data for 2004 through 2008 showed an outmigration peak within Iliamna Bay in May driven by chum salmon. In contrast, the outmigration peak in Iniskin Bay was in July, driven by pink salmon (Figure 43-39). This partitioning may be related to the location of the major spawning streams of each species relative to sampling locations. Chum salmon runs are larger than pink in both bays, with the largest run in Cottonwood Creek, on the Iliamna side. Beach seine data show the capture of 39 adult chum and 3 adult pink salmon in Iliamna Bay, consistent with the larger chum runs and juvenile presence. The largest pink salmon run within the IIE is in Y Valley Creek, which discharges between Iniskin and Iliamna bays but is relatively close to the Iniskin beach seine stations; not surprisingly the highest CPUE for juvenile pink salmon (70.8 fish per set) was observed at Station MPS1A, which is situated nearer to the mouth of Y Valley Creek than other stations. For adult pink salmon, the difference in catch between the two bays was less pronounced, but still consistent with juvenile abundance and adult runs—18 adult pink and 12 adult chum were captured in Iniskin Bay.

Juvenile sockeye and coho salmon also showed a distinct preference for Iniskin Bay ($P < 0.05$), but relatively few fish of these species, and no adults, were captured (Figure 43-38).

Other Fishes

Blackburn et al. (1981) found Pacific sand lance to be the numerically dominant fish in their lower Cook Inlet sampling, but also reported that sand lance numbers were low in Iliamna, Iniskin, and Cottonwood bays. This was consistent with findings in the present study: sand lance were observed in lesser numbers than other forage fish, only at a few stations, and most were taken during May.

The 2004 to 2008 data are remarkably consistent with the findings of Blackburn et al. (1981) with regard to the abundance, migratory timing, size, and growth of Dolly Varden within the nearshore. This species was widespread and moderately abundant with multiple cohorts present in the nearshore from May through September. Blackburn et al. (1981) also found juvenile whitespotted greenling as a numerically dominant species in beach seine sets, particularly in Cottonwood Bay (25.7 fish per set), but moderate numbers were also observed in Iliamna Bay (9.3 fish per set) and Iniskin Bay (7.5 fish per set). In the present study, only 13 whitespotted greenling were taken in beach seine sets during the entire sampling period, although 59 adults were collected in gill and trammel nets in 2008.

43.7.3.2 Demersal Fish Community

Nearshore demersal sampling by bottom trawl in 2004 through 2008 revealed a substantially different fish community from that found by beach seine. Like the beach seine assemblage, however, the trawl assemblage was dominated by just a few species. Yellowfin sole, Pacific herring, and snake prickleback together comprised nearly 60 percent of all fish captured in the trawl. Pacific staghorn sculpin, juvenile walleye pollock, starry flounder, great sculpin, and whitespotted greenling also each comprised between 3 and 6 percent of total catch. The number of fish species captured generally increased each month from March to September before declining (Figure 43-40). Blackburn et al. (1981) did not conduct trawl surveys in the IIE, but found yellowfin sole were the most abundant species at stations in more open-water habitats of Kamishak Bay. Their overall species assemblage was similar to that found in the IIE, with the notable exception that they captured no snake prickleback. Blackburn et al. (1981) instead found the closely related species, slender eelblenny (*Lumpenus fabricii*), perhaps suggesting a geographic partitioning of the two species between shoreline and deeper water habitats. The preponderance of juvenile snake prickleback over the sampling period suggests that this species may use the inner bays as a juvenile nursery.

The CPUE for all trawl catch over the 2004 to 2008 period showed an increasing trend through the spring, peaking in May (30.1 fish per set) declining during the summer (Figure 43-40). For all sampling months, total CPUE was lowest during June and July (11.2 and 11.3 fish per set). After July, CPUE increased through September and October, with catch rates near the May peak, followed by a slight decline in November. These catch trends were driven by the relatively high abundance of late young-of-the-year herring during the fall and winter, as well as young-of-the-year snake prickleback during the fall. Relatively high CPUEs found during spring were driven by peak abundances of adult snake prickleback and yellowfin sole in May.

An important commercial species, Pacific halibut, was commonly captured in trawls. Juvenile halibut (<200 millimeters) were captured at all trawl stations at relatively low, but consistent catch rates (0.2 to 0.7 fish per set; Table 43-10) from May through November (Table 43-11), suggesting year-round juvenile rearing in the area. Adult halibut were not sampled in a systematic manner, but hook and line sampling for tissue chemistry analysis (Chapter 35.4) was conducted in both bays during all spring and summer months. Consistently, adult halibut were available only during April, May, and June; after which very few were landed. Spiny dogfish, another large predator, was only captured in trammel net sets in August 2008 when they were numerous (CPUE =9.0; Table 43-9). This coincided with high catches of this species by hook and line from July on.

43.7.3.3 Open Water Fish Community

Blackburn et al. (1981) sampled surface water habitats with tow nets farther from shore in Kamishak Bay. Pacific sand lance and herring dominated tow net catches with adult herring common in spring and larval herring relatively abundant during summer. Blackburn et al. (1981) herring data are consistent with ADF&G spawning surveys that show the presence of adults farther from shore in study area bays. The abundance of larval herring seen by Blackburn et al. (1981) farther from shore coincides with the high abundance in beach seines during June through August in the present study, suggesting a widespread distribution in nearshore habitats.

During some periods, young-of-the-year whitespotted greenling, adult capelin, and juvenile pink, sockeye, chum, and Chinook salmon also were commonly taken in open water habitats by Blackburn et al. (1981). During the early summer, a few relatively large catches of sand lance occurred, along with some large catches of juvenile herring, and adult capelin with flowing sex products. Young-of-the-year greenling were common in small numbers through the summer months. Juvenile sockeye salmon were common in June and early July. In July and August, juvenile pink, chum, and Chinook salmon were relatively common (Blackburn et al., 1981). The relatively low numbers of juvenile salmon in beach seine catches in late summer in this study were consistent with the findings of Blackburn et al. and are consistent with reports that larger juvenile salmon of all species tend to move offshore as they grow (e.g., Healey, 1982; Simenstad et al., 1982).

43.7.3.4 Distinct or Valuable Habitats

Data collected over the sampling period were evaluated to determine whether any distinct or valuable habitats exist within the IIE.

Inner Iliamna Bay

CPUE calculated for beach seine sampling show that catch rates within inner Iliamna Bay were substantially higher relative to the rest of the IIE (Figure 43-41), although no sampling was conducted at comparable stations in inner Iniskin Bay. For example, CPUE at Station MPSE1 along the west shore of inner Iliamna Bay was over seven times higher than mean CPUE within the IIE. This high catch rate was largely due to the very high catch of juvenile herring in June 2008 (>2,000 fish per set), but relatively high levels of catch were consistent at all innermost stations. CPUEs at inner Iliamna Stations MPSE2, MBS4, MBS3 and MPSE were between 1.3 and 2.0 times higher than mean catch rates within the IIE, again the result of high juvenile herring abundance. Statistical analyses (single factor analysis-of-variance) show a significant difference between the inner Iliamna stations relative to outer Iliamna and Iniskin stations. There was also a significant bay preference found for Pacific staghorn sculpin, which were caught more frequently in inner Iliamna ($P = 0.03$). Catch at stations MPSE and MPSE1 accounted for approximately 70 percent of the total staghorn sculpin catch for the IIE in all 5 years sampled. Longfin smelt also appeared to prefer inner Iliamna (CPUE of 5.3 catch per set v. 0.25 catch per set for the two other areas), although this difference was not significant ($P = 0.29$). Similar results were observed with starry flounder in trawl catches at inner Iliamna station MTR3 relative to mid- and outer-Iliamna and Iniskin stations. Here, CPUE of starry flounder was 6.9 fish per haul compared with catch rates of <1 fish per haul at all other trawl stations within the IIE ($P < 0.14$).

These analyses show that inner Iliamna Bay has distinct habitat attributes that attract and retain these species. Inner Iliamna Bay is substantially more protected from wind and storm influences relative to outer Iliamna Bay and to the outer Iniskin Bay stations sampled. As reported above, sampling on either side of rocky outcrops appear to show that juvenile herring prefer more protected nearshore habitats. The substantial mud and sandflat habitats present within the inner bay also likely attract starry flounder. Numerous starry flounder were observed on two occasions by field crews walking with the leading edge of the flooding tide in inner Iliamna. The largest numbers of adult starry flounder were in trawl catches also taken at inner Iliamna Station MTR3 and substantial numbers of juvenile and subadults were captured at inner beach seine Stations MPSE and MBS4.

Y Valley Between North Head and Knoll Head

Sampling data suggest that the portion of outer Iniskin Bay area between North Head and Knoll Head provides relatively valuable nearshore and stream habitats for pink salmon and Dolly Varden in the IIE. A distinct statistical preference for Iniskin Bay was observed in Dolly Varden ($P < 0.05$). The highest catch rates for Dolly Varden were found at Station MPS1 (23.7 fish per set), but all outer Iniskin stations had catch rates substantially above the mean. The highest proportion of adult fish was also observed at Station MYVCM near the mouth of Y Valley Creek, suggesting that this may be a natal or overwintering stream for this species. Similarly, as reported earlier, juvenile pink salmon showed a statistical preference for the cluster of outer Iniskin stations relative to the rest of the IIE, perhaps due to the large pink salmon runs known to occur in Y Valley Creek.

Outer Iniskin Herring Spawn Habitat

In 2008, herring spawn surveys showed spawning areas concentrated on the western shore of outer Iniskin Bay from north of MPS1C to Knoll Head. The densest concentrations of spawn, relative to other areas of the IIE, were observed in mid-June along approximately 3,500 feet of shore near MPS1 (Figure 43-22). Spawn in this area was near continuous on a variety of marine vegetation (and rock), but herring apparently preferred to spawn on the seaward face of the outermost intertidal rocky outcrops. Herring did not spawn inside of the outermost outcrops despite the presence of similar vegetation types. This general area (west shore, outer Iniskin Bay) was consistently used by spawning fish during the mid-to-late 1980s when Kamishak Bay spawners were relatively abundant. However, data also indicate that when Kamishak spawners are not abundant, then none of the IIE is used by spawning herring.

Intertidal Lagoons

Considerable use of the three intertidal lagoons in the IIE was found for juvenile chum, pink, and sockeye salmon during spring to early summer. These lagoons appear to provide the three main estuarine habitat functions ecologically important to juvenile salmonids—foraging habitat, areas of transition to marine salinities, and areas where predators can be avoided (Thorpe, 1994). The lagoons have the same attributes of “pocket estuaries”—defined by Beamer et al. (2003) as small sub-estuaries that form behind spits or barrier beach landforms, characterized by having lower wave energy and reduced longshore currents, freshwater inputs (stream or groundwater), and depressed salinities. This may be important in the IIE given the frequency of poor weather and high energy nearshore. Beamer et al. (2003), investigating pocket estuaries in Skagit Bay, Washington, found use by juvenile Chinook salmon in these kinds of habitats at 10 to 100 times the densities found in surrounding delta or beach environments, respectively. Healy (1982) found that juvenile chum salmon often occupy tidal sloughs (at higher tidal elevations) that drain completely at low tide, a characteristic of two of the tidal lagoons sampled. Mason (1974) found that juvenile chum exploit both freshwater and marine foodwebs and, by doing so, are exposed to marked daily fluctuations in salinity (0 to 27 parts per thousand), also a characteristic of two of the three lagoons within the IIE. In addition, beach seine and length frequency data indicate a lagoon community comprising only small juvenile species and the small forage species threespine stickleback, providing juvenile salmon refuge from predation. AC Point lagoon (MACL), in particular, constitutes high quality habitat for juvenile salmon due to its high productivity (from shallow nutrient rich waters and abundant small invertebrates) and added refuge due to the presence of eelgrass which increases habitat complexity.

Iniskin Trench

Most of Iniskin Bay and all of Iliamna Bay is relatively shallow, usually less than -30 feet MLLW, with the exception of approximately 1.5 miles of deeper water (–60 to –85 feet MLLW) located relatively close to shore near MPS1. At the request of ADF&G, trawl catch within Iniskin Bay was evaluated to determine if this deep water trench contained a different fish community than the other relatively shallow shelf habitats present at the remaining stations within the bay. The deeper water trench within Iniskin Bay was sampled at trawl Station MPS1T; average trawl lengths were 757 feet and average trawl depth was 62 feet within the trench. Findings indicate that the fish community within the trench was not significantly different than other areas of Iniskin Bay (Figure 43-42). Snake prickleback were the dominant species at three of four Iniskin trawl stations, and yellowfin sole the second most abundant (at the fourth station, the two species were switched in abundance).

43.7.3.5 Invertebrates

Invertebrates and Fish Dietary Analysis

Marine macroinvertebrate data show that productivity is high for several species of shrimp and mysids in the IIE. Fish stomach content analyses show that these species are important in the food web of the study area. *Pandalus* spp., *C. alaskensis,* and *Heptacarpus* spp. were abundant in trawls for much of the sampling period, particularly in Iniskin Bay (Tables 43-14 and 43-15). Adult mysid shrimp (*Neomysis* spp.), including many gravid females, were particularly abundant in early spring and late summer/early fall trawl catches. Although not quantified because of the net mesh size, numerous and very small young-of-the-year mysid shrimp often were found in beach seine sets during late spring and summer, particularly at protected stations within Iliamna Bay. Analyses indicate that young-of-the-year mysid shrimp were an important prey of whitespotted greenling in 2008 (Figure 43-34). Small broken back shrimp, *Heptacarpus* spp., and the larger crangonid and adult hippolytid shrimp were also important components in the diet of whitespotted greenling. Starry flounder, the primary demersal species found in Iliamna Bay, fed heavily on bivalves (Figure 43-29), particularly *Macoma balthica*. In contrast, yellowfin sole, the second most abundant demersal species in the IIE fed mostly on polychaete worms. Both fish species are closely associated with soft sediment benthic habitats (Figure 43-28) and these were the most abundant infauna in the areas where the sampled fish were captured.

Other important invertebrate prey of juvenile chum salmon, juvenile pink salmon, surf smelt, and yellowfin sole were the small nearshore planktonic calanoid copepods *Acartia clausi* and *Eurytemora* sp. These copepods are too small to be collected by seine or trawl gear. Blackburn et al. (1981) reported that several species of copepods and other small zooplankters were preyed upon by young, small-mouthed fish including juvenile salmon, greenling, Pacific herring, sand lance, surf smelt, and rock sole. Damkaer (1977) found that copepods were the numerically dominant zooplankters in lower Cook Inlet. Calanoid and harpacticoid copepods (the latter more epibenthic than planktonic) are among the most important prey of juvenile chum and pink salmon during their nearshore outmigratory period in many areas (Takagi et al., 1981; Simenstad et al., 1982). It is worth noting the importance of small intertidal gastropods (*Lacuna* sp.) in the diets of juvenile salmonids in 2005. Approximately 40 percent (n = 46) of the chum salmon sampled in 2005 had this small gastropod present in their stomachs, indicating an unusually strong reliance on a benthic epifaunal species. This active predation on a cryptic intertidal species may represent a shift in prey selection to a less desirable but abundant species in the absence of preferred species (e.g., Simenstad and Kinney, 1978).

Amphipods often were observed during the intertidal and herring spawn surveys swimming among macrovegetation in rocky intertidal areas. Given the rocky nature of their habitat, quantitative measures of gammarid amphipod abundance could not be obtained with the sampling gears used. The amphipods *Pontogeneia intermedia* (in 2005) and *Lagunogammrus setosus* (in 2007) were the principal prey of subadult Dolly Varden and *Anisogammarus pugettensis* was an important prey of Pacific staghorn sculpin and yellowfin sole (in 2005 only). Although the sample size for Dolly Varden was small, the dominance of amphipods in their stomachs indicate that fish were targeting this prey. There were also a number of Dolly Varden that had been feeding entirely on herring eggs; these fish were collected where herring spawning had been observed. In 2008, individual Dolly Varden stomachs typically contained only one type of prey item, again suggesting that this species targets locally abundant resources. It is somewhat surprising that Dolly Varden were not feeding on juvenile salmon which were abundant in nearshore habitats, but Lagler and Wright (1962) have shown that the species often will feed on other prey such as sand lance, herring, and capelin, even if juvenile salmon are abundant. Other studies have shown a tendency for Dolly Varden to feed on crustaceans, mainly amphipods and mysids (Armstrong, 1965; Neuhold et al., 1974).

Considering declines in nearshore abundance of other marine animals in the fall, demersal macroinvertebrates were relatively abundant in fall trawl catches farther from shore in the IIE (Figure 43-23). Fall sampling occurred in September 2006, September and October 2007, and September through November 2008. September catches were substantially greater in 2007 than in 2006 and remained comparably high in 2008. This pattern was attributable primarily to the increased catch of pandalid shrimp at MTR1 and to a lesser extent MPS2TB in fall 2007 and 2008 (Figures 43-24 and 43-25). Similarly, macroinvertebrate catches nearly doubled between October 2007 and October 2008; while the November 2008 catches decreased to near the September catch rates. These changes were mostly attributed to large catches in October of *Crangon* spp. at MPS2TB and MTR2 and *Neomysis rayii* at MTR3.

In September and especially in October trawl samples (2006 through 2008), pandalid shrimp were large in size compared to samples taken earlier in the season (2004 through 2008) and an appreciable percentage of the fall population was gravid with well-developed eggs. October samples showed two distinct cohorts for *Pandalus danae*, with both large sexually mature adults ($\geq$80 millimeters) and small juveniles ($\leq$20 millimeters).

Trawl catch rates in September and October were expected to be lower than seen in the historical summer catch data. However, macroinvertebrate abundances in fall 2007 and 2008 were similar to or greater than those in mid-summer samples taken in 2005 and 2008 (Figure 43-23). This suggests year-round presence and utilization of project area habitats, independent of the fall–winter decline in numbers of demersal fish.

The apparently more stable seasonal abundance of macroinvertebrates, relative to that of demersal fish, may be explained by examining the reproductive ecology and biology of the two most numerous invertebrate groups present in the samples, pandalid and crangonid shrimp. Pandalid shrimp, and to a lesser degree crangonid shrimp, are protandrous hemaphrodites that mature as males during the first year of life but change sex the following summer as they grow in size. Their ovigerous period starts in the fall and continues through the winter into the next spring (Berkeley, 1931); rates may vary depending on temperature. The large pandalids encountered during the 2007 sampling year represented 1+ year old females beginning their reproductive cycle while the remaining mature shrimp represented young-of-the-year males (Butler, 1980). This reproductive activity, starting in late fall, likely aggregates these shrimp to help facilitate fertilization success. This may explain the large increase in pandalid catch for October trawl samples. Also, it is characteristic in pandalid shrimp for the larvae to remain in place after hatching (Berkeley, 1930) and this helps to explain the patchy yet dense catch data recorded to date for this group of shrimp in the IIE.

This sex change in 1+ year shrimp is somewhat plastic and can be environmentally mediated. There is evidence in other pandalid species that the mean size of breeding females decreases (i.e., they switch from male to female at a younger age) in response to older females disappearing from the population. Earlier onset of the ovigerous period may occur to compensate for reduced reproductive capacity at the population level, when fishing pressure or environmental change result in increased mortality of older females (Charnov and Anderson, 1989).

Crangonid shrimp have been reported to have two protracted spawning peaks that roughly coincide with early fall and late spring (Butler, 1980). This explains the presence of large gravid females in the IIE in fall samples. Crangonids are quite fecund with females often carrying over 3,000 eggs per individual and they have a more dispersive larval stage than do pandalid shrimp (Butler, 1980). This translates into a more uniform dispersion across a region, with less patchiness in distribution than pandalid shrimp. Crangonids are tolerant of a wide range of conditions including fairly low temperatures (Squires and Figueira, 1974) and they do not appear to migrate to warmer temperatures during winter except during extreme conditions. Although they may aggregate to enhance reproductive success in the early fall, they are likely year-round residents in the IIE and the large amounts of detritus in the IIE (much of it plant material of terrestrial origin) may provide a substantial source of food during heavy ice conditions. These factors in combination help to explain the consistent month-to-month presence of crangonid shrimp within the IIE. The year-round presence of detritus in the IIE may support the year-round persistence of infauna and epibenthic zooplankton, which in turn supports nearshore and demersal fish populations, transient populations, and concentrations of various marine birds (Baldwin and Lovvorn, 1994) and mammals in fall and spring.

The pandalid *P. goniurus,* or humpy shrimp, is known to be a consumer of polychaetes, crustaceans, hydroids, and bivalves, as well as copepods and euphausiids in the eastern Pacific (Chuhukalo and Shebanova, 2008). Humpy shrimp, are known to be detritivores or omnivores that benefit from the presence of detritus. In turn, this group of shrimp plays a substantial role in the diet of walleye pollock, cod, sculpins, rays, saffron cod, rockfish, Atka mackerel, Irish lords, snailfish, halibut, and many other fish (as reviewed in Chuhukalo and Shebanova, 2008). Pandalids had a high importance in the limited number of stomachs of Dolly Varden and whitespotted greenling examined from the IIE. These invertebrates may therefore be an important ecological link between the detrital food subsidies present in the winter in the IIE and higher trophic level organisms found in the IIE/lower Cook Inlet region.

43.8 Summary

Marine investigations over the 5-year period 2004 through 2008 included numerous sampling events of fish and macroinvertebrate populations within the IIE in all seasons but mid-winter, when ice and weather conditions inhibit safe and easy access. These multi-year studies provide an ecological baseline characterization of the IIE. The conclusions of this investigation are as follows:

- The IIE is a complex marine ecosystem with numerous fish and macroinvertebrate species that use the area for juvenile rearing, refuge, adult residence, migration corridor, foraging, staging, and reproduction. An array of marine habitats are available for use including cobble/sand and rocky intertidal areas, intertidal and subtidal mud/sand flats, intertidal and subtidal reefs, and intertidal lagoons. Over 50 species of fish were captured in beach seine, bottom trawl, gill net, and trammel net sampling over the course of the study.

- The IIE is used as a rearing area by juvenile Pacific herring. Young-of-the-year and 1 year old herring were the dominant fish species and life stages throughout the March through November sampling period, with peak occurrences during the summer. Size data indicate that young-of-the-year from different areas of Cook Inlet are recruited to the IIE annually, along with progeny from IIE spawning events. Substantial rearing of herring occurs in the nearshore for at least 1 year, followed by an offshore movement as fish reach approximately 100 millimeters in length.

- Of the areas sampled, juvenile herring were significantly more abundant in inner Iliamna Bay and extremely high catch rates of juveniles were observed at times during the summer. Data suggest that the higher abundance may be related to the availability of sheltered habitats in the inner bay. Note that all Iniskin stations were in the outer third of the Bay, while Iliamna sampling included stations throughout the bay. Substantially lower, but ubiquitous, use was observed in nearly all areas studied in the IIE.

- Adult herring spawned in Iniskin Bay in 2008 from late May through mid-June, the first documented spawn deposition on beaches in the area since 1994. Trace to low densities of spawn were observed along eastern outer Iniskin Bay near Scott Island and adjacent reefs. Trace to moderate amounts were observed along the western shore of the bay. Historically, herring spawned annually in Kamishak Bay, expanding to reaches of the IIE during large biomass years. It is not known whether herring spawn detected in 2008 represents a long-term recolonization of the area by spawning fish.

- In 2008, herring spawn was found in two general areas in the IIE: along the western shore of outer Iniskin Bay from north MPS1C to Knoll Head, and along the outer shorelines of Scott Island and adjacent islands, islets, and reefs of eastern Iniskin Bay. Areas used by spawning fish were generally the same areas most consistently used historically between 1979 and 1991. The presence of spawning fish was confirmed by the capture of gravid adults in floating gill net sets in May 2008.

- The IIE nearshore is used as a rearing area by juvenile salmon which, as a group were second to herring in abundance in this and another local study (Blackburn et al., 1981). Juvenile pink and chum salmon were the most abundant salmonid species showing a typical spring and summer outmigration as young-of-the-year fish. Juvenile chum displayed a short outmigration period during May and June, while juvenile pink salmon remained in the IIE into August. Both salmonid species were largely gone by September. Juvenile pink salmon were significantly more abundant in Iniskin Bay while juvenile chum preferred Iliamna Bay. Again, note that all Iniskin stations were in the outer third of the Bay, while Iliamna sampling included stations throughout the bay.

- More than one cohort of juvenile sockeye salmon also use the IIE nearshore during spring and summer, though at much lower abundances than chum and pink. Very few juvenile coho and Chinook salmon were captured in the IIE.

- Multiple cohorts of subadult and adult Dolly Varden maintained a moderately high and widespread abundance in the IIE nearshore from spring through late summer, with a distinct preference for Iniskin Bay.

- Adult chum and pink salmon stage in the IIE principally in July and August. ADF&G data show these species spawn in several streams within Iliamna, Cottonwood, and Iniskin bays. No other salmon species are known to spawn in these streams, although coho salmon are documented in small numbers in Y Valley Creek (Chapter 15).

- Several other forage fish species, including surf smelt, longfin smelt, and Pacific sand lance, use nearshore areas of the IIE, but at much lower abundances than juvenile herring or salmonids. Starry flounder also were commonly found in nearshore areas within inner Iliamna Bay.

- Demersal fish assemblages farther from shore in the IIE were substantially different from assemblages caught in beach seines and snake prickleback was the most abundant species. Yellowfin sole, juvenile halibut and several other flatfish species, whitespotted greenling, juvenile walleye pollock, and several species of sculpin were common in bottom trawl tows. Juvenile Pacific herring were also relatively abundant during the fall months and during March, providing evidence for an offshore movement during the winter.

- The highest catch rates of fish at stations sampled within the IIE were in inner portions of Iliamna Bay. Fish species included juvenile herring, Pacific staghorn sculpin, longfin smelt, and starry flounder. Abundances were sufficiently high to suggest that this area provides a distinct and valuable habitat for herring and other fish species within the IIE, although comparable sheltered, inner bay habitats were not sampled in Iniskin Bay.

- Three intertidal lagoons were commonly used by juvenile chum, pink, and sockeye salmon early in the outmigratory season. Abundance was sufficiently high to indicate that these lagoons provide a distinct and important local rearing habitat for juvenile salmonids.

- Macroinvertebrates were abundant in otter trawl catches during the entire March through November sampling period; catches were dominated by a few species of pandalid and crangonid shrimp.

- Macroinvertebrate densities did not decrease during the fall and winter periods, as did demersal fish species, suggesting the year-round use of the IIE by macroinvertebrates. Increased spawning activity of some macroinvertebrates, including shrimp, was observed during the fall and winter months.

- Juvenile Dungeness and tanner crab were at times moderately abundant in trawl catches within the IIE, especially tanner crab in the fall.

- Substantially fewer invertebrate species were observed in beach seine sets than in deeper demersal samples with the notable exception of high densities of mysids in inner Iliamna Bay.

- Mysids were a principal prey species for juvenile salmonids and several other fish species within the IIE.

- The epibenthic macroinvertebrates were principal prey organisms for several fish species within the IIE including whitespotted greenling, Dolly Varden, and Pacific staghorn sculpin. Several families of invertebrates (amphipods, pandalid shrimp, and crangonid shrimp), some common in trawl surveys, also comprised a substantial portion of the diet of these fish.

43.9 References

Abookire, A.A., J.F. Piatt, and M.D. Robards. 2000. “Nearshore Fish Distributions in an Alaskan Estuary in Relation to Stratification, Temperature, and Salinity.” Estuarine, Coastal and Shelf Science 51: 45-59.

Alaska Department of Fish & Game, Division of Commercial Fisheries. 2002. Kamishak Bay Herring Data Synthesis, Version 1.0a. CD-ROM. Homer, Alaska.

Alaska Department of Fish & Game, Division of Commercial Fisheries Staff. 2004. 2003 Lower Cook Inlet Annual Finfish Management Report. Homer, Alaska.

Alaska Department of Fish & Game, Division of Commercial Fisheries Staff. 2009. 2008 Lower Cook Inlet Annual Finfish Management Report. Homer, Alaska.

Anderson, P. J., and J.F. Piatt. 1999. "Community Reorganization in the Gulf of Alaska Following Ocean Climate Regime Shift." Marine Ecology Progress Series Vol. 189. Pp. 117–123.

Armstrong, R.H. 1965. Some Feeding Habits of the Anadromous Dolly Varden in Southeastern Alaska. Alaska Department of Fish and Game Informational Leaflet 51: 1–27.

Arthur, J.R., and H.P. Arai. 1980. "Studies on the Parasites of Pacific Herring (*Clupea harengus pallasi* Valenciennes): Survey Results." Canadian Journal of Zoology 58: 64–70.

Baldwin, J.R., and J.R. Lovvorn. 1994 Habitats and Tidal Accessibility of the Marine Foods of Dabbling Ducks and Brant in Boundary Bay, British Columbia. Marine Biology 120: 627–638.

Beamer, E., A. McBride, R. Henderson, and K. Wolf. 2003. The Importance of Non-Natal Pocket Estuaries in Skagit Bay to Wild Chinook Salmon: An Emerging Priority for Restoration. Skagit River System Cooperative Research Department, La Conner, Washington.

Berkeley, A.A. 1930. The Post-embryonic Development of the Common Pandalids of British Columbia. Contributions to Canadian Biology and Fisheries, being studies from the Biological Stations of Canada N.S. Vol. 6. Pp. 79–163.

Berkeley, A.A. 1931. Mating Oviposition in *Pandalus danae*. Canadian Field-Naturalist 45(5): 107–108.

Blackburn, J.E., K. Anderson, C.I. Hamilton, and S.J. Starr. 1981. Pelagic and Demersal Fish Assessment in the Lower Cook Inlet Estuary System. U.S. Dept. of Commerce, NOAA, OCSEAP Final Rep. 12. Pp. 259–602.

Brown, E.D. 2002. Effects of Climate on Pacific Herring, *Clupea pallasii*, in the Northern Gulf of Alaska and Prince William Sound, Alaska. PICES-Global International Program on Climate Change and Carrying Capacity. North Pacific Marine Science Organization (PICES), Sydney, British Columbia, Canada.

Butler, T.H. 1980. Shrimps of the Pacific Coast of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences. 202. 280 pp.

Caliet, G.M. 1976. "Several Approaches to the Feeding Ecology of Fishes." C.A. Simenstad and S.J. Lipovsky, (eds.). Fish Food Habitat Studies. Washington Sea Grant. Seattle, WA. Pp. 1–18.

Charnov, E.L., and P.J. Anderson. 1989. Sex Change and Population Fluctuations in Pandalid Shrimp. American Naturalist 134: 824–827.

Chuhukalo, V.I., and M.A. Shebanova. 2008. Feeding Habits of Several Mass Shrimp Species the in Sea of Okhotsk. Russian Journal of Marine Biology 34 (7): 468–471.

Damkaer, D.M. 1977. Initial Zooplankton Investigations in Prince William Sound, Gulf of Alaska and Lower Cook Inlet. U.S. Dep. of Commer. U.S. Dept. of Interior. Environmental Assessment of the Alaskan Continental Shelf. Annual Rep. Pp. 137–274.

Hay, D.E., P.B. McCarter, and K. Daniel. 2001. Tagging of Pacific Herring *Clupea pallasi* from 1936–1992: A Review With Comments on Homing, Geographic Fidelity, and Straying. Canadian Journal of Fisheries and Aquatic Sciences 58: 1,356–1,370.

Harrison, P.J., P.J. Clifford, W.P. Cochlan, K. Yin, M.A. St. John, P.A. Thompson, M.J. Sibblad, and L.J. Albright. 1991. "Nutrient and Plankton Dynamics in the Fraser River Plume, Strait of Georgia, British Columbia." Marine Ecology Progress Series. Vol. 70. Pp. 291–304.

Healey, M.C. 1982. Juvenile Pacific Salmon in Estuaries: The Life Support System. V.S. Kenedy (ed.). Estuarine Comparisons. New York, New York: Academic Press.

Kaczynski, V.W., R.J. Feller, and J. Clayton. 1973. Trophic Analysis of Juvenile Pink and Chum Salmon in Puget Sound. Journal of the Fisheries Research Board of Canada 30: 1,003–1,008.

Karpenko, V.I. 1987. "Growth Variation of Juvenile Pink Salmon and Chum Salmon during the Coastal Period of Life." Journal of Ichthyology 27: 117–125.

Koeller, P., R. Mohn, and M. Etter. 2000. Density Dependant Sex Change in Northern Shrimp, *Pandalus borealis*, on the Scotian Shelf. Journal of Northwest Atlantic Fishery Science 27: 107–118.

Køie, M. 1992. "Life Cycle and Structure of the Fish Digenean *Brachyphallus creatus* (Hemiuridae)." Journal of Parasitology 78(2): 338–343.

Lagler, K.F., and T. Wright. 1962. "Predation of the Dolly Varden on Young Salmon in an Estuary of Southeastern Alaska." Transactions of the American Fisheries Society 91: 90–93.

Larrance, J.D., D.A. Tennant, A.J. Chester, and P.A. Ruffio. 1977. Phytoplankton and Primary Productivity in the Northeast Gulf of Alaska and Lower Cook Inlet. U.S. Dept. of Commerce, U.S. Dept. of Interior. Environmental Assessment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators. Final Report. Vol. X. Pp. 1–136.

Marty, G.D., E.F. Freiberg, T.R. Meyers, J. Wilcock, T.B. Farver, and D.E. Hinton. 1998. Viral Hemorrhagic Septicemia Virus, *Ichthyophonus hoferi,* and Other Causes of Morbidity in Pacific Herring *Clupea pallasi* Spawning in Prince William Sound, Alaska, USA. Diseases of Aquatic Organisms 32: 15–40

Mason, J.C. 1974. Behavioral Ecology of Chum Salmon fry (*Oncorhynchus keta*) in a Small Estuary. Journal of the Fisheries Research Board of Canada 31: 83–92.

Moles, A., and R.A. Heintz. 2007. "Parasites of Forage Fishes in the Vicinity of Steller Sea Lion (*Eumetopias jubatus*) Habitat in Alaska." Journal of Wildlife Diseases 43(3): 366–375.

Neuhold, J.M., W.T. Helm, and R.A. Valdez. 1974. Amchitka Bioenvironmental Program. Freshwater Vertebrate and Invertebrate Ecology of Amchitka Island. Battelle Memorial Institute, Columbus Laboratories, USAEC Report. BMI-171-154.

Otis, E.O., W.R. Bechtol, and W.A. Bucher. 1998. Coping with a Challenging Stock Assessment Situation: the Kamishak Bay Sac-Roe Herring Fishery. F. Funk, T.J. Quinn II, J. Heifetz, J.N. Ianelli, J.E. Powers, J.F. Schweigert, P.J. Sullivan, and C.I. Zhang (eds.), Fishery Stock Assessment Models. Alaska Sea Grant College Program Report No. AK-SG-98-01. University of Alaska Fairbanks. Pp. 557–573.

Pentec. 2006. False Pass Marine and Aquatic Surveys, September 2005–July 2006. False Pass, Alaska. Project Number 12634-01. Edmonds, Washington.

Pentec. 2005a. Marine Fish and Benthos Studies in Knik Arm, Anchorage, Alaska. Project Number 12214-10/12214-12. Edmonds, Washington.

Pentec. 2005b. 2004–2005 Marine Fish and Benthos Studies—Port of Anchorage. Project Number 12618-01. Edmonds, Washington.

Prado-Rosas, M.D., J.N. Alvarez-Cadena, L. Segura-Puertas, and R. Lamothe-Argumedo. 2005. “*Hemiurid metacercariae* (Trematoda) in chaetognaths from the Mexican Caribbean Sea.” Comparative Physiology 72(2): 230–233.

Robards, M.D., J.F. Piatt, A.B. Kettle, and A.A. Abookire. 1999. “Temporal and Geographic Variation in Fish Communities of Lower Cook Inlet, Alaska.” Fisheries Bulletin 97(4): 962-977.

Sibert, J., T.J. Brown, M.C. Healey, B.A. Kask, and R.J. Naiman. 1977. Detritus-Based Food Webs: Exploitation by Juvenile Chum Salmon. Science 196: 649–650.

Simenstad, C.A., and W.J. Kinney. 1978. Trophic Relationships of Outmigrating Chum Salmon in Hood Canal. Fisheries Research Institute publication FRI-UW-7810. Prepared for the Washington Department of Fisheries. 75 pp.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The Role of Puget Sound and Washington Coastal Estuaries in the Life History of Pacific Salmon: An Unappreciated Function. V.S. Kenedy (ed.). Estuarine Comparisons. New York, New York: Academic Press.

Simenstad, C.A., W.J. Kinney, S.S. Parker, E.O. Salo, J.R. Cordell, and H Buechner. 1980. Prey Community Structure and Trophic Ecology of Outmigrating Juvenile Chum and Pink Salmon in Hood Canal, Washington: A Synthesis of Three Years’ Studies, 1977–1979. Final Report. University of Washington Fisheries Research Institute. FRI-UW-8026. 113 pp.

Squires, H.J., and A.J.G. Figueira. 1974. Shrimps and Shrimp-like Anomurans (Crustacea, Decapoda) from Southeastern Alaska and Prince William Sound. National Museum of Natural Science Ottawa Publication of Biological Oceanography. Vol. 6. 23 pp.

Stick, K.C. 1994. Summary of 1993 Pacific Herring Spawning Ground Surveys in Washington State Waters. Washington Department of Fish. Progress Report No. 311. 49 pp.

Takagi, K., K.V. Aro, A.C. Hartt, and M.B. Dell. 1981. Distribution and Origin of Pink Salmon in Offshore Waters of the North Pacific Ocean. International North Pacific Fish Commission Bulletin. Vol. 40. 195 pp.

Thorpe, J.E. 1994. Salmonid Fishes and the Estuarine Environment. Estuaries 17: 76–93.

Ware, D.M., and C. Tovey. 2004. Pacific Herring Spawn Disappearance and Recolonization Events. Canadian Science Advisory Secretariat. Research document 2004/008. Fisheries and Oceans Canada.

Yang, M. 1999. The Trophic Role of Atka Mackerel, *Pleurogrammus monopterygius*, in the Aleutian Islands Area. Fisheries Bulletin 97(4): 1,058–1,065.

43.10 Glossary

Beach seine—A large enclosing net, deployed by a skiff parallel to shore and pulled to shore by two field teams on the beach. The net has lead weights to keep the bottom near the sea floor and floats to keep the top of the net at or near the surface. A fine mesh codend is located in the center of the net to gather fish once to shore.

Beam trawl—A trawl with short wings and a head rope attached to a metal or wooden beam. The beam keeps the net open horizontally while metal frames on each end of the beam keep the net open vertically.

Benthic—Dwelling on the bottom of a body of water; also refers to aquatic invertebrates that dwell within bottom sediments of a body of water.

Codend—Innermost portion of the trawl with finer mesh for retaining the catch.

Cohort—Those individuals of a population born in the same reproductive period.

Copepod—A major group of small aquatic crustaceans, known to be important food prey for juvenile salmon.

Demersal—Having an association with or residing on the bottom; living on or near the bottom and feeding on benthic organisms.

Detritus—Decomposing organic debris; small pieces of dead and decomposing plants and animals.

Diatoms—Unicellular algae with silica walls; microscopic single-celled algae which have two ornate interfitting outer shells containing silica.

El Nino—A warm ocean current setting south along the coast of Ecuador, occurring every 3 to 7 years. In exceptional years, concurrently with a southerly shift in the tropical rain belt, the current may extend up the Pacific coast of North America and warm sea-surface temperatures as far north as British Columbia. When this occurs, fish communities may shift or change in population.

Epibenthic—Living just above the bottom, or small aquatic invertebrates that live on the surface or just above the surface of bottom sediments.

Escapement—The total number of adult fish, usually referring to salmonids, returning to a stream to spawn.

Estuary—Near the mouth of a river where tide meets current; transitional environments between fresh water and salt water, often associated with lower salinity waters.

Gill net—A mesh net used to tangle or snare fish by the gills.

Gravid—Carrying unborn young; pregnant. Often refers to female fish having a body distended with ripe eggs.

Littoral—Nearshore shallow waters; often delimited by the low and high tide lines or just beyond.

Macroinvertebrate—Larger aquatic invertebrates such as shrimp and crab species, usually associated with the bottom.

Mean lower low water (MLLW)—A tidal datum. The average of the lower low water height of each tidal day observed over the National Tidal Datum.

Microflagellates—Heterotrophic protozoa, typically between 2 and 20 micrometers in size, that feed upon picoplankton (generally bacteria) and represent an important food source for larger zooplankton representing a critical trophic pathway.

Nearshore—Waters generally extending from the high tide line to as far as approximately 1 kilometer from shore.

Otter trawl—A towed net that captures demersal fish. Rectangular otter boards of wood or steel on the tow ropes plane through the water and help keep the mouth open and give the trawl its name; floats on the headrope and weights on the ground line also assist in this.

Phytoplankton—Unicellular aquatic algae that form the base of the food web in many aquatic systems.

Salmonid—Fish of the Family Salmonidae; includes all species of Pacific salmon as well as species such as Dolly Varden char.

Species richness—The number of species within a specified region or locality.

Trammel net—Similar to a gill net, but composed of multiple side-by-side panels of meshed net to entangle fish.

Try net—A small experimental otter trawl, usually between 3 and 7 meters in total length.

Zooplankton—Small aquatic invertebrate and vertebrate (larval fish) organisms that drift freely in the water column, usually very important to the aquatic food web.

TABLES

TABLE 43-1

Sampling Dates and Equipment Used for Sampling Nearshore Fish and Invertebrates in Cook Inlet, 2004 through 2008

Year	Cruise Dates	Research Vessel	120-ft Beach Seine	30-ft Beach Seine	Otter Trawl	Gill and Trammel Net	Herring Spawn Survey	Stomach Content Analysis	Sediment Chemistry [g]	Tissue Chemistry [g]	Water Chemistry [g]
2004	Aug. 26-Sept. 2[a]	Kittiwake II	X		X				X	X	
2005	May 9-12	Columbia	X		X						
	May 22-26	Outer Limits	X		X						
	June 5-9	Outer Limits	X		X			X			
	June 24-27	Bay Explorer	X		X					X	
	July 17-23	Outer Limits	X		X			X			
	Aug. 15-19[b]	Outer Limits	X		X						
2006	April 24-28	Outer Limits	X		X						
	May 14-18	Outer Limits	X		X		X				
	Sept. 25-28	Foxfire	X		X						
2007	Sept. 5-9[c]	Bay Explorer	X	X	X	X					
	Oct. 10-14	Susitna	X	X	X						
2008	March 17-21[d]	Susitna	X		X			X			
	April 14-19	Outer Limits	X		X	X		X			
	May 23-30[e]	Susitna	X	X	X	X	X	X	X	X	X
	June 3-6[f]	Bay Explorer		X			X				
	June 15-19	Outer Limits	X	X	X	X	X	X			
	July 11-20	Outer Limits	X	X	X	X		X	X	X	X
	Aug. 11-15	Bay Explorer	X	X	X	X		X			
	Sept. 13-18	Outer Limits	X		X	X		X	X	X	X
	Oct. 8-13	Susitna	X	X	X	X					
	Nov. 10-14	Susitna	X		X	X		X			

Notes:

a. Marine reconnaissance level studies

b. Two attempts to sample in September aborted due to high seas

c. Lagoon sampling began with 30 foot beach seine; gill and trammel net sampling began at request of ADF&G

d. Systematic sampling for SCA began in 2008

e. First attempt to sample in May aborted due to high seas

f. Abbreviated cruise for herring spawn studies only

g. Sediment and Tissue Chemistry are discussed in Chapter 35.4, and Water Chemistry in Chapter 34

TABLE 43-2

Number of Sets by Gear Type, Iliamna Bay and Iniskin Bay, 2004 through 2008

Stations	120 ft Beach Seine	30 ft Beach Seine	Gill Net	Trammel Net	Trawl
Iliamna Bay					
MBS1	19	--	--	--	--
MBS3	19	--	--	--	--
MBS4	16	--	--	--	--
MPS3	17	--	--	--	--
MPSE	18	--	--	--	--
MPSE1	11	--	--	--	--
MPSE2	7	--	--	--	--
MBSA1	19	--	4	4	--
MPS4	22	--	5	5	--
MACL	--	7	--	--	--
MCWL	--	5	--	--	--
MCWSL	--	3	--	--	--
MUI1	--	1	--	--	--
MUI2	--	1	--	--	--
MTR1	--	--	--	--	22
MTR2	--	--	--	--	20
MTR3	--	--	--	--	12
Iniskin Bay					
MPS1	15	--	--	--	--
MPS1A	13	--	3	3	--
MPS1B	21	--	3	3	--
MPS1C	20	--	--	--	--
MYVCM	4	--	--	--	--
MYVL	--	--	2	2	--
MBR	--	--	1	1	--
MSLF	--	1	--	--	--
MPS1T	--	--	--	--	22
MPS2T	--	--	--	--	23
MPS2TA	--	--	--	--	24
MPS2TB	--	--	--	--	19
MTR4	--	--	--	--	1
MBB	16	--	--	--	--
Totals	**237**	**18**	**18**	**18**	**143**

TABLE 43-3

CPUE by Station of Fish Captured by 120-foot Beach Seine, 2004 through 2008

Species	Iliamna Bay									Iniskin Bay						Mean CPUE
	MBS1	MBSA1	MBS3	MBS4	MPSE	MPS4	MPS3	MPSE1	MPSE2	MPS1	MPS1A	MPS1B	MPS1C	MYVCM	MBB Reference	
Chinook salmon (*Oncorhynchus tshawytscha*), juvenile								0.09			0.08	0.10	0.10			0.03
Chum salmon (*O. keta*)																
Adult	0.05		0.05	0.06			2.06		0.14				0.50	0.50		0.22
Juvenile	4.58	15.37	36.79	20.44	27.78	5.59	25.00	5.36	62.57	3.73	16.92	2.52	4.20	0.25	3.31	14.42
Coho salmon (*O. kisutch*), juvenile			0.11		0.17	0.14		0.09		0.53	1.15			3.25		0.19
Sockeye salmon (*O. nerka*), juvenile	0.26	0.89	2.37	1.50	1.94	1.14	1.18	0.73		1.53	2.92	2.43	6.65	1.25	5.19	2.16
Pink salmon (*O. gorbuscha*)																
Adult							0.18						0.80	0.50		0.09
Juvenile	6.11	13.74	11.53	3.38	2.67	15.32	6.29	2.36	0.43	22.53	70.77	11.19	46.10	1.50	10.75	15.88
Dolly Varden (*Salvelinus malma*)	1.32	2.63	0.37	0.38	1.22	2.86	1.41	0.82	0.57	21.27	4.00	3.76	9.30	9.50	13.00	4.61
Capelin (*Mallotus villosus*)				0.06												0.00
Longfin smelt (*Spirinchus thaleichthys*)	0.32		0.42		19.67	0.05	0.47	1.36		1.13			0.05			1.73
Surf smelt (*Hypomesus pretiosus*)	26.79	67.37	10.26	29.63	20.83	4.36	5.65	2.82	1.57	0.13	8.46	0.52	2.95		2.00	13.84
Pacific herring (*Clupea pallasii*)	40.79	25.58	354.37	521.94	276.11	99.23	145.35	2,123.00	439.57	60.40	5.46	17.33	17.05		72.00	233.05
Threespine stickleback (*Gasterosteus aculeatus*)		0.16	0.74	0.06	0.06		0.06		0.14	0.07	0.08	0.14			0.25	0.13
Ninespine stickleback (*Pungitius pungitius*)				0.25	0.17		0.06	0.55								0.06
Sculpin, unid.. (Cottidae)	0.05						0.06	0.09								0.01
Pacific staghorn sculpin (*Leptocottus armatus*)		1.16	1.00	3.81	26.06	0.23	0.41	14.27	1.14	0.07	0.15	0.14	0.05		1.25	3.27
Buffalo sculpin (*Enophrys bison*)													0.05			0.00
Silverspotted sculpin (*Blepsias cirrhosus*)	0.21					0.36										0.05
Calico sculpin (*Clinocottus embryum*)						0.05										0.00
Great sculpin (*Myoxocephalus polyacanthocephalus*)	0.05	0.21	0.05			0.50	0.24			0.07		0.33			1.00	0.19
Variegated snailfish (*Liparis gibbus*)					0.17											0.01
Yellow Irish lord (*Hemilepidotus jordani*)						0.05									0.06	0.01
Whitespotted greenling (*Hexagrammos stelleri*)		0.37	0.37		1.44	1.05	0.24			0.40	0.08	0.62			0.06	0.39
Greenling, unid.. (*Hexagrammos* sp.)					0.06											0.00
Kelp greenling (*Hexagrammos decagrammus*)					0.06											0.00
Tubenose poacher (*Pallasina barbata*)		0.21			0.17	0.23	0.29		0.57	0.07				0.75		0.11
Snake prickleback (*Lumpenus sagitta*)			1.26		0.56	0.05			0.71						0.06	0.17
Pacific sand lance (*Ammodytes hexapterus*)	22.84	0.68	6.26			0.55	0.24	0.09		14.00	42.77	4.76	1.15	0.75	8.44	6.79
Crescent Gunnel (*Pholis laeta*)		0.21				0.14		0.09								0.03
Flatfish, unid. (Pleuronectidae)	0.05												0.10			0.01
Starry flounder (*Platichthys stellatus*)	0.05	0.42	2.53	6.63	22.83	0.05	0.06	7.27	2.57			0.10			1.19	2.93
Arrowtooth flounder (*Atheresthes stomias*)			0.11		0.06					0.13						0.02
Pacific Halibut (*Hippoglossus stenolepis*)					0.06											0.00
Flathead sole (*Hippoglossoides elassodon*)						0.05										0.00
Rock sole (*Pleuronectes bilineatus*)	0.05											0.05	0.05			0.01
Yellowfin sole (*Pleuronectes asper*)		0.11														0.01

Species	Iliamna Bay									Iniskin Bay						Mean CPUE
	MBS1	MBSA1	MBS3	MBS4	MPSE	MPS4	MPS3	MPSE1	MPSE2	MPS1	MPS1A	MPS1B	MPS1C	MYVCM	MBB Reference	
Pacific Cod (*Gadus macrocephalus*)					0.50	0.23					0.15	0.43	0.15		1.00	0.19
Tomcod (*Microgadus proximus*)			0.05		0.11								0.05			0.02
Lingcod (*Ophiodon elongatus*)		0.05														0.00
Saffron cod (*Eleginus gracilis*)							0.06									0.00
Sturgeon poacher (*Podothecus acipenserinus*)			0.21										0.05			0.02
Pacific sandfish (*Trichodon trichodon*)	0.05					0.05						0.05			0.13	0.02
Tubesnout (*Aulorhynchus flavidus*)					0.06										0.25	0.02
All Species (CPUE)	**103.84**	**129.16**	**428.84**	**588.13**	**402.72**	**132.23**	**189.29**	**2,159.00**	**510.00**	**126.07**	**153.00**	**44.48**	**89.35**	**18.25**	**119.94**	**300.73**
Juvenile Salmon (CPUE)	**10.95**	**30.00**	**50.79**	**25.31**	**32.56**	**22.18**	**32.47**	**8.64**	**63.00**	**28.33**	**91.85**	**16.24**	**57.05**	**6.25**	**19.25**	**32.68**
Number of Species	**17**	**16**	**19**	**12**	**23**	**22**	**19**	**15**	**11**	**15**	**13**	**16**	**18**	**9**	**17**	
Number of Sets	**19**	**19**	**19**	**16**	**18**	**22**	**17**	**11**	**7**	**15**	**13**	**21**	**20**	**4**	**16**	**237**

Notes: An empty cell indicates the species was not captured at that location.

TABLE 43-4
CPUE by Month of Fish Captured by 120-foot Beach Seine, 2004 through 2008

Species	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Mean CPUE
Chinook salmon (*Oncorhynchus tshawytscha*), juvenile				0.06	0.14					0.03
Chum salmon (*O. keta*)										
Adult					0.41	1.11				0.22
Juvenile		12.94	46.88	17.17	3.79	0.89				14.42
Coho salmon (*O. kisutch*), juvenile			0.08	0.69	0.48		0.03	0.05		0.19
Sockeye salmon (*O. nerka*), juvenile			0.04	8.33	7.00	0.17		0.05		2.16
Pink salmon (*O. gorbuscha*)										
Adult					0.62	0.09				0.09
Juvenile		1.65	27.06	34.56	34.83	2.00	0.16			15.88
Dolly Varden (*Salvelinus malma*)			1.75	20.08	5.90	2.26	0.81	0.10		4.61
Capelin (*Mallotus villosus*)							0.03			0.00
Longfin smelt (*Spirinchus thaleichthys*)			1.06	0.03	0.41	1.66	8.88			1.73
Surf smelt (*Hypomesus pretiosus*)	0.67	6.35	0.94	6.81	13.52	7.14	25.88	64.95	8.31	13.84
Pacific herring (*Clupea pallasii*)	227.00		32.40	998.89	162.48	202.40	136.47	28.45	13.46	233.05
Threespine stickleback (*Gasterosteus aculeatus*)		0.06	0.25	0.31	0.10	0.06				0.13
Ninespine stickleback (*Pungitius pungitius*)									1.08	0.06
Sculpin, unid.. (Cottidae)			0.02		0.03	0.03				0.01
Pacific staghorn sculpin (*Leptocottus armatus*)			1.48	2.39	9.14	6.94	2.63	0.90	0.15	3.27
Buffalo sculpin (*Enophrys bison*)			0.02							0.00
Silverspotted sculpin (*Blepsias cirrhosus*)					0.10	0.14	0.06	0.05	0.08	0.05
Calico sculpin (*Clinocottus embryum*)							0.03			0.00
Great sculpin (*Myoxocephalus polyacanthocephalus*)			0.10	0.17	0.41	0.14	0.44	0.10	0.08	0.19
Variegated snailfish (*Liparis gibbus*)							0.09			0.01
Yellow Irish lord (*Hemilepidotus jordani*)				0.03	0.03					0.01
Whitespotted greenling (*Hexagrammos stelleri*)			0.02	0.36	1.00	1.31	0.13			0.39
Greenling, unid. (*Hexagrammos* sp.)						0.03				0.00
Kelp greenling (*Hexagrammos decagrammus*)					0.03					0.00
Tubenose poacher (*Pallasina barbata*)			0.02	0.06	0.17	0.23	0.28			0.11
Snake prickleback (*Lumpenus sagitta*)					1.31	0.06	0.03			0.17
Pacific sand lance (*Ammodytes hexapterus*)		0.59	3.77	11.14	3.10	4.03	21.81	3.70		6.79
Crescent Gunnel (*Pholis laeta*)			0.08	0.03	0.07		0.03			0.03
Flatfish, unid. (Pleuronectidae)			0.06							0.01
Starry flounder (*Platichthys stellatus*)			2.85	1.33	11.03	2.51	2.66	0.05	0.38	2.93
Arrowtooth flounder (*Atheresthes stomias*)			0.04	0.08						0.02
Pacific Halibut (*Hippoglossus stenolepis*)					0.03					0.00
Flathead sole (*Hippoglossoides elassodon*)									0.08	0.00
Rock sole (*Pleuronectes bilineatus*)			0.02	0.03	0.03					0.01
Yellowfin sole (*Pleuronectes asper*)			0.04							0.01
Pacific Cod (*Gadus macrocephalus*)				0.17	0.10		1.09			0.19
Tomcod (*Microgadus proximus*)				0.08		0.03				0.02
Lingcod (*Ophiodon elongatus*)							0.03			0.00
Saffron cod (*Eleginus gracilis*)						0.03				0.00
Sturgeon poacher (*Podothecus acipenserinus*)				0.14						0.02
Pacific sandfish (*Trichodon trichodon*)					0.07		0.06	0.05		0.02
Tubesnout (*Aulorhynchus flavidus*)			0.10							0.02
All Species (CPUE)	**227.67**	**21.59**	**119.06**	**1,102.92**	**256.38**	**233.26**	**201.63**	**98.45**	**23.62**	**300.73**
Juvenile Salmon (CPUE)		**14.59**	**74.06**	**60.81**	**46.24**	**3.06**	**0.19**	**0.10**		**32.68**
Number of Species	**2**	**5**	**23**	**23**	**28**	**22**	**21**	**11**	**8**	
Number of Sets	**3**	**17**	**52**	**36**	**29**	**35**	**32**	**20**	**13**	**237**
Number of Years Sampled	**1**	**2**	**3**	**2**	**2**	**3**	**3**	**2**	**1**	

Notes: An empty cell indicates the species was not captured during that month.

TABLE 43-5

Total Catch by Station of Fish Captured by 30-foot Beach Seine, 2008

Species	MACL	MCWL	MCWSL	MUI1	MUI2	Mean CPUE
Chum salmon (*Oncorhynchus keta*)						
Adult						
Juvenile	172	206	61	4		443
Coho salmon (*O. kisutch*)						
Adult						
Juvenile			1			1
Sockeye salmon (*O. nerka*)						
Adult						
Juvenile	3		43			46
Pink salmon (*O. gorbuscha*)						
Adult						
Juvenile		254	1	5	5	265
Surf smelt (*Hypomesus pretiosus*)		4				4
Pacific herring (*Clupea pallasii*)		2		5		7
Threespine stickleback (*Gasterosteus aculeatus*)	13,335		73		1	13,409
Pacific staghorn sculpin (*Leptocottus armatus*)	16	14				30
Sand Sole (*Psettichthys melanostictus*)	1					1
Starry flounder (*Platichthys stellatus*)	25	4				29
All Species (CPUE)	**13,552**	**484**	**179**	**14**	**6**	**14,235**
Number of Species	**6**	**6**	**5**	**3**	**2**	
Number of Sets	**5**	**5**	**3**	**1**	**1**	**15**

Notes: An empty cell indicates the species was not captured at that location.

TABLE 43-6

CPUE by Station of Fish Captured by 30-foot Beach Seine, 2008

Species	MACL	MCWL	MCWSL	MUI1	MUI2	Mean CPUE
Chum salmon (*Oncorhynchus keta*)						
Adult						
Juvenile	34.40	41.20	20.33	4.00		29.53
Coho salmon (*O. kisutch*)						
Adult						
Juvenile			0.33			0.07
Sockeye salmon (*O. nerka*)						
Adult						
Juvenile	0.60		14.33			3.07
Pink salmon (*O. gorbuscha*)						
Adult						
Juvenile		50.80	0.33	5.00	5.00	17.67
Surf smelt (*Hypomesus pretiosus*)		0.80				0.27
Pacific herring (*Clupea pallasii*)		0.40		5.00		0.47
Threespine stickleback (*Gasterosteus aculeatus*)	2,667.00		24.33		1.00	893.93
Pacific staghorn sculpin (*Leptocottus armatus*)	3.20	2.80				2.00
Sand Sole (*Psettichthys melanostictus*)	0.20					0.07
Starry flounder (*Platichthys stellatus*)	5.00	0.80				1.93
All Species (CPUE)	**2,710.40**	**96.80**	**59.67**	**14.00**	**6.00**	**949.00**
Number of Species	**6**	**6**	**5**	**3**	**2**	
Number of Sets	**5**	**5**	**3**	**1**	**1**	**15**

Notes: An empty cell indicates the species was not captured at that location.

TABLE 43-7
CPUE by Month of Fish Captured by Gill Net, 2008

Species	April	May	June	August	October	Mean CPUE
Dolly Varden (*Salvelinus malma*)			0.17	1.50		0.39
Pacific herring (*Clupea pallasii*)		23.20	0.67	6.50		8.11
Pacific staghorn sculpin (*Leptocottus armatus*)		0.20				0.06
Calico sculpin (*Clinocottus embryum*)		0.40				0.11
Yellowfin sole (*Pleuronectes asper*)		0.20				0.06
Starry flounder (*Platichthys stellatus*)			0.17			0.06
Sturgeon poacher (*Podothecus acipenserinus*)		0.40				0.11
All Species (CPUE)	**0.00**	**24.40**	**1.00**	**8.00**	**0.00**	**8.89**
Number of Species	**0**	**5**	**3**	**2**	**0**	
Number of Sets	**1**	**5**	**6**	**4**	**2**	**18**

Notes: An empty cell indicates the species was not captured during that month.

TABLE 43-8

CPUE by Station of Fish Captured by Gill Net, 2008

Species	MBR	MBSA1	MPS1A	MPS1B	MPS4	MYVL	Mean CPUE
Dolly Varden (*Salvelinus malma*)			1.00	1.33			0.39
Pacific herring (*Clupea pallasii*)		5.25	23.33	2.67	5.80	9.00	8.11
Pacific staghorn sculpin (*Leptocottus armatus*)				0.33			0.06
Calico sculpin (*Clinocottus embryum*)				0.67			0.11
Yellowfin sole (*Pleuronectes asper*)				0.33			0.06
Starry flounder (*Platichthys stellatus*)			0.33				0.06
Sturgeon poacher (*Podothecus acipenserinus*)				0.67			0.11
All Species (CPUE)	**0.00**	**5.25**	**24.67**	**6.00**	**5.80**	**9.00**	**8.89**
Number of Species	**0**	**1**	**3**	**6**	**1**	**1**	
Number of Sets	**1**	**4**	**3**	**3**	**5**	**2**	**18**

Notes: An empty cell indicates the species was not captured at that location.

TABLE 43-9
CPUE by Month of Fish Captured by Trammel Net, 2008

Species	April	May	June	August	October	Mean CPUE
Dolly Varden (*Salvelinus malma*)		0.40				0.11
Pacific herring (*Clupea pallasii*)		1.20			1.00	0.33
Pacific staghorn sculpin (*Leptocottus armatus*)			0.50	0.25	0.50	0.22
Calico sculpin (*Clinocottus embryum*)		0.20				0.06
Whitespotted greenling (*Hexagrammos stelleri*)			0.83	10.50	0.50	2.61
Yellowfin sole (*Pleuronectes asper*)		0.60				0.17
Rock sole (*Pleuronectes bilineatus*)			0.17			0.06
Sand Sole *(Psettichthys melanostictus)*		0.20				0.06
Starry flounder (*Platichthys stellatus*)		0.40	3.17			1.17
Pacific Halibut (*Hippoglossus stenolepis*)			0.17	0.25		0.11
Pacific Cod (*Gadus macrocephalus*)					0.50	0.06
Kelp greenling (*Hexagrammos decagrammus*)			0.33			0.11
Spiny Dogfish *(Squalus acanthias)*				9.00		2.00
All Species (CPUE)	**0.00**	**3.00**	**5.17**	**20.00**	**2.50**	**7.28**
Number of Species	**0**	**6**	**6**	**4**	**4**	
Number of Sets	**1**	**5**	**6**	**4**	**2**	**18**

Notes: An empty cell indicates the species was not captured during that month.

TABLE 43-10

CPUE by Station of Fish Captured by Trammel Net, 2008

Species	MBR	MBSA1	MPS1A	MPS1B	MPS4	MYVL	Mean CPUE
Dolly Varden (*Salvelinus malma*)				0.33		0.50	0.11
Pacific herring (*Clupea pallasii*)			2.00				0.33
Pacific staghorn sculpin (*Leptocottus armatus*)		1.00			0.20		0.28
Calico sculpin (*Clinocottus embryum*)				0.33			0.06
Whitespotted greenling (*Hexagrammos stelleri*)		1.00	5.67	3.00	3.40		2.61
Yellowfin sole (*Pleuronectes asper*)		0.25		1.00			0.22
Rock sole (*Pleuronectes bilineatus*)				0.33			0.06
Sand Sole *(Psettichthys melanostictus)*				0.33			0.06
Starry flounder (*Platichthys stellatus*)			6.67	0.33			1.17
Pacific Halibut (*Hippoglossus stenolepis*)		0.50		0.67			0.22
Pacific Cod (*Gadus macrocephalus*)					0.20		0.06
Kelp greenling (*Hexagrammos decagrammus*)					0.40		0.11
Spiny Dogfish *(Squalus acanthias)*		1.25	4.00	2.33	2.40		2.00
All Species (CPUE)	**0.00**	**4.00**	**18.33**	**8.67**	**6.60**	**0.50**	**7.28**
Number of Species	**0**	**5**	**4**	**9**	**5**	**1**	
Number of Sets	**1**	**4**	**3**	**3**	**5**	**2**	**18**

Notes: An empty cell indicates the species was not captured at that location.

TABLE 43-11

CPUE by Station of Fish Captured by Otter Trawl, 2004 through 2008

	Iniskin Bay				Iliamna Bay			Mean
Species	**MPS1T**	**MPS2T**	**MPS2TA**	**MPS2TB**	**MTR1**	**MTR2**	**MTR3**	**CPUE**
Pacific herring (*Clupea pallasii*)	1.68	0.09	2.00	0.89	12.05	0.89	3.67	2.94
Longfin smelt (*Spirinchus thaleichthys*)	0.27		0.13	0.11	0.10	0.05		0.10
Surf smelt (*Hypomesus pretiosus*)					0.05	0.11		0.02
Capelin (*Mallotus villosus*)		0.05				0.05		0.01
Ninespine stickleback (*Pungitius pungitius*)			0.04					0.01
Sculpin, unid.. (Cottidae)	0.05		0.04	0.26		0.05		0.06
Pacific staghorn sculpin (*Leptocottus armatus*)	0.36	0.09	0.67	0.84	0.15	0.37	2.83	0.62
Buffalo sculpin (*Enophrys bison*)		0.09		0.26	0.05			0.06
Calico sculpin (*Clinocottus embryum*)	0.09	0.05	0.04	0.11	0.10			0.06
Padded Sculpin (*Artedius fenestralis*)		0.05				0.05		0.01
Spinyhead sculpin (*Dasycottus setiger*)			0.04	0.05				0.01
Threaded Sculpin (*Gymnocanthus pistilliger*)			0.04					0.01
Great sculpin (*Myoxocephalus polyacanthocephalus*)	0.45	0.77	0.33	0.63	2.25	0.21	0.25	0.72
Variegated snailfish (*Liparis gibbus*)	0.55	0.32	0.63	1.11	0.75	0.47	0.17	0.59
Saffron cod (*Eleginus gracilis*)			0.08					0.01
Kelp greenling (*Hexagrammos decagrammus*)					0.05		0.08	0.01
Rock greenling (*Hexagrammos lagocephalus*)					0.05			0.01
Whitespotted greenling (*Hexagrammos stelleri*)	0.32	0.50	0.29	0.26	2.20	1.00	0.33	0.70
Yellow Irish Lord (*Hemilepidotus jordani*)	0.27	0.32	0.50	1.21	0.55	0.21		0.46
Tubenose poacher (*Pallasina barbata*)	0.64	0.18	0.29	0.37	0.25	0.26	0.33	0.33
Snake prickleback (*Lumpenus sagitta*)	7.09	7.59	2.58	7.89	6.25	4.37	3.00	5.64
Pacific sand lance (*Ammodytes hexapterus*)						0.05		0.01
Crescent gunnel (*Pholis laeta*)	0.09	0.09		0.05				0.04
Bering poacher (*Occela dodecaedron*)				0.05				0.01
Flatfish, unid. (Pleuronectidae)	0.23	0.32	0.08	0.11	0.05		0.25	0.14
Starry flounder (*Platichthys stellatus*)			0.75	0.53	0.80	0.68	6.92	1.06
Arrowtooth flounder (*Atheresthes stomias*)	0.32	0.05	0.25	0.42		0.21		0.19
Pacific Halibut (*Hippoglossus stenolepis*)	0.18	0.91	0.63	0.37	0.70	0.63	0.42	0.56
Rock sole (*Pleuronectes bilineatus*)	0.36	0.36	0.29	0.21	0.75	0.74	0.08	0.41
Sand sole (*Psettichthys melanostictus*)	0.73	0.23	0.13	0.26		0.47	0.17	0.29
Yellowfin sole (*Pleuronectes asper*)	2.05	3.32	2.08	8.58	0.50	2.21	0.67	2.83
Alaska plaice (*Pleuronectes quadrituberculatus*)			0.08				0.08	0.02
Dover sole (*Microstomus pacificus*)				0.11		0.05		0.02
Flathead sole (*Hippoglossoides elassodon*)	0.05			0.05				0.01
Pacific Cod (*Gadus macrocephalus*)	0.68	0.14	0.33	0.26	0.20	0.74		0.36
Tomcod (*Microgadus proximus*)			0.04					0.01
Lingcod (*Ophiodon elongatus*)					0.05			0.01
Pacific sandfish (*Trichodon trichodon*)			0.08	0.05				0.02
Sturgeon poacher (*Podothecus acipenserinus*)	0.50	0.09	0.17	0.63		0.42	0.75	0.33
Walleye pollock (*Theragra chalcogramma*)	0.55	0.23	1.63	1.11		1.42		0.75
Spiny dogfish (*Squalus acanthias*)					0.05			0.01
All Species (CPUE)	**17.77**	**15.82**	**14.25**	**26.79**	**27.95**	**15.74**	**20.00**	**19.48**
Number of Species	**23**	**22**	**28**	**28**	**22**	**24**	**16**	
Number of Sets	**22**	**22**	**24**	**19**	**20**	**19**	**12**	**138**

Notes: An empty cell indicates the species was not captured at that location.

TABLE 43-12

CPUE by Month of Fish Captured by Otter Trawl, 2004 through 2008

Species	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Mean CPUE
Pacific herring (*Clupea pallasii*)	12.00	1.08				0.24	10.52	3.77	6.33	2.94
Longfin smelt (*Spirinchus thaleichthys*)			0.17			0.24	0.22		0.33	0.10
Surf smelt (*Hypomesus pretiosus*)							0.13			0.02
Capelin (*Mallotus villosus*)								0.08	0.17	0.01
Ninespine stickleback (*Pungitius pungitius*)	0.20									0.01
Sculpin, unid.. (Cottidae)		0.08		0.06	0.23	0.06		0.08		0.06
Pacific staghorn sculpin (*Leptocottus armatus*)	0.80	0.17	0.44	0.55	1.85	1.00	0.17	0.62	0.33	0.62
Buffalo sculpin (*Enophrys bison*)		0.33		0.06		0.12				0.06
Calico sculpin (*Clinocottus embryum*)		0.08		0.10			0.09	0.15		0.06
Padded Sculpin (*Artedius fenestralis*)					0.08				0.17	0.01
Spinyhead sculpin (*Dasycottus setiger*)							0.04	0.08		0.01
Threaded Sculpin (*Gymnocanthus pistilliger*)							0.04			0.01
Great sculpin (*Myoxocephalus polyacanthocephalus*)	1.20	0.67	0.22	0.19	0.62	0.47	0.70	2.31	2.17	0.72
Variegated snailfish (*Liparis gibbus*)	0.80	0.58	0.83	0.19	0.08	0.06	0.65	1.31	2.50	0.59
Saffron cod (*Eleginus gracilis*)						0.12				0.01
Kelp greenling (*Hexagrammos decagrammus*)				0.03		0.06				0.01
Rock greenling (*Hexagrammos lagocephalus*)									0.17	0.01
Whitespotted greenling (*Hexagrammos stelleri*)	0.40	0.08	0.28	0.29	0.62	1.59	0.83	1.31	1.50	0.70
Yellow Irish Lord (*Hemilepidotus jordani*)			0.17		0.23	0.53	1.00	1.46	1.00	0.46
Tubenose poacher (*Pallasina barbata*)		0.33	0.17	0.03	0.15	0.35	0.52	1.23	0.33	0.33
Snake prickleback (*Lumpenus sagitta*)	0.20	8.25	10.28	2.81	2.23	6.06	7.22	7.46	2.00	5.64
Pacific sand lance (*Ammodytes hexapterus*)							0.04			0.01
Crescent gunnel (*Pholis laeta*)			0.22			0.06				0.04
Bering poacher (*Occela dodecaedron*)							0.04			0.01
Flatfish, unid. (Pleuronectidae)	0.20		0.33	0.26	0.15	0.12	0.04			0.14
Starry flounder (*Platichthys stellatus*)		0.58	1.61	0.77	0.85	1.94	0.65	1.54	0.83	1.06
Arrowtooth flounder (*Atheresthes stomias*)			0.28	0.48		0.18	0.09	0.08		0.19
Pacific Halibut (*Hippoglossus stenolepis*)			0.61	0.55	0.62	1.18	0.13	1.31	0.17	0.56
Rock sole (*Pleuronectes bilineatus*)		0.08	0.33	0.55	0.54	1.12	0.09	0.38		0.41
Sand sole (*Psettichthys melanostictus*)		0.67	0.11	0.35	0.15	0.12	0.43	0.38		0.29
Yellowfin sole (*Pleuronectes asper*)	0.40	0.67	11.11	3.03	2.31	1.59	0.91	0.62	0.17	2.83
Alaska plaice (*Pleuronectes quadrituberculatus*)			0.06		0.08	0.06				0.02
Dover sole (*Microstomus pacificus*)			0.06		0.08		0.04			0.02
Flathead sole (*Hippoglossoides elassodon*)							0.04		0.17	0.01
Pacific Cod (*Gadus macrocephalus*)			0.11	0.16	0.15	1.53	0.43	0.31		0.36
Tomcod (*Microgadus proximus*)				0.03						0.01
Lingcod (*Ophiodon elongatus*)							0.04			0.01
Pacific sandfish (*Trichodon trichodon*)								0.23		0.02
Sturgeon poacher (*Podothecus acipenserinus*)		0.58	0.61	0.16	0.15	0.35	0.17	0.85		0.33
Walleye pollock (*Theragra chalcogramma*)	3.80	1.42	1.72	0.45			0.43	0.92	0.17	0.75
Spiny dogfish (*Squalus acanthias*)						0.06				0.01
All Species (CPUE)	**20.40**	**15.67**	**29.72**	**11.13**	**11.15**	**19.18**	**25.74**	**26.46**	**18.50**	**19.48**
Number of Species	**11**	**16**	**21**	**21**	**19**	**25**	**28**	**22**	**17**	
Number of Sets	**5**	**12**	**18**	**31**	**13**	**17**	**23**	**13**	**6**	**138**

Notes: An empty cell indicates the species was not captured during that month.

TABLE 43-13

Catch per 10,000 square feet by Month of Fish Captured by Otter Trawl, 2008

Species	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Mean CPUE
Pacific herring (*Clupea pallasii*)	15.66	4.50				1.12	2.68	16.36	10.88	6.00
Longfin smelt (*Spirinchus thaleichthys*)						0.84			0.57	0.18
Capelin (*Mallotus villosus*)								0.34	0.29	0.07
Ninespine stickleback (*Pungitius pungitius*)	0.26									0.04
Sculpin, unid.. (Cottidae)		0.41			0.43	0.28				0.11
Pacific staghorn sculpin (*Leptocottus armatus*)	1.04	0.41	0.37		0.86	0.56	0.34	1.36	0.57	0.60
Calico sculpin (*Clinocottus embryum*)		0.41		0.52			0.34	0.68		0.21
Great sculpin (*Myoxocephalus polyacanthocephalus*)	1.57	1.64	1.12	1.55	3.01	1.39	2.35	9.88	3.72	2.84
Padded Sculpin *(Artedius fenestralis)*					0.43				0.29	0.07
Threaded Sculpin (*Gymnocanthus pistilliger)*							0.34			0.04
Spinyhead sculpin *(Dasycottus setiger)*							0.34	0.34		0.07
Variegated snailfish (*Liparis gibbus*)	1.04	1.64	4.48	1.03			3.02	4.77	4.30	2.20
Rock greenling *(Hexagrammos lagocephalus)*									0.29	0.04
Whitespotted greenling (*Hexagrammos stelleri*)	0.52	0.41		1.29	2.15	7.53	1.01	5.45	2.58	2.41
Yellow Irish Lord *(Hemilepidotus jordani)*			1.12		1.29	2.51	7.72	6.48	1.72	2.24
Tubenose poacher (*Pallasina barbata*)			0.37		0.86	1.12		1.70	0.57	0.50
Bering poacher *(Occela dodecaedron)*							0.34			0.04
Snake prickleback (*Lumpenus sagitta*)	0.26	2.05	7.83	15.45	10.74	25.37	22.82	29.31	3.44	13.10
Flatfish, unid. (Pleuronectidae)	0.26					0.28				0.07
Starry flounder (*Platichthys stellatus*)	0.52	1.23	2.98	4.38	2.58	4.74	3.69	4.43	1.43	2.91
Arrowtooth flounder (*Atheresthes stomias*)			0.75			0.56	0.67			0.21
Pacific Halibut (*Hippoglossus stenolepis*)			2.61	2.06	1.72	4.18		5.45	0.29	1.81
Rock sole (*Pleuronectes bilineatus*)			0.75	4.12	1.72	4.18	0.67	1.36		1.53
Sand sole *(Psettichthys melanostictus)*		2.05		0.26	0.86	0.28	2.01	0.34		0.57
Yellowfin sole (*Pleuronectes asper*)	0.52	0.41	7.83	5.15	2.58	1.39	1.34	1.70	0.29	2.31
Alaska plaice *(Pleuronectes quadrituberculatus)*					0.43					0.04
Dover sole *(Microstomus pacificus)*					0.43		0.34			0.07
Flathead sole *(Hippoglossoides elassodon)*							0.34		0.29	0.07
Pacific Cod (*Gadus macrocephalus*)			0.75	0.26		6.69	1.34	1.36		1.24
Pacific sandfish (*Trichodon trichodon*)								1.02		0.11
Sturgeon poacher (*Podothecus acipenserinus*)		2.86	2.61	0.26	0.86	1.39	0.67	3.07		1.17
Walleye pollock *(Theragra chalcogramma)*	4.96	0.41	2.24				1.01	4.09	0.29	1.49
Spiny dogfish *(Squalus acanthias)*						0.28				0.04
All Species	**26.63**	**18.41**	**35.80**	**36.32**	**30.93**	**64.68**	**53.36**	**99.51**	**31.79**	**44.39**
Number of Species	**11**	**13**	**14**	**12**	**16**	**19**	**21**	**20**	**17**	
Total Area Trawled (square feet)	**38,304**	**24,444**	**26,814**	**38,826**	**23,280**	**35,868**	**29,796**	**29,343**	**34,912**	**281,587**

Notes: An empty cell indicates the species was not captured during that month.

TABLE 43-14

Catch per 10,000 square feet by Station of Fish Captured by Otter Trawl, 2008

	Iniskin Bay				Iliamna Bay			Mean
Species	**MPS1T**	**MPS2T**	**MPS2TA**	**MPS2TB**	**MTR1**	**MTR2**	**MTR3**	**CPUE**
Pacific herring (*Clupea pallasii*)	7.17		9.64	5.23	3.02	3.63	14.93	6.00
Longfin smelt (*Spirinchus thaleichthys*)	0.58				0.60			0.18
Capelin (*Mallotus villosus*)		0.22				0.23		0.07
Ninespine stickleback (*Pungitius pungitius*)			0.21					0.04
Sculpin, unid.. (Cottidae)	0.19		0.21			0.23		0.11
Pacific staghorn sculpin (*Leptocottus armatus*)	0.39	0.22	0.21	1.05	0.30	0.91	1.70	0.60
Calico sculpin (*Clinocottus embryum*)	0.19	0.22	0.21	0.35	0.60			0.21
Great sculpin (*Myoxocephalus polyacanthocephalus*)	0.97	2.61	1.23	3.14	12.69	0.68	1.02	2.84
Padded Sculpin *(Artedius fenestralis)*		0.22				0.23		0.07
Threaded Sculpin (*Gymnocanthus pistilliger)*			0.21					0.04
Spinyhead sculpin *(Dasycottus setiger)*			0.21	0.35				0.07
Variegated snailfish (*Liparis gibbus*)	1.36	0.87	2.05	6.27	4.53	1.82		2.20
Rock greenling *(Hexagrammos lagocephalus)*					0.30			0.04
Whitespotted greenling (*Hexagrammos stelleri*)	0.39	0.65	1.03	1.05	10.27	3.86	1.36	2.41
Yellow Irish Lord *(Hemilepidotus jordani)*	1.16	1.52	2.46	8.01	3.32	0.91		2.24
Tubenose poacher (*Pallasina barbata*)	0.78	0.22	0.41	1.05	0.91		0.34	0.50
Bering poacher *(Occela dodecaedron)*				0.35				0.04
Snake prickleback (*Lumpenus sagitta*)	3.49	15.46	10.46	18.12	30.51	12.48	7.13	13.10
Flatfish, unid. (Pleuronectidae)	0.19		0.21					0.07
Starry flounder (*Platichthys stellatus*)	0.58		1.23	0.70	3.62	2.04	16.97	2.91
Arrowtooth flounder (*Atheresthes stomias*)	0.19	0.22	0.41	0.70				0.21
Pacific Halibut (*Hippoglossus stenolepis*)	0.19	2.40	2.05	0.70	3.93	2.04	1.70	1.81
Rock sole (*Pleuronectes bilineatus*)	0.97	0.87	0.62	1.05	3.93	3.18	0.34	1.53
Sand sole *(Psettichthys melanostictus)*	0.97	0.22	0.41	1.74		0.45	0.34	0.57
Yellowfin sole (*Pleuronectes asper*)	0.19	4.79	1.85	3.48	0.60	4.54	0.34	2.31
Alaska plaice *(Pleuronectes quadrituberculatus)*			0.21					0.04
Dover sole *(Microstomus pacificus)*				0.35		0.23		0.07
Flathead sole *(Hippoglossoides elassodon)*	0.19			0.35				0.07
Pacific Cod (*Gadus macrocephalus*)	2.52	0.65	1.44	0.70	0.30	2.04		1.24
Pacific sandfish (*Trichodon trichodon*)			0.41	0.35				0.11
Sturgeon poacher (*Podothecus acipenserinus*)	1.74	0.44	0.62	2.09		1.36	2.38	1.17
Walleye pollock *(Theragra chalcogramma)*	0.19	0.87	5.13	2.79		0.91		1.49
Spiny dogfish *(Squalus acanthias)*					0.30			0.04
All Species	**24.62**	**32.66**	**43.08**	**59.92**	**79.75**	**41.76**	**48.53**	**44.39**
Number of Species	**22**	**18**	**25**	**23**	**17**	**19**	**12**	
Total Area Trawled (square feet)	**51,577**	**45,925**	**48,747**	**28,705**	**33,105**	**44,058**	**29,469**	**281,587**

Notes: An empty cell indicates the species was not captured at that location.

TABLE 43-15

CPUE by Station of Macroinvertebrates Captured by Otter Trawl, 2004 through 2008

	Iniskin Bay					Iliamna Bay			Mean
Taxon	**MPS1T**	**MPS2T**	**MPS2TA**	**MPS2TB**	**MTR4**	**MTR1**	**MTR2**	**MTR3**	**CPUE**
MOST ABUNDANT TAXA									
Pandalus goniurus	135.42	272.29	205.95	359.44		310.53	44.05	1.18	200.32
Crangon alaskensis	253.68	100.43	220.14	216.83		93.26	263.58	243.09	193.30
Neomysis rayii	187.74	15.67	55.59	110.00		100.63	63.26	184.09	94.14
Pandalus danae	31.47	22.19	3.64	8.61		244.11	14.47	1.45	47.91
Heptacarpus brevirostris	1.89	8.10	1.32	56.33		86.89	4.89	0.45	23.06
Heptacarpus tridens	4.00	6.24	12.55	19.06		63.16	6.53	0.27	16.56
Crangon sp.	0.21	2.33	2.91	0.28	1,500.00	1.84	1.63	0.64	13.04
Balanus sp.	9.89	2.38	22.86	21.61		4.16	0.74	10.45	10.29
Neomysis sp.	2.68	6.38	8.68	3.17		5.58	16.79	21.55	8.42
Spirontocaris ochotensis	4.16	6.48	0.59	2.00		32.84	4.74	0.36	7.55
Polyorchis penicillatus	4.89	2.62	2.86	5.56		6.21	3.37	6.36	4.33
Pandalus sp.	0.05	23.86					0.05		3.87
Heptacarpus tenuissimus	1.42	1.05	3.05	2.89		14.63	1.58		3.66
Oregonia gracilis	2.00	3.33	3.41	3.83		5.16	3.79	0.36	3.28
Sclerocrangon boreas	1.37	2.86	1.86	1.22		9.16	1.47		2.70
Pagarus beringanus	1.21	3.19	3.14	0.61		4.42	1.47		2.17
Pagurus sp.	3.79	3.00	2.77	0.72		1.37	0.84	0.09	1.94
Acanthomysis pseudomacropsis	11.63						0.26		1.74
Crangon franciscorum	4.58	1.10	0.36	3.78			0.21	1.64	1.60
Heptacarpus sitchensis	1.79	0.29	0.14	0.50		6.74	0.58		1.47
Hyas lyratus	1.37	0.48	2.05	2.72		1.26	1.58		1.42
Lagunogammrus setosus	0.26		0.23	0.28		0.21	3.53	6.55	1.22
Chionoecetes bairdi	2.84	0.48	2.36	0.61		0.16	0.84		1.12
Ischyrocerus sp.	2.11	0.14		2.89		0.11	1.95		1.03
	1.58	2.38	2.41	0.22		0.26	0.05		1.10
COMMERCIALLY IMPORTANT TAXA									
Chionoecetes bairdi	2.84	0.48	2.36	0.61		0.16	0.84		1.12
Telemessus cheiragonus	0.47	0.19	0.05	0.28		1.53	0.58		0.45
Cancer magister	0.68	0.71		0.11			0.16	0.09	0.26
All Species (CPUE)	**672.95**	**488.00**	**558.91**	**823.56**	**1,500.00**	**994.21**	**442.95**	**478.64**	**647.88**
Number of Species	**28**	**26**	**24**	**26**	**1**	**24**	**28**	**16**	
Number of Sets	**19**	**21**	**22**	**18**	**1**	**19**	**19**	**11**	**130**

Notes: An empty cell indicates the species was not captured at that location.
See Appendix A for the full list of macroinvertebrates caught with otter trawl.

TABLE 43-16

CPUE by Month of Macroinvertebrates Captured by Otter Trawl, 2004 through 2008

Taxon	Mar 08	Apr 06/08	May 05/06/08	Jun 05/08	Jul 05/08	Aug 04/05/08	Sep 06-08	Oct 07/08	Nov 08	Mean CPUE
MOST ABUNDANT TAXA										
Pandalus goniurus	215.20	84.23	361.43	55.14	30.43	265.40	204.00	522.62	287.83	200.32
Crangon alaskensis	923.00	262.23	57.21	36.52	42.14	265.67	200.29	392.15	227.67	193.30
Neomysis rayii	440.20	310.54	27.64	8.48	29.50	117.40	2.24	230.85	24.17	94.14
Pandalus danae	35.40	2.38	0.07	2.66	23.64	58.80	48.14	237.38	105.33	47.91
Heptacarpus brevirostris	87.40	2.38	2.36	38.52	1.29	20.00	2.57	51.23	57.00	23.06
Heptacarpus tridens	2.00	0.92		3.10	2.21	0.40	34.76	83.46	31.50	16.56
Crangon sp.			2.64	1.59	5.50		73.10			13.04
Balanus sp.			5.64	31.62		22.80				10.29
Neomysis sp.		46.62	1.00	0.10			5.95	26.69		8.42
Spirontocaris ochotensis	34.60		0.57	1.41	2.93	5.20	4.62	29.62	26.50	7.55
Polyorchis penicillatus				1.10	1.14	8.47	18.48			4.33
Pandalus sp.			35.71	0.03			0.10			3.87
Heptacarpus tenuissimus	4.00	0.31			1.50	1.47	10.71	10.69	7.50	3.66
Oregonia gracilis	1.20	1.23	1.29	2.55	3.29	4.07	3.95	6.08	7.17	3.28
Sclerocrangon boreas	7.80	0.77	0.64	0.90	1.43	0.73	1.90	10.08	10.83	2.70
Pagarus beringanus	10.00	2.15	1.29	1.52	1.93	1.60	1.76	1.92	4.83	2.17
Pagurus sp.		0.62	2.00	3.62	0.29	2.73	2.71	0.69		1.94
Acanthomysis pseudomacropsis				0.17		14.73				1.74
Crangon franciscorum					0.07		6.10	5.62	1.00	1.60
Heptacarpus sitchensis				3.72		0.73	1.90	2.00	1.00	1.47
Hyas lyratus	1.60	0.62	1.36	0.93	0.43	6.47	0.67	0.38		1.42
Lagunogammrus setosus	1.20			0.10	1.43	1.13	0.19	6.92	3.00	1.22
Chionoecetes bairdi	1.40	0.08	0.14	0.17	0.14	0.20	4.14	2.38	1.33	1.12
Ischyrocerus sp.			0.07	0.10				3.31	14.50	1.03
	2.80	1.54	1.21	1.07	1.14	0.40	0.48	1.53	1.50	1.10
COMMERCIALLY IMPORTANT TAXA										
Chionoecetes bairdi	1.40	0.08	0.14	0.17	0.14	0.20	4.14	2.38	1.33	1.12
Telemessus cheiragonus			0.14	0.52	0.43	0.67	0.48	1.15	0.17	0.45
Cancer magister			1.43	0.38		0.07	0.05	0.08		0.26
All Species (CPUE)	**1,767.80**	**716.62**	**503.86**	**196.03**	**150.86**	**799.13**	**629.00**	**1,626.69**	**812.67**	**647.88**
Number of Species	**16**	**16**	**21**	**26**	**21**	**23**	**25**	**23**	**19**	
Number of Sets	**5**	**13**	**14**	**29**	**14**	**15**	**21**	**13**	**6**	**130**

Notes: An empty cell indicates the species was not captured during that month.
See Appendix A for the full list of macroinvertebrates caught with otter trawl.

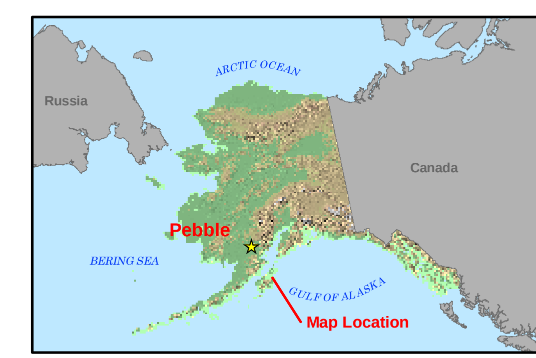
FIGURES

THE pebble PARTNERSHIP

Figure 43-1
Lower Cook Inlet and Study Area for Nearshore Fish and Invertebrates

Legend

- Nearshore Fish and Invertebrate Study Area
- Bristol Bay/Cook Inlet Drainages Boundary
- National Park or Preserve



0 5 10 15 20 25 Miles

0 10 20 30 Kilometers

N

Scale 1:750,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_Pen_Cook_43-1_11x17L_1of1_D03.mxd	Date: December 13, 2010
Version: 3	Author: RDI-LS

Miles
0 0.5 1 1.5 2 2.5
Kilometers
0 0.75 1.5 2.25 3 3.75

N

Scale 1:110,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

Legend

- 120-feet Beach Seine Sampling Site
- 30-feet Beach Seine Sampling Site
- Trawl Sampling Site
- Gill/Trammel Net Sampling Site
- Nearshore Fish and Invertebrate Study Area
- Salmon Bearing Streams (ADF&G)

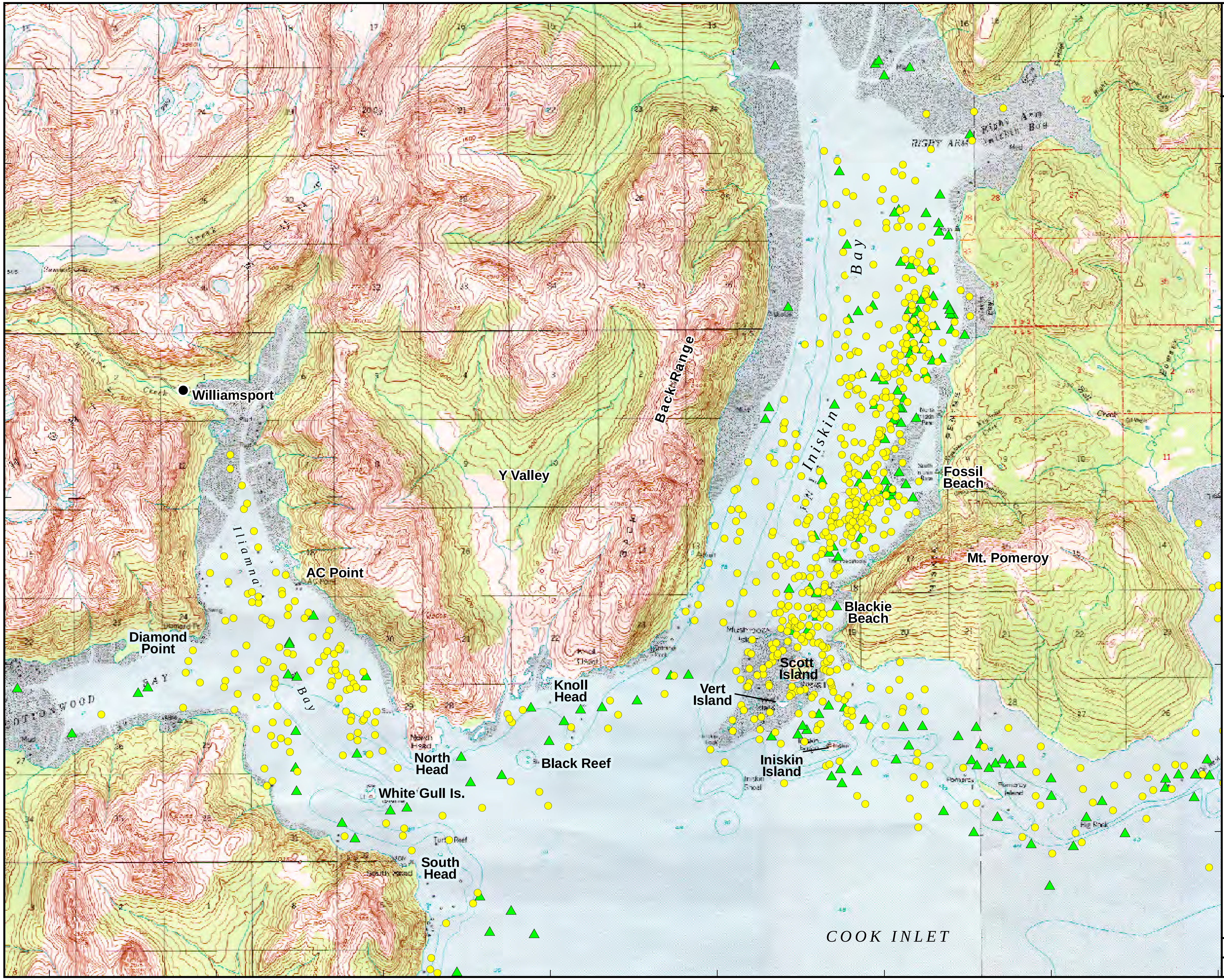
THE pebble PARTNERSHIP

Figure 43-2
Nearshore Fish and Invertebrate Sampling Locations, Iniskin and Iliamna Bays, 2004 through 2008

File: RDI_Pen_Seine_Trawl_ Fig43-2_11X17P_V04.mxd	Date: December 16, 2010
Version: 4	Author: RDI-LS

THE pebble PARTNERSHIP

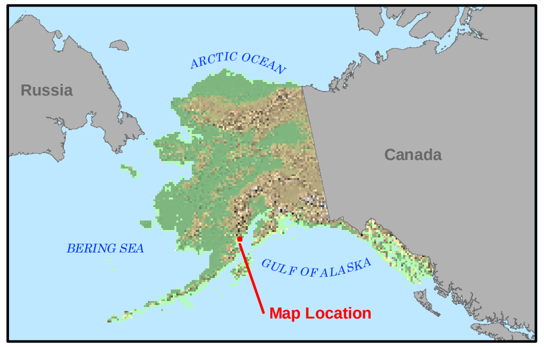
Figure 43-3
Locations of Pre-spawning Adult Herring, Iniskin and Iliamna Bays, 1978 through 2002



Legend

- Locations of Pre-spawning Adult Herring 1990 through 2002
- Locations of Pre-spawning Adult Herring 1978 through 1989

Notes:
1. Adult herring location from aerial surveys, data from ADF&G, 2002.



0 0.5 1 1.5 2 2.5 Miles

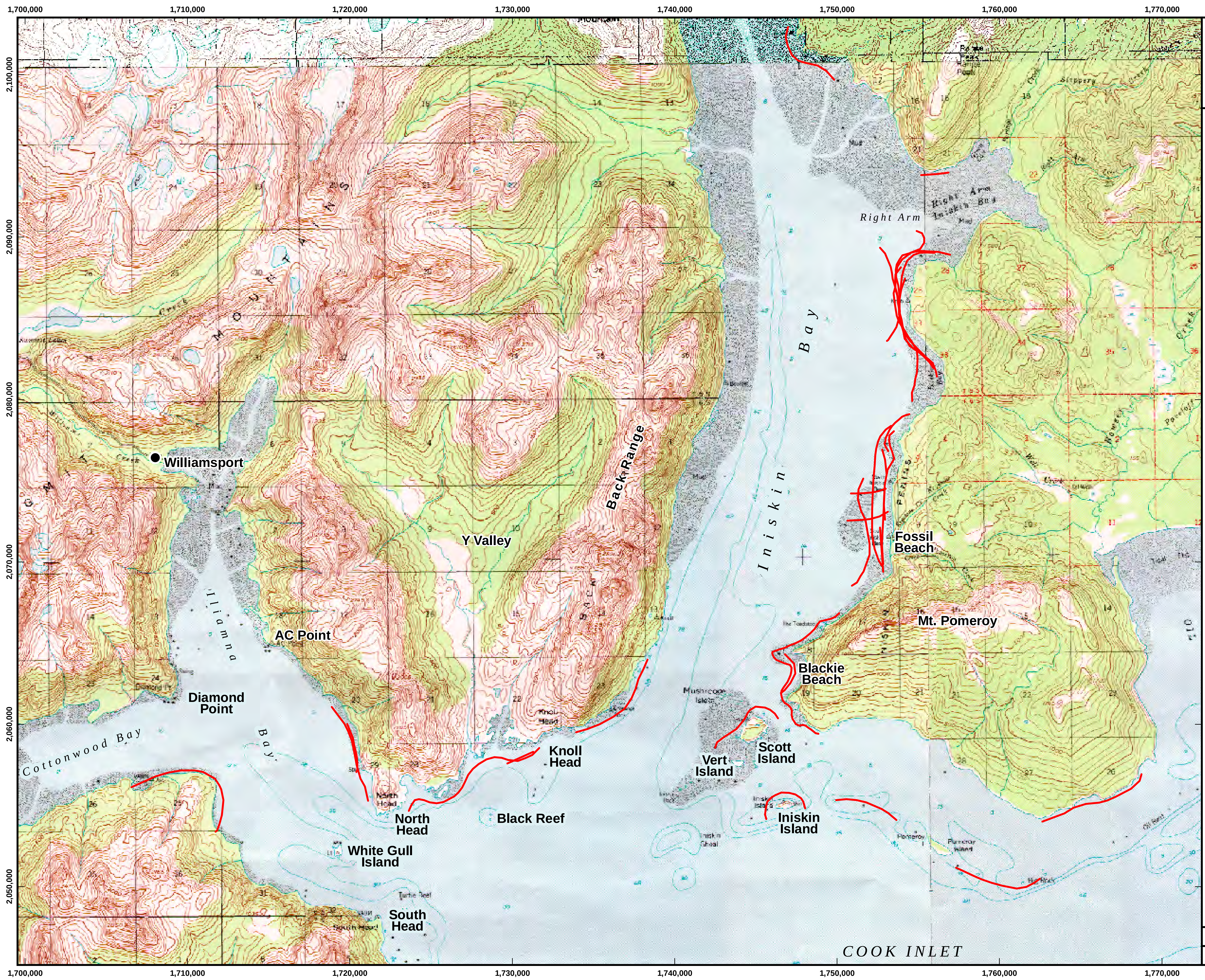
0 1 2 3 Kilometers

Scale 1:70,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_Pen_HerringDist_Fig43-3_11X17L_1of1_D04.mxd	Date: December 13, 2010
Version: 4	Author: RDI-LS



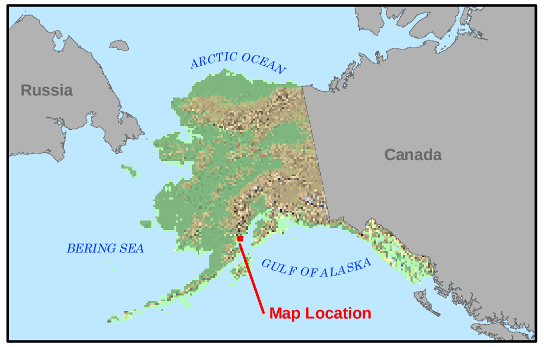
THE pebble PARTNERSHIP

Figure 43-4
Locations of Herring Spawn, Iniskin and Iliamna Bays, 1978 through 1989

Legend

Locations of Herring Spawn 1978 through 1989

Notes:
1. Adult herring location from aerial surveys, data from ADF&G, 2002.



Miles: 0 0.5 1 1.5 2 2.5
Kilometers: 0 1 2 3

Scale 1:70,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_Pen_HerringDist_Fig43-4_11X17L_1of1_D04.mxd	Date: December 13, 2010
Version: 4	Author: RDI-LS

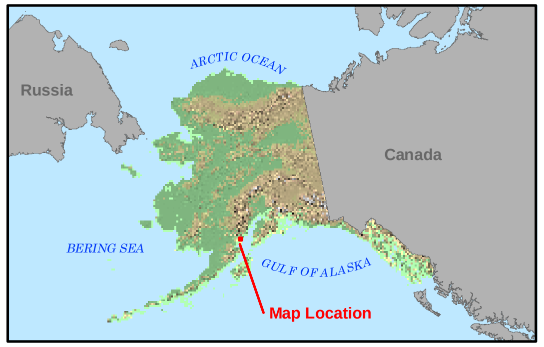
THE pebble PARTNERSHIP

Figure 43-5
Locations of Herring Spawn, Iniskin and Iliamna Bays, 1990 through 2002

Legend

Locations of Herring Spawn, 1990 through 2002

Notes:
1. Adult herring location from aerial surveys, data from ADF&G, 2002.



Miles: 0 0.5 1 1.5 2 2.5

Kilometers: 0 1 2 3

Scale 1:70,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_Pen_HerringDist_Fig43-5_11X17L_1of1_D04.mxd	Date: December 13, 2010
Version: 4	Author: RDI-LS

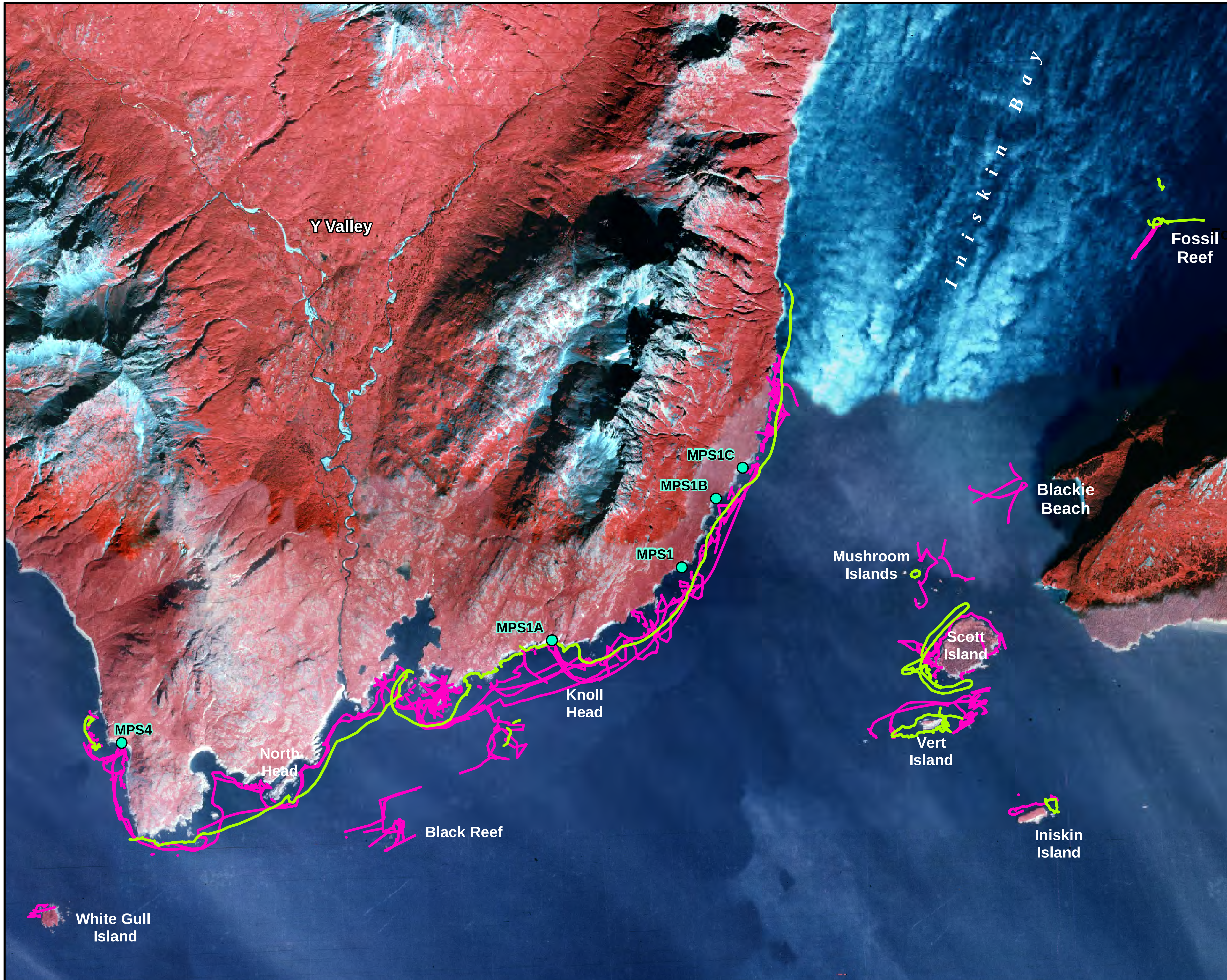
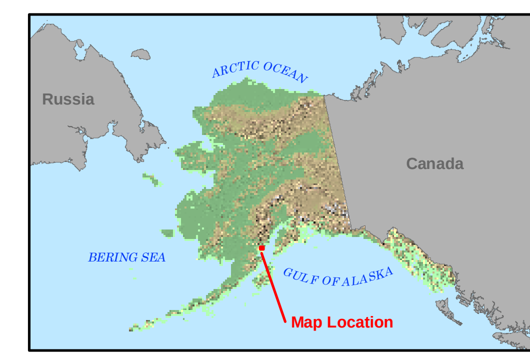


Figure 43-6
Herring Spawn Survey Tracks

Legend

- 2006 Herring Survey Tracks
- 2008 Herring Survey Tracks
- Sampling Location



Miles: 0 0.25 0.5 0.75 1 1.25

Kilometers: 0 0.5 1 1.5

Scale 1:33,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_Pen_Herring_Spawn_Fig-43-6_11X17L_1of1_D02.mxd	Date: December 20, 2010
Version: 2	Author: RDI-LS

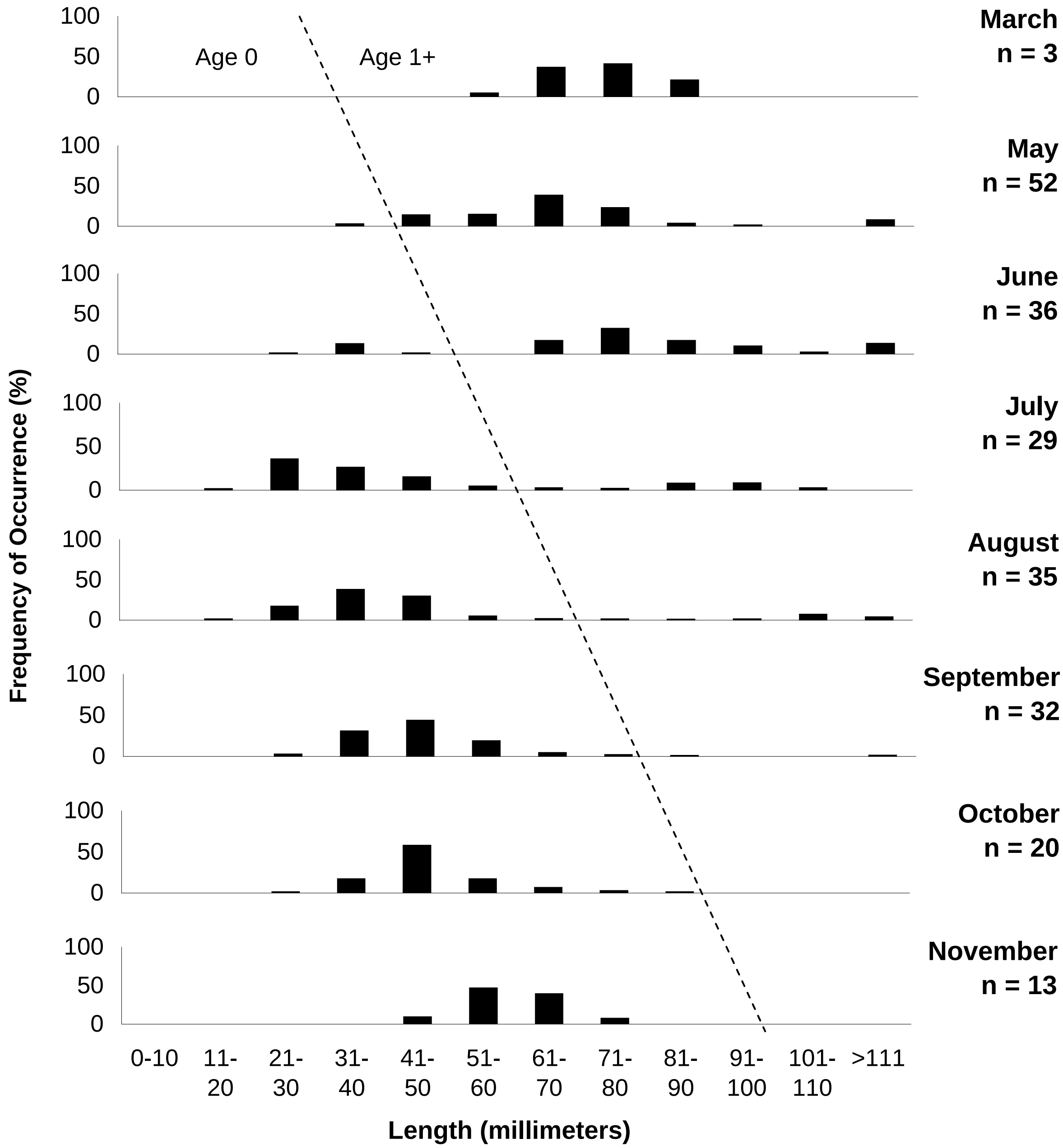


FIGURE 43-7
Length Frequency of Pacific Herring Captured by 120-foot Beach Seine, 2004 through 2008

Notes: n = number of replicates

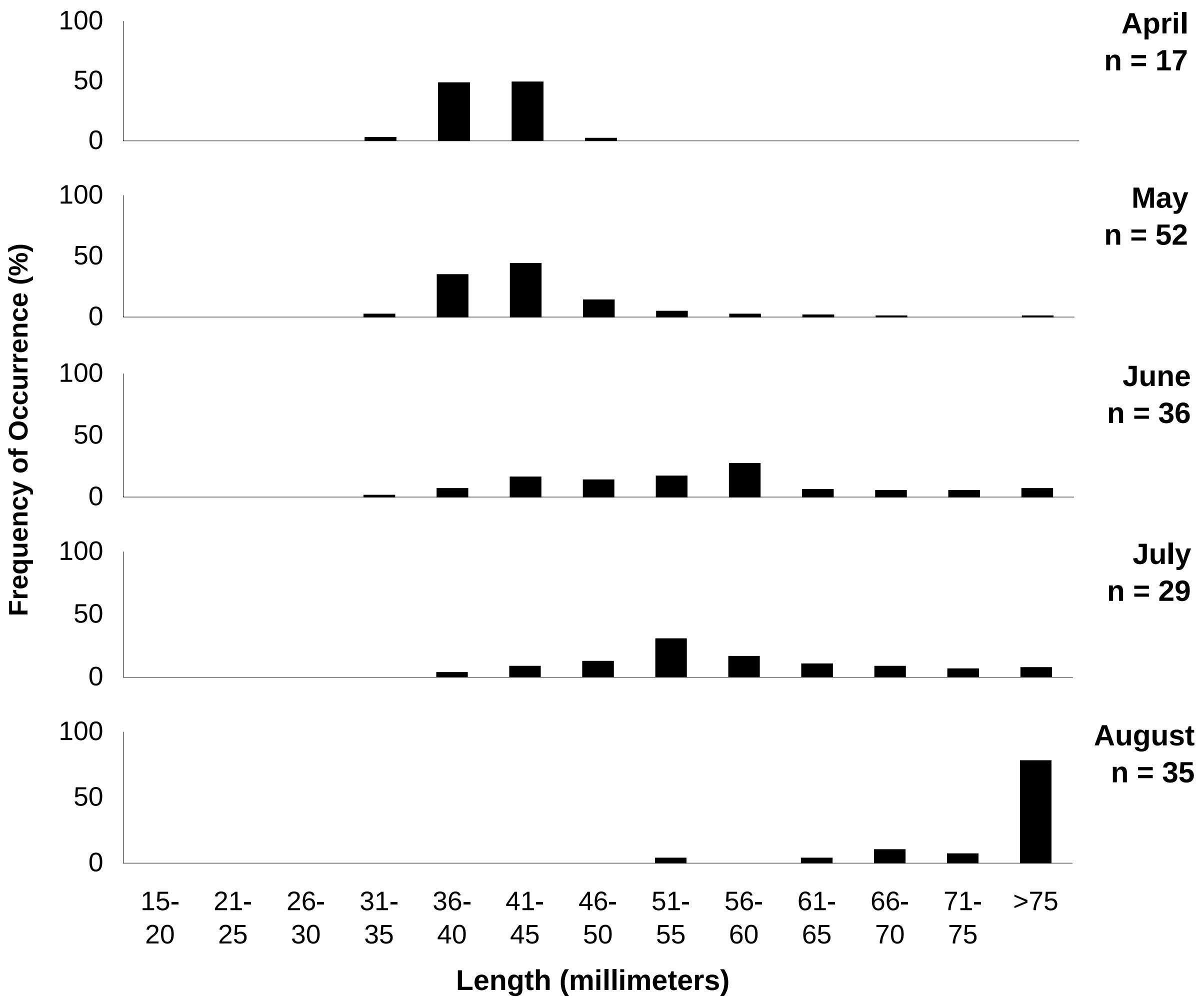


FIGURE 43-8

Length Frequency of Juvenile Chum Salmon Captured by 120-foot Beach Seine, 2004 through 2008

Notes: n = number of replicates

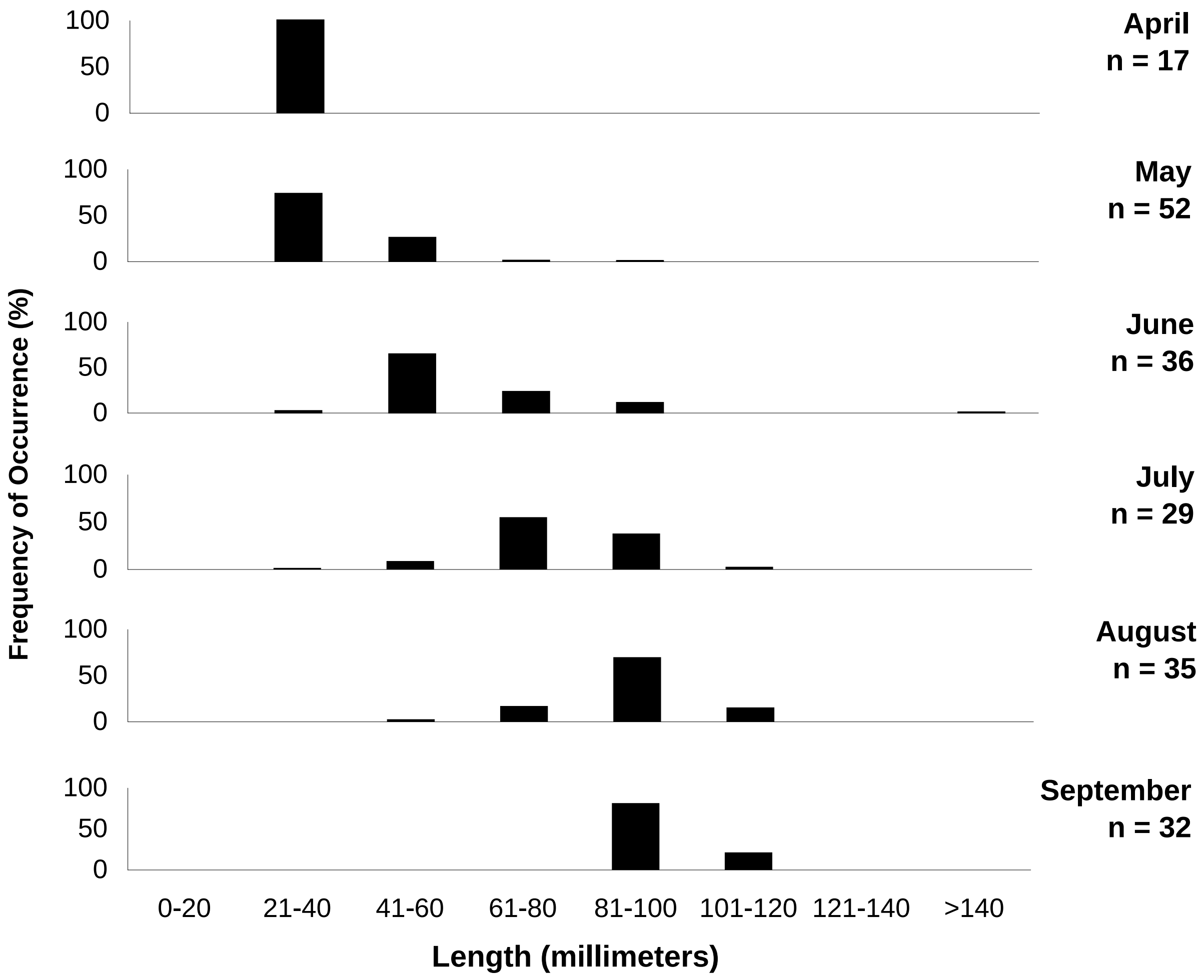


FIGURE 43-9

Length Frequency of Juvenile Pink Salmon Captured by 120-foot Beach Seine, 2004 through 2008

Notes: n = number of replicates

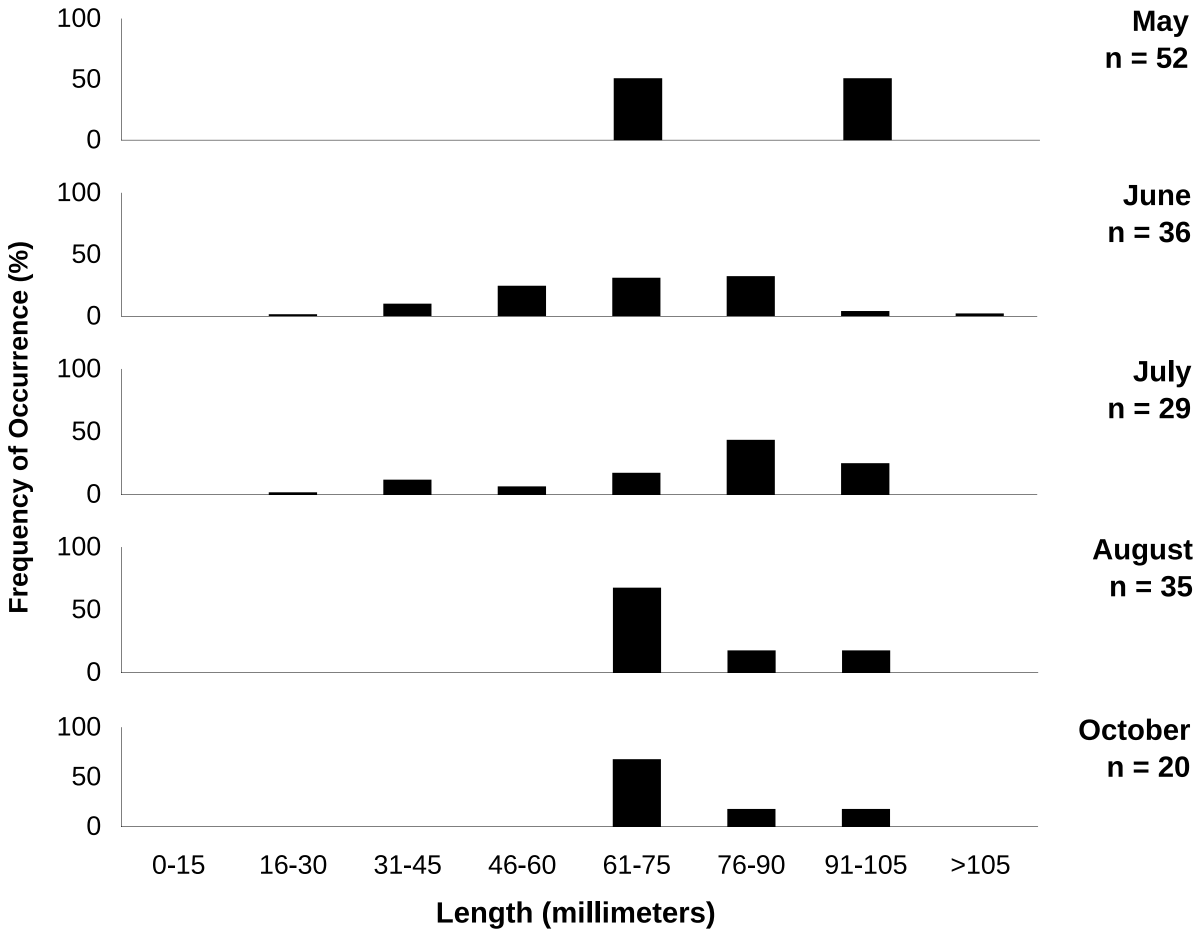


FIGURE 43-10

Length Frequency of Juvenile Sockeye Salmon Captured by 120-foot Beach Seine, 2004 through 2008

Notes: n = number of replicates

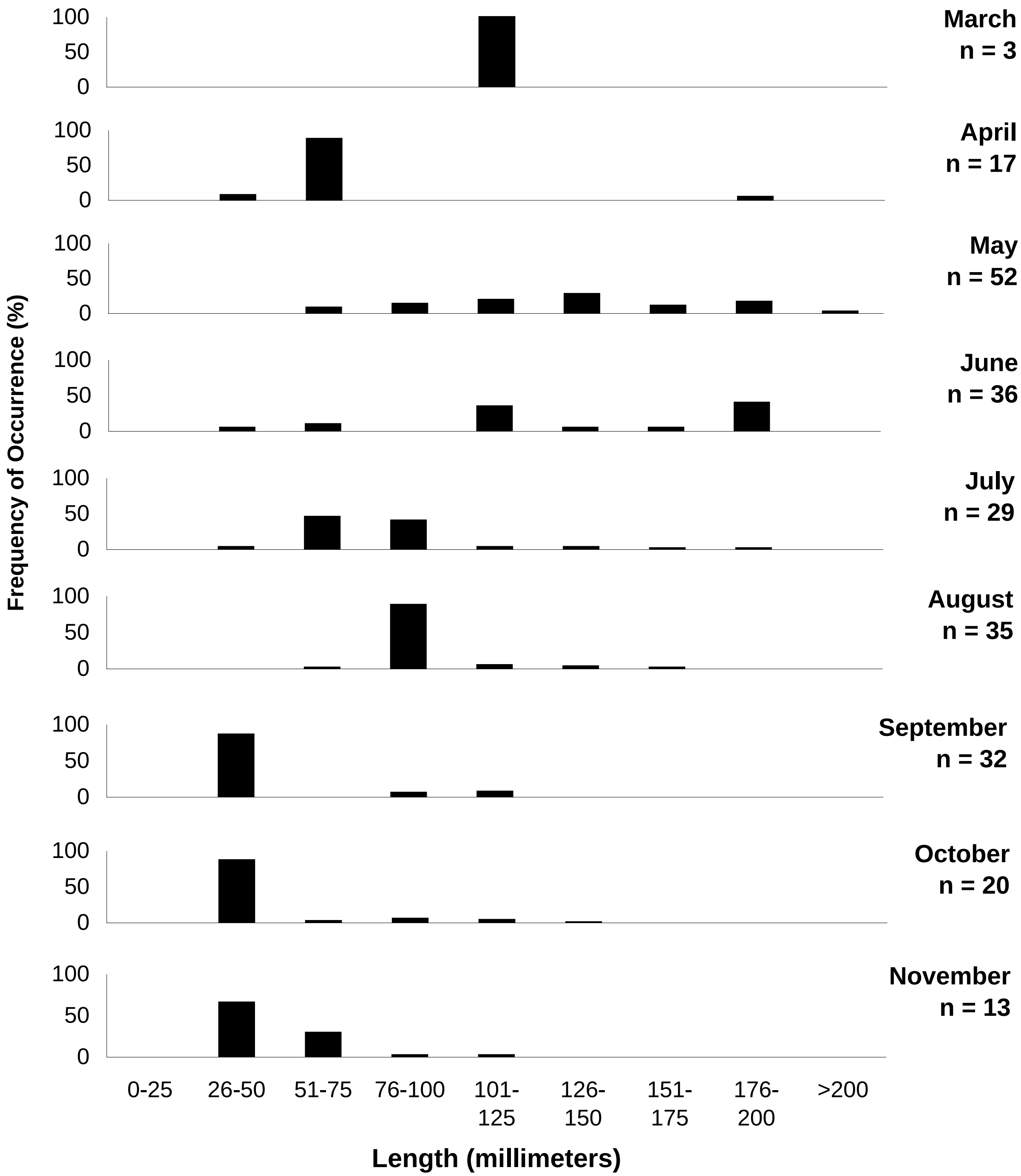


FIGURE 43-11
Length Frequency of Surf Smelt Captured by 120-foot Beach Seine, 2004 through 2008

Notes: n = number of replicates

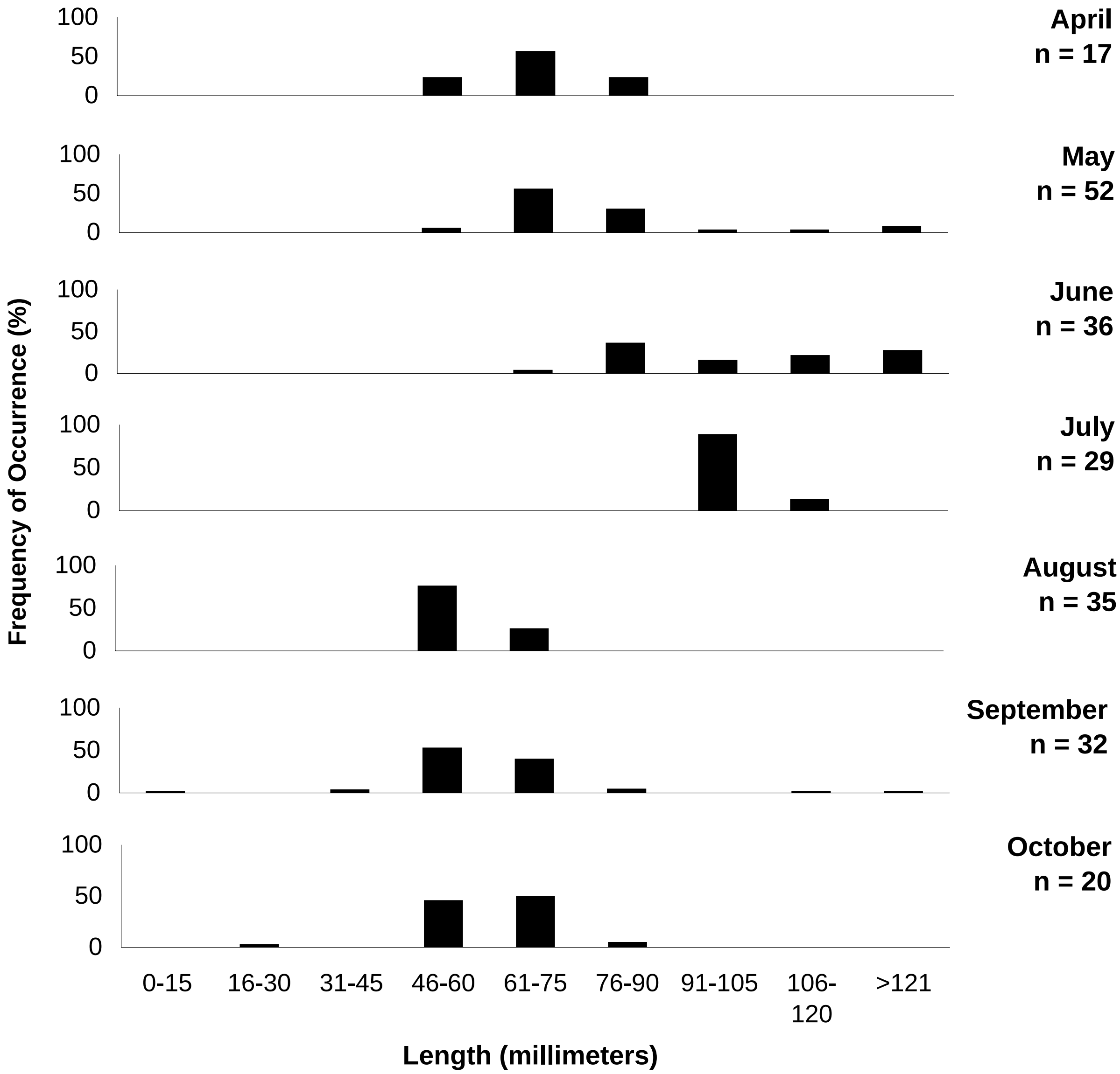


FIGURE 43-12

Length Frequency of Pacific Sand Lance Captured by 120-foot Beach Seine, 2004 through 2008

Notes: n = number of replicates

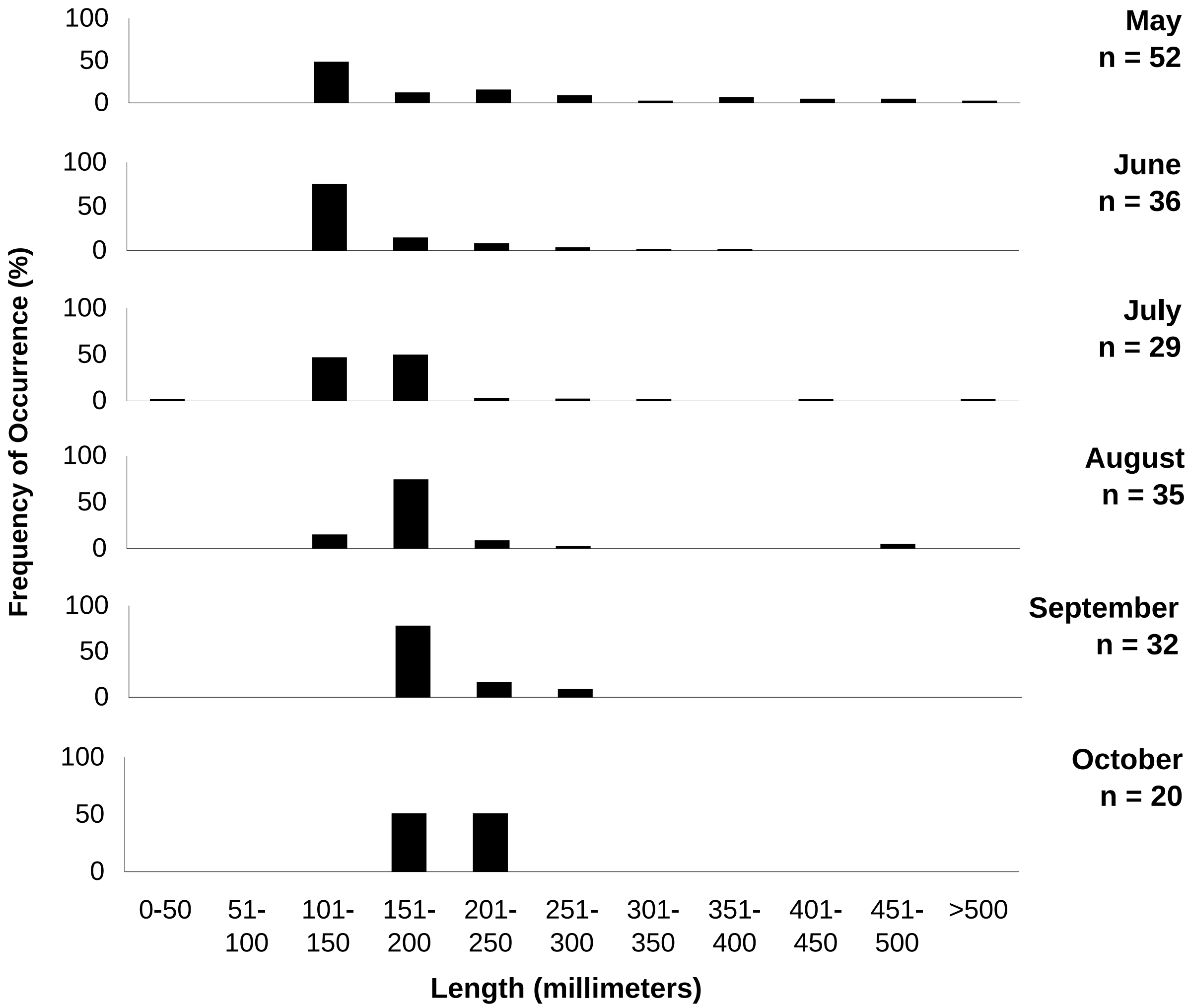


FIGURE 43-13

Length Frequency of Dolly Varden Captured by 120-foot Beach Seine, 2004 through 2008

Notes: n = number of replicates

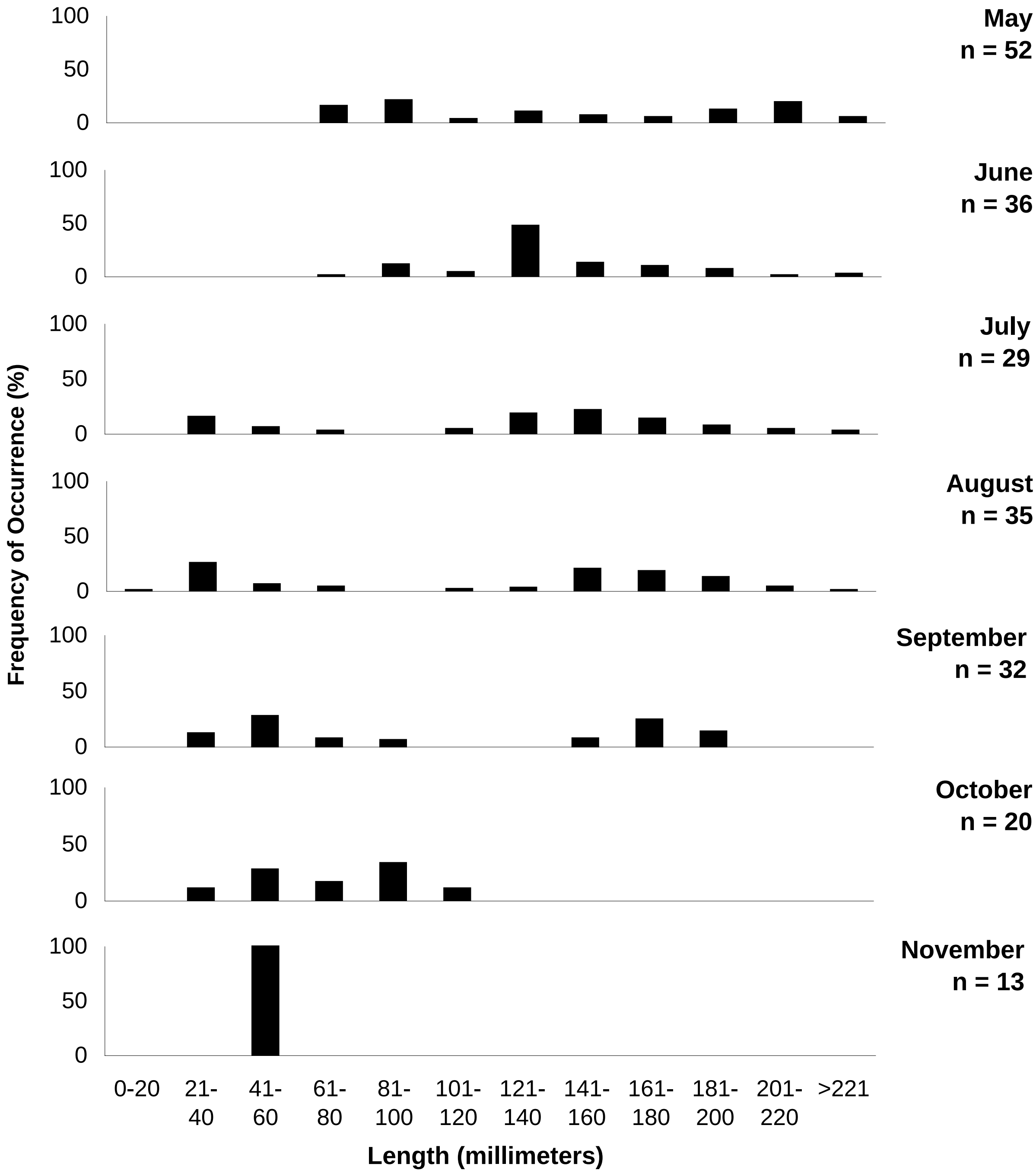


FIGURE 43-14

Length Frequency of Pacific Staghorn Sculpin Captured by 120-foot Beach Seine, 2004 through 2008

Notes: n = number of replicates

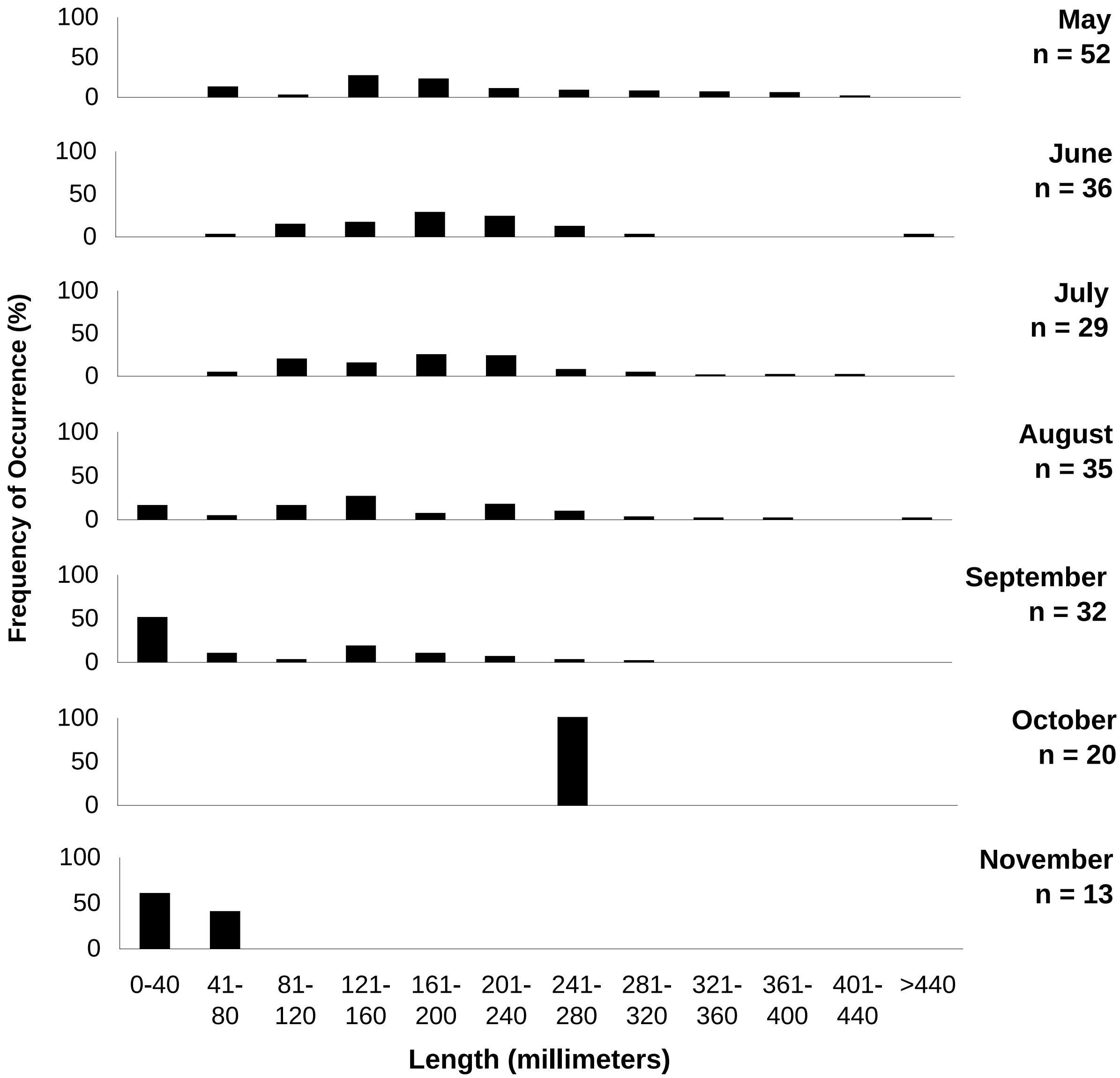


FIGURE 43-15

Length Frequency of Starry Flounder Captured by 120-foot Beach Seine, 2004 through 2008

Notes: n = number of replicates

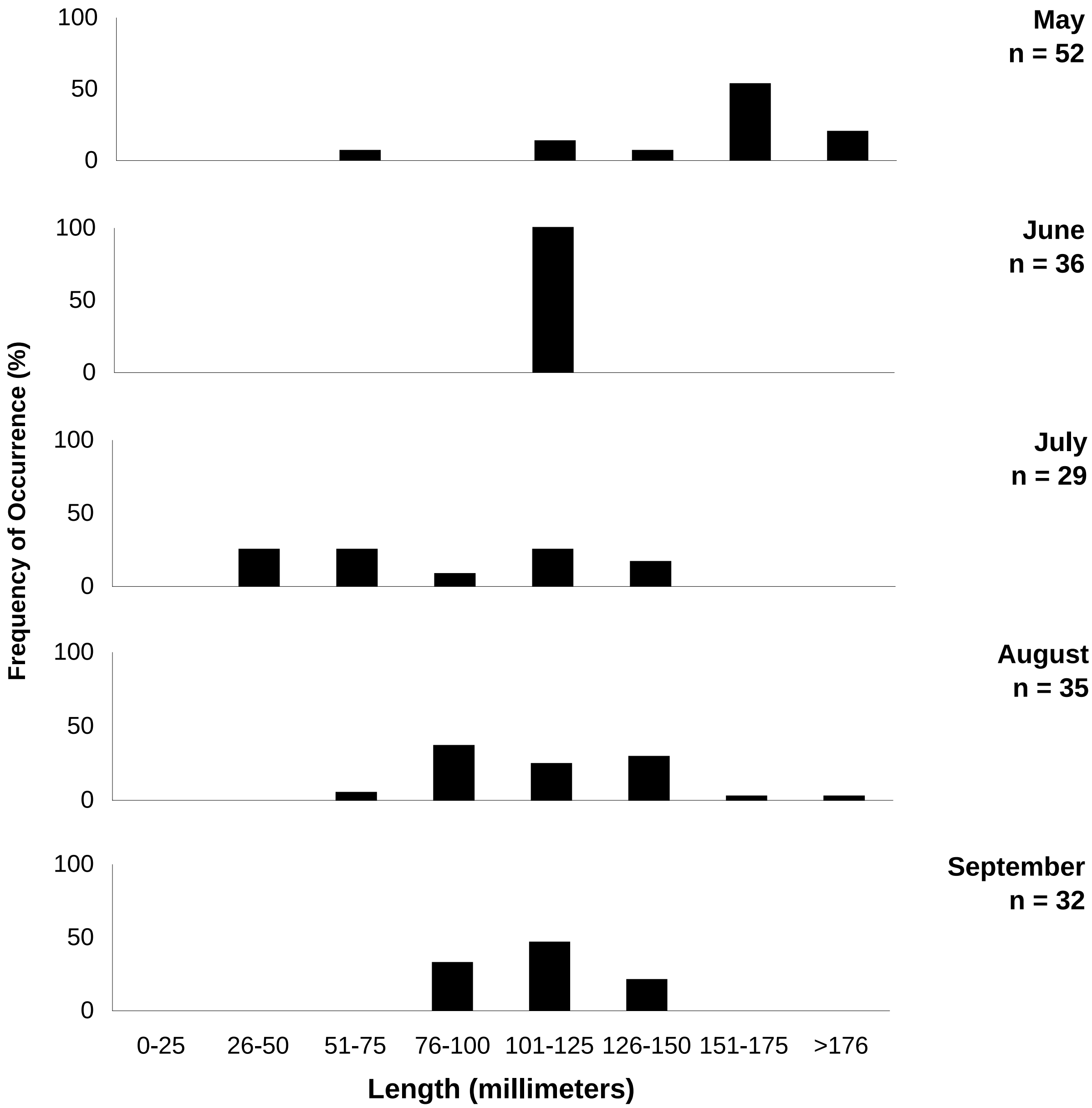


FIGURE 43-16
Length Frequency of Longfin Smelt Captured by 120-foot Beach Seine, 2004 through 2008

Notes: n = number of replicates

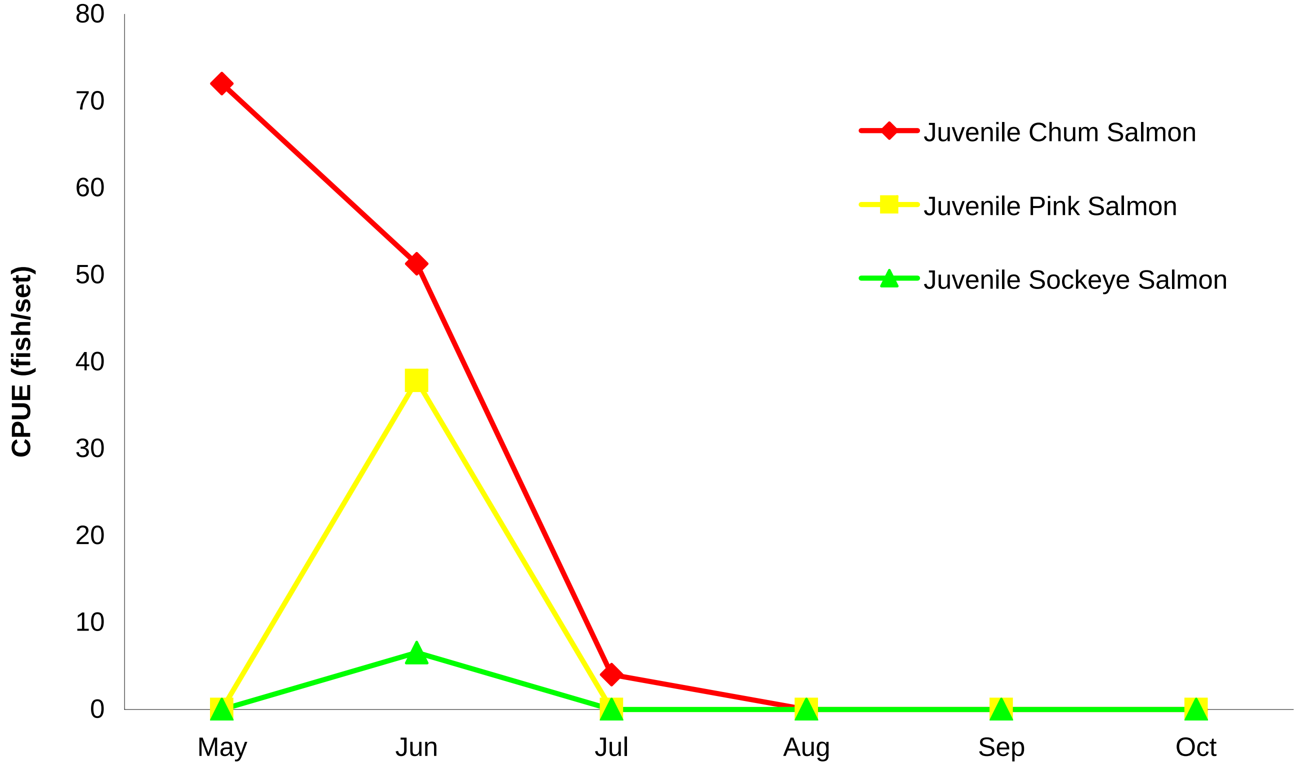


FIGURE 43-17
CPUE by Month of Juvenile Salmon Captured by 30-foot Beach Seine in Intertidal Habitats, 2008

Notes: June CPUE includes juvenile chum and pink salmon captured at upper Iliamna stations, MUI1 and MUI2.

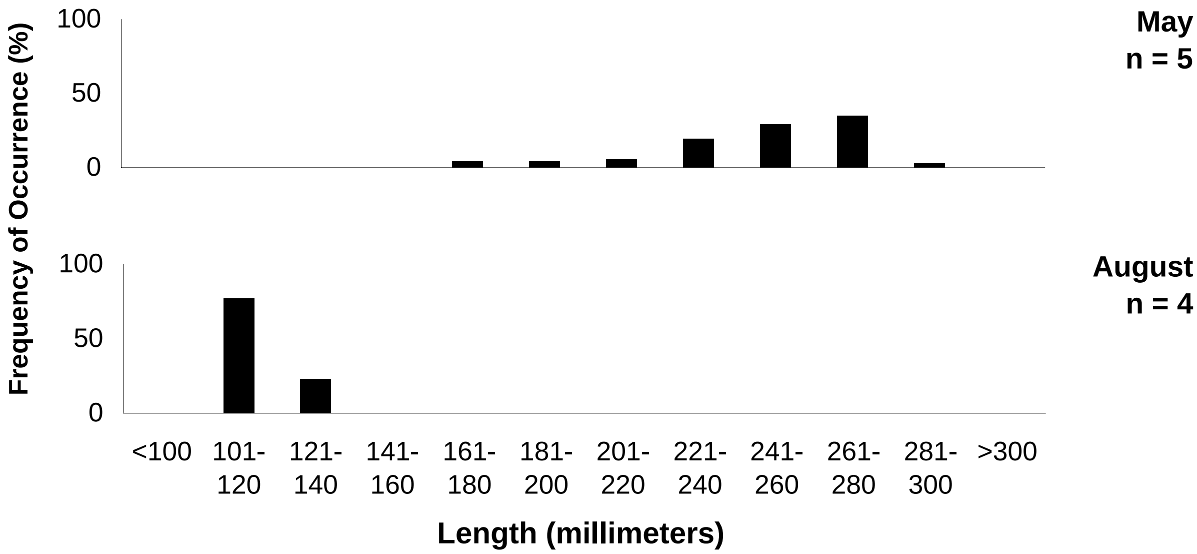


FIGURE 43-18
Length Frequency of Pacific Herring Captured by Gill Net, 2008

Notes: n = number of replicates

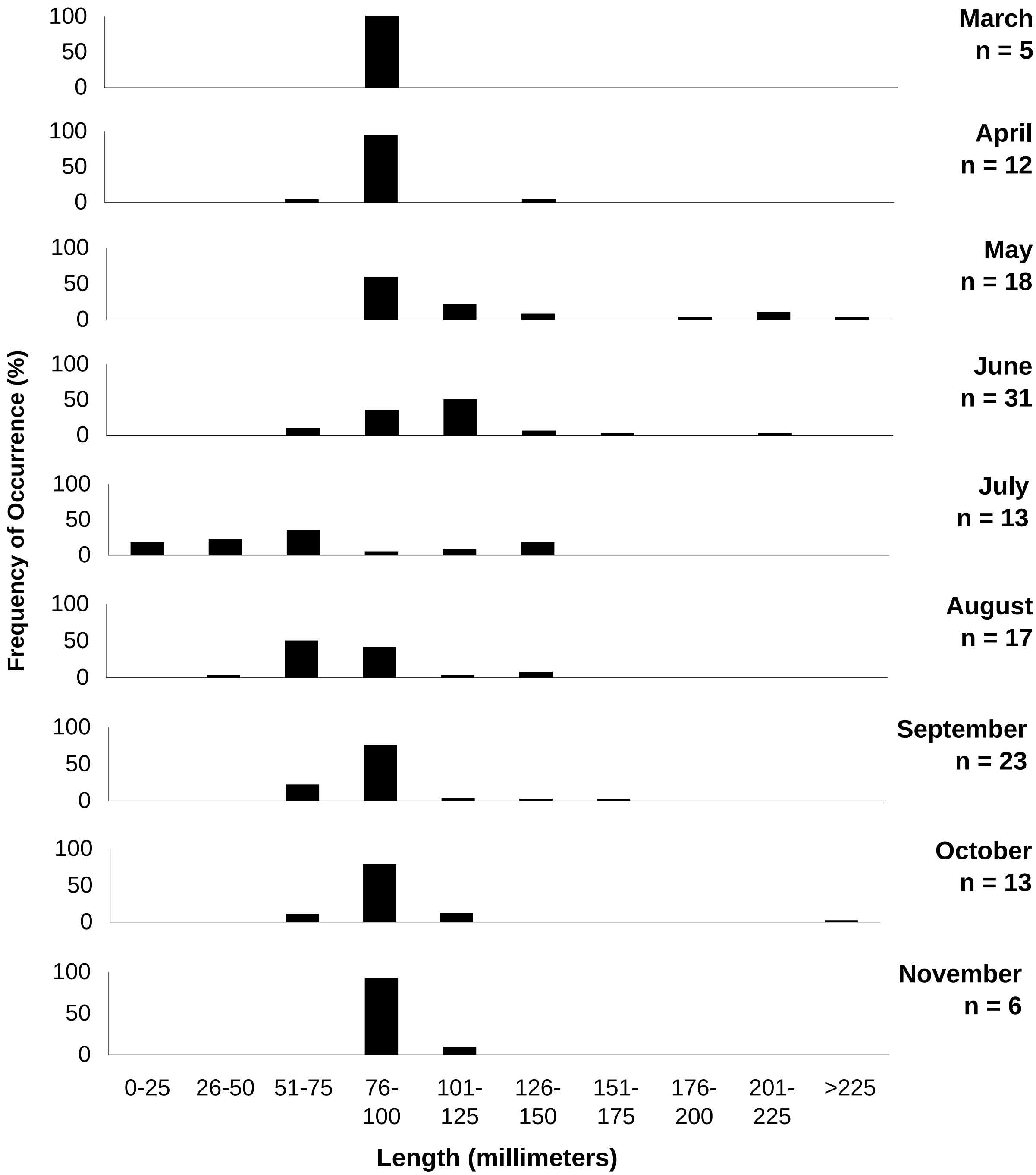


FIGURE 43-19
Length Frequency of Snake Prickleback Captured by Otter Trawl, 2004 through 2008

Notes: n = number of replicates

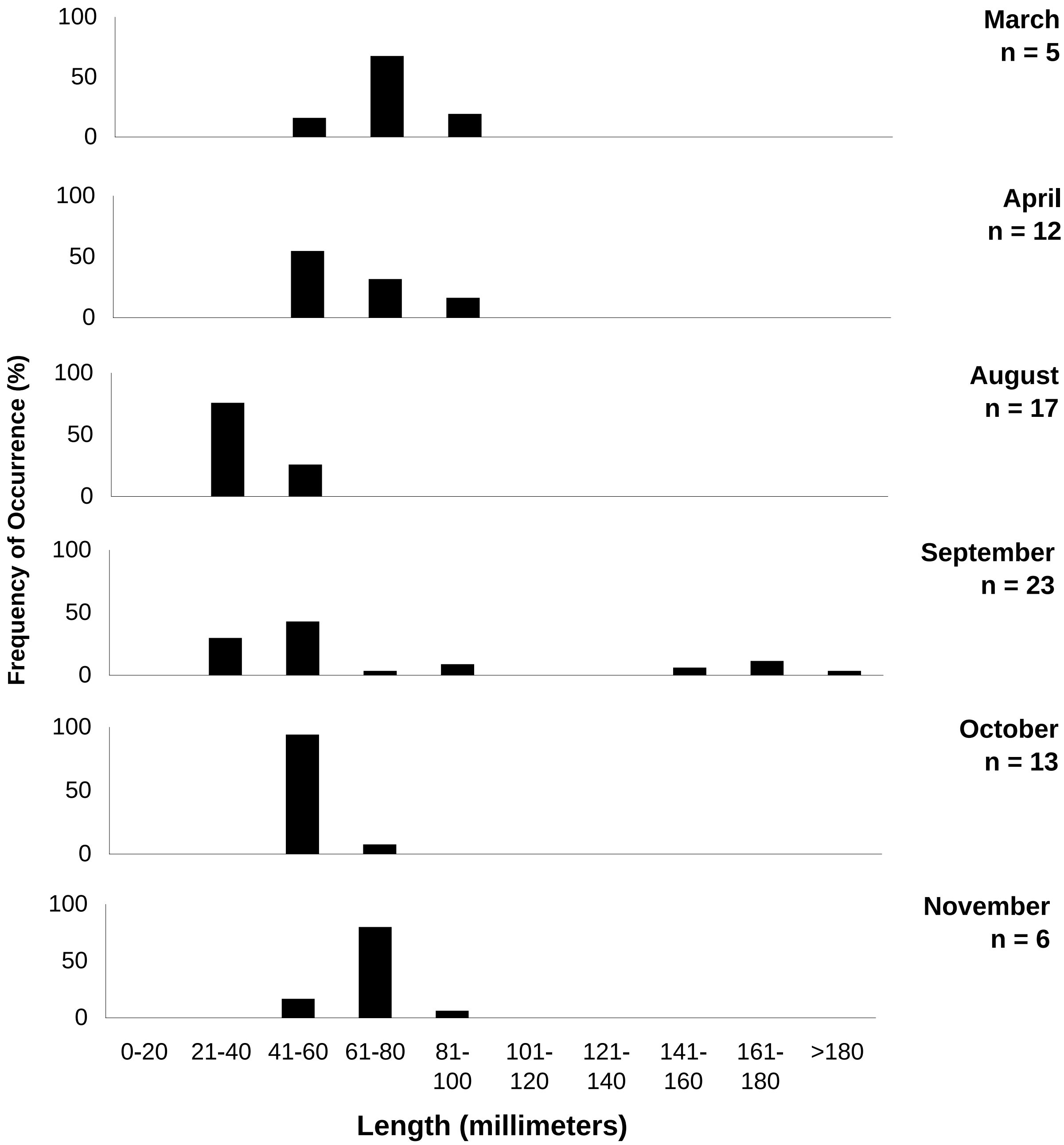


FIGURE 43-20
Length Frequency of Pacific Herring Captured by Otter Trawl, 2004 through 2008

Notes: n = number of replicates

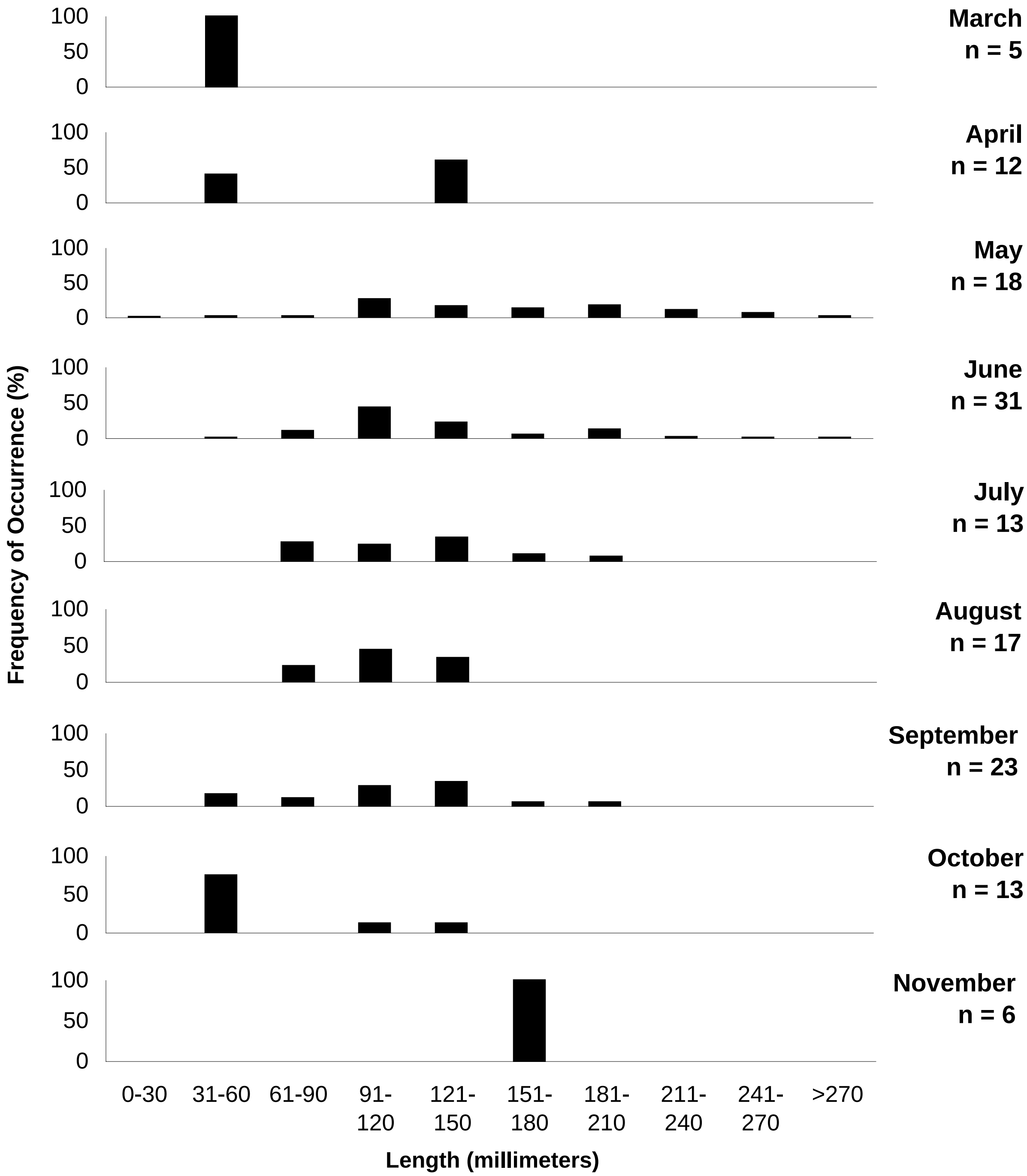
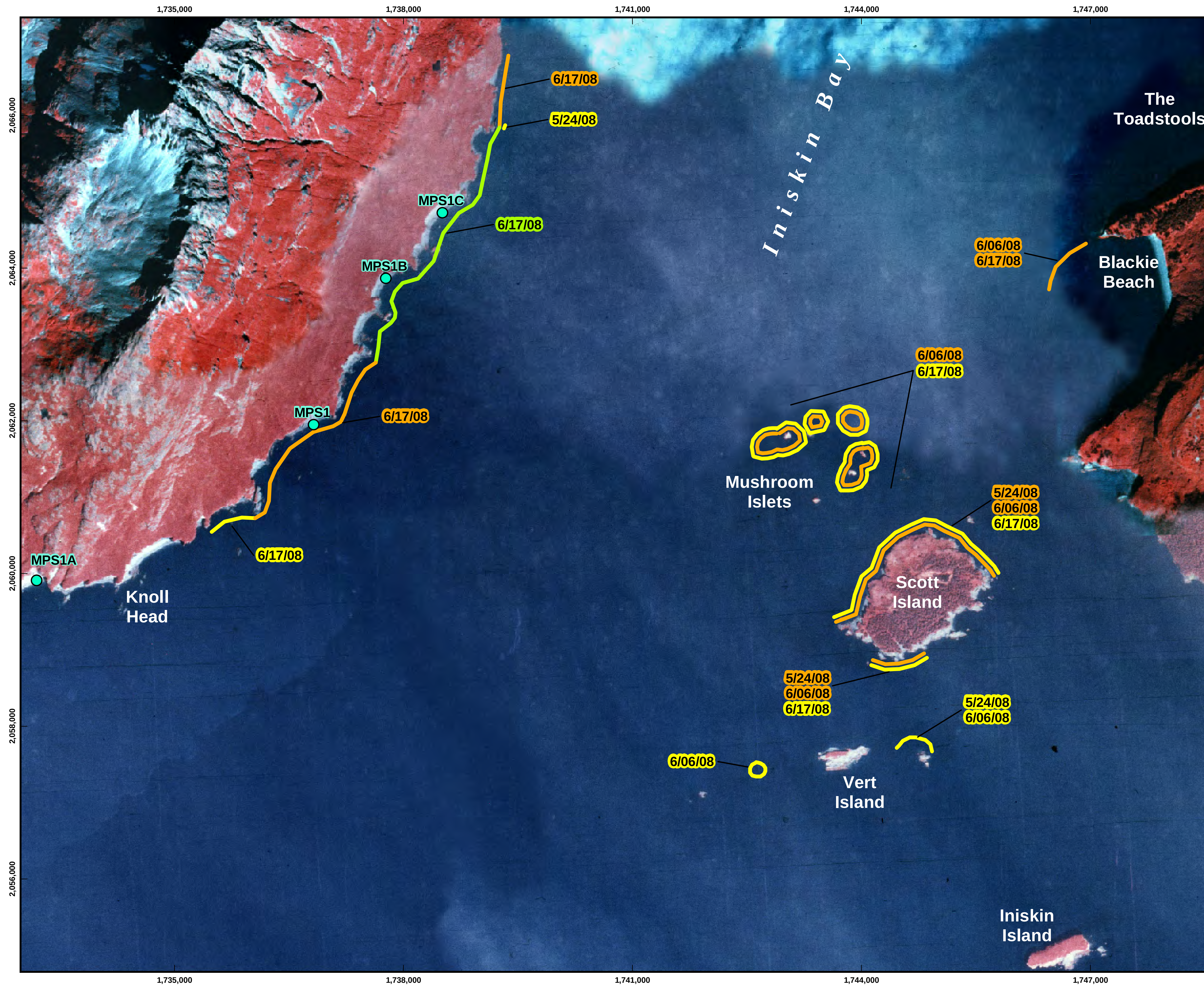


FIGURE 43-21
Length Frequency of Yellowfin Sole Captured by Otter Trawl, 2004 through 2008

Notes: n = number of replicates



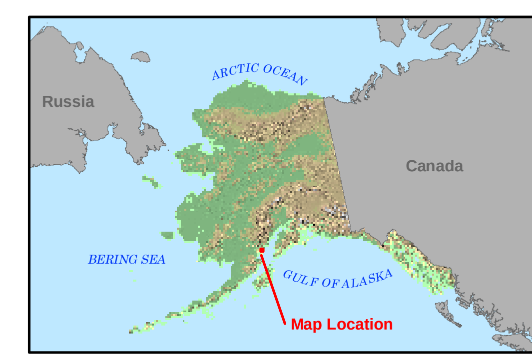
THE pebble PARTNERSHIP

Figure 43-22
Distribution of Herring Spawn, Iniskin Bay, 2008

Legend

Herring Spawn Survey Results

- Moderate
- Low
- Trace
- Sampling Location



Miles: 0, 0.1, 0.2, 0.3, 0.4, 0.5

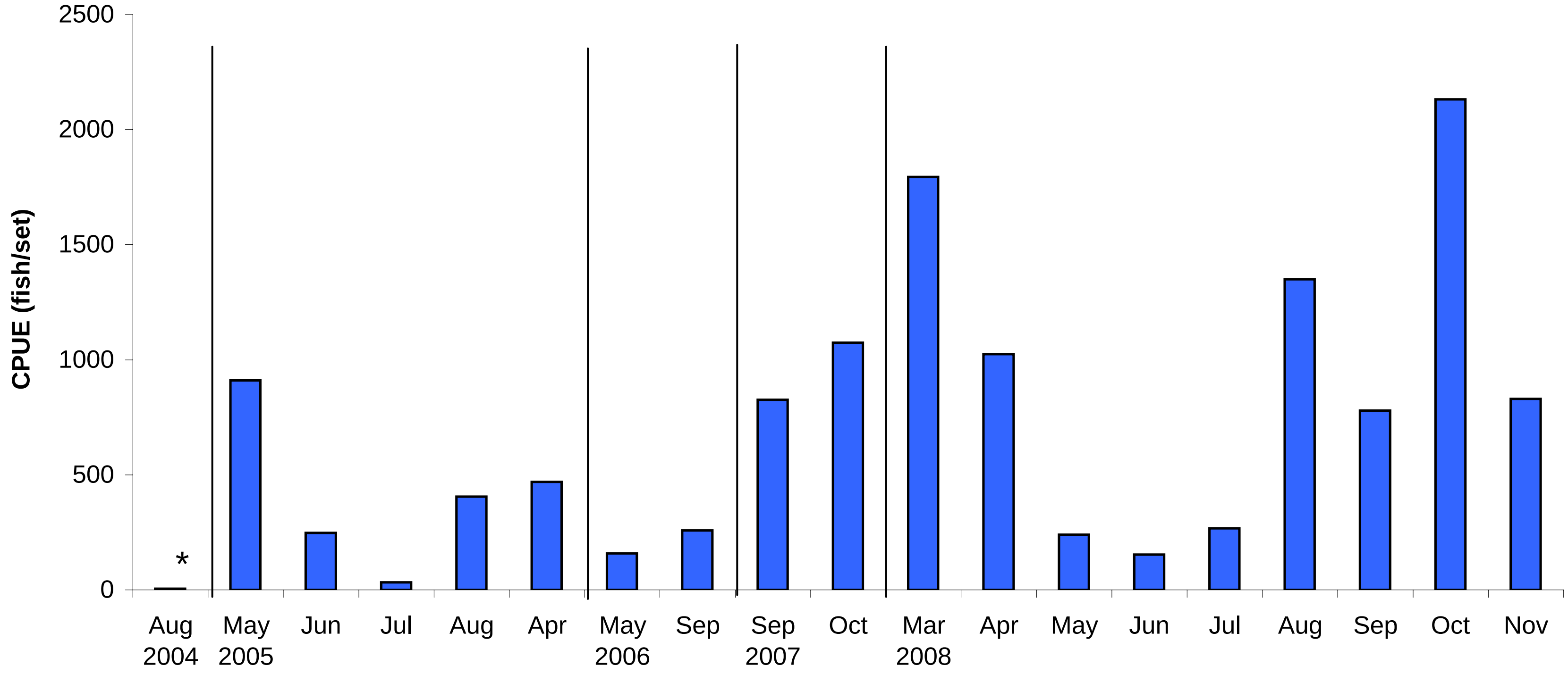
Kilometers: 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6

Scale 1:15,000

N

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: RDI_Pen_Herring_Spawn_Fig43-22_11X17L_1of1_D03.mxd	Date: December 20, 2010
Version: 3	Author: RDI-LS



*Catches were not fully enumerated in 2004.

FIGURE 43-23
CPUE by Month for Macroinvertebrates Captured by Otter Trawl, 2004 through 2008

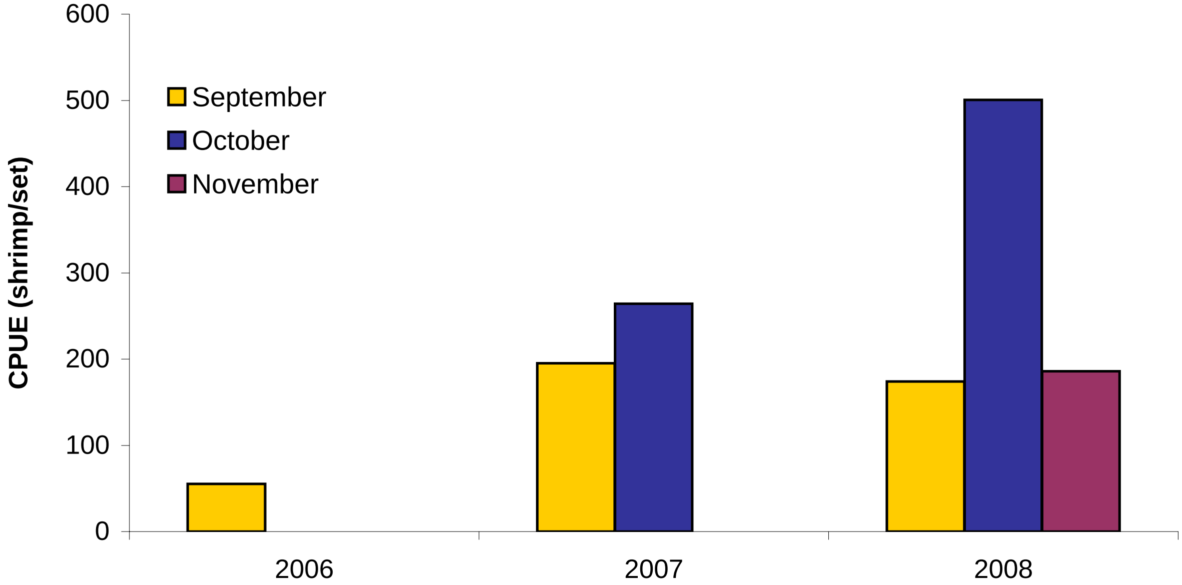


FIGURE 43-24
CPUE for Shrimp Captured by Otter Trawl during September, October, and November, 2006 through 2008

Notes: No bar means no sampling occurred that month

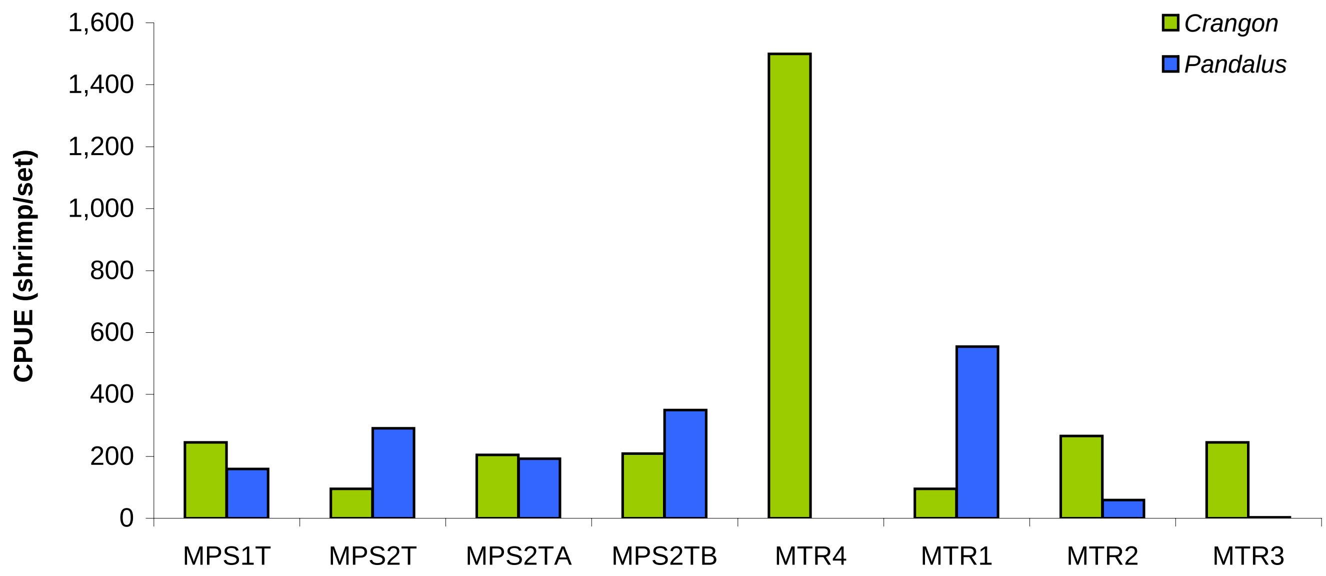


FIGURE 43-25
CPUE by Station for Crangon and *Pandalus* Captured by Otter Trawl, 2005 through 2008

Notes: No bar means no *Pandalus* were caught at that location

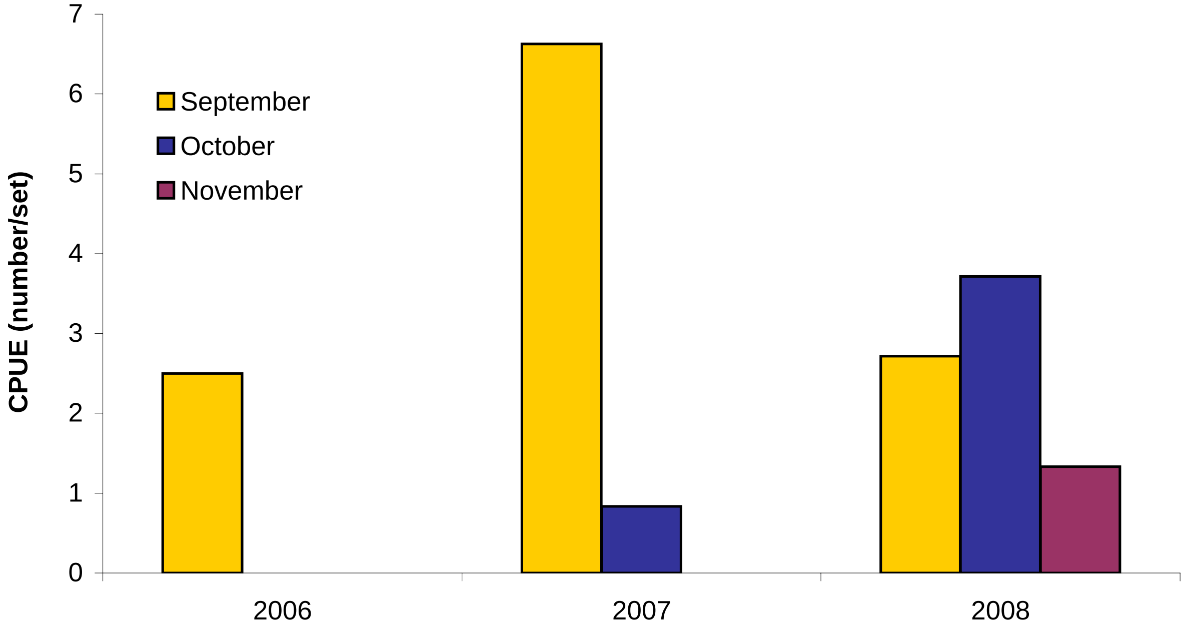


FIGURE 43-26
CPUE for *Chionoecetes bairdi* Captured by Otter Trawl during September, October, and November, 2006 through 2008

Notes: No bar means no sampling occurred that month

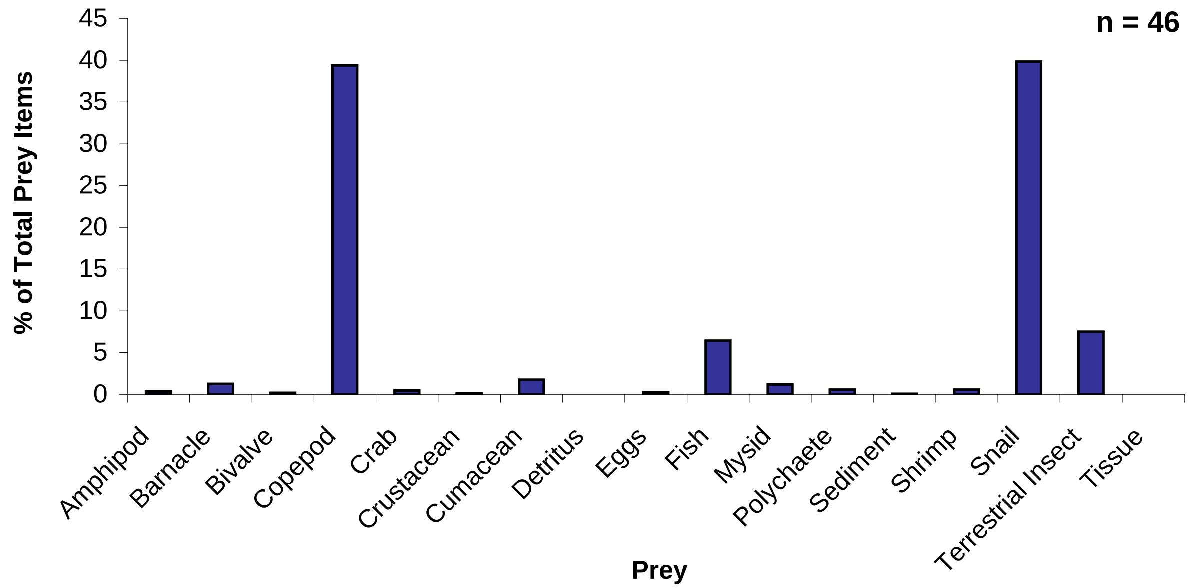


FIGURE 43-27
Juvenile Chum Salmon Stomach Contents (Percent of Total Prey Items), 2005

Notes: Eggs = invertebrate and fish eggs present in the stomach
Tissue = unidentified muscle and tissue, presumably from fish
There appears to be no data for detritus or tissue because the values are so small that the bar is not visible at this scale.

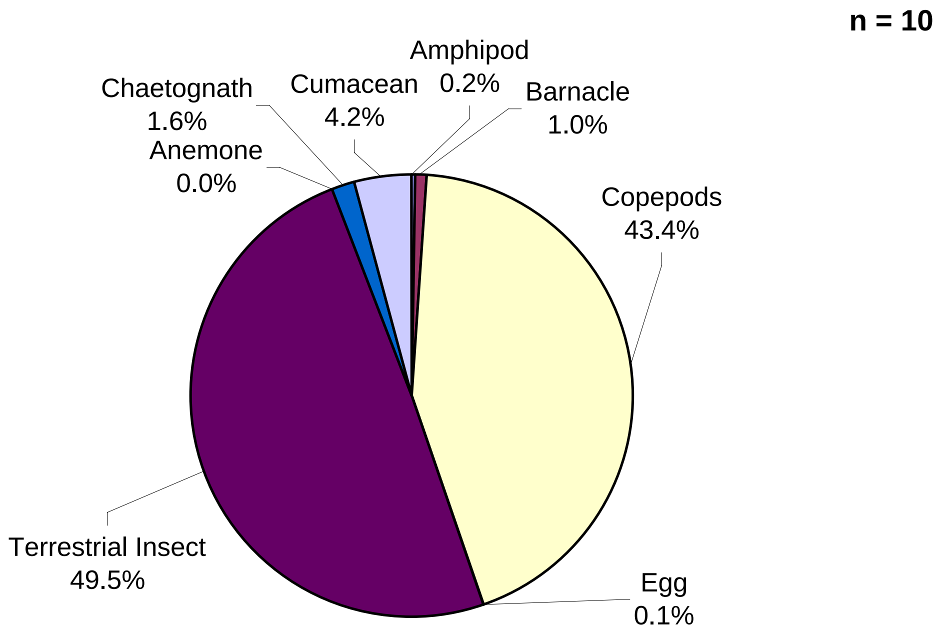


FIGURE 43-28

Index of Relative Importance of Food Items in Stomach Contents of Juvenile Pink Salmon, 2008

Notes: n = number of replicates

n = 8

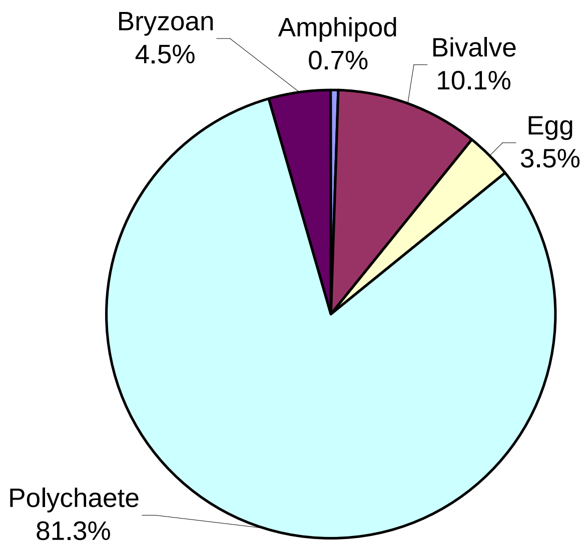


FIGURE 43-29
Index of Relative Importance of Food Items in Stomach Contents of Yellowfin Sole, 2008

Notes: n = number of replicates

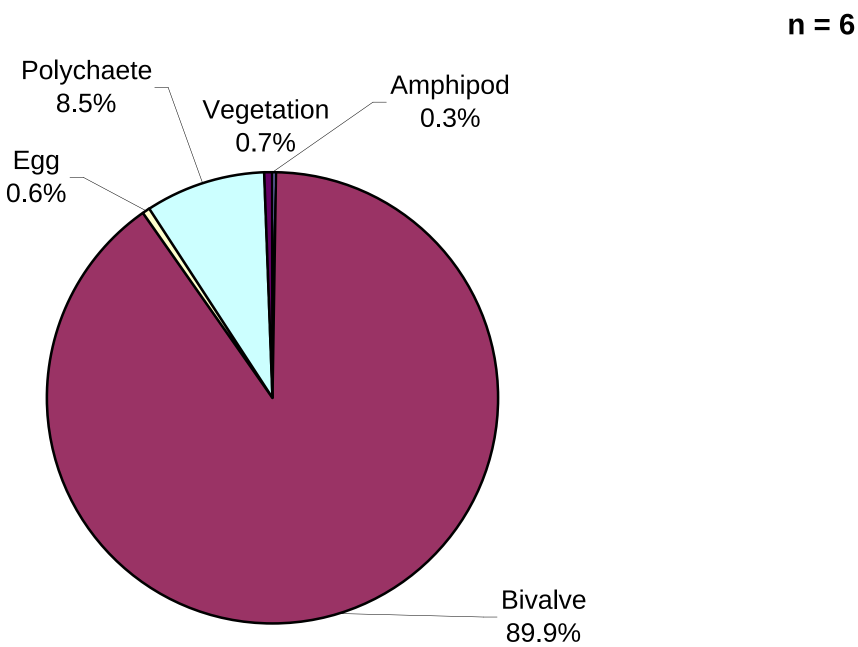


FIGURE 43-30
Index of Relative Importance of Food Items in Stomach Contents of Starry Flounder, 2008

Notes: n = number of replicates

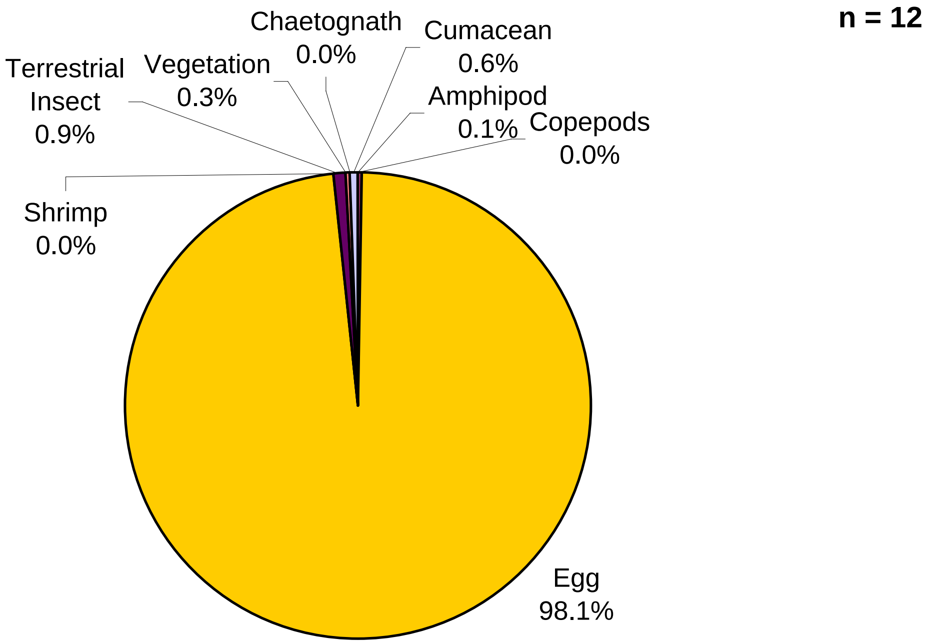


FIGURE 43-31
Index of Relative Importance of Food Items in Stomach Contents of Dolly Varden at Station MPS1, 2008

Notes: n = number of replicates

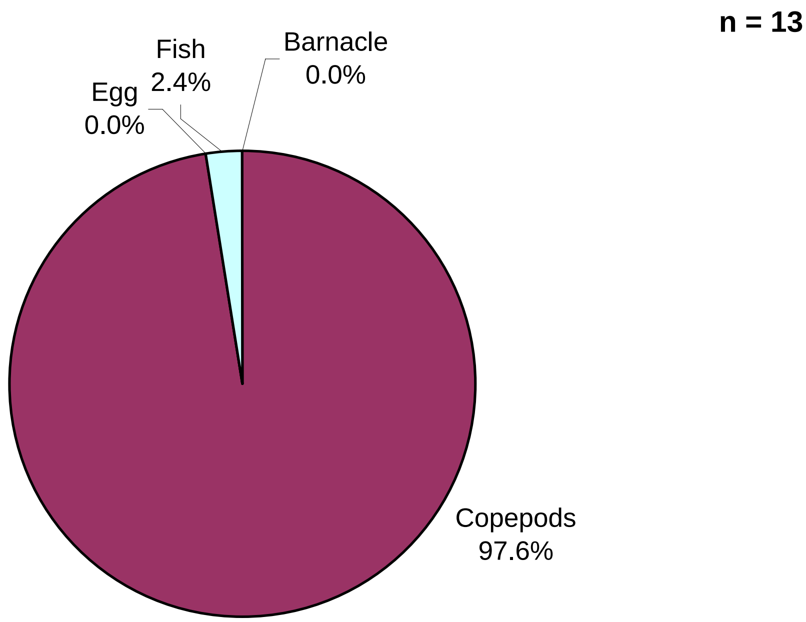


FIGURE 43-32
Index of Relative Importance of Food Items in Stomach Contents of Pacific Herring, 2008

Notes: n = number of replicates

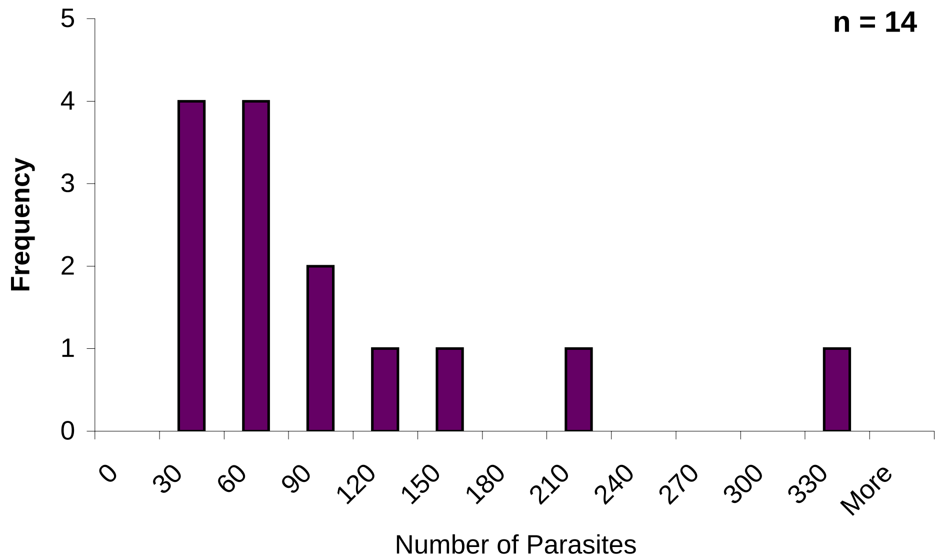


FIGURE 43-33
Frequency Distribution of Parasite Numbers in Stomach Contents of Pacific Herring, 2008

Notes: n = number of replicates
No bar means no fish were found to have the number of parasites within that range.

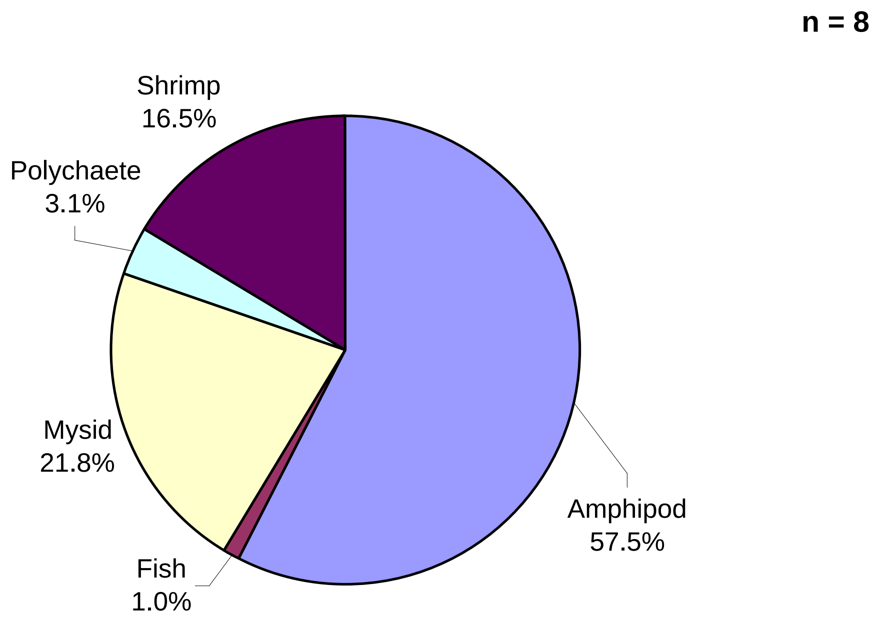


FIGURE 43-34

Index of Relative Importance of Food Items in Stomach Contents of Whitespotted Greenling, 2008

Notes: n = number of replicates

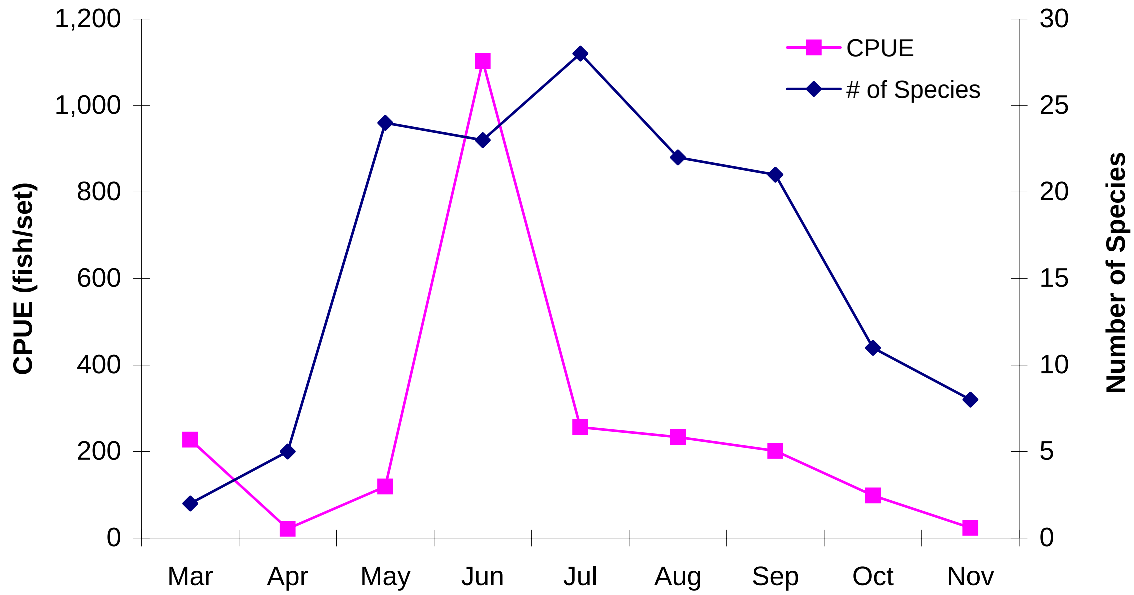


FIGURE 43-35

CPUE and Species Richness of the Fish Catch in 120-foot Beach Seine by Month, 2004 through 2008

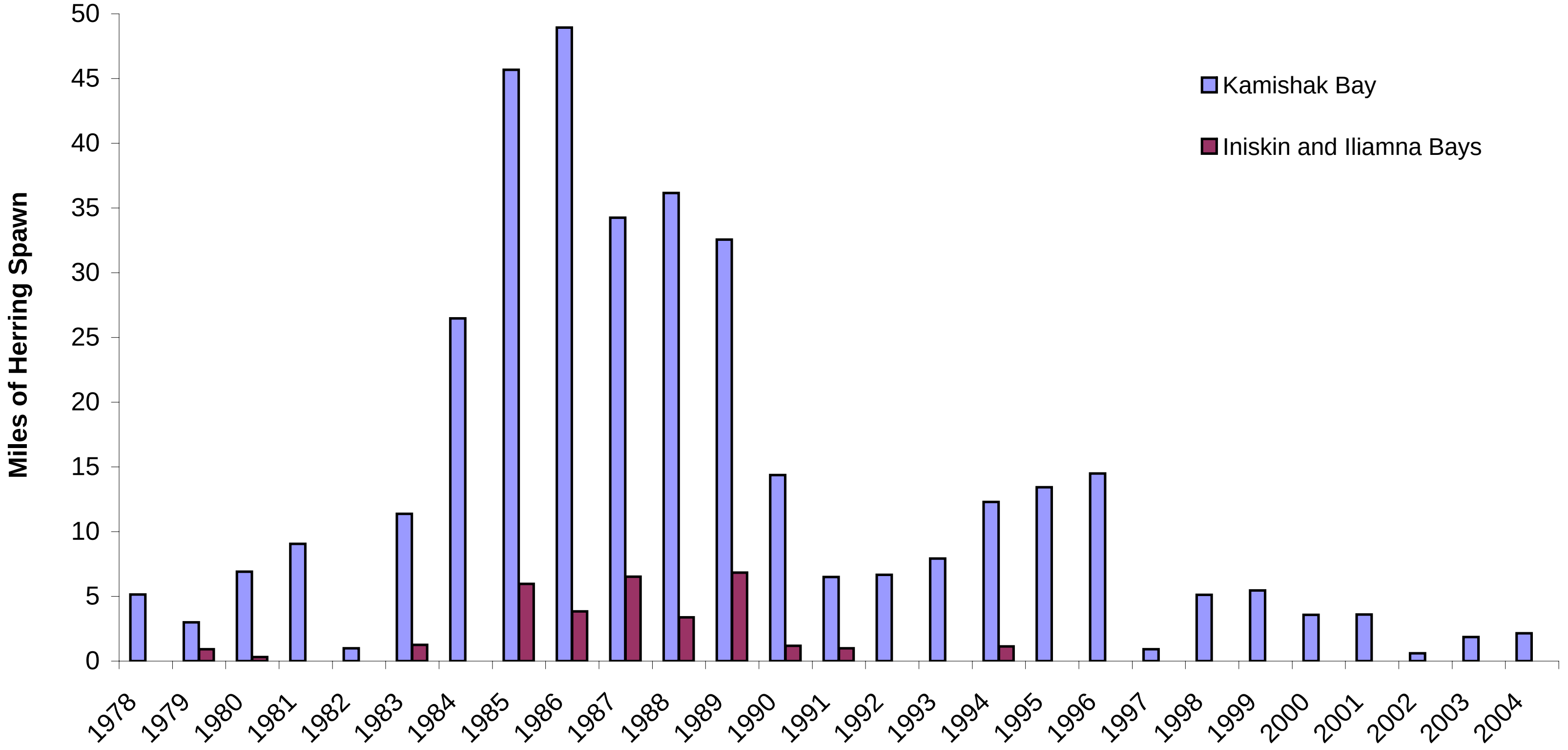


FIGURE 43-36
Miles of Herring Spawn in Iniskin and Iliamna Bays and in Kamishak Bay, 1978 through 2004

Notes: No bar represents no herring spawn observed

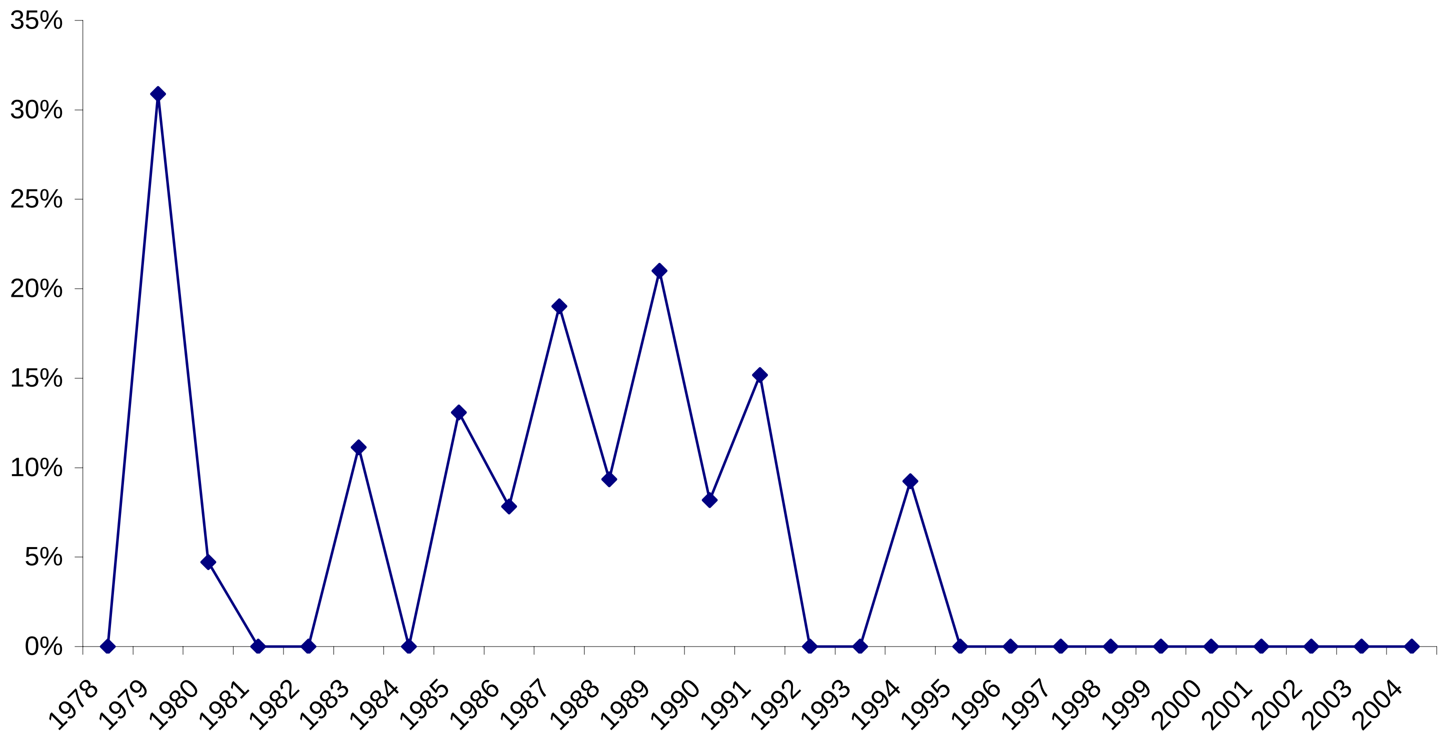


FIGURE 43-37
Percentage of Total Southwest Cook Inlet Herring Spawn Located within Iniskin and Iliamna Bays, 1978 through 2004

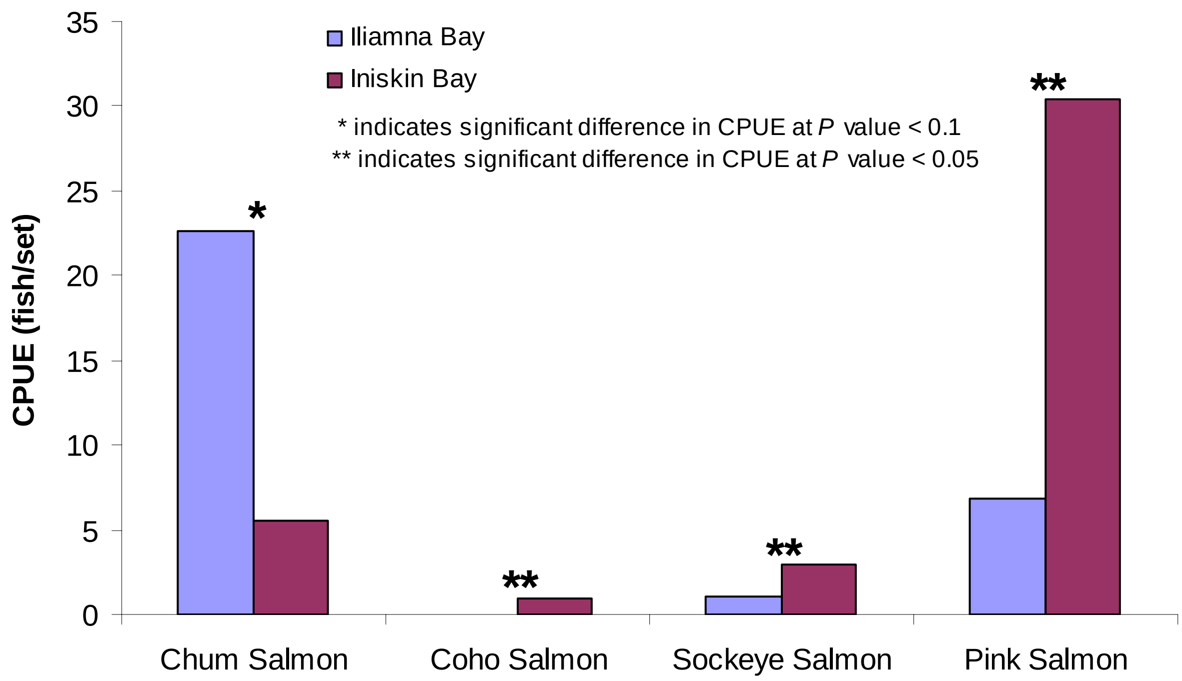
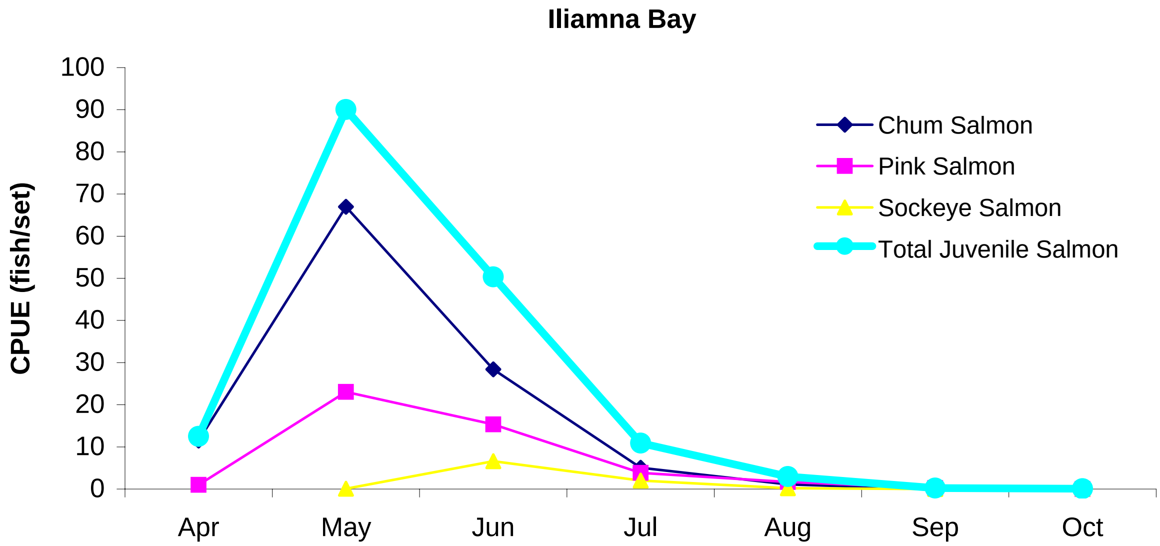


FIGURE 43-38
CPUE by Species for Juvenile Salmon Captured by 120-foot Beach Seine, Iliamna Bay and Iniskin Bay, 2004 through 2008

Notes: There appears to be no data for coho in Iliamna Bay because the value is so small that the bar is not visible at this scale.



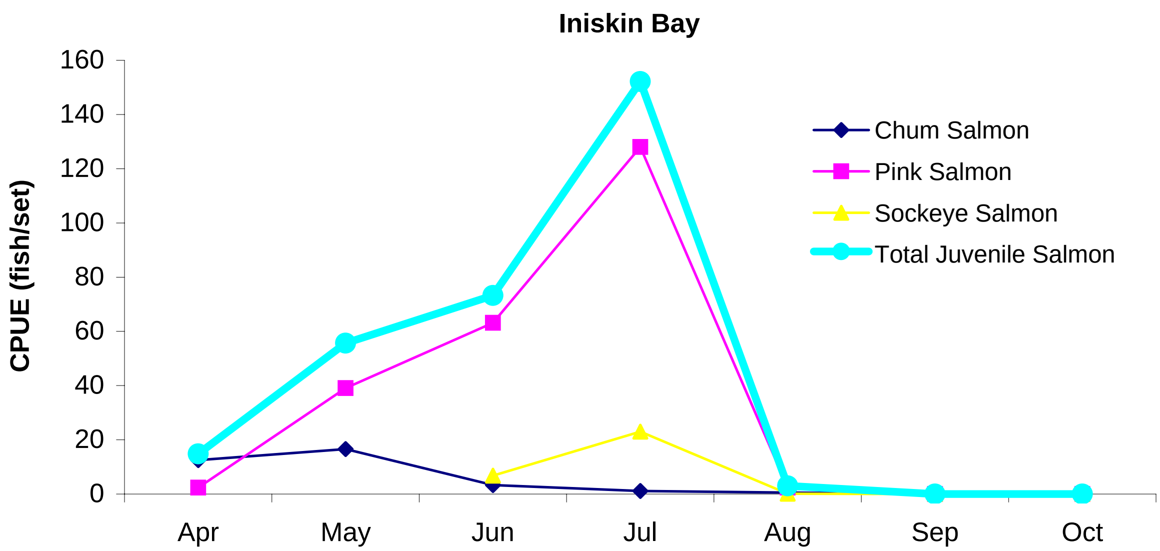


FIGURE 43-39

CPUE by Month for Juvenile Salmon Captured by 120-foot Beach Seine, Iliamna Bay and Iniskin Bay, 2004 through 2008

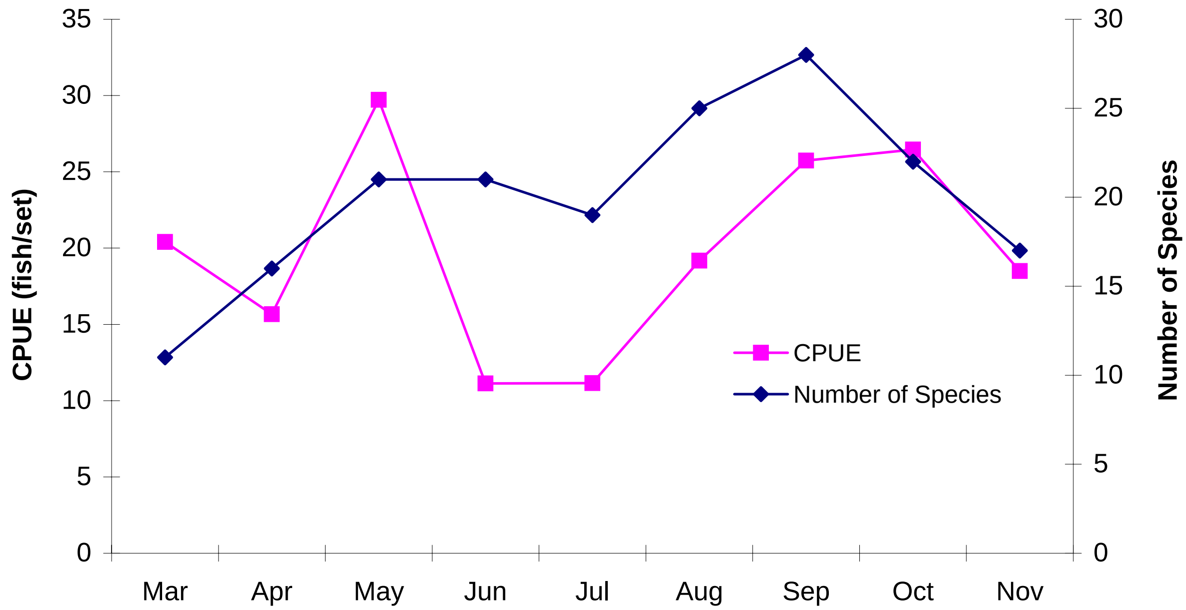


FIGURE 43-40
CPUE and Species Richness of the Fish Catch in Otter Trawls by Month, 2004 through 2008

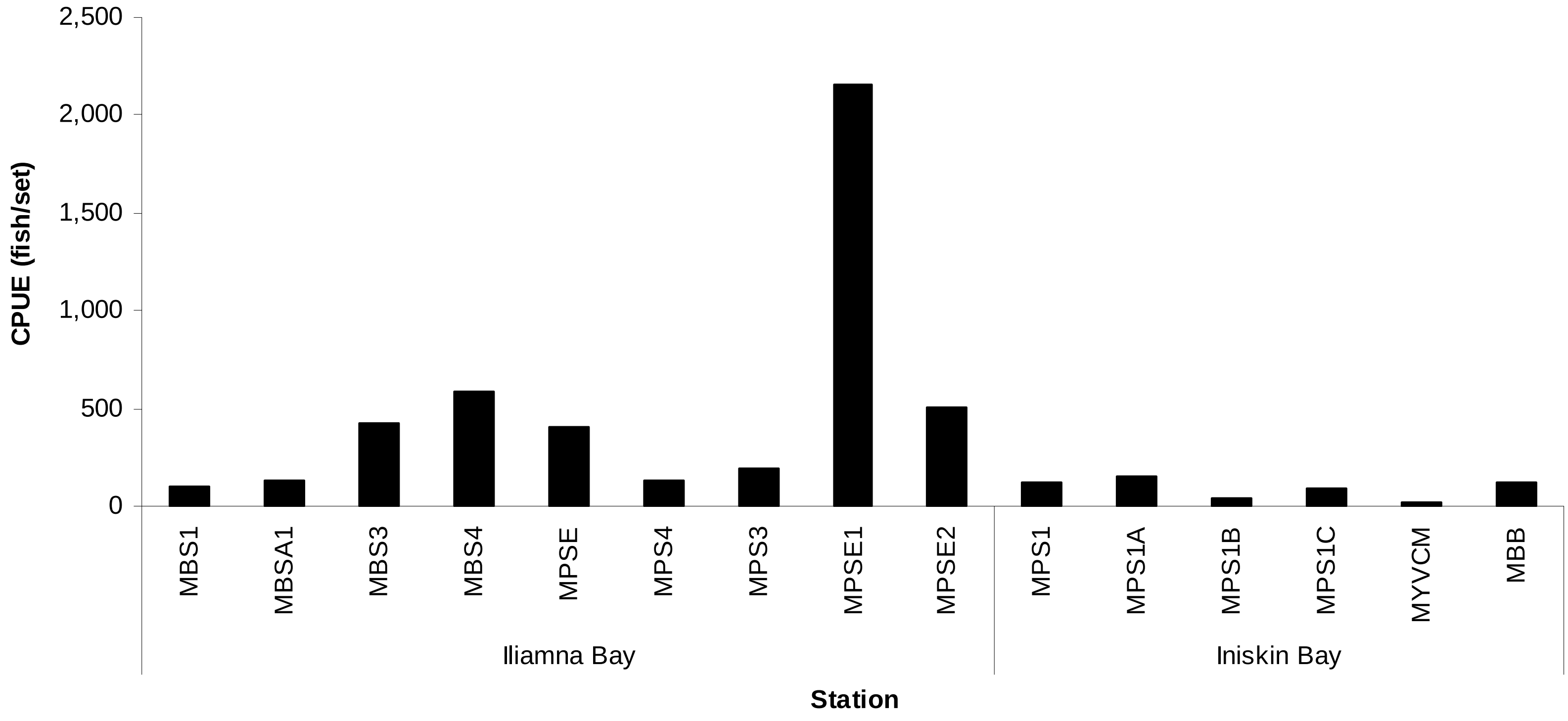


FIGURE 43-41
CPUE by Station for Fish Captured by 120-foot Beach Seine, Iliamna and Iniskin Bays, 2004 through 2008

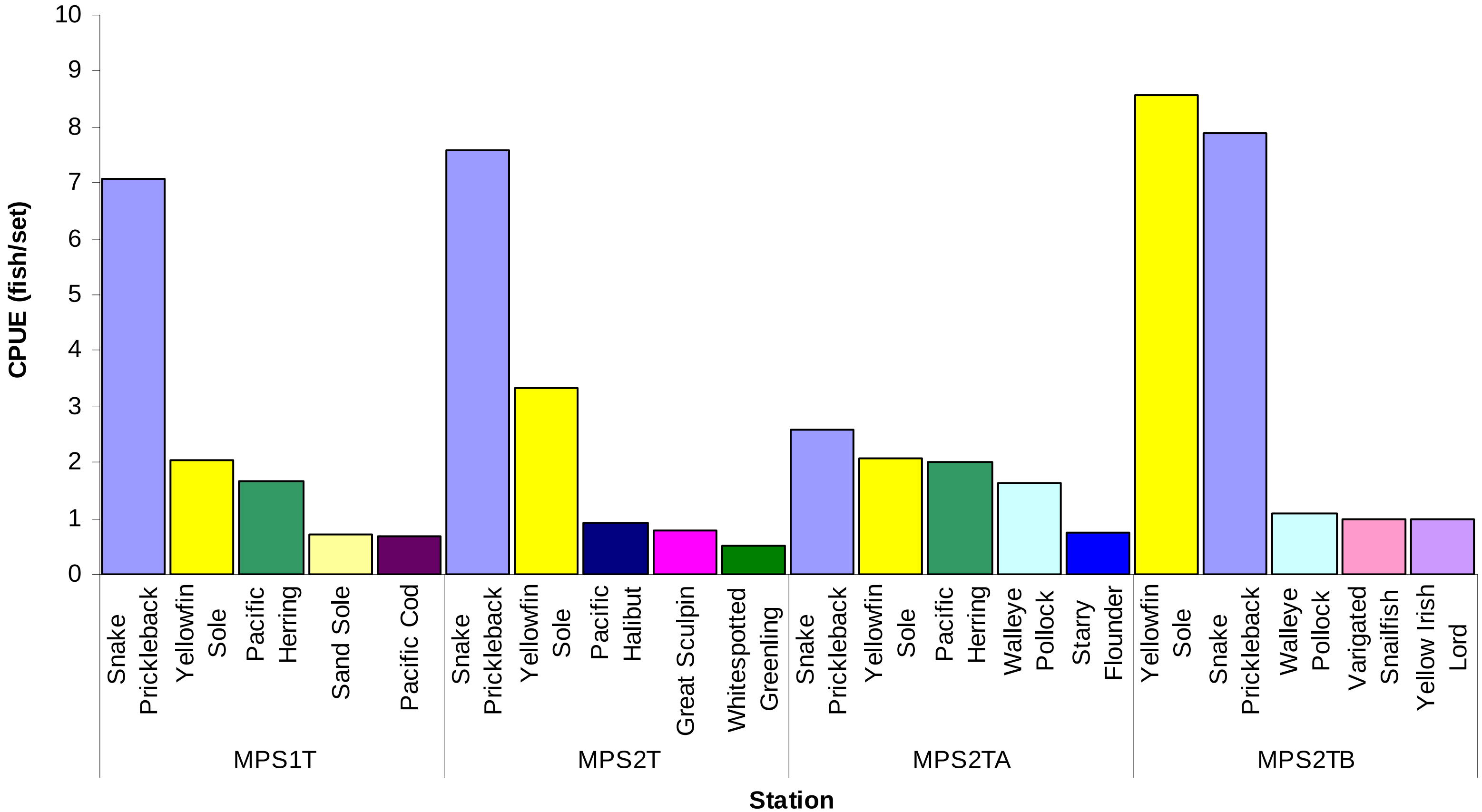


FIGURE 43-42

CPUE by Station for the Five Most Common Fish Captured by Otter Trawl, Iniskin Bay, 2004 through 2008

APPENDICES

Appendix 43A

CPUE by Station for Macroinvertebrates

Appendix 43A - CPUE by Station for Macroinvertebrates Captured by Otter Trawl, 2004 through 2008

	Iniskin Bay				Iliamna Bay				Mean
Taxon	MPS1T	MPS2T	MPS2TA	MPS2TB	MTR4	MTR1	MTR2	MTR3	CPUE
Abietinaria abietina				0.06					0.01
Acanthodoris pilosa	3.53			0.06		0.16			0.55
Acanthodoris sp.			0.05	0.06					0.02
Acanthomysis pseudomacropsis	11.63						0.26		1.74
Alcyonidium pedunculatum				0.06					0.01
Alcyonidium polyoum				0.06					0.01
Alcyonidium sp.	0.11	0.05	0.09	1.94	35.00				0.58
Amphipod (unid.)	0.05						0.05		0.02
Ampithoe dalli	0.11	0.38	0.14	0.06		0.16	0.32		0.18
Ampithoe spp.			0.05						0.01
Anisogammarus pugettensis	0.05						0.11		0.02
Anonyx lilljeborgi			0.05						0.01
Anthomedusae						0.05			0.01
Aplidium sp.								0.09	0.01
Argis dentata		0.05							0.01
Ascidiacea						0.68	0.05		0.11
Asteroidea	0.79	0.10	0.09	0.17		0.32	0.16		0.24
Atylus tridens			0.05	0.22			0.79	0.82	0.22
Balanus crenatus				0.06					0.01
Balanus sp.	9.89	2.38	22.86	21.61		4.16	0.74	10.45	10.29
Beringus kennicottii				0.06					0.01
Bopyroides hyppolytes			0.09			0.05			0.02
Bryozoan (unid.)			0.18	0.06	17.00		0.05		0.18
Bugula pacifica				0.06					0.01
Byblis sp.	0.05								0.01
Calliostoma ligatum							0.05		0.01
Campanulariidae				0.06					0.01
Cancer magister	0.68	0.71		0.11			0.16	0.09	0.26
Cancer oregonensis	0.11								0.02
Cancer sp.		0.05	0.05						0.02
Caprella sp.				0.11					0.02
Carbasea carbasea				0.06					0.01
Caulibugula sp.						0.11			0.02
Cerebratulus sp.	0.05								0.01
Chaetozone sp.						0.05			0.01
Chionoecetes bairdi	2.84	0.48	2.36	0.61		0.16	0.84		1.12
Clinocardium nuttallii				0.06				0.09	0.02
Crab (unid.)	0.26	0.05	0.05				0.26		0.09
Crangon alaskensis	253.68	100.43	220.14	216.83		93.26	263.58	243.09	193.30
Crangon franciscorum	4.58	1.10	0.36	3.78			0.21	1.64	1.60
Crangon nigricauda				0.06					0.01
Crangon sp.	0.21	2.33	2.91	0.28	1,500.00	1.84	1.63	0.64	13.04
Cucumaria japonica							0.05		0.01
Cumacean (order)		0.05							0.01
Dendrobeania murrayana		0.10		0.06					0.02
Elassochirus tenuimanus	0.89	0.81	1.95	0.39		0.68	0.47		0.82
Eteone sp.						0.05			0.01
Eualus fabricii	0.16								0.02
Eucratea loricata				0.06					0.01
Euphausid sp.							0.05		0.01
Exogone sp.			0.05						0.01
Flabellina salmonacea						0.16			0.02
Flustra sp.			0.09	0.11					0.03
Flustrella sp.	0.16	0.05	0.14	0.22		0.05	0.05		0.10
Fusitriton oregonensis	0.05	0.10					0.26		0.06
Gnorimosphaeroma oregonensis				0.06					0.01
Harmothoe imbricata	0.05							0.09	0.02
Harmothoe sp.	0.42	0.95	0.95	0.56		1.00	0.26		0.64

Henricia leviuscula	0.05								0.01
Henricia tumida				0.06					0.01
Heptacarpus brevirostris	1.89	8.10	1.32	56.33		86.89	4.89	0.45	23.06
Heptacarpus camtschaticus		0.10		0.11		4.53			0.69
Heptacarpus decorus	0.16	0.05							0.03
Heptacarpus kincaidi						0.11		2.45	0.22
Heptacarpus sitchensis	1.79	0.29	0.14	0.50		6.74	0.58		1.47
Heptacarpus sp.				0.06		1.05			0.16
Heptacarpus stimpsoni		0.10	0.50	0.39		0.53			0.23
Heptacarpus stylus						2.05			0.30
Heptacarpus tenuissimus	1.42	1.05	3.05	2.89		14.63	1.58		3.66
Heptacarpus tridens	4.00	6.24	12.55	19.06		63.16	6.53	0.27	16.56
Hiatella arctica		0.05		0.17					0.03
Hirundinea		0.05							0.01
Hyale frequens	0.16	0.05	0.05	0.06			0.32		0.09
Hyas lyratus	1.37	0.48	2.05	2.72		1.26	1.58		1.42
Hydrozoa				0.06					0.01
Idotea fewkesi							0.05		0.01
Ischnochiton sp.						0.05			0.01
Ischyrocerus sp.	2.11	0.14		2.89		0.11	1.95		1.03
Lacuna crassior				1.22					0.17
Lacuna sp.	0.37	0.05		0.22			0.05		0.10
Lacuna vincta	0.79	0.38	0.91	0.11		0.26	0.42		0.45
Lagunogammrus setosus	0.26		0.23	0.28		0.21	3.53	6.55	1.22
Lebbeus groenlandicus	1.16	0.62	1.14	2.78		0.37	0.26	0.18	0.95
Leptasterias hexactis							0.05		0.01
Leptasterias polaris						0.21	0.05		0.04
Leptasterias polaris ascervata	0.05			0.06		0.05			0.02
Leptasterias polaris katherinae	0.05	0.05							0.02
Leptasterias sp.	0.21			0.11		1.00	0.05	0.18	0.22
Littorina sitkana								0.09	0.01
Lyssianasidae						0.05			0.01
Macoma baltica	0.05								0.01
Macoma calcarea	0.11								0.02
Macoma sp.						0.16			0.02
Margarites pupillus		0.05	0.05						0.02
Melita dentata	0.05	0.10	0.09	0.06					0.05
Melita sp.	0.11		0.09			0.05	0.05	0.09	0.05
Mnemiopsis sp.								0.18	0.02
Modiolus modiolus			0.05						0.01
Monoculodes spp.		0.43	0.27			0.11	0.68		0.23
Mopalia spp.							0.05		0.01
Mya sp.							0.05		0.01
Mysidacea					35.00	0.05			0.28
Neanthes limnicola						0.21			0.03
Neanthes sp.			0.32			0.11	0.11		0.08
Nemertea				0.06					0.01
Neomysis czerniavsky	0.42						1.95		0.35
Neomysis mercedis	0.05	0.05	0.18	0.22		0.32	0.95		0.26
Neomysis rayii	187.74	15.67	55.59	110.00		100.63	63.26	184.09	94.14
Neomysis sp.	2.68	6.38	8.68	3.17		5.58	16.79	21.55	8.42
Nephtys ciliata						0.05			0.01
Nephtys sp.						0.05		0.09	0.02
Neptunea lyrata	0.68	0.29	1.14	0.11			0.47		0.42
Neptunea pribiloffensis							0.05		0.01
Neptunea sp.	0.05								0.01
Nucella lamellosa		0.24	0.14						0.06
Nucella sp.	0.63	0.33	0.27	0.11			0.21		0.24
Nudibranch (unid.)	0.05		0.50	0.22		0.26		0.09	0.17
Nymphon grossipes	0.05	0.05	0.18	0.33			0.05		0.10
Nymphon sp.						0.05			0.01

Onchidoris bilamellata		0.29	0.14	1.28		0.63			0.34
Ophiosphalma jolliense		0.10							0.02
Ophiosphalma sp.		0.10							0.02
Ophiura lutkeni		0.10							0.02
Ophiura sp.		0.10							0.02
Ophiuridae	0.11	0.33							0.07
Oregonia gracilis	2.00	3.33	3.41	3.83		5.16	3.79	0.36	3.28
Pagarus beringanus	1.21	3.19	3.14	0.61		4.42	1.47		2.17
Pagarus capillatus	0.05								0.01
Pagarus hirsutiusculus		0.10				0.05			0.02
Pagarus ochotensis	0.05	0.05	0.27	0.44		0.11	0.42		0.20
Pagurus armatus	0.16	0.14	0.95	0.06		0.11	0.26		0.27
Pagurus caurinus	0.26	0.05	1.14	0.39		0.47	0.68		0.46
Pagurus kennerlyi	1.58	2.38	2.41	0.22		0.26	0.05		1.10
Pagurus sp.	3.79	3.00	2.77	0.72		1.37	0.84	0.09	1.94
Pandalus danae	31.47	22.19	3.64	8.61		244.11	14.47	1.45	47.91
Pandalus goniurus	135.42	272.29	205.95	359.44		310.53	44.05	1.18	200.32
Pandalus hypsinotus			0.14						0.02
Pandalus sp.	0.05	23.86					0.05		3.87
Pandalus tridens	1.21			0.67		0.11	0.11		0.30
Pherusa plumosa						0.05			0.01
Pisaster brevispinus	0.05					0.47	0.05	0.09	0.09
Pisaster ochraceous						0.16			0.02
Platynereis bicanaliculata						0.11			0.02
Pleustes depressa	0.05								0.01
Pleusymtes sp.				0.06					0.01
Polinices lewisii	0.05	0.05	0.14						0.04
Polychaeta	0.42	0.33	0.27	0.67		0.68		0.18	0.37
Polynoidae (family)			0.14			0.11	0.05		0.05
Polyorchis penicillatus	4.89	2.62	2.86	5.56		6.21	3.37	6.36	4.33
Pontogenia rostrata		0.05							0.01
Porifera	0.21	0.14	0.09				0.05		0.08
Pseudione sp.			0.05						0.01
Pugettia gracilis	0.16	0.29	0.32	1.06		0.05	0.32	0.09	0.33
Rhamphostomella costata				0.06					0.01
Sabellidae (family)						0.11			0.02
Schisturella cocula				0.06			0.05		0.02
Schizobranchia insignis						1.58			0.23
Sclerocrangon boreas	1.37	2.86	1.86	1.22		9.16	1.47		2.70
Selaginopsis cylindrica				0.06					0.01
Snail unid.	0.11	0.33	0.45	0.17		0.32	0.21		0.25
Spirontocaris ochotensis	4.16	6.48	0.59	2.00		32.84	4.74	0.36	7.55
Spirontocaris prionata	0.26	0.38		0.22		2.05	0.11	0.09	0.45
Spirontocaris snyderi				0.17					0.02
Stegophiura nodosa		0.10							0.02
Stenothoidae	0.42			0.06					0.07
Suberites sp.	0.26	0.86	0.77	0.28		1.32			0.54
Telemessus cheiragonus	0.47	0.19	0.05	0.28		1.53	0.58		0.45
Terebellidae (family)						0.05			0.01
Thelepus setosus						0.05	0.16		0.03
Thuiaria sp.				0.06					0.01
Tonicella lineata							0.05		0.01
Trichotropis cancellata		0.33		0.06		0.16	0.26		0.12
unid. Anemone		0.05							0.01
unid. Egg Case							0.05		0.01
Urticina lofotensis				0.06					0.01
Velutina velutina						0.05	0.05		0.02
Yolida seminuda	0.21								0.03
All Species	689.37	498.10	573.68	840.56	1,587.00	1,018.21	454.79	483.55	663.09
Number of Species	80	76	68	89	4	81	77	32	
Number of Sets	19	21	22	18	1	19	19	11	130

Appendix 43B

CPUE by Month for Macroinvertebrates

Appendix 43B - CPUE by Month for Macroinvertebrates Captured by Otter Trawl, 2004 through 2008

Taxon	Mar 2008	Apr 2006, 2008	May 2005, 2006, 2008	Jun 2005, 2008	Jul 2005, 2008	Aug 2004, 2005, 2008	Sep 2006, 2007, 2008	Oct 2007, 2008	Nov 2008	Mean CPUE
Abietinaria abietina						0.07				0.01
Acanthodoris pilosa			0.21	0.07		4.40				0.55
Acanthodoris sp.			0.14							0.02
Acanthomysis pseudomacropsis				0.17		14.73				1.74
Alcyonidium pedunculatum						0.07				0.01
Alcyonidium polyoum		0.08								0.01
Alcyonidium sp.	0.40				0.14		3.38			0.58
Amphipod (unid.)		0.08		0.03						0.02
Ampithoe dalli	2.40	0.23			0.14		0.05	0.08	0.67	0.18
Ampithoe spp.						0.07				0.01
Anisogammarus pugettensis		0.23								0.02
Anonyx lilljeborgi		0.08								0.01
Anthomedusae			0.07							0.01
Aplidium sp.					0.07					0.01
Argis dentata				0.03						0.01
Ascidiacea			0.07	0.45						0.11
Asteroidea			0.07	0.48		0.53	0.38			0.24
Atylus tridens								1.62	1.33	0.22
Balanus crenatus						0.07				0.01
Balanus sp.			5.64	31.62		22.80				10.29
Beringus kennicottii								0.08		0.01
Bopyroides hyppolytes								0.08	0.33	0.02
Bryozoan (unid.)	0.80					0.07	0.86			0.18
Bugula pacifica						0.07				0.01
Byblis sp.									0.17	0.01
Calliostoma ligatum	0.20									0.01
Campanulariidae						0.07				0.01
Cancer magister			1.43	0.38		0.07	0.05	0.08		0.26
Cancer oregonensis				0.03				0.08		0.02
Cancer sp.		0.15								0.02
Caprella sp.									0.33	0.02
Carbasea carbasea						0.07				0.01
Caulibugula sp.					0.14					0.02
Cerebratulus sp.									0.17	0.01
Chaetozone *sp*									0.17	0.01
Chionoecetes bairdi	1.40	0.08	0.14	0.17	0.14	0.20	4.14	2.38	1.33	1.12
Clinocardium nuttallii				0.03			0.05			0.02
Crab (unid.)				0.21	0.07	0.33				0.09
Crangon alaskensis	923.00	262.23	57.21	36.52	42.14	265.67	200.29	392.15	227.67	193.30
Crangon franciscorum					0.07		6.10	5.62	1.00	1.60
Crangon nigricauda					0.07					0.01
Crangon sp.			2.64	1.59	5.50		73.10			13.04
Cucumaria japonica						0.07				0.01
Cumacean (order)							0.05			0.01
Dendrobeania murrayana	0.40					0.07				0.02
Elassochirus tenuimanus	3.80	0.46	0.50	0.52	0.64	0.73	1.29	0.69	0.50	0.82
Eteone sp.			0.07							0.01
Eualus fabricii				0.03			0.10			0.02
Eucratea loricata						0.07				0.01
Euphausid sp.		0.08								0.01
Exogone sp.				0.03						0.01
Flabellina salmonacea			0.21							0.02
Flustra sp.				0.10		0.07				0.03
Flustrella sp.			0.07	0.28		0.27				0.10
Fusitriton oregonensis			0.07	0.14		0.07	0.05	0.08		0.06
Gnorimosphaeroma oregonensis				0.03						0.01
Harmothoe imbricata								0.15		0.02
Harmothoe sp.	1.20					0.33	0.57	2.15	5.33	0.64
Henricia leviuscula					0.07					0.01
Henricia tumida					0.07					0.01

Heptacarpus brevirostris	87.40	2.38	2.36	38.52	1.29	20.00	2.57	51.23	57.00	23.06
Heptacarpus camtschaticus			2.00	0.10		3.93				0.69
Heptacarpus decorus				0.03		0.20				0.03
Heptacarpus kincaidi		0.15			1.93					0.22
Heptacarpus sitchensis				3.72		0.73	1.90	2.00	1.00	1.47
Heptacarpus sp.		0.08			1.43					0.16
Heptacarpus stimpsoni				0.07			1.19	0.23		0.23
Heptacarpus stylus		0.54						2.46		0.30
Heptacarpus tenuissimus	4.00	0.31			1.50	1.47	10.71	10.69	7.50	3.66
Heptacarpus tridens	2.00	0.92		3.10	2.21	0.40	34.76	83.46	31.50	16.56
Hiatella arctica		0.23				0.07				0.03
Hirundinea				0.03						0.01
Hyale frequens		0.08		0.07	0.57				0.17	0.09
Hyas lyratus	1.60	0.62	1.36	0.93	0.43	6.47	0.67	0.38		1.42
Hydrozoa				0.03						0.01
Idotea fewkesi									0.17	0.01
Ischnochiton sp.			0.07							0.01
Ischyrocerus sp.			0.07	0.10				3.31	14.50	1.03
Lacuna crassior						1.47				0.17
Lacuna sp.				0.31			0.19			0.10
Lacuna vincta		0.54	0.50			0.40	1.81			0.45
Lagunogammrus setosus	1.20			0.10	1.43	1.13	0.19	6.92	3.00	1.22
Lebbeus groenlandicus		0.08		0.14		1.13	2.33	2.92	2.50	0.95
Leptasterias hexactis							0.05			0.01
Leptasterias polaris	0.40						0.14			0.04
Leptasterias polaris ascervata		0.15	0.07							0.02
Leptasterias polaris katherinae									0.33	0.02
Leptasterias sp.	0.40		0.21	0.52	0.36	0.07	0.10			0.22
Littorina sitkana				0.03						0.01
Lyssianasidae							0.05			0.01
Macoma baltica							0.05			0.01
Macoma calcarea								0.15		0.02
Macoma sp.			0.07			0.13				0.02
Margarites pupillus		0.08					0.05			0.02
Melita dentata		0.08		0.03	0.14	0.13				0.05
Melita sp.	0.20	0.08	0.07	0.07		0.07		0.08		0.05
Mnemiopsis sp.					0.14					0.02
Modiolus modiolus		0.08								0.01
Monoculodes spp.	5.60								0.33	0.23
Mopalia spp.					0.07					0.01
Mya sp.			0.07							0.01
Mysidacea			0.07				1.67			0.28
Neanthes limnicola								0.23	0.17	0.03
Neanthes sp.				0.07	0.64					0.08
Nemertea						0.07				0.01
Neomysis czerniavsky			2.64	0.28						0.35
Neomysis mercedis	0.20				1.29		0.19	0.38	1.00	0.26
Neomysis rayii	440.20	310.54	27.64	8.48	29.50	117.40	2.24	230.85	24.17	94.14
Neomysis sp.		46.62	1.00	0.10			5.95	26.69		8.42
Nephtys ciliata						0.07				0.01
Nephtys sp.		0.08						0.08		0.02
Neptunea lyrata		0.38	0.07	0.79	0.07	0.07	0.95	0.31		0.42
Neptunea pribiloffensis							0.05			0.01
Neptunea sp.							0.05			0.01
Nucella lamellosa		0.15		0.10			0.10	0.08		0.06
Nucella sp.				0.97	0.21					0.24
Nudibranch (unid.)				0.31	0.64	0.07	0.14			0.17
Nymphon grossipes				0.14	0.36	0.27				0.10
Nymphon sp.									0.17	0.01
Onchidoris bilamellata		1.69		0.28	0.07		0.29		1.17	0.34
Ophiosphalma jolliense				0.07						0.02
Ophiosphalma sp.			0.07	0.03						0.02
Ophiura lutkeni			0.14							0.02
Ophiura sp.					0.07		0.05			0.02
Ophiuridae				0.21	0.21					0.07
Oregonia gracilis	1.20	1.23	1.29	2.55	3.29	4.07	3.95	6.08	7.17	3.28

Pagarus beringanus	10.00	2.15	1.29	1.52	1.93	1.60	1.76	1.92	4.83	2.17
Pagarus capillatus						0.07				0.01
Pagarus hirsutiusculus			0.14					0.08		0.02
Pagarus ochotensis			0.14		0.07	1.20	0.14	0.15		0.20
Pagurus armatus			0.29		0.14		1.24	0.15	0.17	0.27
Pagurus caurinus	4.40	0.77		0.24	0.36	0.33	0.19	0.54		0.46
Pagarus kennerlyi	2.80	1.54	1.21	1.07	1.14	0.40	0.48	1.53	1.50	1.10
Pagurus sp.		0.62	2.00	3.62	0.29	2.73	2.71	0.69		1.94
Pandalus danae	35.40	2.38	0.07	2.66	23.64	58.80	48.14	237.38	105.33	47.91
Pandalus goniurus	215.20	84.23	361.43	55.14	30.43	265.40	204.00	522.62	287.83	200.32
Pandalus hypsinotus		0.23								0.02
Pandalus sp.			35.71	0.03			0.10			3.87
Pandalus tridens		0.08	0.29	0.07	2.29					0.30
Pherusa plumosa						0.07				0.01
Pisaster brevispinus	0.40			0.03	0.07	0.07	0.10	0.15	0.50	0.09
Pisaster ochraceous							0.14			0.02
Platynereis bicanaliculata						0.13				0.02
Pleustes depressa								0.08		0.01
Pleusymtes sp.		0.08								0.01
Polinices lewisii			0.07	0.10				0.08		0.04
Polychaeta	0.20	0.85	0.07	0.17	0.79	0.73	0.05	0.54		0.37
Polynoidae (family)			0.14	0.10			0.05			0.05
Polyorchis penicillatus				1.10	1.14	8.47	18.48			4.33
Pontogenia rostrata		0.08								0.01
Porifera	0.40			0.28						0.08
Pseudione sp.									0.17	0.01
Pugettia gracilis			0.14	0.03	1.93	0.67	0.05	0.15		0.33
Rhamphostomella costata						0.07				0.01
Sabellidae (family)						0.13				0.02
Schisturella cocula									0.33	0.02
Schizobranchia insignis			2.14							0.23
Sclerocrangon boreas	7.80	0.77	0.64	0.90	1.43	0.73	1.90	10.08	10.83	2.70
Selaginopsis cylindrica						0.07				0.01
Snail unid.		0.15	0.43	0.79			0.05			0.25
Spirontocaris ochotensis	34.60		0.57	1.41	2.93	5.20	4.62	29.62	26.50	7.55
Spirontocaris prionata		0.08		0.07	0.29	0.47	0.52	1.85	1.67	0.45
Spirontocaris snyderi								0.23		0.02
Stegophiura nodosa					0.14					0.02
Stenothoidae							0.29	0.15	0.17	0.07
Suberites sp.	3.20	0.85	0.57	0.55	0.21	0.53	0.38			0.54
Telemessus cheiragonus			0.14	0.52	0.43	0.67	0.48	1.15	0.17	0.45
Terebellidae (family)			0.07							0.01
Thelepus setosus	0.80									0.03
Thuiaria sp.						0.07				0.01
Tonicella lineata						0.07				0.01
Trichotropis cancellata	0.40	0.15		0.17	0.14	0.07		0.31		0.12
unid. Anemone				0.03						0.01
unid. Egg Case	0.20									0.01
Urticina lofotensis							0.05			0.01
Velutina velutina	0.20	0.08								0.02
Yolida seminuda								0.31		0.03
All Species (CPUE)	1,794.00	725.85	515.93	205.86	166.93	819.47	648.71	1,643.54	830.83	663.09
Number of Species	36	50	55	76	56	72	66	55	42	
Number of Sets	5	13	14	29	14	15	21	13	6	130