

OVERVIEW OF STATE-MANAGED MARINE FISHERIES IN THE CENTRAL
AND WESTERN GULF OF ALASKA, ALEUTIAN ISLANDS,
AND SOUTHEASTERN BERING SEA,
WITH REFERENCE TO STELLER SEA LIONS



By

Gordon H. Kruse, Fritz C. Funk, Harold J. Geiger, Kristin R. Mabry,
Herman M. Savikko, and Shareef M. Siddeek

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Alaska Department of Fish and Game
Division of Commercial Fisheries
P.O. Box 25526
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1. EXECUTIVE SUMMARY

The purpose of this report is to provide information to the National Marine Fisheries Service (NMFS) on fisheries managed by the State of Alaska for consideration in their analysis of the potential cumulative impacts of all fisheries on the endangered status of the western population of Steller sea lion. Specifically, we attempted to answer the following 11 questions that were posed to us: (1) what fisheries occur?; (2) when does each fishery occur?; (3) where does each fishery occur?; (4) what are the status and trends of the fished stock?; (5) what is the biomass available?; (6) what are the stock assessment methods?; (7) what is the catch?; (8) what methods are used to monitor and assess catch?; (9) what is the harvest rate?; (10) what gear types are used?; and (11) what interactions occur with Steller sea lions?

In an attempt to answer these questions to the best of our ability within a very limited time frame specified in the request, we queried the state's electronic database of fish tickets (records of landings). To make the project manageable, we established a number of sideboards including confining our consideration to fisheries in the central and western Gulf of Alaska west of 144° W longitude and in the southeastern Bering Sea that delimits the primary region of NMFS concern about Steller sea lions. Using 1999 as the baseline for analysis, landings data were summarized by fishery, gear type, month and by individual statistical areas within the larger management areas. Detailed maps were made in a Geographic Information System using ArcView. Species were categorized into four groups for analysis: herring, salmon, invertebrates and groundfish. Borrowing from published annual management reports and the expertise of regional fishery management staff, we compiled a history of each fishery, attributes of contemporary fisheries, and readily available information on interactions between the fisheries and Steller sea lions.

In 1999, 37,000 mt of herring were harvested in fisheries from Southeast Alaska to Norton Sound in the eastern Bering Sea. Harvests were below the 10-year average of 49,000 mt owing to lower abundance in some areas. Most herring fisheries are conducted in a very brief time period during spring when herring migrate to the shore for spawning.

The second largest volume of salmon in Alaska's history, 404,000 mt, were harvested in 1999. This near record harvest was driven by record pink salmon returns in Southeast Alaska and Prince William Sound. Healthy catches of sockeye salmon were taken in many areas, and the chum salmon return to Southeast Alaska was very large. Most salmon fisheries in coastal waters occur as the adults migrate in route to their natal streams for spawning.

Most crab fisheries in the central and western Gulf of Alaska and eastern Bering Sea were not opened in 1999 owing to low abundance. Among those fisheries that were opened, catches included 88,088 mt of snow crabs from the eastern Bering Sea, 5,369 mt of red king crabs in Bristol Bay and 14 mt in Norton Sound, 2,457 mt of golden king crabs from the Aleutian Islands area, and 101 mt of hair crabs among a few others. Harvests of other invertebrates included weathervane scallops, shrimp, sea cucumbers and clams. Most, but not all, crab fisheries occur in the winter to optimize meat yield and avoid fisheries during molting and mating periods.

In the geographic region considered in this report, the State of Alaska manages a few groundfish fisheries that include lingcod and black and blue rockfishes throughout state and federal waters, and several fisheries in state waters only: pollock in Prince William Sound; sablefish in Prince William Sound, Cook Inlet, and the South Alaska Peninsula to the West Aleutian Islands; all rockfish species in Prince William Sound and Cook Inlet, and Pacific cod in Prince William Sound, Cook Inlet, Kodiak, Chignik, and the South Alaska Peninsula. In 1999, state-managed fisheries yielded approximately 14,044 mt of Pacific cod, 2,087 mt of pollock, 253 mt of sablefish, 172 mt of rockfish, and 27 mt of lingcod. The groundfish fisheries are conducted at various times of the year depending on species and management area.

Because much of state waters fall within Steller sea lion critical habitat as defined by NMFS, many state-managed fisheries coincide with these areas. Individual fisheries occur within or outside sea lion critical habitats to varying degrees, but the patterns cannot be easily generalized.

In many instances, state fishing regulations are in addition to, and more conservative than, associated federal fishing regulations. For instance, most state waters in the central and western Gulf of Alaska are closed permanently to trawling. The state waters cod fishery is restricted to fixed gear only with restrictions on numbers of pots or jigs in an effort to provide for slow paced fisheries that minimize effects on habitat and other species. State regulations prohibit directed fisheries for sharks and, except for a few minor exceptions, no fisheries are permitted for forage fishes owing to their ecological role in the marine environment. Very strong resource conservation principles are imbedded in a number of policies that guide the Alaska Board of Fisheries in their development of state fishing regulations, including the *Sustainable Salmon Fishery Policy*, *Policy on King and Tanner Crab Resource Management*, and the *Guiding Principles for Groundfish Fishery Management*.

The authors hope that the information provided here is useful, not only to NMFS in their analysis of cumulative fishing impacts, but also to a broad spectrum of individuals with interests in Alaska's fisheries. In this report, we do not draw any conclusions about the potential relationships between state-managed fisheries and the decline of Steller sea lions, because this report is primarily intended for information dissemination, not detailed analysis of complex ecological and fishery relationships. However, we recommend some steps that we feel would be necessary to separate potential natural and human causes for the sea lion declines.

2. INTRODUCTION

2.1 Purpose and Scope of Report

On July 24, 2000, the National Marine Fisheries Service (NMFS)—Alaska Region requested that the Alaska Department of Fish and Game (ADF&G) provide specific information on state-managed fisheries. Information was sought by NMFS so that state fisheries could be considered in an analysis of the cumulative fishery impacts on the endangered western population of Steller sea lions (*Eumetopias jubatus*) along the coast of Alaska. The analysis is part of Endangered Species Act Section 7 Consultation – Biological Opinion (BiOp) expected to be completed by NMFS on October 31, 2000. Specifically, NMFS requested answers to the following questions for state-managed fisheries:

1. What fisheries occur?
2. When does each fishery occur?
3. Where does each fishery occur?
4. What are the status and trends of the fished stock?
5. What is the biomass available?
6. What are the stock assessment methods?
7. What is the catch?
8. What methods are used to monitor and assess catch?
9. What is the harvest rate?
10. What gear types are used?
11. What interactions occur with Steller sea lions?

The purpose of this report is to respond to this information request by answering these questions for state-managed fisheries as best as possible, given available information and very tight time constraints. This information was sought by mid to late September, and ADF&G provided draft chapters at the end of September and early October for use by NMFS in conducting their analysis. This document was completed and submitted in its entirety on October 12th. As just 2.5 months were available to complete the request and existing staff were fully tasked at the time of the request, this project was a substantial effort that is not without its glitches and caveats. Nonetheless, we remain hopeful that this report is useful, not only to NMFS for their analysis, but to others interested in Alaska marine fisheries.

Perhaps it is equally important to state what the report is *not* intended to do. This report is not intended to be the State of Alaska's BioOp. We made no attempt to analyze Steller sea lion populations and state-managed fisheries toward rendering any opinions on their potential interactions and causes of sea lion declines. We were not tasked with such a charge, and clearly such an attempt would be impossible given staffing and time constraints. Rather, this report is an attempt to provide factual answers to the stated 11 questions above to the best of our ability.

As the State of Alaska manages literally several hundreds of individual fisheries, it was impossible to answer all of these questions in detail for every fishery within the prescribed timeframe. Therefore, it was necessary to place several sideboards on the scope of this report. Geographically, we limited our report

to fisheries in the Aleutian Islands (AI) and Gulf of Alaska (GOA) west of 144° W longitude and in the southeastern Bering Sea (BS). These areas tended to delineate the region of primary concern by NMFS for the western population of Steller sea lions. So, fisheries southeast of Cape Suckling (e.g., Yakutat and Southeast Alaska), where sea lions are not endangered, and most fisheries north of Bristol Bay were excluded from this report. Also, the size of the fishery was a factor. Fisheries which produced very small landings and those for which landings were confidential (owing to fewer than three participants) were excluded from much consideration in this report. Also, we restricted our analysis to commercial fisheries data. In some areas of the state, recreational and subsistence harvests may be very important locally even surpassing commercial harvest. However, including them was not practical, given time constraints. We also confined our detailed catch reporting to the most recently completed calendar year, namely 1999. Although a general historical perspective is presented for each fishery group, it was not possible to report detailed catch statistics for multiple years, given time constraints. For a variety of reasons, the year 1999 may not be representative for some particular fisheries. Finally, we did not attempt to answer questions that required major data analyses or new data acquisitions. So, for instance, estimates of biomass and harvest rate are generally not available for most salmon fisheries, because they are managed by an escapement goal harvest strategy using numbers of fish unlike marine fish and invertebrates that tend to be enumerated as biomass and managed by harvest rate management strategies. Ultimately, such estimates could be generated for a number of salmon stocks, but substantial data analyses would be required.

To answer the eleven NMFS questions for each fishery, we took the following approach. First, we compiled a collection of annual management reports prepared by ADF&G regional and area staff. Second, we queried a statewide electronic database of landings, termed the fish ticket database, for each fishery. Answers to most “what” questions were presented in summary tables prepared separately for herring, salmon, invertebrate and groundfish fisheries. The “where” questions were answered by plotting the geographic distribution of catches by state statistical area within each major management area. The “when” questions were answered by plotting the monthly catches by gear type. Additionally, we prepared accompanying text that explains the fishery history, fishery description, and nature of documented interactions with Steller sea lions.

We formed an ADF&G headquarters task force headed by Gordon Kruse, and comprised of Fritz Funk, Kristin Mabry, Herman Savikko, and Shareef Siddeek and we later added Hal Geiger. We also formed two divisional working groups to help meet requests for additional fishery information and to serve as a review committee for interim drafts of individual chapters. The salmon/herring working group included Ted Otis, Lee Hammarstrom, Tim Joyce, Denby Lloyd, Rod Campbell, and Doug Eggers, Fritz Funk, and Kristin Mabry. The groundfish/shellfish working group included Charlie Trowbridge, Linda Brannian, Wayne Donaldson, Dave Jackson, Mike Ruccio, Gordon Kruse, Doug Eggers, and Kristin Mabry. These staff, and others listed in the Acknowledgments section of this report, deserve much credit for their invaluable assistance in the project.

Although the approach taken was designed to efficiently achieve the purpose of this report, there are at least four caveats that deserve mention. First, the primary source of fishery data, the fish ticket database, provides estimates of landings (i.e., deliveries) not catch (i.e., all fish and invertebrates

captured at sea). So, whereas it is common practice to use the terms *catch* and *landings* interchangeably in fisheries circles, as we sometimes do in this report, it is important to keep in mind that we really monitor landings. Second, the fish ticket database may contain some errors in coding that assigns the landings to particular statistical areas and gear types. Although the database provides excellent estimates of fishery harvests, non-critical data fields are subject to normal error rates. Thus, maps of landings by statistical area or bar charts of landings by gear type likely contain some errors in some cases. Because total catch monitoring is the primary use of the database, careful error checking would have been preferable before initiating this project, but it was impractical. Third, the smallest spatial resolution of a landing is a state statistical area – i.e., there is no latitude and longitude assigned to individual landings. So, maps showing catch by statistical area may be misleading with respect to the exact location of the fishery within each statistical area. For instance, in some pink salmon seine fisheries in Prince William Sound (PWS), fishers confine their fishing to a fraction of a statistical area, namely 2-3 seine lengths (i.e., about 0.5 nautical mile, nm, or 0.96 kilometer, km) of shore. So, pinpoint accuracy is impossible with the existing data set. Finally, pursuant to State of Alaska confidentiality statutes, ADF&G does not report landings represented by fewer than three entities. So, landings from individual commercial fisheries with fewer than three participants cannot be reported. Moreover, we cannot plot catches from fewer than three participants in particular statistical areas or in particular months of the year. In such cases, we tried to lump catches over all gear types or we simply present presence and absence of catch on maps to allow us to convey the most salient information about the fisheries.

2.2 Methods Used to Monitor Catches

One of the questions to be answered is: “What methods are used to monitor and assess catch?” As the answer to this question is largely the same for all state-managed fisheries, and as the catch data set is the primary source of information used to prepare this report, we thought it important to answer this question in the Introduction of this report.

The fish ticket database is the primary means of collecting data on commercial fisheries landings in Alaska. A fish ticket is basically a bill of sale that indicates how much fish of each species was delivered and purchased by a processor from a particular vessel on a given date. Note that landing enumeration by fish tickets differs from the product recovery rate methods of estimation used in many federally managed groundfish fisheries. The record includes other information, such as gear type, statistical and management area. A fish ticket is produced for each shoreside delivery. Catches made in a federally-managed groundfish fishery are included only if the vessel happened to deliver the catch to a shoreside plant. So, deliveries made to a floating or catcher-processor vessel outside of state waters are not contained in the database. On the other hand, all landings in state-managed fisheries are included. So, catches made in the high-seas crab fishery in the Bering Sea that are delivered to an offshore processor are included in the database because it is a state-managed fishery in which fish tickets are required.

Thanks partly due to law enforcement efforts, fish tickets are believed to be an excellent accounting of fishery landings. The State of Alaska maintains a Division of Fish and Wildlife Protection within the Department of Public Safety. The division maintains sea-going vessels and an active law enforcement

presence in Alaska that works cooperatively with federal enforcement agencies. Violators are vigorously prosecuted and hefty fines result from serious infractions.

ADF&G maintains other monitoring programs apropos to commercial catches. For instance, the Commercial Operators Annual Report database provides high quality information on seafood processing including price data. In addition, the department maintains monitoring programs to accurately describe the biological attributes of fishery removals. Typical fishery monitoring programs include dockside sampling of age, weight, and length, and other attributes of the catch. Such information, coupled to fishery independent stock assessment surveys, are used to estimate stock abundance in many fisheries. Moreover, ADF&G maintains onboard observer programs to monitor the total catch from certain fisheries, such as the scallop fishery in the GOA and BS/AI areas and aboard crab vessels that process catches at-sea in the BS/AI area. There are other limited state observer programs, but the scallop and crab programs are the main ones.

2.3 Review of Regulatory Regime

The following review of the regulatory regime for fisheries off Alaska is borrowed largely from Rigby et al. (1995). After statehood in 1959, the State of Alaska took management control of its fishery resources from the federal government. In fact, control of its fisheries was a primary incentive of the statehood movement. The federal and state roles in fisheries management, however, again changed in 1977. Since the creation of the Exclusive Economic Zone (EEZ) within 200 miles of U.S. coasts by the Magnuson Fishery Conservation and Management Act of 1976, which was since revised and renamed the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), fisheries off Alaska have been managed by a combination of state and federal regulatory agencies. ADF&G is the primary state fisheries management agency and NMFS is the primary federal fisheries management agency. In general, with the exception of some fisheries within the inside waters of Southeast Alaska and others described in chapter 7 of this report, NMFS is primarily responsible for management of groundfish fisheries off Alaska. On the other hand, in general, ADF&G is primarily responsible for management of fisheries for salmon, herring, crabs, and other invertebrates. However, in many instances, fishery management has evolved into a complex of state, federal, and international advisory and regulatory bodies that affect management of the fishery resources off Alaska.

Alaska's constitution is unique in that an entire section (Article VIII) is devoted to the management of natural resources. "Maximum benefit of its people" and "Management of renewable resources on a sustained yield basis" are two primary directives given to the legislature and executive branch by the state's constitution. To provide for an open public process and to give direction to ADF&G, the Alaska State Legislature created the Alaska Board of Fisheries (BOF). The BOF is responsible for developing fishery management plans, making allocative decisions, and promulgating regulations. ADF&G, which supports and takes direction from the BOF, has unique Emergency Order (EO) authority which provides ADF&G fishery managers with the essential ability to expeditiously open and close fisheries inseason. Besides its regulatory function, ADF&G has a substantial fisheries monitoring and research program to document catches inseason, assess stock condition, and determine appropriate harvest levels. Another state agency with regulatory authority is the Commercial Fisheries Entry Commission

(CFEC). CFEC has the authority to establish moratoria or limited entry systems for state-managed fisheries.

Several federal laws substantially direct the regulation of some of Alaska's fisheries and actions of NMFS. Foremost is the MFCMA, which was enacted, in large part, because of unrestricted foreign catches off Alaska. Created under the MFCMA, the North Pacific Fishery Management Council (NPFMC) develops federal fishery management plans (FMPs) for fisheries occurring within the 3- to 200-mile EEZ. Five FMPs approved by the U.S. Secretary of Commerce are now in effect and include two groundfish fishery FMPs, one each for the Bering Sea/Aleutian Islands area and the Gulf of Alaska; a salmon FMP; and a Bering Sea/Aleutian Islands crab FMP, and a statewide scallop FMP. Each of these defer varying levels of management authority to the state. In each case, ADF&G still retains inseason management authority for all but the groundfish fisheries in the EEZ.

Implementation of two other federal laws, the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA), have had increasing implications on Alaska fisheries pertaining to the goal of increased protection of pinnipeds (seals and sea lions) and depressed salmon stocks of Oregon and Washington which migrate into Alaska waters. Indeed, concerns for cumulative effects of fishing on Steller sea lions prompted the NMFS BioOp and their request for fishery information contained in this report.

Two treaties between Canada and the U.S. regulate fisheries for transboundary salmon and halibut and influence management of other Alaska fisheries that impact these stocks. As a revision of the International Fisheries Convention, the International Pacific Halibut Commission (IPHC) was created in 1953 to jointly regulate harvest and to conduct research on halibut (*Hippoglossus stenolepis*) in the North Pacific. The IPHC determines catch quotas, but within-nation catch allocations are implemented separately by Canada and in the U.S. through the NPFMC. The 1985 Pacific Salmon Treaty has established an international management regime designed to rebuild some salmon stocks, limit harvests in specific fisheries, and define equitable allocations between U.S. and Canadian fishermen.

2.4 Principles of State Management

Unique among the 50 states, Alaska's constitution has an article solely devoted to the management and utilization of natural resources that mandates that renewable resources "shall be utilized, developed and maintained on the sustained yield principle." Alaska law states that the ADF&G Commissioner "*shall manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well-being of the state ... through rehabilitation, enhancement, and development programs, [the department must] do all things necessary to insure perpetual and increasing production and use of the food resources of state waters and continental shelf areas.*"

In practice, state regulations tend to be more conservative than required by federal law. For those fisheries in which most management has been delegated to the state through a federal fishery management plan (FMP), state regulations are in addition to and generally stricter than associated

federal regulations. Examples include the specification of guideline harvest levels (GHLs), the state equivalent of a total allowable catch (TAC), that are well below those permitted in the federal FMP for species groups such as demersal shelf rockfishes (DSR) in the eastern GOA (EGOA) regulatory area, scallops in the GOA and BS/AI areas, and king and Tanner crabs in the BS/AI areas. The reasons for the conservative approaches to fishery management lie in the principles that underpin state management.

In the case of salmon, the BOF recently adopted a *Sustainable Salmon Fishery Policy for the State of Alaska* that directs the management of salmon fisheries based on the following five criteria (see the policy for full details):

- Wild salmon stocks and their habitats should be maintained at levels of resource productivity that assure sustained yields;
- Fisheries shall be managed to allow escapements within ranges necessary to conserve and sustain potential salmon production and maintain normal ecosystem functioning;
- Effective salmon management systems should be established and applied to regulate human activities that affect salmon;
- Public support and involvement for sustained use and protection of salmon resources shall be sought and encouraged; and
- In the face of uncertainty, salmon stocks, fisheries, artificial propagation and essential habitats shall be managed conservatively.

In addition to the conservation basis for salmon management, Alaska has strict regulations governing development activities that may affect salmon habitat, such as road building and mining. Alaska's Forest Practices Act requires buffer zones from logging along salmon streams to prevent erosion and protect spawning and rearing habitat. Additionally, Alaska has chosen to forego the economic benefits of large-scale hydropower development to sustain salmon resources for future generations. For example, hydropower facilities on the Susitna and Yukon Rivers were considered but rejected primarily due to the salmon resources of these drainages.

In the case of king and Tanner crabs, the BOF developed a *Policy on King and Tanner Crab Resource Management* that includes, among others, the following policies:

- Maintain crab stocks comprised of various size and age classes of mature animals in order to sustain the long-term reproductive viability of the stock;
- Routinely monitor crab resources to provide information on abundance;
- Protect king and Tanner crab stocks during biologically sensitive periods of their life cycle;

- Minimize handling and unnecessary mortality of non-legal crabs and other non-target animals; and
- Maintain an adequate brood stock to rebuild king or Tanner crab populations when they are depressed.

In establishing this policies, the BOF recognized that they may not result in maximization of physical or economic yield. However, they are intended to provide better biological protection and help preserve the stocks that inherently vary in abundance due to environmental conditions.

For other depleted shellfish stocks such as Dungeness crabs and miscellaneous shellfish species in Cook Inlet (CI) and shrimp in the westward region, the BOF have permanently closed commercial fisheries until such time that BOF-approved management plans are developed. Plans must include a suite of progressive measures such as maintenance of biogeographic distribution of the species, ecosystem function of target and non-target species, a set of management measures to conservatively regulate the harvest, and routine stock assessment and fishery monitoring programs.

In the case of groundfish, the BOF adopted *Guiding Principles for Groundfish Fishery Regulations* that specify that the BOF will consider the following (among others described fully in chapter 7 of this report) when adopting regulations for groundfish fishery management:

- Conservation of the groundfish resource to ensure sustained yield, which requires that the allowable catch in any fishery be based upon the biological abundance of the stock;
- Minimization of bycatch of other associated fish and shellfish and prevention of the localized depletion of stocks;
- Protection of the habitat and other associated fish and shellfish species from nonsustainable fishing practices;
- Maintenance of slower harvest rates by methods and means and time and area restrictions to ensure the adequate reporting and analysis necessary for management of the fishery;
- Extension of the length of fishing seasons by methods and means and time and area restrictions to provide for the maximum benefit to the state and to regions and local areas of the state; and
- Harvest of the resource in a manner that emphasizes the quality and value of the fishery product.

These policies have led to the development of conservative state-waters management plans, such as for Pacific cod (*Gadus macrocephalus*), in which trawl gear is banned to protect bottom habitat and species such as crabs, and vessels are limited to 60 pots or 5 jigging machines or less to provide for protracted fisheries. Regulations, such as these, are much more conservative than those imposed in the federal cod fisheries in Alaska. Moreover, the BOF has closed to bottom trawling most of the state

waters in the central (CGOA) and western GOA (WGOA), an action unparalleled in federal waters and territorial waters of other states in the U.S. (Figure 1.1).

Conservative measures apply to other fish species that do not have a long fishery history in Alaska, as well. In 1998, the BOF banned all directed commercial fisheries for sharks except that sharks may be retained when taken as bycatch. In 1999, with the exception of a few very minor extant fisheries, the BOF banned all commercial fisheries for forage fishes. In making these regulations, the BOF noted that *“forage fish perform a critical role in the complex marine ecosystem by providing the transfer of energy from primary and secondary producers to higher trophic levels.”* Forage fish may only be retained up to no more than 2% of the weight of groundfish aboard the vessel. Finally, in 1991, the BOF established a *Management Plan for High Impact Emerging Fisheries* that lays out a detailed set of criteria, including a BOF-approved FMP, prior to the establishment of a commercial fishery.

In summary, the State of Alaska has an impressive track record of marine resource conservation and science-based management of fishery resources. This legacy is a testimony to the placement of fish and fishing in the value systems of Alaskan residents and the importance of commercial, recreational, and subsistence fisheries to the state’s economy.

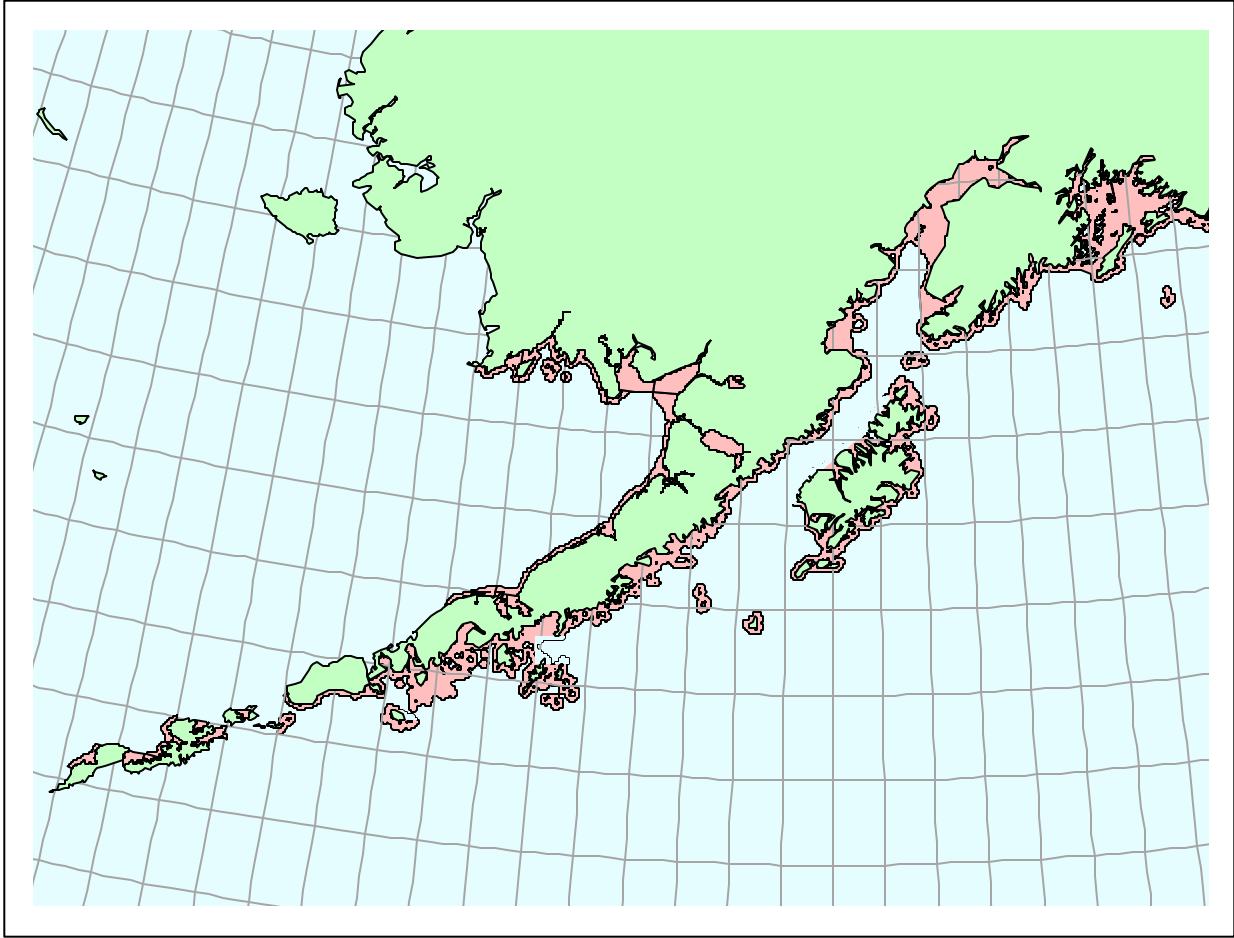


Figure 1.1. Year-round non-pelagic trawl closure areas (dark shading) in state waters of the central and western Gulf of Alaska and southeastern Bering Sea. Additional seasonal closures are imposed in other areas, such as Kodiak (not shown).

3. STELLER SEA LION BIOLOGY

Given the time constraints, it was not possible for ADF&G to prepare a review of Steller sea lion biology. However, the report authors felt it was important to include such information for completeness. This chapter is a condensed version of chapter 3 in NMFS (1999), *Endangered Species Act Section 7 Consultation – Biological Opinion*, dated December 12, 1999. This condensed version is printed here with permission of NMFS. For a more complete review of sea lion biology, the reader is referred to NMFS (1999) or more recent revisions of their biological opinion.

3.1 Species Description

The Steller sea lion (*Eumetopias jubatus*) is the only extant species of the genus *Eumetopias*, and is a member of the subfamily Otariinae, family Otariidae, superfamily Otarioidea, order Pinnipedia.

3.2 Distribution

The Steller sea lion is distributed around the North Pacific rim from the Channel Islands off Southern California to northern Hokkaido, Japan. The species' distribution extends northward into the Bering Sea and along the eastern shore of the Kamchatka Peninsula. The center of distribution has been considered to be in the GOA and the Aleutian Islands (NMFS 1992).

Within this distribution, land sites used by Steller sea lions are referred to as rookeries and haulout sites. Rookeries are used by adult males and females for pupping, nursing, and mating during the reproductive season (late May to early July). Haulouts are used by all size and sex classes but are generally not sites of reproductive activity as occurs on rookeries.

The distribution of Steller sea lions at sea is also not well understood. Their at-sea distribution is, however, a critical element to any understanding of potential effects of fisheries on Steller sea lions, and will be considered in greater detail below in the section on foraging patterns.

3.3 Reproduction

The reproductive cycle includes mating, gestation, parturition, and nursing or post-natal care. The pupping and mating season is relatively short and synchronous, probably due to the strong seasonality of the sea lions' environment and the need to balance aggregation for reproductive purposes with dispersion to take advantage of distant food resources (Bartholomew 1970). In May, adult males compete for rookery territories. In late May and early July, adult females arrive at the rookeries, where pregnant females give birth to a single pup. Mating occurs about one to two weeks later (Gentry 1970). The gestation period is probably about 50 to 51 weeks, but implantation of the blastocyst is delayed until late September or early October (Pitcher and Calkins 1981).

For females with a pup, the nursing period continues for months to several years. Pitcher and Calkins (1981) suggested that it is more common for pups to be weaned before the end of their first year, but they

also observed nursing juveniles (aged 1 to 3). Porter (1997) suggested that metabolic weaning (i.e., the end of nutritional dependence of the pup or juvenile on the mother) is more likely a gradual process occurring over time and more likely to occur in March-April, proceeding the next reproductive season. The transition to nutritional independence may, therefore, occur over a period of months as the pup begins to develop essential foraging skills, and depends less and less on the adult female. Relatively little is known about the life history of sea lions during the juvenile years between weaning and maturity.

Males appear to reach sexual maturity at about the same time as females (i.e., 3 and 7 years of age; Perlov 1971 reported in Loughlin et al. 1987), but generally do not reach physical maturity and participate in breeding until about 8 to 10 years of age (Pitcher and Calkins 1981).

3.4 Survival

Much of the recent effort to understand the decline of Steller sea lions has been focused on juvenile survival, or has assumed that the most likely proximate explanation is a decrease in juvenile survival rates. This contention is supported by direct observations and a modeling study, and is consistent with the notion that juvenile animals are less adept at avoiding predators and obtaining sufficient resources (prey) for growth and survival. Modeling by York (1994) provides evidence that the observed decline in sea lion abundance in the GOA is most consistent with a decrease in juvenile survival on the order of 10 to 20% annually. However, juvenile survival may not be the only factor influencing the decline of the western population of Steller sea lions. A decline in reproductive success and changes in adult survival may also have contributed to the decline. At present, survival rates for adult animals cannot be determined with sufficient resolution to determine if those rates have changed over time or are somehow compromised to the extent that population growth and recovery are compromised.

3.5 Age Distribution

Two life tables have been published with age-specific rates (Table 3.1). The first (Calkins and Pitcher 1982) was based on sea lions killed in the late 1970s. York (1994) created a second life table using a Weibull model and data from Calkins and Pitcher (1982) and Calkins and Goodwin (1988). York's analysis of these two data sets suggests a shift from the 1970s to 1980s in mean age of females older than 3 years. The shift was about 1.55 years, and provided the basis for her determination that increased juvenile mortality may have been an important proximate factor in the decline of Steller sea lions. That is, such a shift in mean age would occur as the adult population aged without expected replacement by recruiting young females. The present age distribution may or may not be consistent with these life tables. Nevertheless, these tables provide the best available information on vital parameters, and the present age structure of sea lions may be similar if the immediate causes of the decline (e.g., low juvenile survival or low reproductive rates) have remained relatively constant.

3.6 Foraging Patterns

The foraging patterns of the Steller sea lion are clearly central to any discussion of the potential for interaction between this species and fisheries. A partial list of foraging studies is provided in Table 3.2,

together with notes on the sample sizes, locations, years, and primary findings of those studies.

3.6.1 Methods for Researching Sea Lion Foraging Behavior

Observations: Foraging patterns can be discerned, in part, simply by observational studies. Observations can be useful for identifying areas that may be important foraging sites (e.g., Kajimura and Loughlin 1988, Fiscus and Baines 1966). In general, however, the power of observational studies is limited to situations where sea lions bring their prey to the surface and the prey can be identified, or where the sea lions can be observed diving repeatedly and the assumption that they are foraging is reasonable.

Stomach and intestinal contents: Stomach contents are generally considered to be the most reliable indication of foraging patterns. Biases may occur from a number of sources. Variable rates of digestion of soft tissues or variable retention of hard tissues (e.g., squid beaks) may result in misrepresentation of prey detection in the stomach. Stomach contents generally indicate prey items recently consumed, and may or may not be representative of prey items over a longer period of time. Analyses of stomach contents have provided a large portion of our information on sea lion foraging (e.g., Calkins and Pitcher 1982, Calkins and Goodwin 1988), but under most conditions, killing for collection of stomach contents is no longer considered appropriate. Stomach and intestinal contents are now available only from dead animals or live animals that are under sedation and can be lavaged or given an enema.

Scat analysis: Materials from scats, or feces, such as otoliths, can be used with additional information (e.g., size at age) to make inferences about the prey consumed (Pitcher 1981, Frost and Lowry 1986). As with stomach and intestinal contents, scats are a biased index of prey selection because some prey may not have hard parts that resist digestion and can be identified in a scat, and the scat generally contains prey items consumed relatively recently. Nevertheless, scat collections provide a non-lethal means of assessing diet and diet changes over time and space, and estimating relative frequency of occurrence of prey items in the sea lion diet.

Telemetry: At least three types of telemetry are (or have been) used to study sea lion foraging. Very high frequency (VHF) telemetry can be used to determine presence or absence of an animal and, to a limited extent, animal location and whether it is on land or in the water. Satellite-linked telemetry is being used to determine animal location and, when coupled with time-depth recorders, diving patterns (e.g., Merrick et al. 1994). Stomach telemetry is being developed and offers an opportunity to determine when an animal has consumed prey, rather than requiring the investigator to infer feeding from diving behavior. Stomach telemetry, in combination with satellite-linked telemetry, may provide greater understanding of foraging behavior and discrimination of at-sea activities that may or may not be related to foraging.

Captive studies: Studies of animals in captivity may be useful for understanding prey selection, diving and foraging physiology, and energetics.

Fatty acid analysis: Removal of small tissue (blubber) plugs from Steller sea lions and analysis for fatty acid composition can be used to identify prey types. This method of prey analysis is relatively new (e.g., Iverson 1993), but has been used successfully to identify prey types of harbor seals in different regions of Prince

William Sound (Iverson et al. 1997).

Isotope analysis: Isotope ratios for various elements differ in prey types in a manner that allows estimation of general prey category and trophic level. These analyses can be conducted using small amounts of tissue (e.g., vibrissae or whiskers) and may provide evidence of long term changes in general prey type, trophic level, or feeding strategy.

3.6.2 Foraging Distributions

At present, our understanding of Steller sea lion foraging distribution is based on sightings at sea or observations of foraging behavior (or presumed foraging behavior) in areas such as the southeastern Bering Sea (Fiscus and Baines 1966, Kajimura and Loughlin 1988, NMFS unpublished data from the Platform-of-Opportunity Program [POP]), records of incidental take in fisheries (Perez and Loughlin 1991), and satellite telemetry studies (e.g. Merrick et al. 1994, Merrick and Loughlin 1997).

The POP database provides our best overall view of the foraging range or distribution of Steller sea lions. This database should be viewed with some caution, yet when combined with the locations of sea lions taken incidentally in groundfish fisheries (1973-1988, Perez and Loughlin 1991), indicate that sea lions disperse widely to forage throughout much of the Bering Sea and the GOA, at least as far out as the continental shelf break.

The results of limited telemetry studies in the GOA and BSAI region suggest that foraging distributions vary by individual, size or age, season, site, and reproductive status (i.e., is the female still supporting a pup; Merrick and Loughlin 1997). The foraging patterns of adult females differed during summer months when females were with pups versus winter periods when considerable individual variation was observed, but may be attributable to the lactation condition of the females. Trip duration for females ($n = 14$) in summer was approximately 18 to 25 hours. For five females tracked in winter months, mean trip duration was 204 hours, mean trip length was 133 km, and they dove 5.3 hours per day. Estimated home ranges (mean \pm 1 SE) were $319 \pm 61.9 \text{ km}^2$ for adult females in summer, $47,579 \pm 26,704 \text{ km}^2$ for adult females in winter, and $9,196 \pm 6799 \text{ km}^2$ for winter young-of-the-year.

Overall, the available data seem to suggest two types of foraging patterns: (1) foraging around rookeries and haulouts and that is crucial for adult females with pups, pups, and juveniles, and (2) foraging that may occur over much larger areas where these and other animals may range to find the optimal foraging conditions once they are no longer tied to rookeries and haulouts for reproductive or survival purposes.

3.6.3 Foraging Depths

The sea lions in the Merrick and Loughlin (1997) study tended to make relatively shallow dives, with few dives recorded at greater than 250 m. Maximum depth recorded for the five summer adult females were in the range from 100 to 250 m, and maximum depth for the five winter adult females was greater than 250 m. The maximum depth measured for winter young-of-the-year was 72 m. These results suggest that sea lions are generally shallow divers, but are capable of deeper dives (i.e., greater than 250 m). The results

from this study also may not be indicative of diving depths and patterns for other sea lions at other times of year or in other locations. The winter young-of-the-year were instrumented in the period from November to March, when they were probably about five to nine months old and may have still been nursing. At this age, they are just beginning to develop foraging skills, which may take years to learn. The diving depths and patterns exhibited by these young-of-the-year are likely poor indicators of the foraging patterns of older juveniles (one- to three-year-olds). For example, Swain and Calkins (1997) report dives of a 2-year-old male sea lion to 252 m, and regular dives of this animal and a yearling female to 150 m to 250 m. Clearly, if young-of-the-year are limited to relatively shallow depths, and older animals are capable of diving to much greater depths, then those younger animals are just beginning to develop the diving and foraging skills necessary to survive.

3.6.4 Prey, Energetics, Nutrition, and Diversity

A (partial) listing of Steller sea lion prey species or prey types would include (not in order of priority): Atka mackerel, capelin, crabs, dogfish sharks, eulachon, flatfish, greenling, hake, halibut, herring, lamprey, lingcod, mollusks, octopus, Pacific cod, pollock, rattfish, rockfishes, salmon, sand lance, sculpins, shrimps, smelt, squid, and yellowfin sole.

The quality of the sea lion diet appears to be determined not only by the individual components (species) of the diet, but also by the mix or diversity of prey in the diet. Merrick et al. (1997) found a correlation between a measure of diet diversity in different geographic regions of the western population and population trends in those regions. In addition, the spatial and temporal distributions of prey types is a critical determinant of their availability to sea lions. The availability and characteristics of prey patches (pollock, Atka mackerel, Pacific cod, or other prey) may be essential to the foraging success of sea lions. Important patch characteristics may include their size, location, persistence, composition (e.g., prey sizes) and density (number of patches per area). Unfortunately, the information available to characterize such prey patches (and evaluate their potential importance to sea lions) is limited to trawl and hydroacoustic surveys that generally provide a single broad-scale snapshot of prey distribution on an annual or less frequent basis.

3.6.5 Foraging - integration and Synthesis

- While much remains to be learned about Steller sea lions, the available information is sufficient to begin a description of their foraging patterns. The emerging picture appears to be that:
- Steller sea lions are land-based predators but their attachment to land and foraging patterns/distribution may vary considerably as a function of age, sex, site, season, reproductive status, prey availability, and environmental conditions;
- Steller sea lions tend to be relatively shallow divers but are capable of (and apparently do) exploit deeper waters (e.g., to beyond the shelf break);
- at present, pollock and Atka mackerel appear to be their most common or dominant prey, but Steller sea lions consume a variety of demersal, semi-demersal, and pelagic prey;

- diet diversity may influence status and growth of Steller sea lion populations;
- the life history and spatial/temporal distribution of important prey species are likely important determinants of sea lion foraging success;
- foraging sites relatively close to rookeries may be particularly important during the reproductive season when lactating females are limited by the nutritional requirements of their pups; and
- the broad distribution of sea lions sighted in the POP database indicates that sea lions also forage at sites distant from rookeries and haulouts; the availability of prey at these sites may be crucial in that they allow sea lions to take advantage of distant food sources, thereby mitigating the potential for intraspecific competition for prey in the vicinity of rookeries and haulouts.

3.7 Natural Predators

The Recovery Plan for the Steller Sea Lion (NMFS 1992) states: “Steller sea lions are probably eaten by killer whales and sharks, but the possible impact of these predators is unknown. The occurrence of shark predation on other North Pacific pinnipeds has been documented, but not well quantified (Ainley et al. 1981).” Perhaps the most noteworthy anecdotal observation of apparent killer whale predation on sea lions occurred in 1992, when flipper tags from 14 sea lions that were both tagged and branded were found in the stomach of a killer whale dead on the beach in Prince William Sound (NMFS 1995). Barrett-Lennard et al. (unpubl. rep.) model sea lion mortality due to killer whales, and suggest that while such predation may account for a significant portion of natural mortality at the current low size of the sea lion population, it was not likely to have been the cause of the decline.

3.8 Natural competitors

Steller sea lions forage on a variety of marine prey that is also consumed by other marine mammals (e.g., northern fur seals, harbor seals, humpback whales), marine birds (e.g., murre and kittiwakes), and marine fishes (e.g., pollock, arrowtooth flounder). Steller sea lions are most likely to compete with these species for food, although they may also compete for habitat (e.g., potential competition with northern fur seals for rookery or haulout space).

3.9 Disease

Hoover (1988) lists parasites known to infect sea lions, including cestodes, acanthocephalans, and nematodes (Hill 1968, Dailey and Brownell 1972, Daily 1975, Fay et al. 1978, Geraci 1979, Dieterich 1981). In addition, Thorsteinson and Lensink (1962) reported two types of parasites: Body louse severely infesting pups and nose mites invariably found on adults. Scheffer (1946) reported ascarid worms nearly always found in adult stomachs.

3.10 Population Dynamics

An understanding of the natural biogeography of the Steller sea lion is essential to describe their population size or status, trends, variability, and stability, and to identify the potential effects of human activities. Those natural factors that determine their biogeography include climate and oceanography, avoidance of predators, distribution of prey, the reproductive strategy of the species, and movement patterns between sites. Avoidance of terrestrial predators must clearly be an important factor, as rookeries and haulouts are virtually all located at sites inaccessible to such predators. Distribution of prey is likely a critical determinant of sea lion biogeography, and probably determines the extent of their dispersion during the non-reproductive season. The reproductive strategy of the species, on the other hand, requires aggregation at rookery sites, and therefore likely places important limits on the species' movement patterns and dispersion. Finally, movement patterns between sites determine, in part, the extent to which such groups of sea lions at different rookeries and haulout sites are demographically independent.

3.11 Population Status and Trends

Assessments of the status and trends of Steller sea lion populations are based largely on (a) counts of nonpups (juveniles and adults) on rookeries and haulouts, and (b) counts of pups on rookeries in late June and early July. Population size can be estimated by standardizing the indices (e.g., with respect to date, sites counted, and counting method), by making certain assumptions regarding the ratio of animals present versus absent from a given site at the time of the count, and by correcting for the portion of sites counted. Counts of adult and juvenile Steller sea lions at rookeries and haulout sites by region are shown in Table 3.3.

For the western U.S. population (i.e., west of 144° W long.), counts of adults and juveniles fell from 109,880 animals in the late 1970s to 22,167 animals in 1996, a decline of 80% (Hill and DeMaster 1998, based on NMFS 1995, Strick et al. 1997, Strick et al. in press). From the late 1970s to 1996, abundance estimates for the GOA dropped from 65,296 to 9,782 (85%), and for the BSAI region dropped from 44,584 to 12,385 (72%). For the western population, the number of animals lost appears to have been far greater from the late 1970s to the early 1990s. Nevertheless, the rate of decline in the 1990s has remained relatively high. In addition, the portion of (nonpup) sea lions counted on rookeries versus haulouts appears to have declined considerably during the 1990s (Sease and Loughlin 1999, their Table 7).

For the eastern population (east of 144° W long.), counts of nonpups (adults and juveniles) have increased overall from just under 15,000 in 1982 to just over 20,000 in 1994 (Hill and DeMaster 1998). Counts of nonpups in California/Oregon were essentially unchanged from 1982 to 1996 at about 3,300. Counts of nonpups in British Columbia increased from 4,700 to 8,100 in 1994. In Southeast Alaska, counts of nonpups at trend sites have increased from 6,400 in 1979 to 8,700 in 1998 (NMFS 1995, Sease and Loughlin 1999). The number of pups born in Southeast Alaska increased from ca. 2,200 in 1979 to ca. 3,700 in 1994 (NMFS 1995).

3.12 Population Variability and Stability

Populations change as a function of births, deaths, immigration, and emigration. Net migration out of the western population is not considered a factor in the decline; over the past two decades, the amount of growth observed in the eastern population is equivalent to only a small fraction of the losses in the western population. Computer modeling (York 1994) and mark-recapture experiments (Chumbley et al. 1997) indicate that the most likely problem leading to the decline is decreased juvenile survival, but lower reproductive success is almost certainly a contributing factor. Any description of population stability for the Steller sea lion should be written with caution. Over the past three decades (or perhaps longer), we have witnessed a severe decline of the western population throughout most of its range. Our inability to anticipate those declines before they occurred, our limited ability to explain them now, and our limited ability to predict the future suggests that we are not yet capable of describing the stability of Steller sea lion populations.

3.13 Population Projections

Based on recent trends in Southeast Alaska and British Columbia, prospects for recovery of the eastern population are encouraging. Merrick and York (1994) and York et al. (1996) have conducted population viability analyses for the western population. The results of these analyses indicate that the next 20 years may be crucial for the western population of Steller sea lions, if the rates of decline observed in recent years continue. Extinction rates for rookeries or clusters of rookeries could increase sharply in 40 to 50 years, and extinction for the entire Kenai-to-Kiska region could occur in the next 100-120 years.

3.14 Listing Status

On 26 November 1990, the Steller sea lion was listed as threatened under the Endangered Species Act of 1973 (55 FR 49204). The listing followed a decline in the U.S. population of about 64% over the three decades prior to the listing. In 1997, the species was split into two separate stocks on the basis of demographic and genetic dissimilarities (Bickham et al. 1996, Loughlin 1997), the status of the western stock was changed to endangered, and the status of the eastern stock was left unchanged (62 FR 30772).

3.15 Critical Habitat Description

The term “critical habitat” is defined in the Endangered Species Act (16 U.S.C. 153) to mean: “*the specific areas within the geographic area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of this Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management consideration or protection; and (ii) the specific areas outside of the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential to the conservation of the species.*”

3.15.1 Establishment of Critical Habitat

The areas designated as critical habitat for the Steller sea lion were determined on the basis of the available information on life history patterns of the species, with particular attention paid to land sites where animals haul out to rest, pup, nurse their pups, mate, and molt, and to marine sites considered to be essential foraging areas. The foraging areas were determined on the basis of sightings of sea lions at sea, incidental catch data (Loughlin and Nelson 1986, Perez and Loughlin 1991), and foraging studies using satellite-linked tracking systems. The following areas have been designated as critical habitat under the ESA (Figure 3.1).

- (a) Alaska rookeries, haulouts, and associated areas. Critical habitat includes an aquatic zone that extends 3,000 feet (0.9 km) seaward in State and Federally managed waters from the baseline or basepoint of each major haulout in Alaska that is east of 144° W long. Critical habitat includes an aquatic zone that extends 20 nautical miles (nm, 37 km) seaward in State and Federally managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144° W long.
- (b) Three special aquatic foraging areas in Alaska, including the Shelikof Strait area, the Bogoslof area, and the Segum Pass area.

3.15.2 Physical and Biological Features of Steller Sea Lion Critical Habitat

For the Steller sea lion, the physical and biological features of its habitat that are essential to the species' conservation are those that support reproduction, foraging, rest, and refuge. Terrestrial habitat is relatively easy to identify on the basis of use patterns and because land use patterns are more easily observed.

Prey resources are the most important feature of marine critical habitat, and foraging is the most important activity that occurs when the animals are at sea. Two kinds of marine habitat were designated as critical. First, areas around rookeries and haulouts were chosen based on evidence that many foraging trips by lactating adult females in summer may be relatively short (20 km or less; Merrick and Loughlin 1997). Also, mean distances for young-of-the-year in winter may be relatively short (about 30 km; Merrick and Loughlin 1997). Similarly, areas around rookeries are likely to be important for juveniles. The areas around rookeries and haulouts must contain essential prey resources for at least lactating adult females, young-of-the-year, and juveniles.

Second, three areas were chosen based on 1) at-sea observations indicating that sea lions commonly used these areas for foraging, 2) records of animals killed incidentally in fisheries in the 1980s, 3) knowledge of sea lion prey and their life histories and distributions, and 4) foraging studies. In 1980, Shelikof Strait was identified as a site of extensive spawning aggregations of pollock in winter months. Records of incidental take of sea lions in the pollock fishery in this region provide evidence that Shelikof Strait is an important foraging site (Loughlin and Nelson 1986, Perez and Loughlin 1991). The southeastern Bering Sea north of the Aleutian Islands from Unimak Island past Bogoslof Island to the Islands of Four Mountains is also considered a site that has historically supported a large aggregation of spawning pollock, and is also an area where sighting information and incidental take records support the notion that this is an important foraging

area for sea lions (Fiscus and Baines 1966, Kajimura and Loughlin 1988). Finally, large aggregations of Atka mackerel are found in the area around Seguam Pass. Atka mackerel are an important prey of sea lions in the central and western Aleutian Islands. Records of incidental take in fisheries also indicate that the Seguam area is an important for sea lion foraging (Perez and Loughlin 1991).

3.15.3 Critical Habitat and Environmental Carrying Capacity

Prey resources are not only the primary feature of Steller sea lion critical habitat, but they also appear to determine the carrying capacity of the environment for Steller sea lions. At this time, the best scientific and commercial data available are not sufficient to distinguish the relative influences of natural (i.e., oceanographic) factors versus human-related activities (i.e., fisheries) on the availability of prey for sea lions. The notion that the observed changes in sea lion vital parameters are consistent with a change in “carrying capacity” does not necessarily mean that the changes are entirely natural.

Table 3.1. Life history table for Steller sea lions based on Calkins and Pitcher (1982) and York (1994). From York (1994) as reported in NMFS (1999).

Ages		Calkins-Pitcher life table			York life table			
From	To	Fecundity	Cum. survival	Annual survival	Percent at age	Cum. survival	Annual survival	Percent at age
0	1	0.000	1.000	0.776	16.676	1.000	0.782	16.251
1	2	0.000	0.776	0.776	12.546	0.782	0.782	12.709
2	3	0.000	0.603	0.776	9.438	0.612	0.782	9.938
3	4	0.105	0.468	0.868	7.100	0.478	0.930	7.772
4	5	0.267	0.406	0.879	6.163	0.445	0.909	7.228
5	6	0.286	0.357	0.888	5.417	0.404	0.895	6.570
6	7	0.315	0.317	0.893	4.811	0.362	0.884	5.880
7	8	0.315	0.283	0.898	4.296	0.320	0.875	5.198
8	9	0.315	0.254	0.874	3.857	0.280	0.867	4.548
9	10	0.315	0.222	0.899	3.372	0.242	0.859	3.943
10	11	0.315	0.200	0.893	3.031	0.208	0.853	3.338
11	12	0.315	0.178	0.896	2.707	0.178	0.847	2.889
12	13	0.315	0.160	0.895	2.425	0.150	0.841	2.447
13	31	0.315	0.160	0.895	15.99	0.150	p(x)d	11.239

Table 3.2. A partial listing of studies on the prey of Steller sea lions (from NMFS (1999). When prey are listed in order of frequency of occurrence, an asterisk (*) or dagger (†) indicate that rank of the marked prey item was tied with the similarly marked prey item listed before or after. Sample sizes (*n*) for studies of stomach contents are given only for the number of stomachs with contents; empty stomachs are not included. Note that some studies used the same data and results are redundant (e.g., Merrick and Calkins [1996] present reanalysis of data reported in Pitcher [1981], Calkins and Pitcher [1982], and Calkins and Goodwin [1988]).

Study	Years	Location	Methods	Main findings
Imler and Sarber 1947	1945-1946	Sitka to Kodiak Island	Stomach contents (<i>n</i> = 15)	<ul style="list-style-type: none"> · Eight sea lions sampled in southeast Alaska; all but one fed principally on pollock, and exception contained a skate and an octopus. · Three sampled from Barren Islands contained pollock, starry flounder, tom cod, arrow-toothed halibut, common halibut, and octopus. · Two from Chiswell Island contained salmon. · Two from Kodiak Island contained pollock and arrow-toothed halibut.
Sleptsov 1950 (cited in Spaulding 1964)	Unknown	Kuril Islands	Unknown	<ul style="list-style-type: none"> · Reported sea lion feeding on octopus.
Wilke and Kenyon 1952	1949, 1951	St. Paul Island	Stomach contents (<i>n</i> = 3)	<ul style="list-style-type: none"> · One sea lion contained primarily sand lance but also starry flounder, one contained halibut, cod, pollock, and flounders, and one contained a large cephalopod beak.
Pike 1958	Summary, 1901-1958	Primarily BC, but also off California and Alaska	Stomach contents, (<i>n</i> = 19)	<ul style="list-style-type: none"> · Reports a range of fish and cephalopods for 12 time/area studies. · Disputes claim that studies provide evidence of serious commercial competition. · For his study (in British Columbia), prey (in order of frequency of occurrence) included squid, herring, rockfish, octopus, salmon*, skate*, and hake*. · For other studies in his table (except Imler and Sarber 1947), prey items listed were (in no particular order) rockfish, perch, herring, skate, shark, squid, octopus, lamprey, salmon, “cod,” “bass,” mussels, clam, crab, dogfish, flatfish, and sardines.
Mathisen <i>et al.</i> 1962	1958	Chernabura	Stomach contents (<i>n</i> = 94; 14 yearlings, 42 adult females, 18 harem bulls, 20 unattached bulls)	<ul style="list-style-type: none"> · Prey (in order of frequency of occurrence) included squid/octopus, common bivalves, smelts, greenlings, shrimp/crabs, rockfish, sculpins, isopods, unclassified crustaceans*, segmented worms*, and single occurrences of lamprey, salmon, sand lance, sand dollar, and coelenterate.

Table 3.2. (cont.)

Study	Years	Location	Methods	Main findings
Thorsteinson and Lensink 1962	1959	Marmot, Atkins, Ugamak, Jude, Chowiet	Stomach contents ($n = 56$); primarily adult males	<ul style="list-style-type: none"> · Prey (in order of frequency of occurrence) included squid/octopus, clam/mussel/snail, sand lance, rockfish, crab, greenling*, sculpins*, flatfish*, and single occurrences of halibut and lumpfish.
Spaulding 1964	1956-1963(?)	British Columbia	Stomach contents ($n = 190$; overlap with specimens reported in Pike [1958] above)	<ul style="list-style-type: none"> · Suggests sea lions prey mainly on one item per feeding period. · Some seen feeding at surface on lingcod, rockfish, salmon, or halibut ($n = 8$). · Feed primarily at night ($n = 269$ or 393 sampled). · Consumption of herring and salmon by sea lions, fur seals, and harbor seals estimated about 2% to 4% of commercial catch. · Prey (in order of frequency of occurrence) included octopus, rockfish, herring*, whiting*, salmon, dogfish, squid*, hake*, flatfish[†], clam[†], ratfish, shrimp*, sand lance*, graycod[†], lingcod[†], and single occurrences of lamprey, skate, eulachon, halibut, and mackerel/jack.
Tikhomirov 1964	1962	Bering Sea	Stomach contents $n =$ unknown)	<ul style="list-style-type: none"> · Large numbers of sea lions in the southeastern Bering Sea, winter/spring of 1962. · Suggests herring “staple food” of sea lions during this period. · Suggests sea lion distribution was influenced by the distribution of herring.
Fiscus and Baines 1966	1958-1963	California to Bering Sea	Stomach contents ($n = 22$)	<ul style="list-style-type: none"> · Steller sea lions taken off central California and Oregon fed only on bottom fish. · Steller sea lions taken in Alaskan waters fed mainly on small, schooling fishes. · Near Unimak Pass in 1962, capelin was the major food species. · A Steller sea lion taken on the Fairweather Grounds in the eastern GOA in May 1958 had eaten three salmon. · Most of the food species (capelin, sand lance, sculpins, rockfishes and flatfishes) found in the stomachs of Steller sea lions suggest that they feed near land or in relatively shallow water (<100 fm, 180 m). · Steller sea lions were seen at distances of 70-85 miles from land by Fiscus and Kenyon in 1960 (Kenyon and Rice 1961).

Table 3.2. (cont.)

Study	Years	Location	Methods	Main findings
Jameson and Kenyon 1977	1973-1976	Rogue River, Oregon	Observations of sea lions feeding at surface (84 observations; number of sea lions unknown)	· Prey consisted of 73 lampreys, 2 salmonids, 9 unidentified.
Gentry and Johnson 1981	1974-1975	St. George Island (Pribilof Islands)	Observations (163 verified observations, number of sea lions unknown)	· Observed sea lions taking 163 fur seal pups. Estimated such predation may result in the mortality of about 3% to 7% of fur seal pups born at St. George Island.
Jones 1981	1968-73	North and Central California	Stomach contents ($n = 9$)	· Noted 9 stomachs with fish, and 7 with squid and octopus. · Grouped 127 identified fishes from northern sea lions according to schooling (open-water), bottom-dwelling (rocky), and inshore-schooling species (his Table 6), and suggested results indicate that the northern sea lion feeds mainly on bottom-dwelling fishes.
Pitcher 1981	1975-78	GOA	Stomach contents ($n = 153$)	· Stomach contents were 95.7% fishes by volume, and included 14 species of fish in 11 families. · Gadids comprised 59.7% of total contents and occurred in 82.4% of stomachs with food. · Walleye pollock comprised 58.3% of the total volume and occurred in 66.7% of stomachs with food. · Cephalopods occurred in 36.6% of stomachs with contents but made up only 4.2% of total volume. · Predation on salmon and capelin appeared to be largely limited to spring and summer. · Prey (by combination rank index) included pollock, squids, herring, capelin, cod, salmon, octopus, sculpins, flatfishes, rockfishes. · Herring and squids were extensively used by sea lions in Prince William Sound but appeared to be relatively unimportant in other areas. · Results for sea lions similar to results for harbor seals. · Mean fork length of 2030 pollock otoliths = 29.8cm (range 5.6-62.9, SD=11.6cm)

Table 3.2. (cont.)

Study	Years	Location	Methods	Main findings
Calkins and Pitcher 1982 (note redundancy with previous results of Pitcher 1981)	1975-1978	GOA, including northeastern GOA, Prince William Sound, Kenai Coast, Kodiak Island, and the Alaska Peninsula region	Stomach contents ($n = 153$)	<ul style="list-style-type: none"> · Fishes comprised 72.8%, cephalopods (octopus and Gonatid squids) 21.5%, decapod crustaceans (shrimps, tanner and spider crabs) 4.2%, gastropods (marine snails) 0.8%, and mammals 0.4% of the prey occurrences. · Fishes included minimum of 14 species of 11 families. · Gadids composed nearly half of total occurrences and nearly 60% of total volume. · Harbor seal remains were found in two stomachs (see Pitcher and Fay 1982). · Seven top-ranked prey (in order of modified Index of Relative Importance) were pollock, herring, squids, capelin, salmon, Pacific cod, and sculpins. · Pollock was dominant prey accounting for about 39% of all occurrences and 58% of the total volume. · Pollock was top-ranked prey in all areas except Kodiak, where it was ranked second below capelin. · Herring and squid were used extensively in Prince William Sound, but not in other areas. · Predation on salmon and capelin was largely limited to spring and summer. · Geographic differences in use of salmon and capelin may have been due to sampling at different sites and seasons. · Comparison with previous studies (Imler and Sarber 1947, Mathisen <i>et al.</i> 1962, Thorsteinson and Lensink 1962, and Fiscus and Baines 1966) which had more invertebrates, no herring, but included sand lance. Noted differences in sampling for this study (throughout year at wide range of locations) versus earlier studies (near rookeries during breeding season). · Four of the five top-ranked prey were off-bottom schooling species.
Lowry <i>et al.</i> 1982	1976	Pribilof Islands	Stomach contents ($n = 4$)	<ul style="list-style-type: none"> · Prey (in order of frequency of occurrence) included pollock, squids, and single occurrences of octopus, flatfish, lamprey, and prickleback. · Based on otoliths, pollock consumed ranged from 34 cm to 57 cm in length. · Also mentions the following prey items from a preliminary examination of 111 stomach samples collected in the central and western Bering Sea (in no particular order): pollock, cod, Gonatid squids, herring, octopus, and sculpins.

Table 3.2. (cont.)

Study	Years	Location	Methods	Main findings
Frost and Lowry 1986			Stomach contents ($n = 90$; not stated how many had contents)	<ul style="list-style-type: none"> · Most pollock eaten by sea lions (76%) were 20 cm or longer. · Younger sea lions (≤ 4 yr) collected in 1981 (all were males) ate significantly smaller fish ($\bar{x} = 22.4$ cm, $n = 37$) than did older animals ($\bar{x} = 26.9$ cm, $n = 51$). · A sea lion collected in 1976 and another collected in 1979 (both near the Pribilofs) had eaten pollock averaging 46.9 cm in length (range 18.4-61.4 cm), while those collected in 1981 to the west had eaten substantially smaller pollock averaging 25.2 cm in length (range 8.3-64.2 cm). · In 1981 sea lions collected in the central Bering Sea had eaten larger pollock than those off the Kamchatka Peninsula ($\bar{x} = 26.8$ cm vs. 23.5 cm). · “It is unknown whether the consumption patterns described above are a result of actual size selection of prey or if they result from coincidental distribution of predators and prey size classes.” · “. . . the size range of pollock eaten by both young and old sea lions was similar.”

Table 3.2. (cont.)

Study	Years	Location	Methods	Main findings
Calkins and Goodwin 1988	1985-1986	GOA and southeast Alaska	Stomach contents ($n = 88$; 47 had only trace amounts. Five with measurable contents and nine with trace amounts from southeast; remainder were from Kodiak area and adjacent portions of Alaska Peninsula.)	<p><u>Southeast</u></p> <ul style="list-style-type: none"> · Fishes comprised 98% of volume, mostly Pacific cod (57% of total volume) and pollock (32%). · Most frequently occurring were pollock (57%) and flatfishes (21%). · Only other prey observed were squid and octopus. · Mean fork length of 80 pollock otoliths from 8 sea lions in southeast was 25.5 cm (range 4.8 to 55.7 cm, SD = 10.4 cm) <p><u>Kodiak area</u></p> <ul style="list-style-type: none"> · Most important by volume were pollock (42%), octopus (26%), and flatfish (25%). · Most frequently occurring were pollock (58%) and octopus (32%). · Other prey (in no particular order) were other fishes, squid, decapod crustaceans, and clams. · Prey rank (based on combined rank index [Pitcher 1981]) in Kodiak area were pollock, octopus, flatfishes, sand lance, Pacific cod, and salmon. · Mean fork length of 1064 otoliths from 43 sea lions in Kodiak area was 25.4 cm (range 7.9 to 54.2 cm, SD = 12.4 cm). · Pollock was the most important prey item in both 1975-1978 collection (39% by frequency of occurrence in Kodiak area) and 1985-1986 collection (58%). · Capelin was most important in Kodiak area in 1975-1978. However, they suggest difference in capelin may be due to seasonal differences when animals collected (spring-summer 1975-1978 versus spring-autumn/early winter 1985-1986). Thus, comparisons may be compromised by potential seasonal bias. · Octopus ranked second in 1985-1986 collection near Kodiak, but fifth in 1975-1978. However, they suggest difference may be due to collection site. Thus comparisons may be compromised by potential location bias. · Sand lance occurred in 26% of sea lions from GOA in 1960s (Mathisen <i>et al.</i> 1962, Thorsteinson and Lensink 1962, Fiscus and Baines 1966), were not found in 1975-1978 sample, but were fourth in 1985-1986 sample.

Table 3.2. (cont.)

Study	Years	Location	Methods	Main findings
Byrnes and Hood 1994	1992	Año Nuevo, California	One observation	<ul style="list-style-type: none"> · Observed a territorial male Steller sea lion attack, kill, and consume what appeared to be a yearling California sea lion.
Merrick and Calkins 1996 (note redundancy with Pitcher 1981, Calkins and Pitcher 1982, and Calkins and Goodwin 1988)	1975-1978, 1985-1986	GOA	Stomach contents, ($n = 178$ in 1975-1978 and $n = 85$ in 1985-1986)	<ul style="list-style-type: none"> · Prey consumption was based on frequency of occurrence. · Most stomachs contained prey of only one kind. · Pollock were the most common prey of juvenile (≤ 4 years old) and adult sea lions in virtually all seasons and areas during these two periods. · Juvenile pollock were a major part of the diet in both periods. · Juvenile sea lions ate smaller and relatively more juvenile pollock. · Small forage fish were consumed on a seasonal basis. · Temporal comparisons were possible only in the Kodiak region. · The proportion of sea lions eating pollock increased from 49% in 1975-1978 to 69% in 1985-1986 in the Kodiak area. · Small forage fish were the second most common prey in the 1970s, and flatfish were second in the 1980s. · Of the fish consumed, 73% were < 30 cm, but they accounted for only 26.8% of the biomass consumed. · Half (50.7%) of the pollock mass consumed by juvenile sea lions came from fish < 30 cm, while only 21% of the pollock mass consumed by adult sea lions came from juvenile pollock. · Seasonal differences were observed in the consumption of all prey taxa, but differences were not found in 1980s. · Between 1970s and 1980s, the portion consuming pollock and cephalopods increased significantly and the portion consuming small forage fish and other demersal fish decreased. · The increase in pollock consumed was only evident in summer months (all ages combined), but was evident in all seasons for juveniles. · (Note that sampling was not consistent with respect to seasons or specific locations between the two sampling periods, which weakens the basis for comparisons.)

Table 3.2. (cont.)

Study	Years	Location	Methods	Main findings
Merrick <i>et al.</i> 1997	1990-93 (summer - last week June, first week July, or first week August)	Kodiak to Agattu and Alaid - 37 collections at 19 rookeries and 3 haulouts	Scat analysis and population trends. No. scats analyzed = 338. Suggests most scats from adult females. Prey pooled into seven categories, rookeries and haulouts pooled into six areas. Report on 40 and 52 scats from Bogoslof and Ugamak (1985-89 and 1990-93, respectively), and compared with stomach contents in Kodiak area for 1976- 78 (20) and 1985-89 (28), and 54 scats in 1990-93.	<ul style="list-style-type: none"> · Scats contained at least 13 species. · Atka mackerel most common prey category (62%), gadids second (43%), salmon (20%) third, cephalopods (12%) fourth, small schooling fish (9%) fifth, then other demersal fish (7%) and flatfish (3%). · Pollock occurred in 29% of the scats and unidentified gadids (which the authors suggest were probably pollock) in 28%. · Pollock dominated in the GOA, was approximately equal in the eastern Aleutian Islands and the area they designated as central Aleutian Islands 1, and Atka mackerel dominated further west. · Salmon, small schooling fish, and flatfish were found more commonly in the eastern areas. · Diet diversity tended to be greater east to west and was correlated with rate of population change. · “The high correlation between area-specific diet diversity and population changes supports the hypothesis that diet is linked with the Steller sea lion population decline in Alaska.” · If diet diversity (as measured in this study) is related to population trends, and the indices of diet are based on adult female foraging patterns, these results would indicate that juvenile survival is not the only vital rate being affected. · Emphasizes the importance of secondary prey.

Table 3.2. (cont.)

Study	Years	Location	Methods	Main findings
Merrick and Loughlin 1997	1990-1993	GOA to eastern Aleutian Islands	Very High Frequency radio transmitters ($n = 10$ adult females instrumented in June-July); Satellite-linked time-depth recorders ($n = 5$ adult females instrumented in June-July, $n = 5$ adult females instrumented in November-March, and $n = 5$ young-of-the-year instrumented in November-March).	<ul style="list-style-type: none"> · Mean trip duration for adult females instrumented (either radio transmitter or satellite-linked time-depth recorder) on the order of 18 to 25 hours, with time on shore on the order of 18 to 19 hours, so slightly more than half of the females' cycles were spent at sea. · Mean trip duration for adult females instrumented (satellite-linked time-depth recorder) in winter was 204 hours, but time on shore was approximately the same as for summer adult females. Adult females in winter spent approximately 90% of their time at sea. · Young-of-the-year animals spent a mean time of 15 hours at sea and 25 hours on land, therefore spending about 37% of their time at sea. · Summer adult females dove about 17 times per hour, winter adult females about 12 times per hour, and young-of-the-year about 12-13 times per hour. All groups dove most frequently in the late afternoon and night. · Maximum dive depths for summer adult females was between 150 m and 250 m, for winter adult females was > 250 m, and for young-of-the-year was 72 m. · Mean number of diving hours per day was 4.7 for summer adult females, 5.3 for winter adult females, and 1.9 for young-of-the-year. · Mean trip distance for summer adult females was 17.1 km, winter adult females 133 km, and young-of-the-year 31 km (but were skewed by one trip by a young-of-the-year of 320 km). · Two of the winter adult females foraged in a manner that suggested they still were nursing pups. These females relatively dove 8.1 hours per day, made short trips (mean 53 km over 18 hours), and returned to the same or nearby haulout at the end of each trip. The remaining three winter adult females was 3.5 hours per day and spent up to 24 days at sea before returning to land. · In general, winter adult females spent more time at sea, dove deeper, and had greater home ranges than summer adult females.

Table 3.3. Counts of adult and juvenile (non-pup) Steller sea lions at rookery and haulout trend sites by region (NMFS unpubl., Sease and Loughlin 1999 as reported in NMFS 1999). For the GOA, the eastern sector includes rookeries from Seal Rocks in Prince William Sound to Outer Island; the central sector extends from Sugarloaf and Marmot Islands to Chowiet Island; and the western sector extends from Atkins Island to Clubbing Rocks. For the Aleutian Islands, the eastern sector includes rookeries from Sea Lion Rock (near Amak Island) to Adugak Island; the central sector extends from Yunaska Island to Kiska Island; and the western sector extends from Buldir Island to Attu Island.

Year	Gulf of Alaska			Aleutian Islands			Southeast Alaska
	Eastern	Central	Western	Eastern	Central	Western	
1975				19,769			
1976	7,053	24,678	8,311	19,743			
1977				19,195			
1979					36,632	14,011	6,376
1982							6,898
1985		19,002	6,275	7,505	23,042		
1989	7,241	8,552	3,800	3,032	7,572		8,471
1990	5,444	7,050	3,915	3,801	7,988	2,327	7,629
1991	4,596	6,273	3,734	4,231	7,499	3,085	7,715
1992	3,738	5,721	3,720	4,839	6,399	2,869	7,558
1994	3,369	4,520	3,982	4,421	5,790	2,037	8,826
1996	2,133	3,915	3,741	4,716	5,528	2,190	8,231
1997		3,352	3,633				
1998		3,346	3,361	3,847	5,761	1,913	8,693

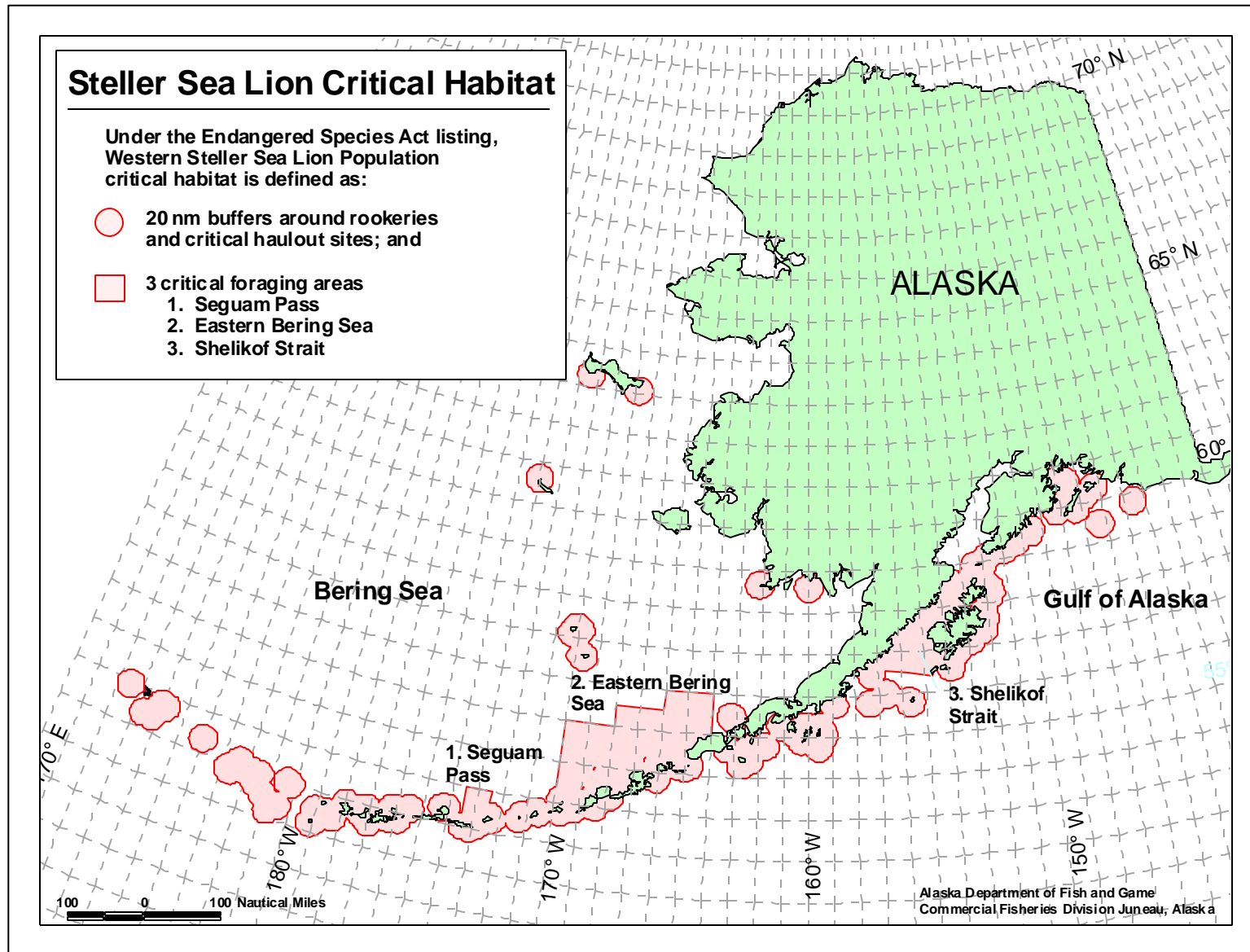


Figure 3.1. Steller sea lion critical habitat defined by NMFS. Map created by ADF&G.

4. HERRING FISHERIES

Fisheries for Pacific herring (*Clupea pallasii*) occur in nearshore areas of Alaska from Norton Sound south (Figure 4.1), overlapping most of the geographic range of the Steller sea lion. Herring fisheries provide an important contribution to the income of many Alaskan fishermen, with most of the harvest concentrated during the brief spring herring-spawning period.

4.1 Fishery History

Herring have supported some of Alaska's oldest commercial fisheries, and subsistence fisheries for herring in Alaska predate recorded history. The spring harvest of herring eggs on kelp has always been an important subsistence resource in coastal communities throughout Alaska. Traditional dried herring remains a major staple of the diet in BS villages near Nelson Island (Pete 1990), where salmon are not readily available.

Alaska's commercial herring industry began in 1878 when 30,000 pounds were prepared for human consumption. By 1882, a reduction plant at Killisnoo in Chatham Strait was producing 30,000 gallons of herring oil annually. The herring reduction industry expanded slowly through the early 20th century reaching a peak harvest of 142,000 metric tons (mt) in 1934 (Figure 4.2). However, as Peruvian anchovetta reduction fisheries developed, Alaska herring reduction fisheries declined so that by 1967 herring were no longer harvested for reduction products.

A Japanese and Russian trawl fishery for herring began in the BS in the late 1950s, reaching a peak harvest of 146,000 mt in 1970. These high harvests were likely not sustainable and the foreign fishery declined until it was finally phased out with the passage of the Magnuson Fishery Conservation and Management Act in 1976.

Substantial catches of herring for sac roe began in the 1970s as market demand increased in Japan, where herring harvests had declined dramatically. Presently, herring are harvested primarily for sac roe, still destined for Japanese markets. Statewide herring harvests have averaged approximately 45,000 mt in recent years, with a value of approximately \$30 million. In addition, commercial fisheries for herring eggs on kelp harvest about 400 mt of product annually with a value of approximately \$3 million.

4.2 Fishery Description

4.2.1 Overview

Approximately 25 distinct fisheries for Pacific herring occur in Alaskan waters (Table 4.1). Almost all of these herring fisheries are closely linked to a specific spawning population of herring. There are three general types of herring fisheries in Alaska, identified by season, product, gear and BOF regulations.

Most of the herring harvest currently occurs during sac roe fisheries, which harvest herring just before their spring spawning period. Both males and females are harvested, although the sac roe fisheries target the much higher-valued roe-bearing females. Alaska statutes require that the

males also be retained and processed and not discarded as bycatch. On occasion the entire allowable harvest has been taken in less than one hour, although most sac roe fisheries occur during a series of short openings of a few hours each, spanning approximately one week. Fishing is not allowed between these short openings to allow processors time to process the catch, and for managers to locate additional herring of marketable quality.

Spawn-on-kelp fisheries harvest intertidal and subtidal macroalgae containing freshly deposited herring eggs. Both of these fisheries produce products for consumption primarily in Japanese domestic markets.

Smaller amounts of herring are harvested from late July through February in herring food/bait fisheries. Most of the herring harvested in these fisheries are used for bait in Alaskan longline and pot fisheries for groundfish and shellfish. Smaller amounts are used for bait in salmon troll fisheries, with occasional utilization for human or zoo food. When herring harvested during spring sac roe fisheries produce low quality roe, they are then sold as food/bait herring, although for regulatory purposes the catch is included as part of the sac roe quota.

Herring spawn timing is temperature dependent, so that herring spawning and roe harvest timing occurs progressively later from Southeast Alaska, where spawning begins in March, through the northern BS, where spawning ends in June (Figure 4.1).

GOA herring have some genetic distinction from BS herring (Grant and Utter 1984) and are smaller and non-migratory, generally moving less than 100 miles among spawning, feeding, and wintering grounds. BS herring are much larger and longer-lived. Most travel to offshore central BS wintering grounds, with some herring migrating over 1,000 miles annually (Funk 1990). Herring are planktivores and provide a key link in pelagic and nearshore food chains between primary production and upper-level piscivores.

4.2.2 Fishing Gear

Purse seines and gillnets are the primary gears used to catch whole herring (Figure 4.3). In herring pound spawn-on-kelp fisheries, herring are captured with purse seines and then towed to net impoundments and held until they spawn on kelp fronds suspended in the impoundments. After spawning, herring are released from the impoundments. Herring pound spawn-on-kelp fisheries occur at Craig, Hoonah Sound and Sitka Sound (a small experimental fishery) in Southeast Alaska, in PWS, and in Norton Sound. Naturally occurring herring spawn on kelp (sometimes called “wild” spawn on kelp) is also harvested by SCUBA divers in PWS and hand picked at low tide in the intertidal zone in Togiak.

Purse seine gear is used almost exclusively in herring food/bait fisheries, although trawls have been used near Kodiak. Trawl gear is no longer legal for fishing herring in Alaska with three exceptions. Trawl gear is legal, but very rarely used, for fishing food and bait herring in PWS. The type of trawl used in PWS has been a pair trawl, similar to a purse seine net, towed between two purse seine vessels. At Kodiak, trawl gear has typically been used to catch a small amount of herring for food/bait. Trawl gear would be legal gear for herring in the General District of Bristol

Bay, if a season were ever opened by emergency order. No such season has ever been opened, and it is considered very unlikely that it would ever occur.

Almost all sac roe purse seine fishers and many gillnetters employ spotter aircraft to locate schools of herring and direct their fishing efforts. These spotter-directed fisheries are highly selective, with essentially no bycatch. Spotter aircraft are able to locate schools of herring very quickly, so that herring fisheries have become extremely efficient. With spotter aircraft support, entire allowable harvests of thousands of tons of herring have been captured in fishery openings as short as 15 minutes.

4.2.3 Fishery Management Strategy

Harvest policies used for herring in Alaska set the maximum exploitation rate at 20% of the exploitable or mature biomass, consistent with other herring fisheries on the west coast of North America. The 20% exploitation rate is lower than commonly used biological reference points (Funk 1991) for species with similar life history characteristics (Figure 4.4). In some areas, such as Southeast Alaska, a formal policy exists for reducing the exploitation rate as the biomass drops to low levels. In other areas, the exploitation rate is similarly reduced, without the formal policy. In addition to exploitation rate constraints, minimum threshold biomass levels are set for most Alaskan herring fisheries. If the spawning biomass is estimated to be below the threshold level, no commercial fishing is allowed. Threshold levels are generally set at 25% of the long-term average of unfished biomass (Funk and Rowell 1995).

Unlike most other Alaskan fisheries, fishery managers actively manage the sac roe fishery to obtain the highest-valued product possible. An intensive sampling program is used to monitor the condition of the ripening females, and fishery managers use this information to carefully time fishery openings down to days or even hours before the main spawning event.

Most herring fisheries in Alaska are regulated by management units or regulatory stocks (i.e., geographically distinct spawning aggregations defined by regulation). Those aggregations may occupy areas as small as several miles of beach or as large as all of PWS. Herring sac roe and spawn-on-kelp fisheries are always prosecuted on individual regulatory stocks. Management of food and bait herring fisheries can be more complicated because they are conducted in the late summer, fall, and winter when herring from several regulatory stocks may be mixed together on feeding grounds distant from the spawning areas. Where possible, the BOF avoids establishing bait fisheries that harvest herring from more than one spawning population. For historically developed food/bait fisheries that harvest more than one regulatory stock, such as the Dutch Harbor or Kodiak fisheries, BOF regulations close the food/bait fishery if any of the component spawning populations is below threshold. Where there is more than one fishery on a spawning population, the BOF allocates specific percentages of the annual allowable harvest to each fishery.

Records of catch are derived from landing receipts forms or “fish tickets” which must be completed for all commercial sales of fish products in Alaska. However because it can take several days to months to obtain final catch records, during the fishing season fishery managers rely in catch weight estimates obtained from fish processors to determine whether fishing quotas

have been obtained. Catch weights at the time of sale are derived from a combination of volumetric and gravimetric methods. Small adjustments are sometimes made to scale weight readings to allow for extra water present with the herring as a result of the fish pumps used to transfer the catch.

4.2.4 Fishery Status in 1999

The 1999 herring catch of approximately 37,000 mt is less than the recent 10 year average catch of approximately 49,000 mt, because of lower abundance in some areas. Allowable harvest quotas in some areas were not entirely taken in 1999 because of marketing and processing considerations. The major populations of herring in Alaska are at moderate levels and in relatively stable condition, with the exception of PWS and Cook Inlet.

4.2.4.1 Prince William Sound

Prince William Sound herring fisheries have been closed since 1998 due to low stock abundance. Abundance was high through the 1980s and into the early 1990s, but dropped sharply in association with a virus outbreak in 1993. Fisheries were closed in 1994, 1995 and 1996 (Figure 4.5). Abundance levels rebounded somewhat and were sufficiently above the threshold biomass of 19,958 mt to allow fishery harvests in 1997 and 1998. High levels of the viral hemorrhagic septicemia virus (VHS) were detected in the 1998 spawning population. In 1999, a very limited pound fishery occurred, but was cut short and all other fisheries cancelled when it became clear that the stock had suffered a major reduction in biomass and poor recruitment. The interaction of the diseases VHS and the fungus-like organism *Ichthyophonus hoferi* with fish condition are thought to be major contributors to the decreased survival rate in PWS during the 1990s, perhaps in combination with lingering effects of the Exxon Valdez oil spill of 1989. Herring abundance levels remain low and stable in PWS, and the commercial herring fishery remained closed in 1999 and 2000, and is not expected to open in 2001. The wide variability in catches through the 20th century suggests that herring abundance may have fluctuated widely in the past also.

During the earlier reduction fishery, catches were taken mostly during the summer and fall, and occurred primarily in the southwestern part of PWS (Figure 4.5). The last sac roe fishery in 1997 occurred almost entirely in the vicinity of northeastern Montague Island (Figure 4.6). During the period of higher abundance of the 1980s and early 1990s, herring spawning locations and sac roe fisheries, were spread throughout a much broader area that included the northeast area, the northern area around Cedar and Granite Bays, and Naked Islands area in central PWS. Pound and wild spawn-on-kelp fisheries historically always occurred in the northeastern area. However, with most of the recent spawn occurring on Montague Island, the wild spawn-on-kelp harvest shifted to that area (Figures 4.7 and 4.8). The use of open pounds near Montague Island was allowed starting in 1997, while closed pounds were restricted to the northern areas. Herring for food and bait have usually been taken in PWS in the fall, either off Knowles Head in southeastern PWS, or between Green and Montague Islands, where the 1997 food and bait catch was taken (Figure 4.9).

4.2.4.2 Cook Inlet

The primary contemporary herring fishery in Cook Inlet occurs in Kamishak Bay, and also was below threshold in 1999. This fishery had an average catch of about 2,400 mt from the mid 1980s through 1997, when the abundance began to decline (Figure 4.10). A very small and atypical catch was taken in 1998, before the fishery was declared below threshold. Another period of low abundance and fishery closures occurred during the period 1980 through 1984. During the last viable fishery in 1997, catch was fairly typically concentrated in the western end of Kamishak Bay (Figure 4.11). Recent surveys from the spring of 2000 indicate that a strong year class is recruiting to the fishery and that the population is likely above threshold. However, the Kamishak Bay fishery will remain closed in 2001 because the size of the recruiting year class is still small. In Kamishak Bay, herring are taken during the spring sac roe fishery by purse seines. Very small and sporadic herring fisheries have also occurred further north in Cook Inlet using gillnet gear. Early in the development of the sac roe fisheries there were some substantial harvests in the southern, eastern, and outer districts of Cook Inlet, but no sac roe catch has occurred in those areas in recent years. Preceding the roe fishery, there was a small herring reduction plant in Kachemak Bay on the eastern side of Cook Inlet.

4.2.4.3 Kodiak

Substantial commercial herring catch has occurred in the vicinity of Kodiak Island since 1920 (Figure 4.12). During the reduction fishery era catches fluctuated widely due to likely over-exploitation and changing market conditions. Catches have been much more stable but lower during the more recent roe fishery period. Strong recruitment allowed higher catches on the order of 4,000 mt annually during the early 1990s. With the senescence of these strong year classes, the catch was reduced to 1,497 mt in 1999.

A small food and bait fishery usually occurs in northern Shelikof Strait, but was closed in 1999 because the fishery also harvests some herring from the Kamishak Bay spawning population in Cook Inlet, which has been below threshold since 1998. In 1997, the last year of a substantial Kodiak food/bait fishery, the harvest occurred in Uganik Bay, the west side of Afognak Island, and the east side of Kodiak Island (Figure 4.13).

The Kodiak fishery sac roe harvest is taken by both gillnet and purse seine gear. Historically about 75% of the catch was typically taken by seine gear. Starting in 2000, allocations to the gears are fixed by regulation. The sac roe fishery opens by regulation on April 15, and most of the catch is usually taken during the first 2 weeks of the season (Figure 4.14, top). Annually the department reviews stock status data and determines sections that will be open and establishes catch quotas or guideline harvest levels for these sections. Historically commercial sac roe herring harvests have occurred in 63 sections in the bays around Afognak Island, Kodiak Island, and along the Alaska Peninsula within the Kodiak Management Area. Most of the catch in recent years has been taken from western side of Afognak and Kodiak Islands, in the Afognak and Uganik Districts (Figure 4.14, bottom).

4.2.4.4 Alaska Peninsula

Alaska Peninsula herring catches are dominated by harvests in the vicinity of Unalaska Island (Dutch Harbor), where the Togiak–spawning herring reside during the summer feeding period. An early food and reduction fishery was established at Dutch Harbor from 1929-1939 (Figure 4.15). The Dutch Harbor fishery resumed in 1982, primarily as a bait fishery. Because the primary stock harvested spawns at Togiak, the overall exploitation rate is set at 7% of the allowable Togiak harvest. In addition, the Dutch Harbor fishery is closed if any of the eastern BS stocks which are thought to contribute to the fishery are below threshold. During 1999 the harvest at Dutch Harbor was 2,175 mt, taken during a 4-day period in Unalaska Bay (Figure 4.16).

Elsewhere along the Alaska Peninsula, herring catch is generally low and sporadic. On occasion, a significant sac roe harvest occurs at Port Moller along the North Peninsula, when in-season aerial surveys document sufficient quantities of herring, and if processing capacity is available. The last substantial herring sac roe harvest along the Alaska Peninsula occurred in 1996, with the catch quite broadly distributed in space and time (Figure 4.17).

4.2.4.5 Bristol Bay

The largest aggregation of herring in Alaska spawns along the northern shore of Bristol Bay, near the village of Togiak. A large purse seine and gillnet fishery harvests the spawning herring in a sac roe fishery. A spawn-on-kelp harvest is also taken, primarily by local residents, usually in Togiak Bay (Figure 4.18). Following spawning, the Togiak herring migrate clockwise around Bristol Bay (Funk 1990), and are taken in the food and bait fishery off of Dutch Harbor in July. These herring then migrate along the shelf edge to spend the fall and winter in the general vicinity of the Pribilof Islands. A large foreign trawl fishery harvested these herring in the central BS area from the late 1950s through 1980 (Figure 4.19). The Togiak sac roe fishery began in 1977, and has supported a fairly stable catch averaging 19,000 mt over the last ten years. The Togiak stock is at moderate levels, with a 1999 sac roe catch of 16,773 mt taken along the northern shore of Bristol Bay (Figure 4.20).

4.3 Interactions with Sea Lions

4.3.1 Predation

Pacific herring appear in the diet of Steller sea lions, though generally herring are not the most important prey item in the diet (Chapter 3 in this report, Hoover 1988). However, existing stomach contents studies are spread throughout the year. For brief periods just prior to spawning, herring could likely be very important items in Steller sea lion diets.

4.3.2 Overview of Sea Lion Associations with Fisheries

Steller sea lions are attracted to areas where herring spawn, likely feeding on the dense aggregations of herring present just offshore during the short spawning period. Because herring spawn timing is somewhat variable, in many areas, Alaska herring fishery managers have

learned to depend on the presence of Steller sea lions to determine when herring spawning is imminent. Fishery managers generally start flying occasional aerial surveys over potential herring spawning grounds well in advance of the expected spawning event. For several weeks prior to spawning, herring are usually present adjacent to the spawning grounds, but they occur in depths too deep to be detected from aircraft. However, the presence of Steller sea lions on the spawning grounds alerts the fishery manager to the presence of herring and impending spawning. Fishery managers usually note the presence of Steller sea lions in their field notebooks, occasionally recording actual counts. With the pending decline of Steller sea lions these observations could provide a platform of opportunity for quantifying Steller sea lion counts. Several days before spawning, herring move into shallower water and become directly detectable by aerial surveyors, without the assistance of the sea lions. About this time the fishing fleet begins arriving in the general area where the fishery will take place. Vessels generally anchor up within a few hours steaming time of where the opening is expected, but not usually in the area where herring and sea lions are concentrated. As the time of spawning approaches, fishery managers will direct a few vessels to likely spawning locations to “test fish”, obtaining samples for biological analysis and ripeness of roe. Fishery managers try to time the fishery opening as close as possible to the time that herring will spawn, ideally about one day before.

Several hours before the opening, the fishing fleet moves into position, directed to the herring schools by spotter aircraft. Fishery openings, particularly purse seine openings, can be very short, on the order of 30 minutes. After the opening, vessels remain on the grounds for several hours until the catch is pumped aboard tender vessels, which will in turn transfer the catch to larger processors anchored offshore. After offloading their catch, fishing vessels return to their anchorages to await another opening, or depart the fishing grounds if no further openings are to be expected. Steller sea lions leave the spawning grounds within a few days after herring spawning. Fishery biologists make good note of their departure in areas where spawn deposition SCUBA surveys are used for herring biomass assessment. For safety reasons, SCUBA surveys will not begin until the sea lions have left the area.

In some areas, such as around Kodiak Island fishery managers do not fly extensive aerial surveys because of weather conditions and the extensive spread of herring spawning locations. In these areas information about Steller sea lion and pre-fishery herring distribution is not available.

One example of a herring spawning event where Steller sea lion counts were quantified during fishery manager aerial surveys is shown in Figure 4.21. Unfortunately there was no fishery at Hobart Bay in spring 2000 because the quota had all been taken in the earlier food/bait herring fishery. However, if a fishery had occurred, managers would typically have allowed 6-12 hours of gillnet fishing about April 29. Steller sea lions were already in the area at the time of the first ADF&G aerial survey on April 19, diving on the deeply submerged herring schools, as were a number of humpback whales. Following the spawning event, large numbers of birds appear on the beaches to feed on the herring eggs, noted in numbers of 11,000 to 20,000 on Figure 4.21. Approximately 150 Steller sea lions were counted in the area. Some similar descriptions of Steller sea lion presence on herring spawning grounds are sometimes available in field notes from other herring fishing areas.

4.3.3 Overlap of Fisheries and Sea Lion Critical Habitat

Almost all of the PWS, Kodiak and Alaska Peninsula herring catch occurs inside the 20 nm definition of Steller sea lion “critical habitat” (Figures 4.6, 4.7, 4.8, 4.9, 4.13, 4.14, 4.16, 4.17). Only part of the Bristol Bay herring catch occurs inside of critical habitat (Figures 4.18, 4.20), while none of the Cook Inlet herring catch occurs inside critical habitat (Figure 4.11). If herring harvests were excessive, it is possible that local depletion in the critical habitat areas could occur, affecting one of the food sources for Steller sea lions. However, Alaska herring fisheries are assessed and managed based on spawning location. A conservative harvest policy provides safeguards against the possibility that local depletion would occur in these areas. The herring food/bait fisheries at Dutch Harbor, in Shelikof Strait, and PWS are not as closely tied to spawning populations as the sac roe fisheries. However, exploitation rate in these fisheries is kept very low, a small fraction of the allowable harvest, so that localized depletion is unlikely. The PWS food/bait fishery is allocated 16.3% of the overall PWS quota, and the Kodiak food/bait fishery is allocated a maximum of 10% of the allowable harvest of Kodiak-spawning herring, with further restrictions associated with the condition of the lower Cook Inlet spawning herring. The Dutch Harbor food and bait fishery is allocated 7% of the targeted Bristol Bay-spawning herring, with further restrictions associated with the condition of other eastern BS stocks that may also be taken in the fishery.

4.3.4 Direct Fishery Interactions

Direct interactions between Steller sea lions and herring fisheries could occur if vessel activity interferes with sea lion presence in the area, or if mortality results from fishery-sea lion interactions. Steller sea lions will often appear in the middle of areas where herring fishing vessels are working, making it unlikely that vessel activity is causing them to leave the fishing grounds. Herring fishing vessel activity in a herring spawning area is limited to the very brief windows of fishery openings, while Steller sea lions tend to remain in the area for the duration of the spawning event. Even if there were fishing vessel-Steller sea lion interactions, these would occur for only a short fraction of the spawning period when herring are in the nearshore areas. Herring pound fisheries also seem to attract sea lions, and provide a potential setting for conflict between Steller sea lions and herring fisheries. No observer information from herring vessels, which would formally record Steller sea lion interactions or mortality, is available.

Table 4.1. Status of Alaska herring fisheries in 1999.

Fishery Area	Season	Gear ¹	Assessment Method ²	Biomass ³ (mt)	Stock Status		Harvest Policy		1999 Fishery			
					Level	Trend	Exploitation Rate Framework	1999	Threshold (mt)	Duration	Catch (mt)	
Southeastern												
Kah Shakes/Cat I.	Sac Roe	Gn	ASA	7,370	Moderate	Stable	0-20%	0%	5,443	-	0	
Sitka Sound	Sac Roe	PS	ASA	39,553	High	Stable	0-20%	19%	18,144	1.3 hrs	7,711	
Seymour Canal	Sac Roe	Gn	ASA	4,706	Moderate	Stable	0-20%	11%	2,722	11 hrs.	649	
Hobart/Houghton	Food/Bait	PS,Gn	ASA	3,417	Moderate	Stable	0-20%	12%	1,814	2 hrs.	499	
Craig, Tenakee	Food/Bait, Pd	PS, Pd	ASA	8,165	Moderate	Stable	0-20%	10%	7,257	5 days	1,238	
Hoonah Sound	Spawn on Kelp	Pd	ASA	2,722	Moderate	Stable	0-20%	10%	1,814	20 days	115	
Prince William Sound		PS,Gn,Pd,Hp	ASA	35,886	Low	Increasing	0-20%	15%	19,958	-	0	
Cook Inlet (Kamishak)	Sac Roe	PS	ASA	5,443-11,79	Low	Stable	0-20%	0%	7,257	-	0	
Kodiak	Sac Roe/Fd. Bait	PS,Gn,Tr	Catch, age comp.	Uncertain	Moderate	Stable	0-20%			30 days	1,488	
Alaska Peninsula	Food/Bait	PS	<i>(Harvest policy specified as 7% allocation of Bristol Bay allowable catch)</i>								13 hrs.	2,175
Bristol Bay (Togiak)	Sac Roe	PS,Gn,Hp	ASA	81,647	Moderate	Declining	20% max.	20%	31,752	32 hrs.	17,190	
Kuskokwim Area												
Security Cove	Sac Roe	Gn	Annual Survey	2,776	Moderate	Declining	20% max.	20%	1,089	9 hrs.	973	
Goodnews Bay	Sac Roe	Gn	Annual Survey	2,730	Moderate	Declining	20% max.	20%	1,089	49 hrs.	1,239	
Cape Avinof	Sac Roe	Gn	Annual Survey	3,225	High	Stable	15% max.	15%	454	51 hrs.	484	
Nelson Island	Sac Roe	Gn	Annual Survey	5,285	High	Declining	20% max.	17%	2,722	22 hrs.	1,239	
Nunivak Island	Sac Roe	Gn	Annual Survey	3,011	Moderate	Declining	20% max.	20%	1,361	-	0	
Cape Romanzof	Sac Roe	Gn	Annual Survey	Uncertain	Moderate	Declining	20% max.	20%	1,361	13.5 hrs.	485	
Norton Sound	Sac Roe	Gn, BS, Pd	Annual Survey	37,348	High	Stable	20% max.	20%	6,350	101 hrs.	2,357	

¹ Gears: Gillnet (Gn), purse seine (PS), pound spawn-on-kelp (Pd), hand-picked spawn-on-kelp (Hp), beach seine (BS), trawl (Tr).

² Assessment methods: Age-structured assessment models (ASA), synthesize several sources of abundance information.

³ Run biomass is defined as the proportion of the population which will return to spawn.

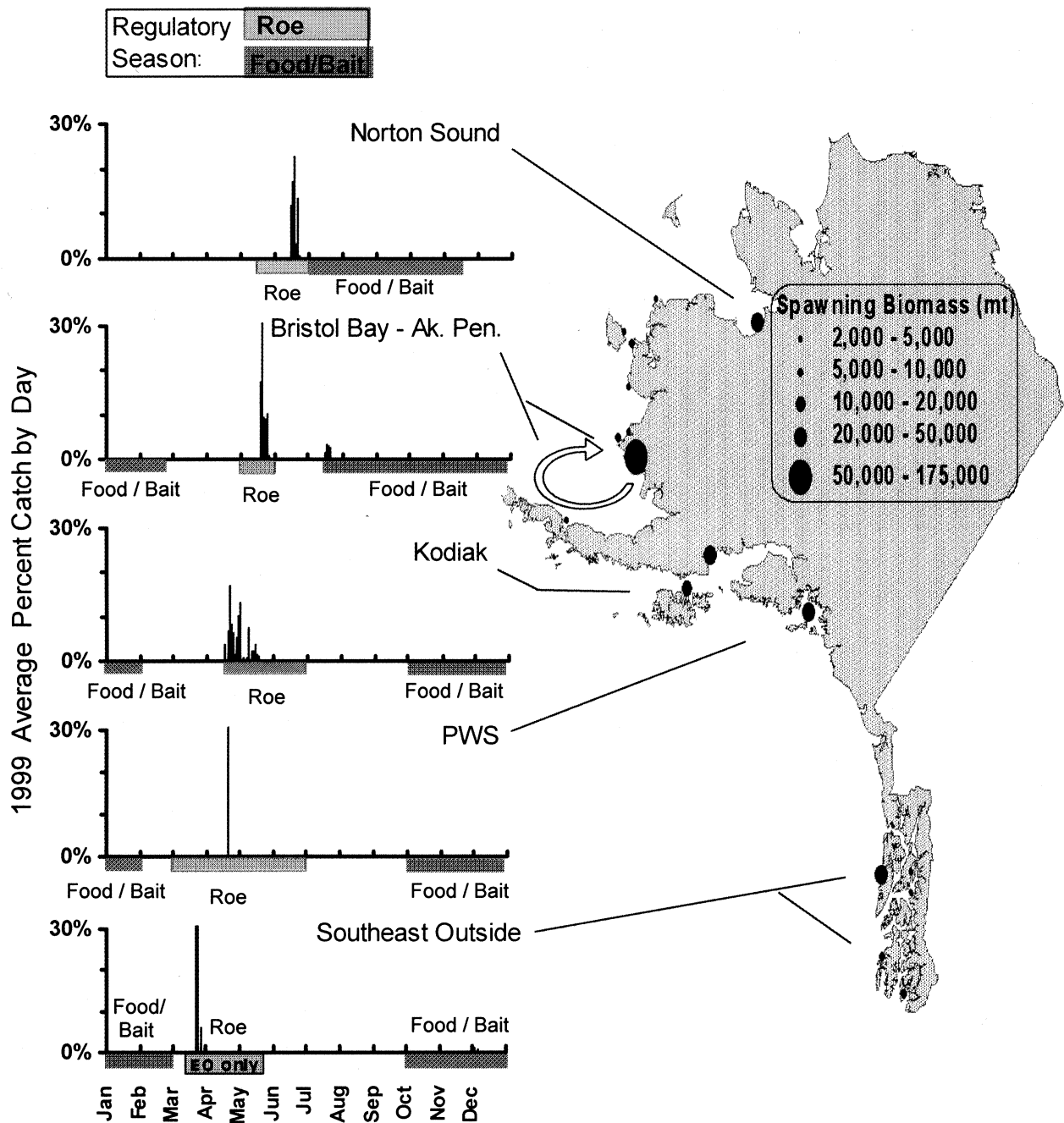


Figure 4.1. Location of Alaska herring spawning populations, and timing of 1999 fisheries on spawning herring, illustrating the south to north gradient in run timing, and the counterclockwise migration of Togiak-spawning herring around the eastern Bering Sea.

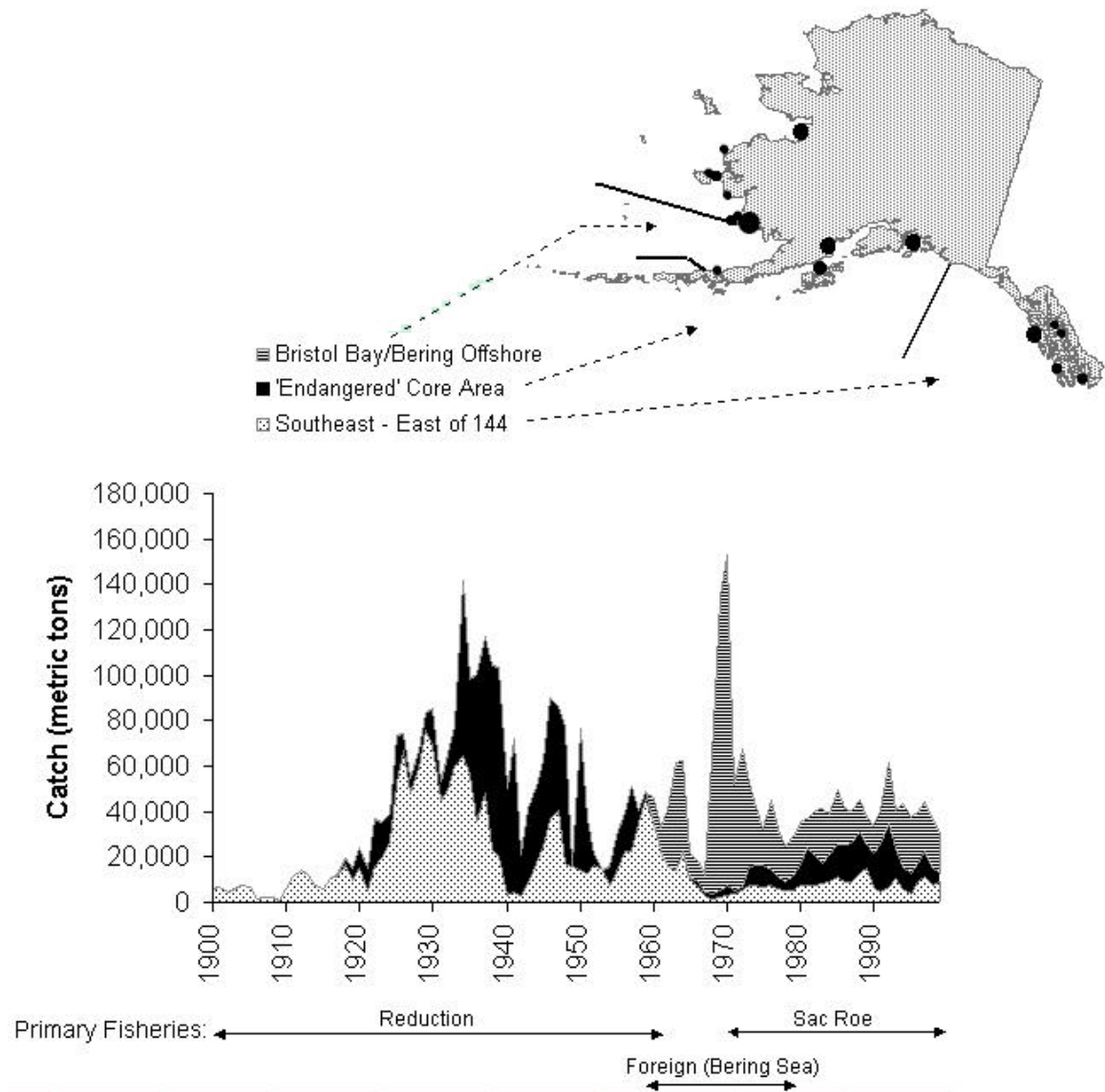
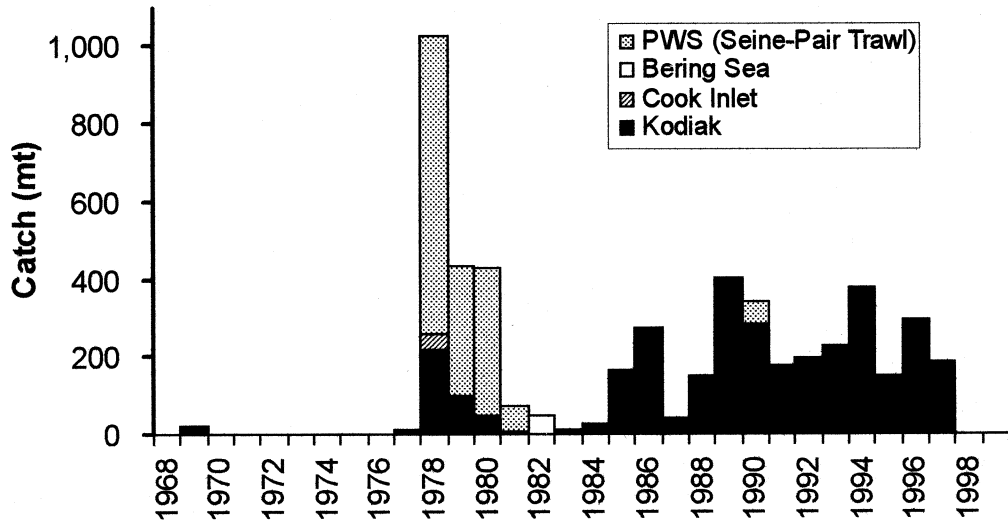


Figure 4.2. Historic harvests of Pacific herring in Alaska, with respect to critical habitat for Steller sea lions

A. Trawl Food/Bait Herring Catch, 1968-99



B. Average Herring Catch by Gear, 1990-99

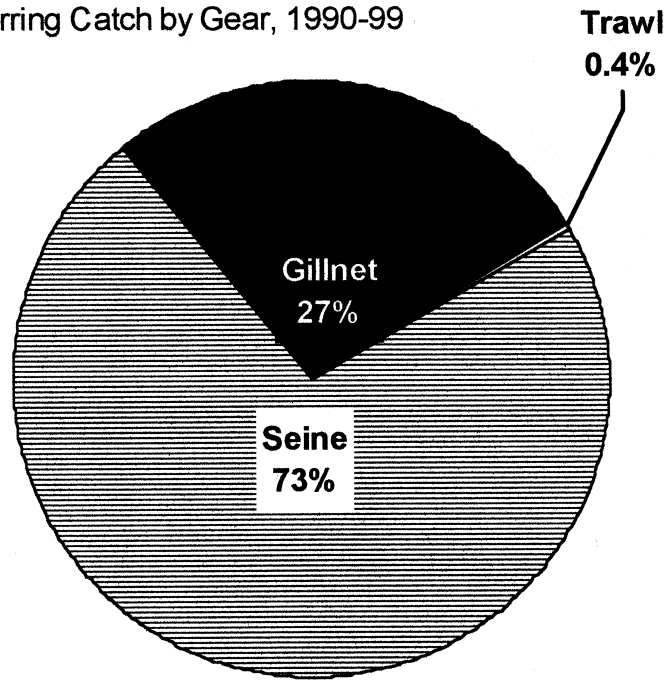


Figure 4.3. Trawl catch of Pacific herring in Alaska by area (upper), and 1990-99 average percent harvested by gear (lower). Harvests from the 1960-80 foreign trawl fishery in the central Bering Sea are not included.

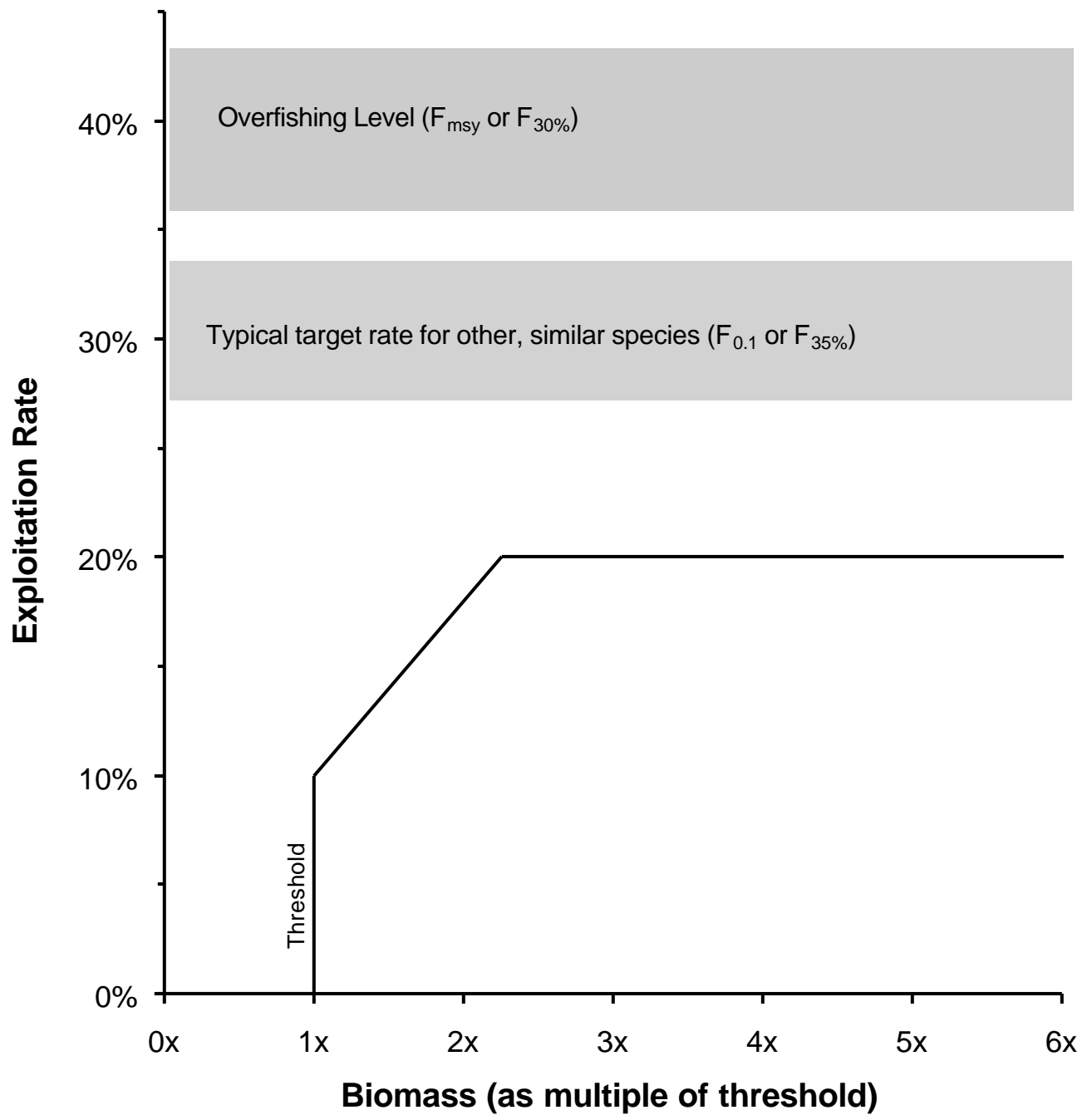


Figure 4.4. Generalized exploitation rate/threshold harvest policy for herring fisheries in Alaska, illustrating the reduction in exploitation rate when abundance is near threshold, and showing exploitation rate biological reference points.

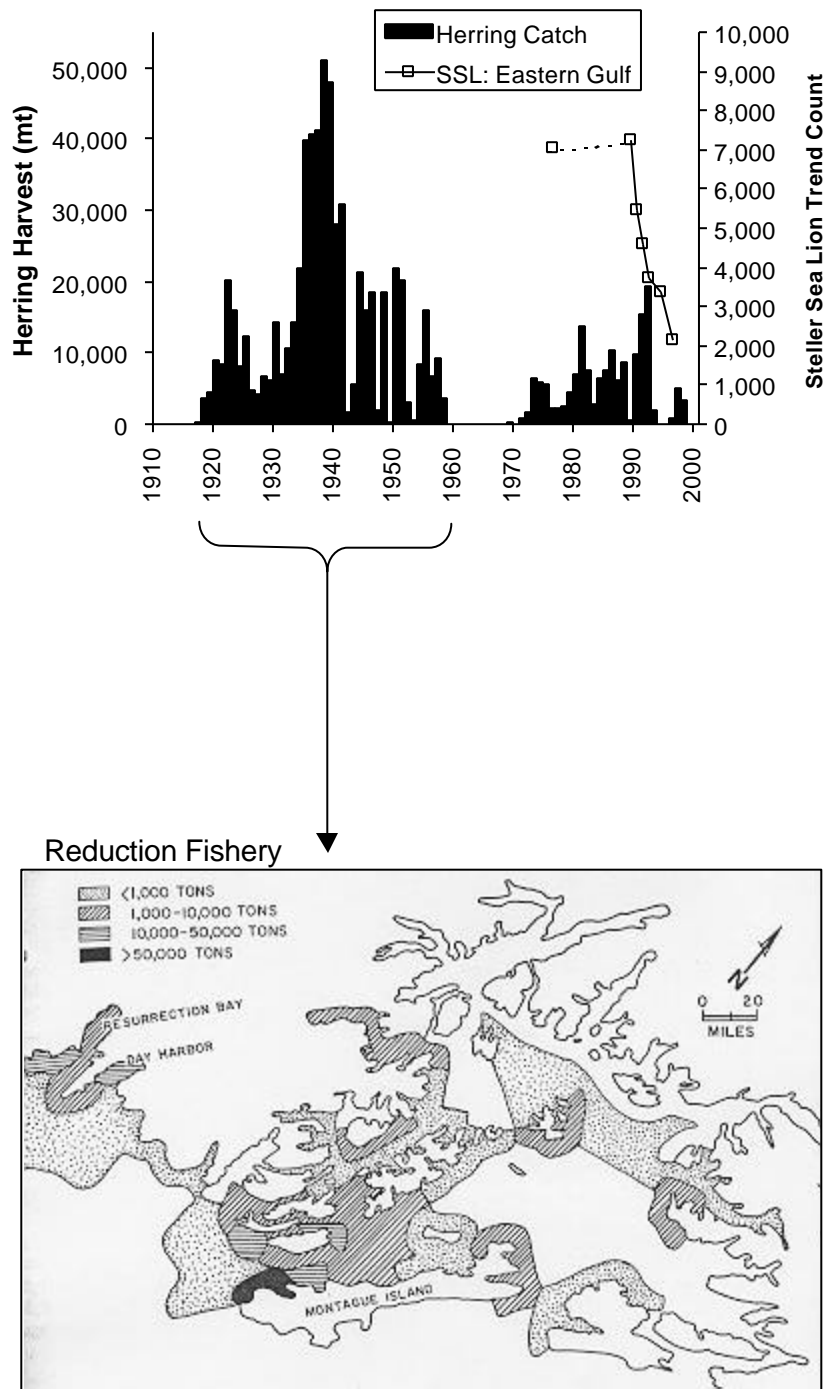


Figure 4.5. Historical catch of herring in Prince William Sound in metric tons (mt) with Steller Sea Lion (SSL) counts from the nearby eastern gulf index area (top), and the spatial distribution of the 1917-1958 reduction fishery (bottom, from Reid, 1971), where catch was reported in short tons (2,000 lbs or 0.907 mt).

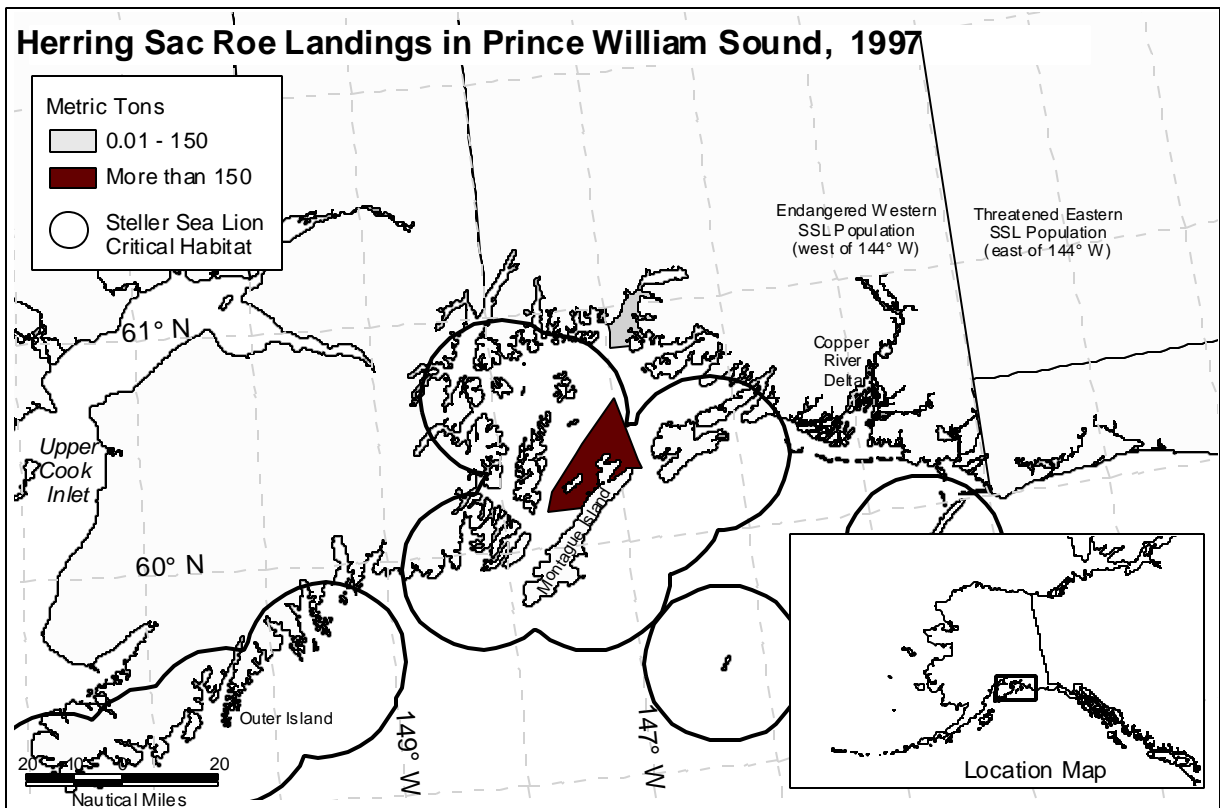
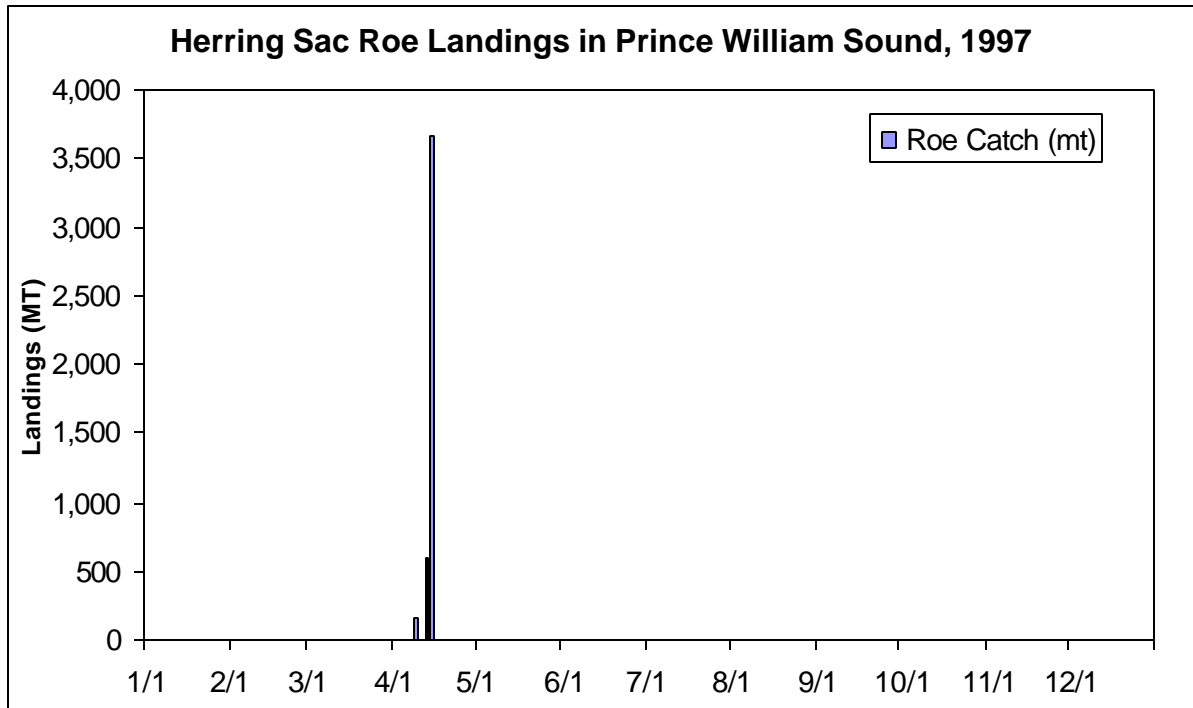


Figure 4.6 Monthly distribution of herring sac roe landings in Prince William Sound, 1997 (top), and Spatial distribution of herring sac roe landings in Prince William Sound, 1997 (bottom).

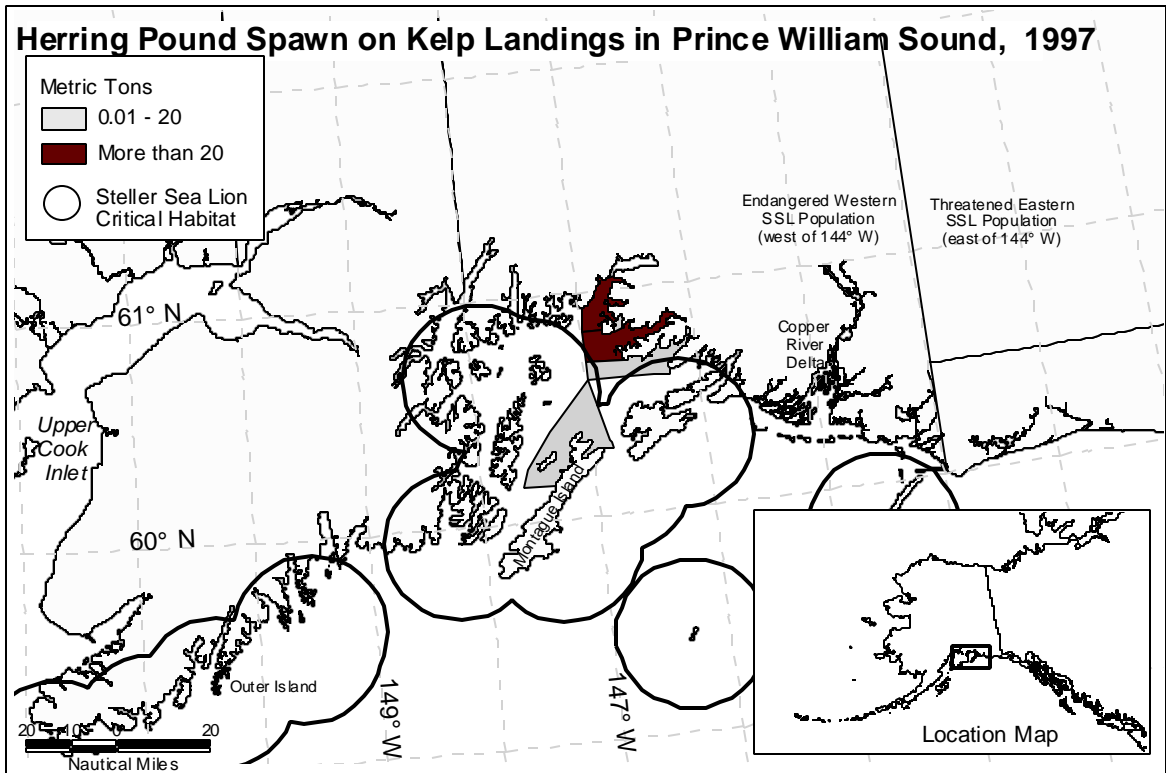
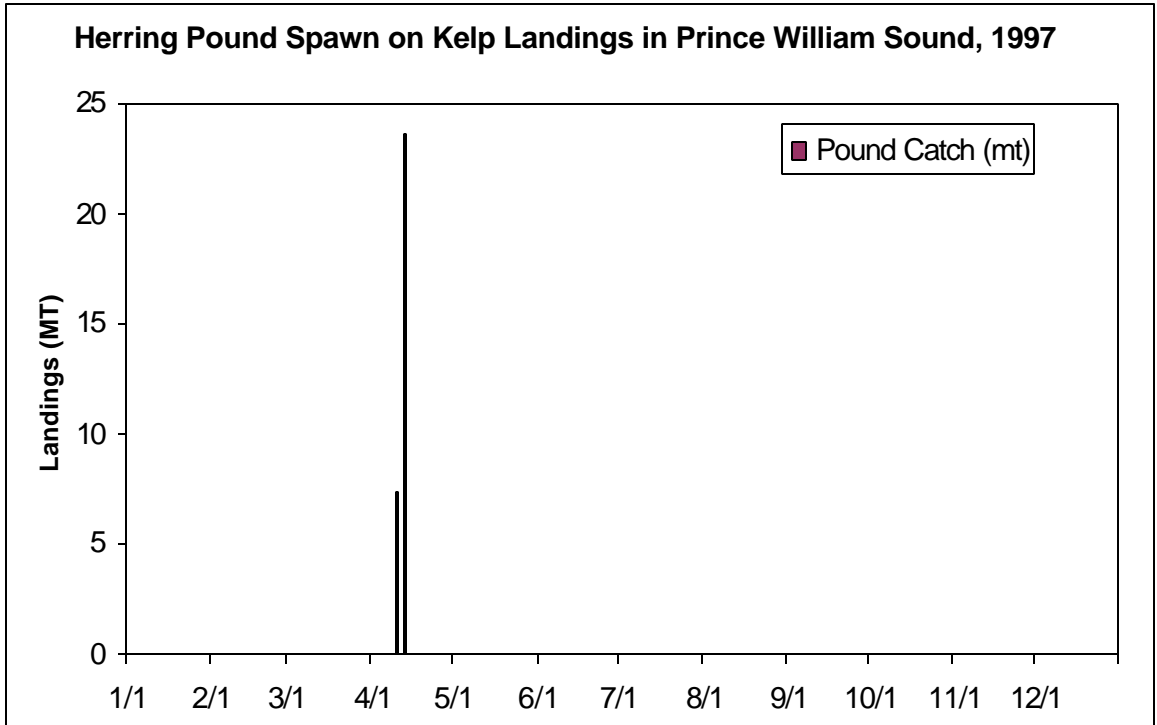


Figure 4.7 Monthly distribution of herring pound spawn on kelp landings in Prince William Sound, 1997 (top), and Spatial distribution of herring pound spawn on kelp landings in Prince William Sound, 1997 (bottom).

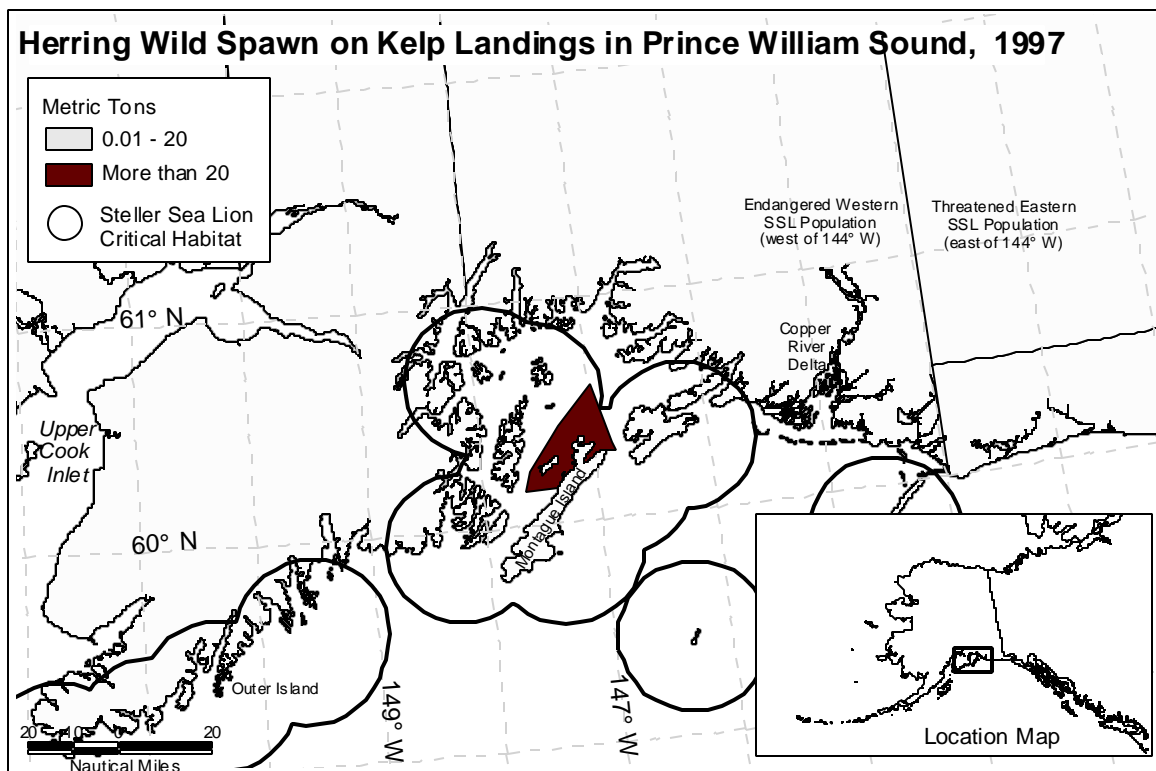
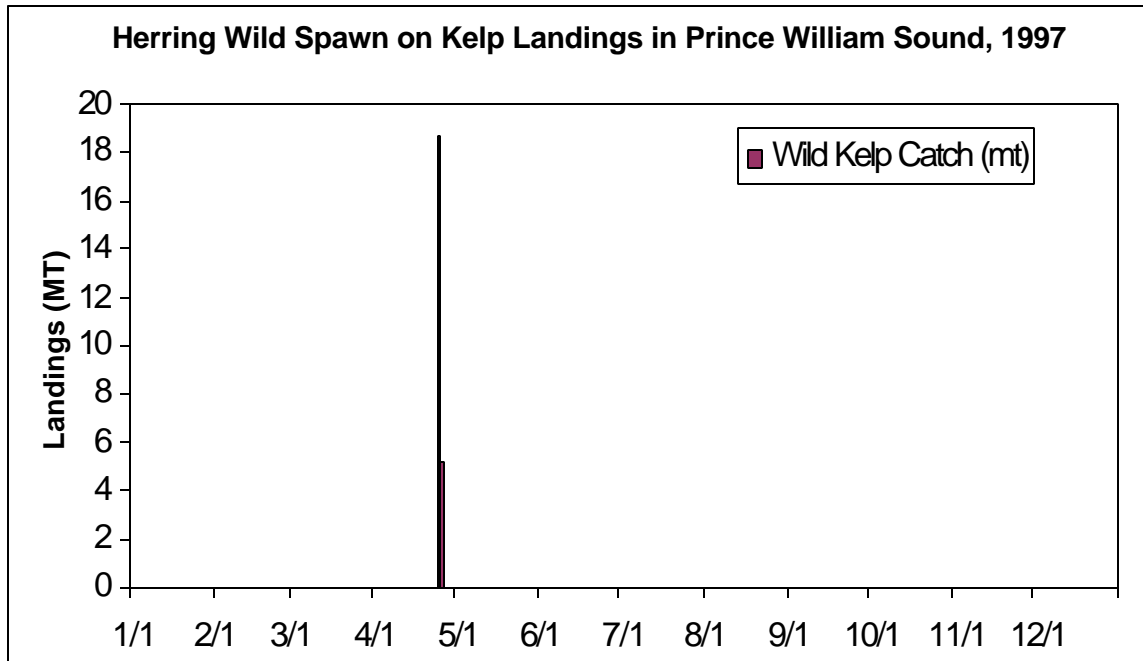


Figure 4.8 Monthly distribution of herring wild spawn on kelp landings in Prince William Sound, 1997 (top), and Spatial distribution of herring wild spawn on kelp landings in Prince William Sound, 1997 (bottom).

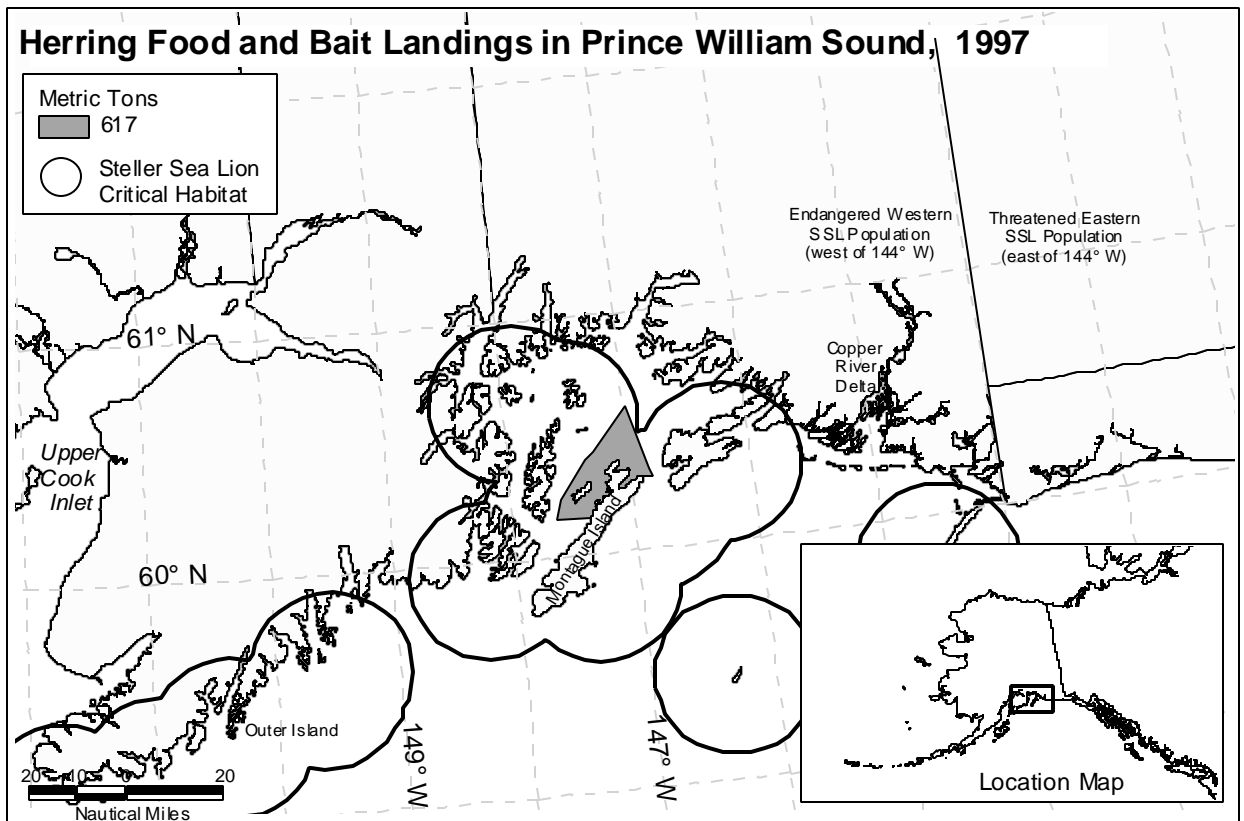
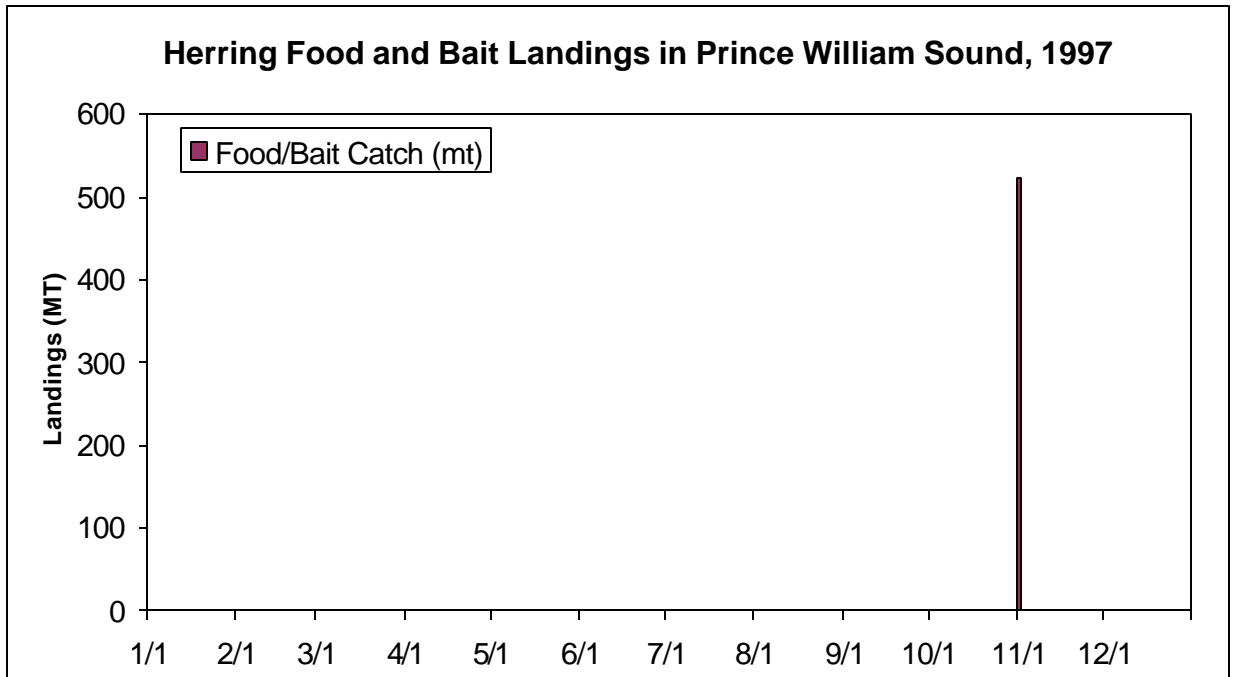


Figure 4.9 Monthly distribution of herring food and bait landings in Prince William Sound, 1997 (top), and Spatial distribution of herring food and bait landings in Prince William Sound, 1997 (bottom).

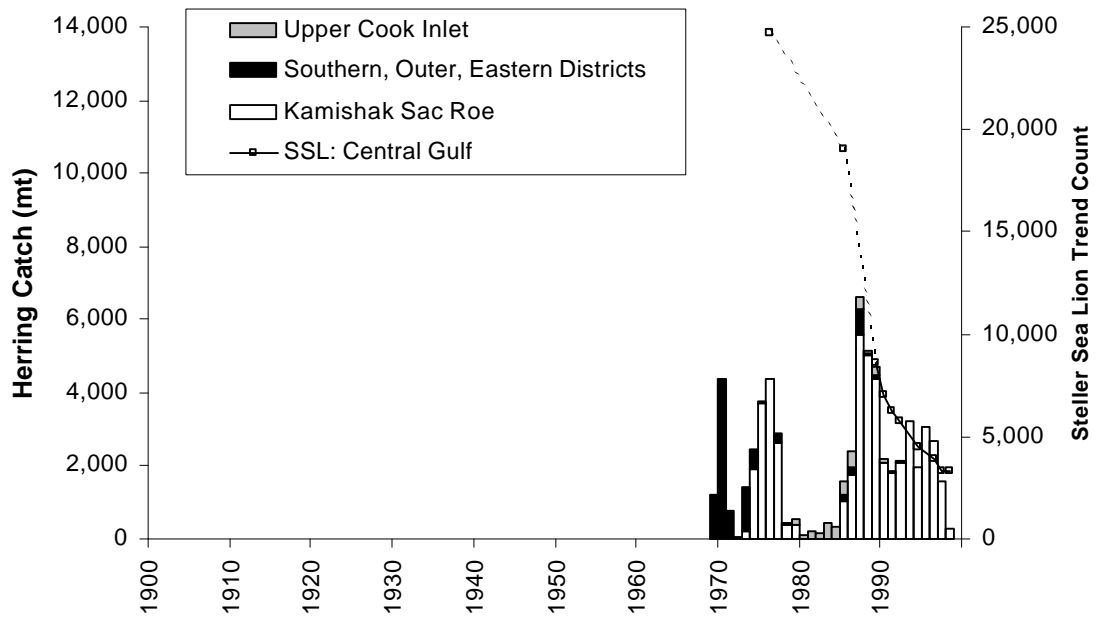


Figure 4.10. Cook Inlet herring catch, 1900-1999, with Steller Sea Lion (SSL) index counts from the nearby central gulf index area.

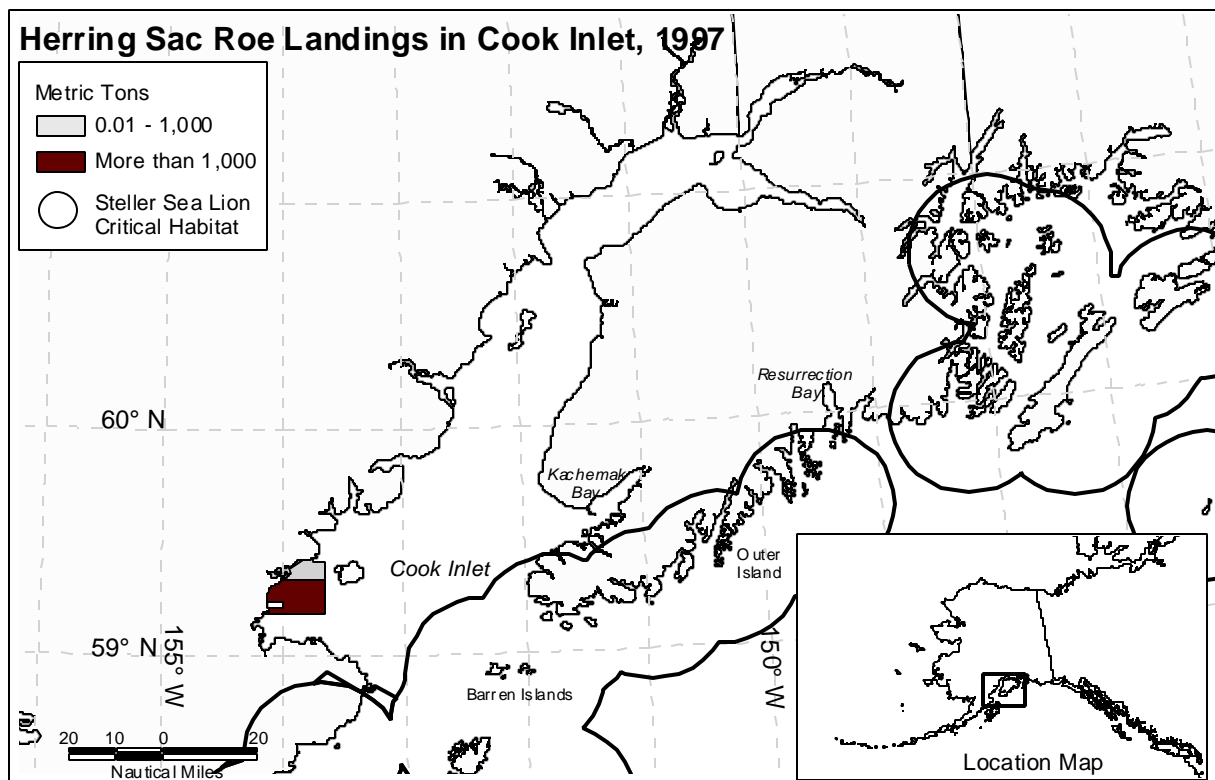
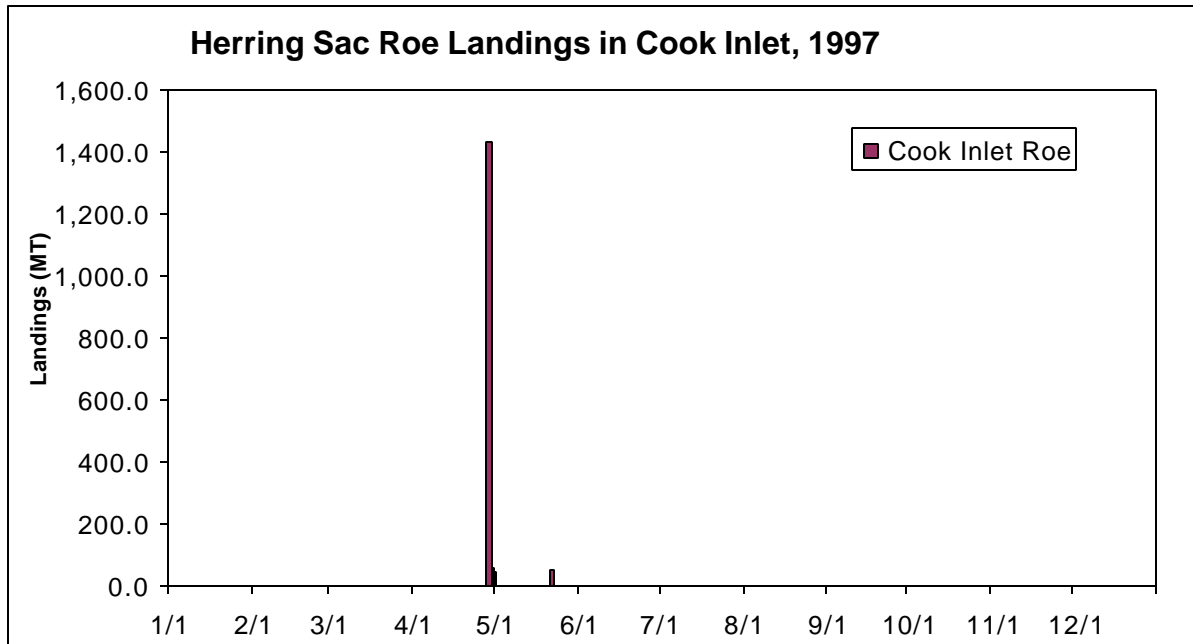


Figure 4.11 Monthly distribution of herring sac roe landings in Cook Inlet, 1997 (top), and Spatial distribution of herring sac roe landings in Cook Inlet, 1997 (bottom).

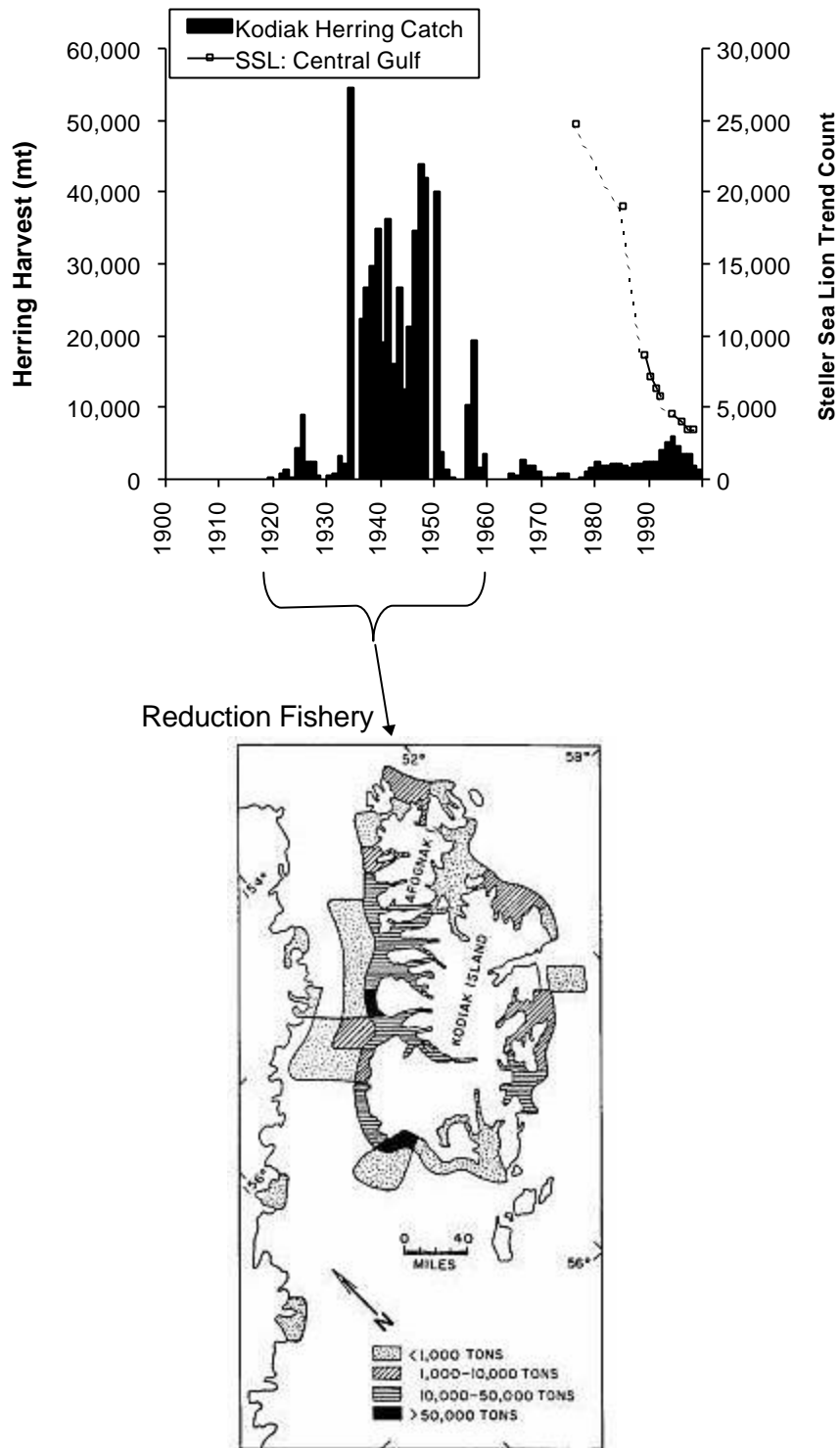


Figure 4.12. Historical herring catch (mt) in the Kodiak area and Steller Sea Lion (SSL) trend counts from the nearby central gulf index area (top), and the spatial distribution of herring catch during the reduction era, 1915 – 1959 (bottom, from Reid, 1971) where catch was reported in short tons (2,000 lbs or 0.907 mt).

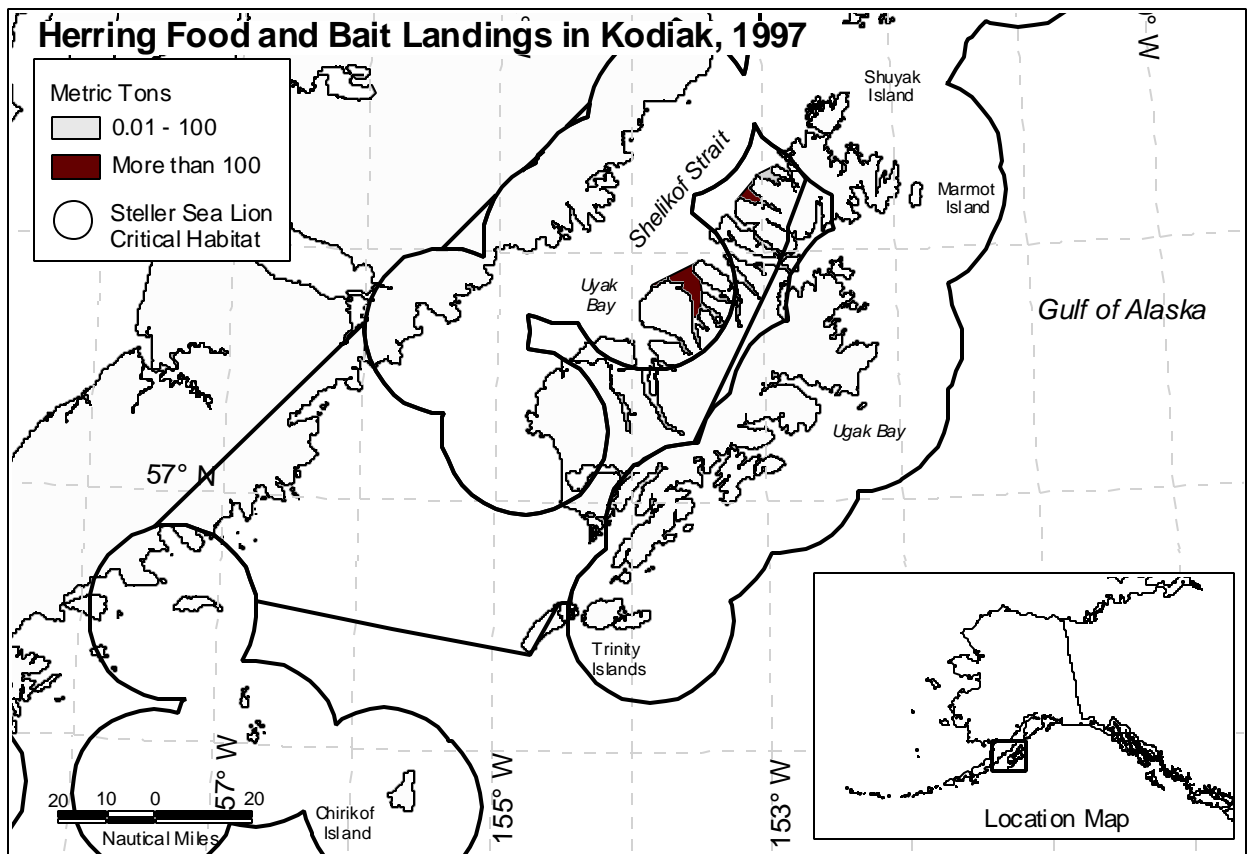
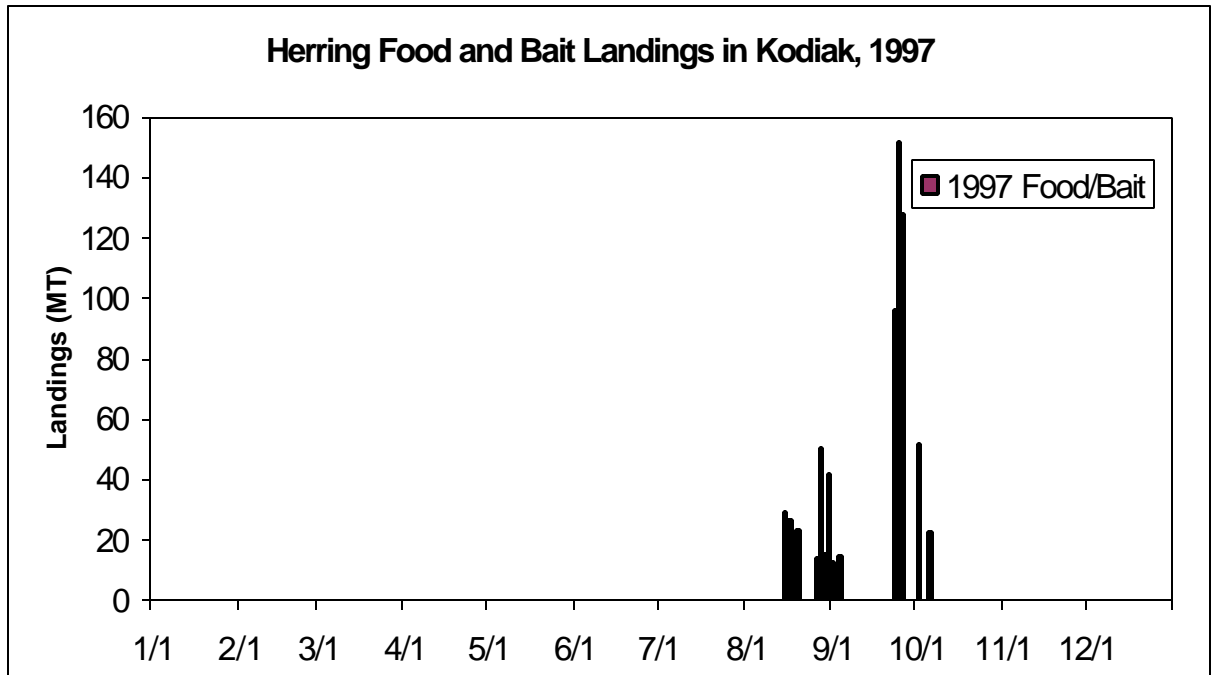


Figure 4.13 Monthly distribution of herring food and bait landings in Kodiak, 1997 (top), and Spatial distribution of herring food and bait landings in Kodiak, 1997 (bottom).

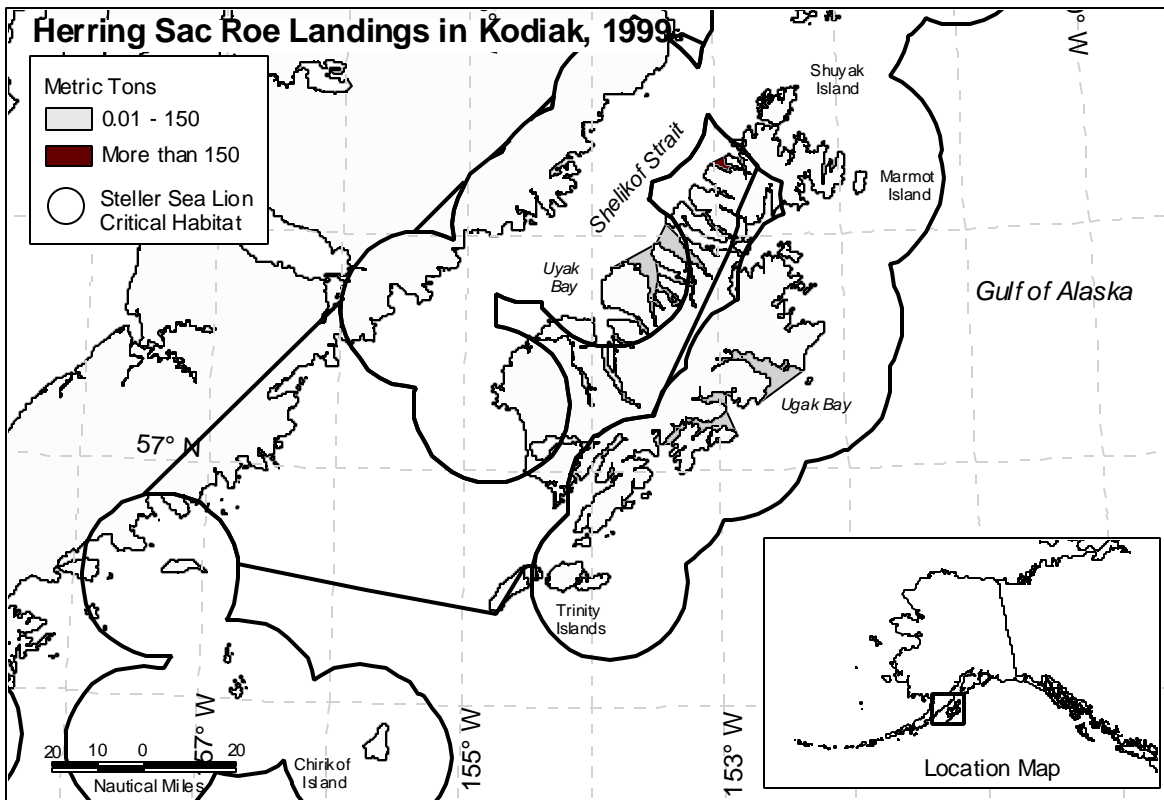
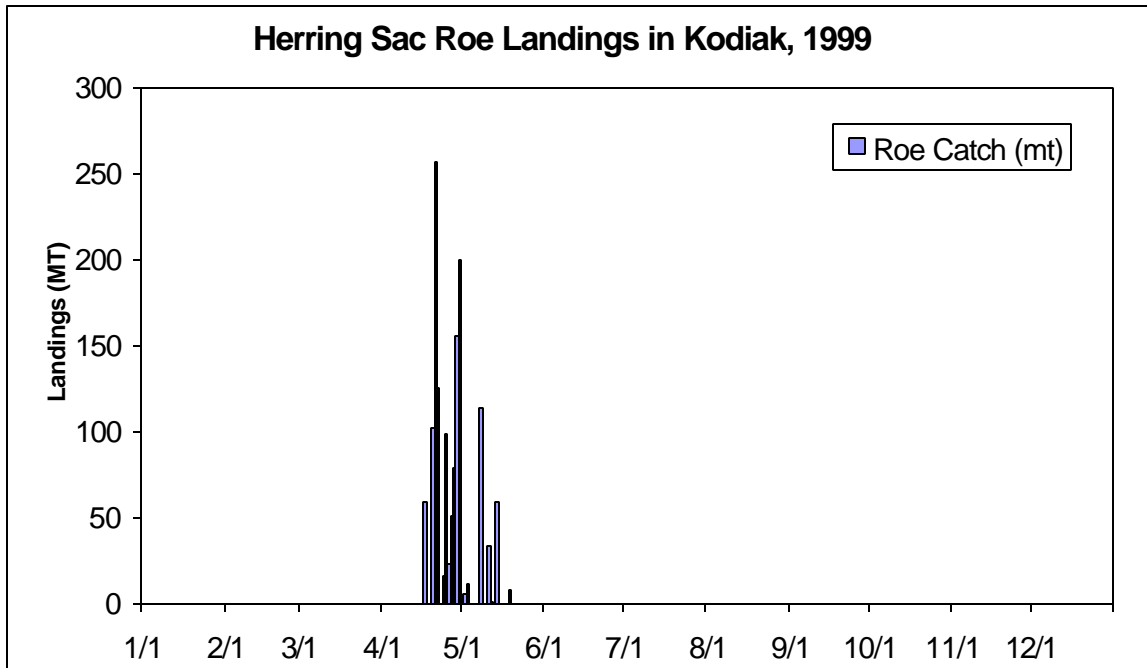


Figure 4.14 Monthly distribution of herring sac roe landings in Kodiak, 1999 (top), and Spatial distribution of herring sac roe landings in Kodiak, 1999 (bottom).

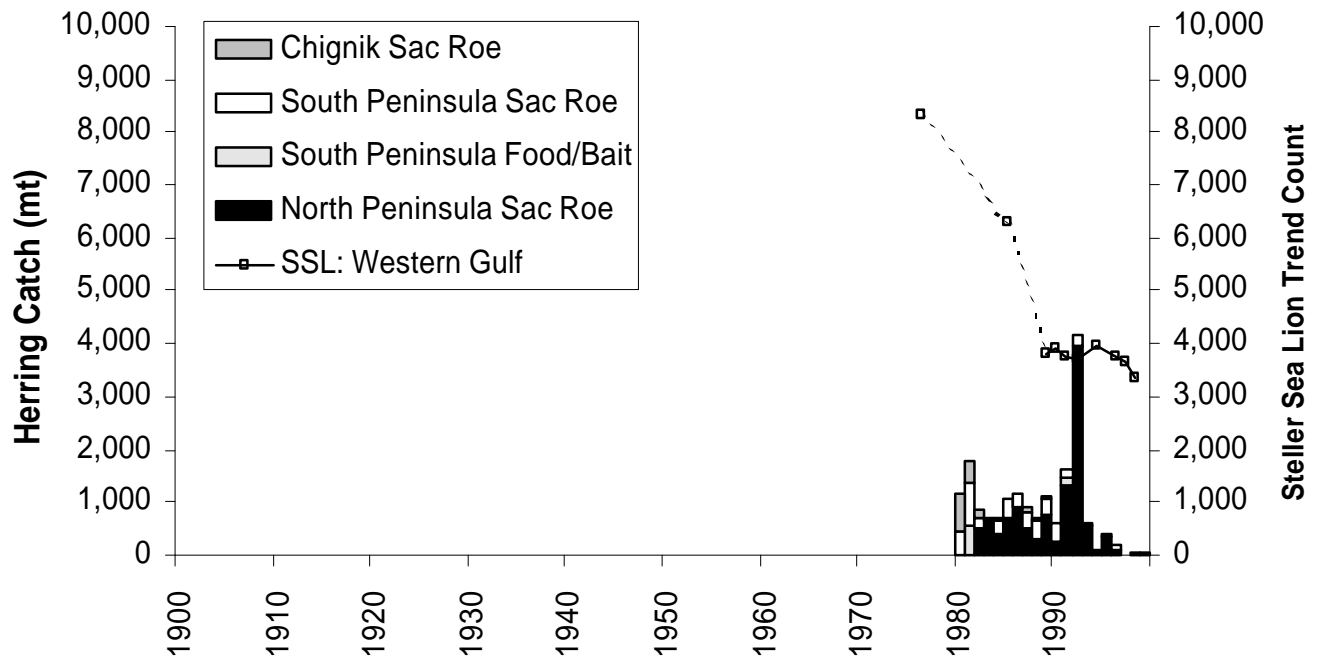
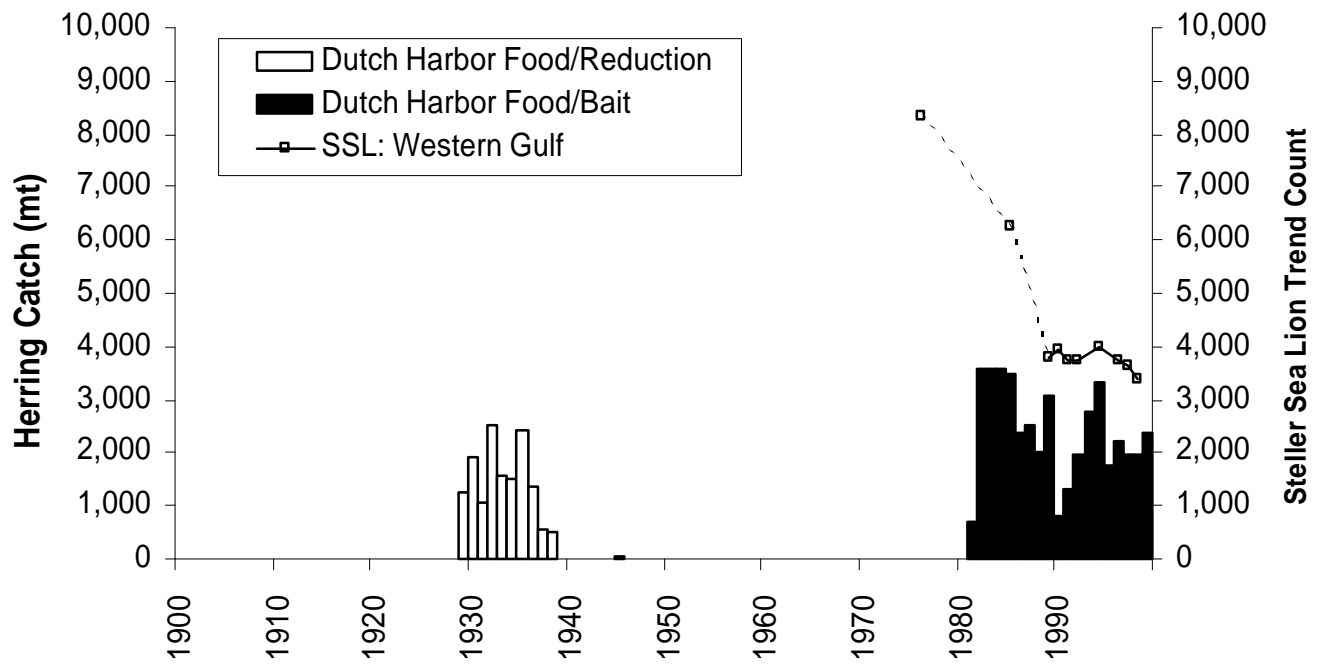


Figure 4.15. Herring catch from the Dutch Harbor area fisheries, taking mostly Bristol Bay spawning herring (top) and South and North Peninsula herring fisheries (bottom), which harvest local stocks and Steller Sea Lion (SSL) trend counts from the nearby western Gulf index area.

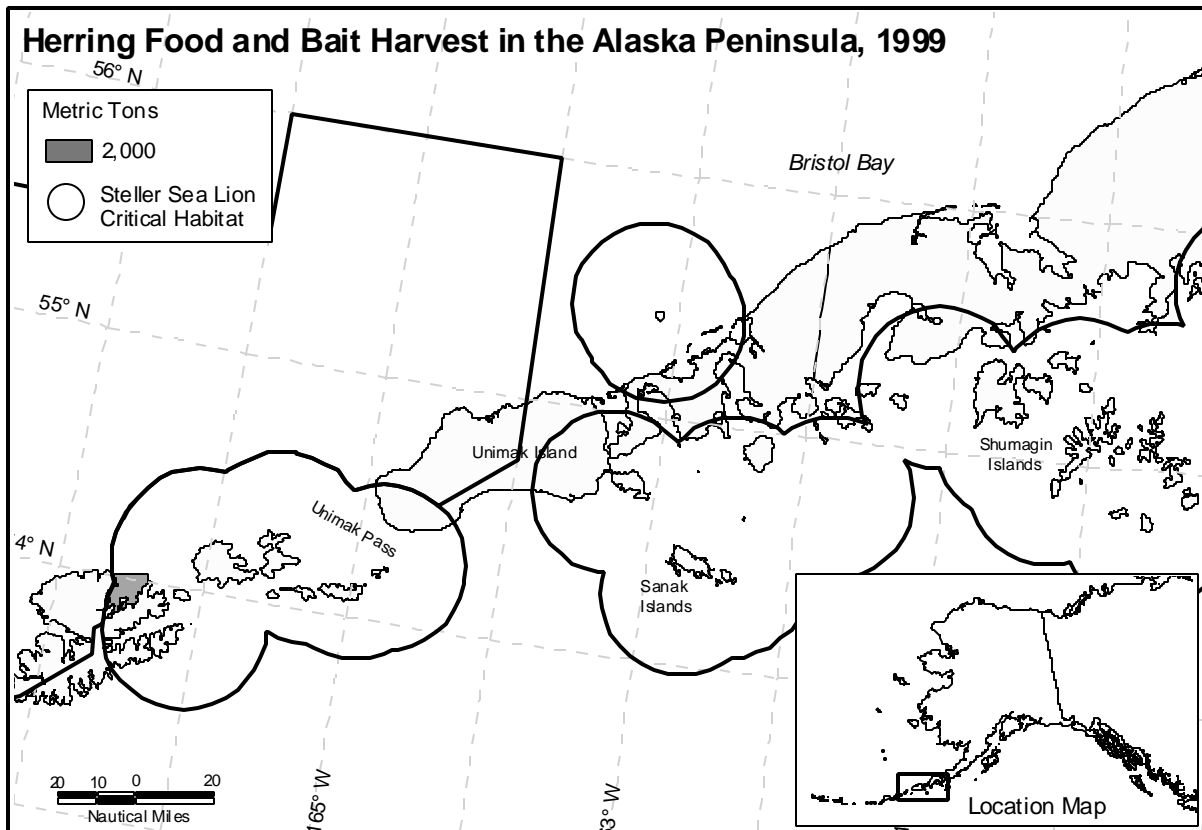
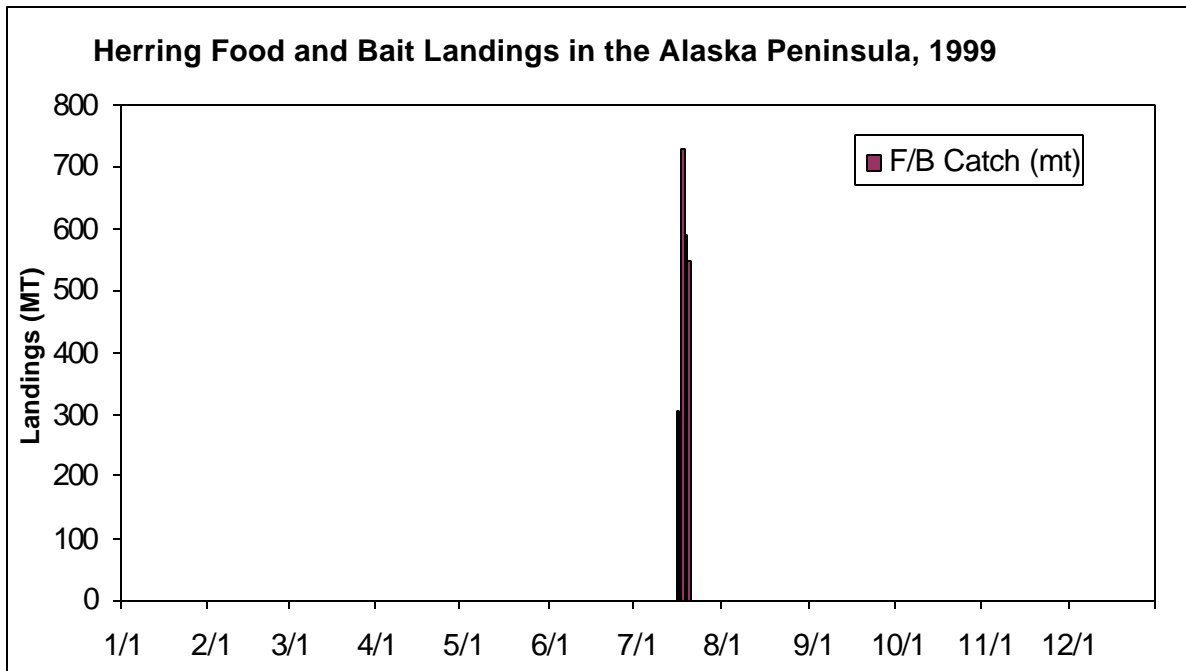


Figure 4.16 Monthly distribution of herring food and bait landings in the Alaska Peninsula, 1999 (top), and Spatial distribution of herring food and bait landings in the Alaska Peninsula, 1999 (bottom).

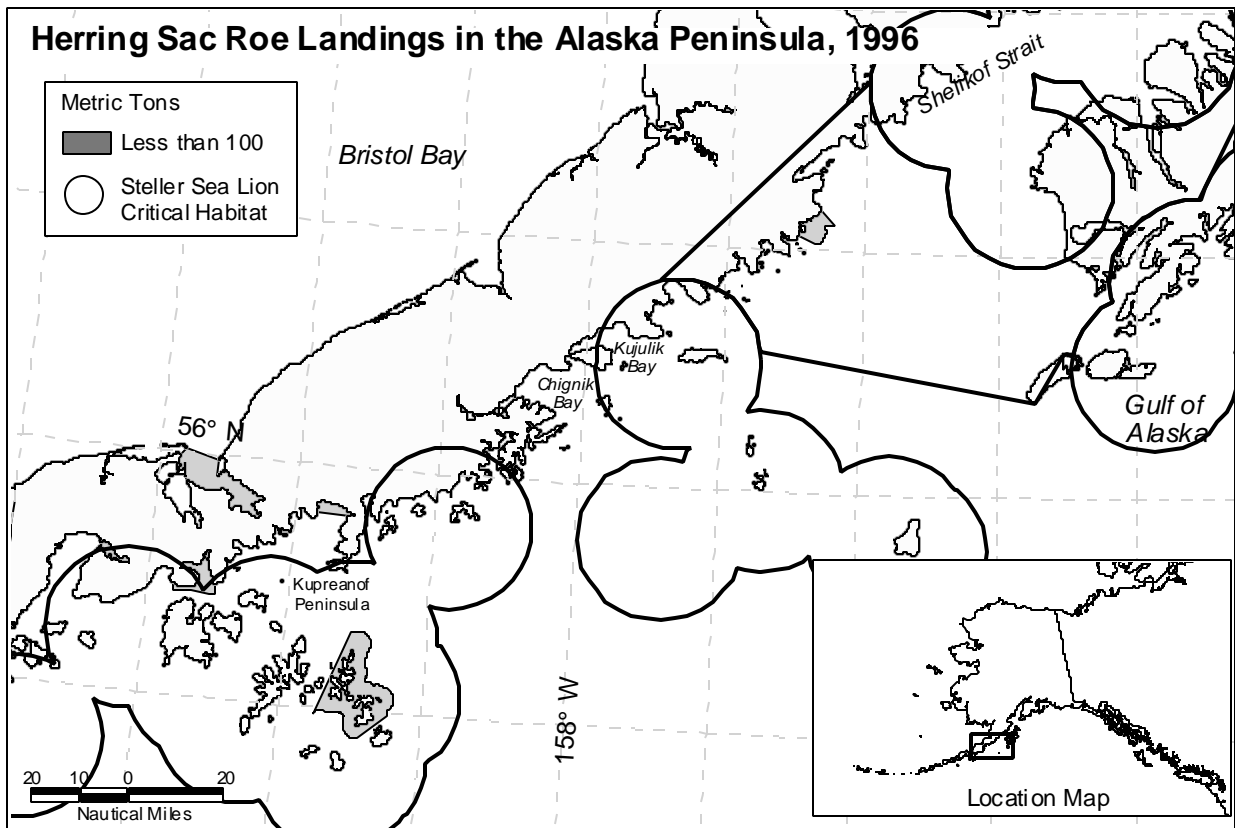
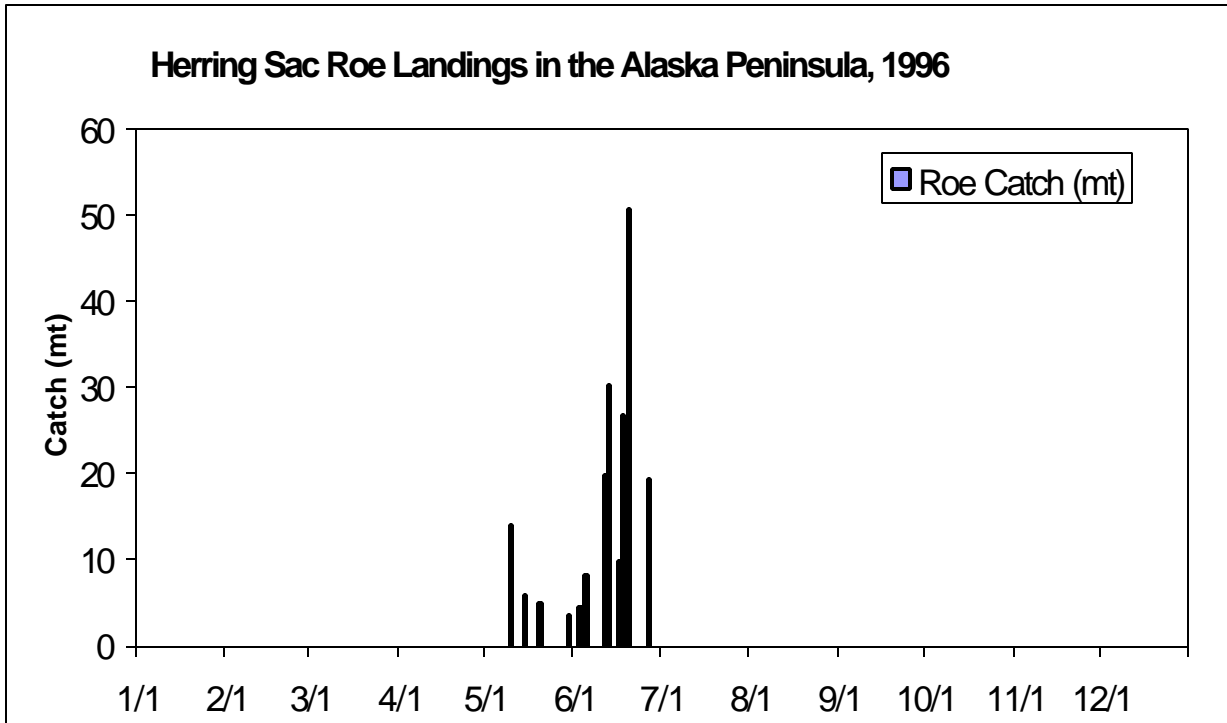


Figure 4.17 Monthly distribution of herring sac roe landings in the Alaska Peninsula, 1996 (top), and Spatial distribution of herring sac roe landings in the Alaska Peninsula, 1996 (bottom).

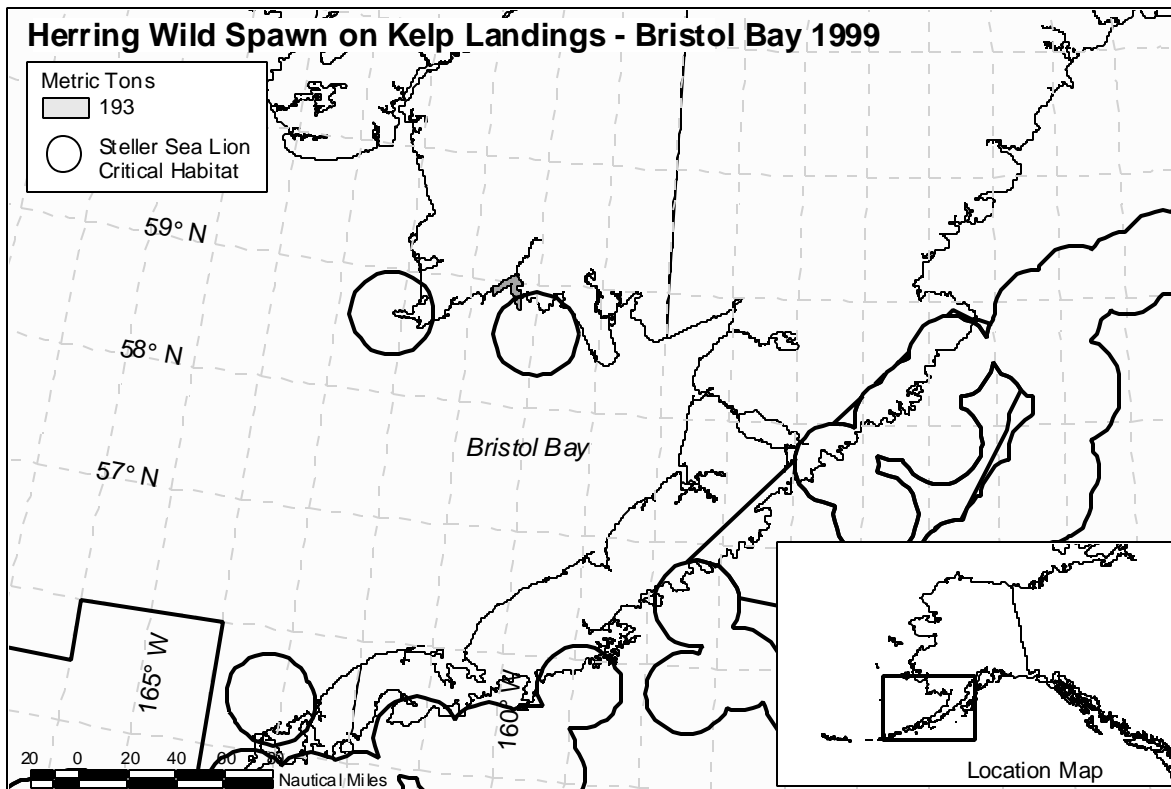
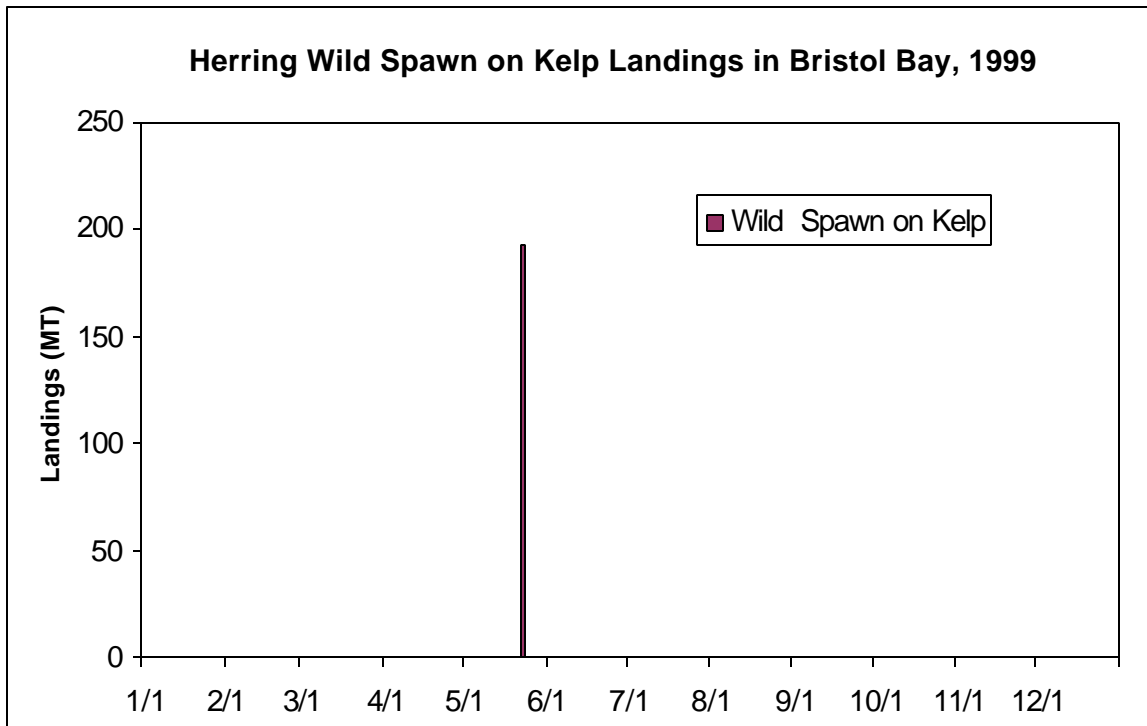


Figure 4.18 Monthly distribution of herring wild spawn on kelp landings in Bristol Bay, 1999 (top), and Spatial distribution of herring wild spawn on kelp landings in Bristol Bay, 1999 (bottom).

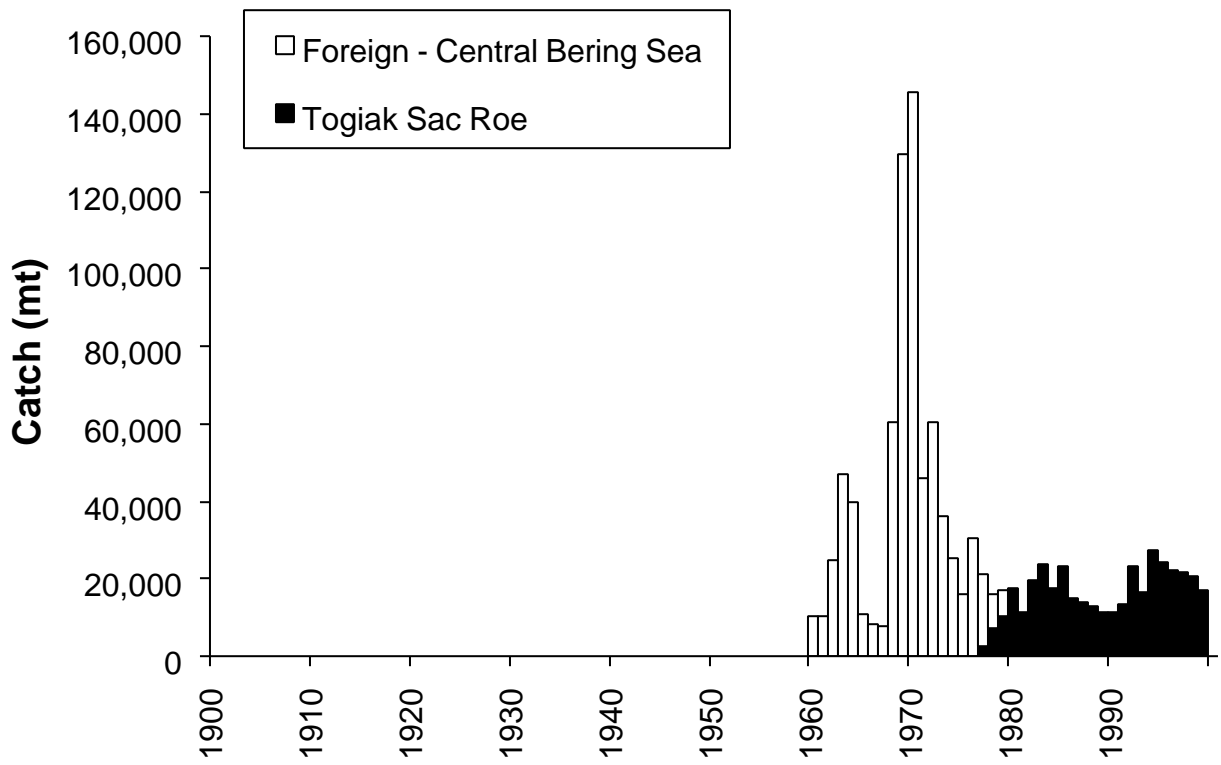


Figure 4.19. Herring catch in the Togiak sac roe fishery, and the offshore foreign fishery, which harvested primarily Togiak-spawning herring.

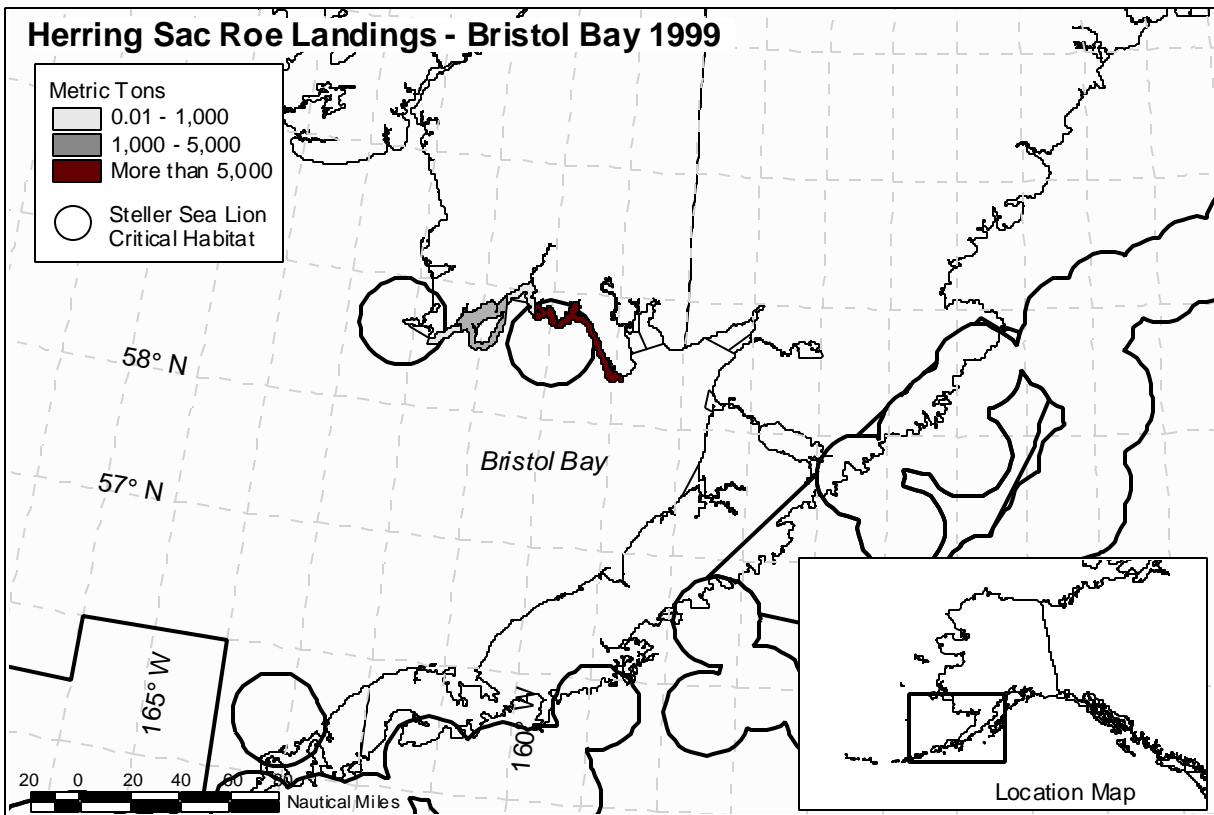
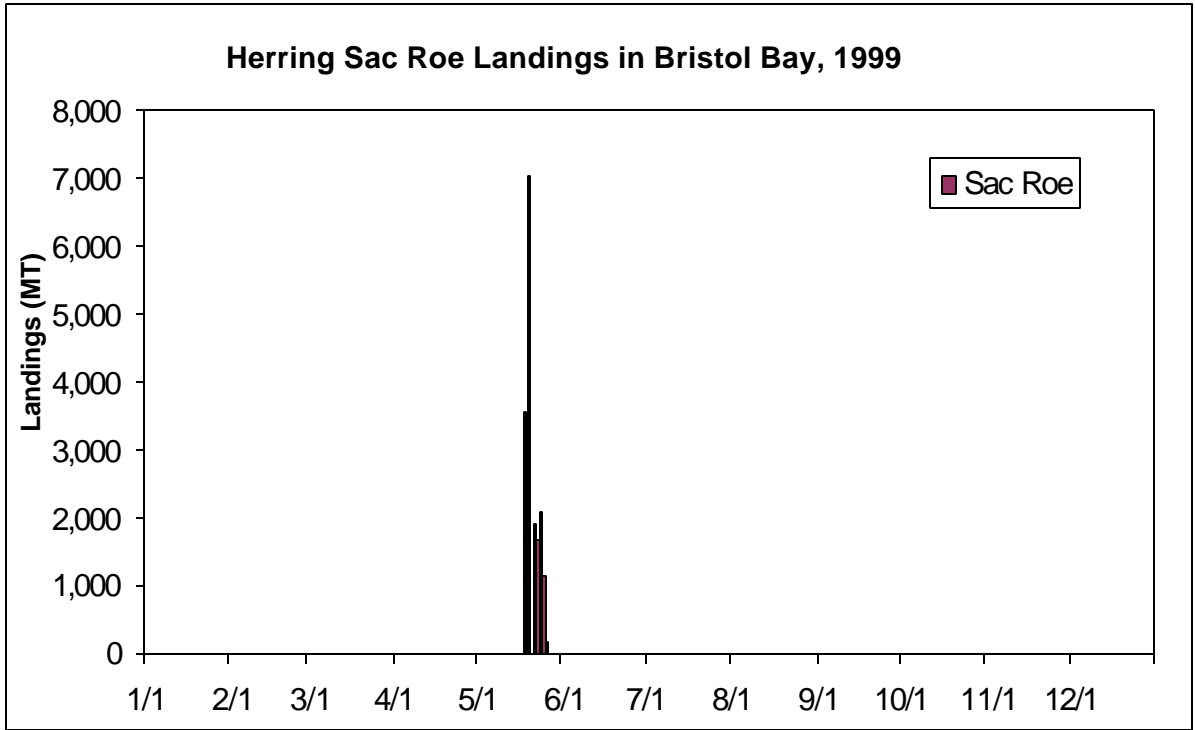


Figure 4.20 Monthly distribution of herring sac roe landings in Bristol Bay, 1999 (top), and Spatial distribution of herring sac roe landings in Bristol Bay, 1999 (bottom).

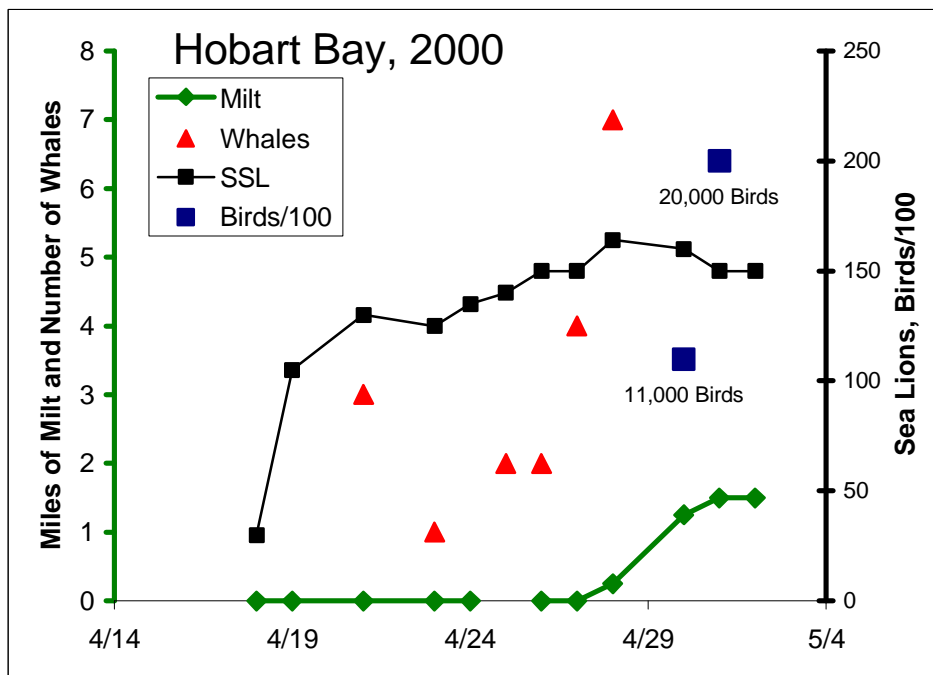


Figure 4.21. Timing of herring spawning and bird and mammal presence at Hobart Bay, southeast Alaska, in the spring of 2000.

5. SALMON FISHERIES

5.1 Fishery History

Salmon provide the basis for one of Alaska's oldest and most important industries and underpin a traditional subsistence lifestyle in Native villages. The history of Alaskan subsistence fisheries for salmon predates recorded time. Commercial salmon fishing in Alaska began in the 1880s. Initial commercial harvests were primarily salted, and canning became predominant at the turn of the century. After the United States purchased Alaska in 1867, the U.S. federal government had jurisdiction over these fisheries until statehood. The White Act, passed in 1924, required fishing seasons, a mandatory 36-hour weekly closed period, and maintenance of escapement levels at 50% of the run. About half of the salmon catch was taken in a relatively small number of large and very efficient fish traps that were directly owned by the processors. Federal management was weak, and heavily influenced by the processing sector. Enforcement of regulations was ineffective or non-existent. Stock assessment programs to monitor escapement were poorly funded and generally not available to ensure that the 50% escapement objectives were achieved. In addition, regulatory actions required secretary level approval and implementation of regulations to close fisheries often occurred too late to effect conservation.

After World War II and at the request of the salmon processing industry, W. F. Thompson of the University of Washington began investigations of salmon and their management in Alaska. After statehood in 1959, the State of Alaska took over salmon management. Fish traps were banned. The overriding goal became resource conservation and scientific research into ways to increase the yield the fisheries. Based on the pioneering work of W. F. Thompson and his students, ADF&G implemented a management system based on attempting to maintain a constant stock size, year after year, and a program to find stock sizes that maximize the yield. A network of regional and area offices were created to closely monitor local salmon runs and to open and close fisheries to meet conservation mandates. A state fish and wildlife enforcement program was instituted to assure compliance. Under the Alaska management system, fisheries were closed by regulation during the period of the run and then opened by emergency order based on inseason assessment run strength to ensure that harvests were surplus to escapement. Largely as a result of this science-based management system, adequate enforcement, and commitment to salmon resource conservation, the fishing industry in Alaska has enjoyed the full benefit of the salmon resource when the environment has been favorable for large fish runs. The industry has accepted and even encouraged restrictions during years of low runs. In general, these salmon runs have been rebuilt, and have been at or near record levels for the past 20 years (Figure 5.1). Escapements have also been met in nearly all instances throughout Alaska. ADF&G has been working with the Governor's Office and other state agencies to also improve the quality of the seafood products provided by these strong salmon runs. Primary salmon products have varied through the years, and by species. However, fresh and frozen forms have come to replace many of the earlier canned product types.

In Alaska, all salmon fisheries operate under a 'limited entry' system. Limited entry is a state program developed to limit the units of gear used in order to maintain the resource and/or economic health of the fishery. It became apparent in the early 1970s that salmon fisheries were

in need of additional help. Management tools such as shortened seasons and catch limits were ineffectual in providing sufficient conservation to many stocks. As a result these fisheries were placed 'under limitation', thereby limiting the number of commercial fishing permits available for the fishery. These permits are "permanent permits." Anyone wishing to enter a limited fishery must receive a permit via transfer from another fisherman. Anyone already participating in the fishery when the fishery became limited could apply for a permanent permit during a one-time only application period. Approximately 12,000 salmon permits were issued initially, although not all of those permits are necessarily active today.

Another tool sought out in the early 1970s was salmon enhancement. Salmon hatcheries have existed in Alaska as far back as the late 1800s. Success of these early facilities was limited. The Federal Government started several research stations as well as territorial hatcheries in the 1930s and 1950s. Enhancement planning in the early to mid-1970s called for significant capital construction under a newly formed division within ADF&G. At its peak, the department operated 20 hatcheries statewide (including two streamside incubation facilities rather than permanent hatchery structures). In 1999, Alaska hatchery operators collected over 1.7 billion salmon eggs. In addition, 1.1 billion fish were released and over 41 million fish were harvested in common property fisheries as a result of the ocean ranching program. This harvest represents 22% of the commercial common property harvest of 215 million fish in 1999.

Habitat protection and restoration also became an important tool in rebuilding salmon stocks in Alaska. Although most of Alaska's habitat remains very pristine and quite productive, the importance of habitat interaction became very apparent in the overall rebuilding process, over the past several decades, and maintenance of the health of those stocks, once rebuilt.

5.2 Fishery Description

5.2.1 Fishery Overview

Five Pacific salmon species reside in Alaska: *Oncorhynchus nerka* commonly known as sockeye or red salmon; *O. gorbuscha* commonly known as pink salmon; *O. keta* known as chum or dog salmon; *O. tshawytscha* commonly called king or chinook salmon; and *O. kisutch* commonly known as coho or silver salmon.

When they reach maturity, adult salmon usually return to the freshwater systems from which they originated. Adult Pacific salmon die after spawning. After hatching, salmon fry rear for a period of time in freshwater and then migrate to the marine environment. The time spent in each environment varies by and within species. Outmigration from fresh water to the marine environment occurs in the spring or early summer. As young juveniles, salmon pass through the nearshore areas, where they grow rapidly and move into the open ocean as pelagic feeders. Salmon, which outmigrate from North American streams, range widely across the North Pacific Ocean and BS.

Pink salmon are the most numerous of the salmon species in the Alaska commercial catch and the most abundant salmon in the Pacific Ocean. Recent (1995-1999 5-yr average) statewide commercial harvests have been over 109 million fish (62% of Alaska's total salmon catch) most

of which is canned (Figure 5.2). Pink salmon are characterized by the smallest size as mature adults; the least dependence on fresh water as their fry migrate to the salt water directly after emergence from the gravel; and a fixed two-year life cycle that results in genetically distinct odd- and even-year runs.

Chum salmon are the third most numerous salmon species in the Alaska commercial catch and the second most abundant salmon in the Pacific Ocean. This species is also important in subsistence fisheries in Western Alaska. Recent statewide commercial harvests averaged near 19 million fish or 11% of total salmon catch (Figure 5.3). Adults are the second largest in size next to chinook salmon. As with pink salmon, chum fry move directly out of fresh water after emergence; however, they may make more use of estuarine environments in the spring. Chum salmon spend between one and five years in the marine environment and have the widest distribution across the Pacific Rim of any salmon.

Sockeye salmon are the second most numerous in the Alaska commercial catch and the third most abundant salmon in the Pacific Ocean. Recent statewide commercial harvests have been near 43 million fish, about 24% of total salmon catch (Figure 5.4). This species of salmon is characterized by the rearing of the juvenile stage in lakes; although in some river systems, sockeye salmon rear in backwaters and sloughs. The majority of sockeye salmon rear from one to three years in lakes prior to outmigration, and spend from one to four years in the marine environment before returning to fresh water to spawn. The Bristol Bay sockeye run is one of Alaska's most important commercial fisheries. This run is harvested as the returning adult salmon migrate past the Alaska Peninsula in June and then as they pass the large gillnet fisheries in Bristol Bay.

Coho salmon are the fourth most numerous in the Alaska commercial catch and the fourth most abundant salmon in the Pacific Ocean. Recent statewide commercial harvests have been near 5 million fish, approximately 3% of total salmon catch (Figure 5.5). In Alaska, coho salmon are important in sport and personal use fisheries. Coho salmon are generally the latest spawners in Alaska, with runs well into the fall or even early winter. Like pink salmon, coho salmon normally spend one winter in the ocean and return to spawn the following fall. Unlike pink salmon, coho can remain in the riverine environment to rear for an additional year prior to outmigration. In the more southerly latitudes of its range, coho salmon mainly spend only one year in fresh water and one year in the ocean. With increases in latitude, an increasing percentage of coho spend a second year in fresh water prior to migration to the marine environment. Because of their late run timing, many coho runs in Alaska may be lightly exploited or even unexploited. Because of poor weather during the coho-spawning period, little information exists about run size and timing in many areas of the state.

Chinook salmon are the least abundant of the five salmon species found on both sides of the Pacific Ocean and the least numerous in the Alaska commercial harvest. Recent statewide commercial harvests have been near 575 thousand fish or about 0.3% of total salmon catch (Figure 5.6). Although they do not constitute a large proportion of the commercial catch, chinook salmon are important in sport and personal use fisheries. They are highly prized because of their large size, which has also earned them the name, king salmon. Chinook salmon can migrate to the marine environment in the spring after they hatch or they can spend up to two years in the

riparian environment prior to outmigration. The timing of outmigration can vary between and within systems, although this generally occurs during the spring. Chinook salmon can spend five or more years in the ocean prior to spawning. A Southeast Alaska troll fishery operates on mixed stocks of migrating chinook salmon throughout the year, and provides consumers with fresh chinook salmon during the winter when other salmon are unavailable.

5.2.2 Fishery Management Strategy

The salmon fishery management strategy in Alaska is based on fixed escapement goals. The fish that are allowed to spawn are those that escaped the fishery, hence the term “escapement.” With a few notable exceptions, for each stock in Alaska, fishery managers attempt to allow a harvest while simultaneously ensuring that a predetermined number of fish are allowed to continue the run to spawn. In other words, managers let the size of the harvest vary with fluctuating run sizes, but year after year, managers attempt to keep the number of spawners close to the size thought to produce the greatest yield or harvest. This strategy depends on the manager’s ability to monitor the size of the runs, while the runs are actually taking place. One reason for this kind of strategy is that Pacific salmon will die after spawning; fish that return to spawn that are not harvested in one year do not live to be harvested at another time. The abundance of Pacific salmon is limited by available freshwater rearing and spawning habitat. Inter-specific competition for these limited resources leads to density-dependent production, and escapement levels that provide for maximum sustain yield are much lower than the pristine or equilibrium abundance. The desire to provide for maximum sustained yield is achieved when spawners, surplus to that needed to the escapement goal, are harvested. This, together with the ability to effectively monitor the abundance of salmon in fishing areas in face of significant inter-annual variation in run strength, has led managers to develop their strategy of fixed escapement goals. Only those fish that are surplus to the goal harvest are harvested.

Salmon stock monitoring, while the runs are in progress, is done in various ways (Table 5.1). Assessments of escapement differ among salmon stocks. Sockeye salmon rear almost exclusively in lakes, and runs of sockeye salmon are concentrated into the outlet rivers of lake system. Sockeye salmon fisheries are conducted in terminal areas in the vicinity of the mouth of the river system producing the salmon. This demographic feature of sockeye-producing systems and the generally clear water discharges from lake systems, make it relatively easy to visually enumerate sockeye salmon escapement. Sockeye salmon escapement is intensively enumerated at counting towers, weirs, and with sonar counting systems installed in outlet rivers of lake systems that support sockeye salmon. The passage of sockeye salmon escaping the fishery is intensively monitored, with estimates of escapement made every hour throughout the run. The escapement estimates from the intensive-counting operations are very accurate and precise, because a large component of the run is actually counted.

There are large pink and chum salmon runs to the coastal waters of Southeast Alaska, PWS, Kodiak Island and mainland coastal areas of the Alaska Peninsula. Because of the large number of coastal streams in which spawning occurs, it is not feasible to install intensive escapement counting systems such as towers, weirs, and sonars. Aerial observation is usually the main assessment tool for pink and chum salmon, in coastal areas. Here aerial counts are made several times a season in a set of key index streams that support most the production. In the case of the

aerial observation, the measurements of spawning stock size may be imprecise with only a fraction of the total escapement actually seen, so the escapement measure is considered an index of escapement.

Coho salmon are the most difficult species to monitor. Spawning often takes place late in the fall when typical Alaskan weather patterns cause poor conditions for airborne observations.

For all salmon species, fishery performance analysis – the analysis of catch rates over a series of years – plays a part in fishery management as a check on the escapement monitoring, or even as the key indicator for hard-to-monitor species like coho salmon.

The use of escapement goals is thought to be one of the keys to the success of salmon fishery management. The criteria that the department uses to determine escapement goals are outlined in the escapement goal policy. ADF&G determines biological escapement goals, as the range of escapement levels that provides the potential for maximum sustained yields. ADF&G seeks to establish and manage salmon fisheries for biological escapement goals unless otherwise directed by the BOF. The status of salmon stocks is determined based on average levels of escapement relative to established escapement goals.

Another key to the success of this kind of fishery management is flexible, dynamic local control. Local fisheries managers are given virtual autonomy to open and close fisheries on very short notice based on assessment information that has been collected in the previous several hours. Usually, local management teams have years of experience with local fishing conditions, weather, and fish behavior. They can respond very quickly to allow additional harvest opportunity if fish runs suddenly build, and managers can quickly restrict harvest to ensure escapement goals if runs appear weaker than expected.

A third key to the success of this kind of management is that local managers are distanced from decisions about the allocation of harvest among competing groups of fishermen. This shields managers from politics, and allows them to concentrate on managing fisheries according to prescribed management plans. The BOF is a separate, explicitly political body that addresses allocation issues. The BOF develops management plans, which directs the local managers on fishery management objectives, including the allocation of harvests among user groups. The plans are developed in open, public meetings after considering public testimony and advice from various scientists, advisors, and interest groups. Because of the magnitude of commercial fisheries for salmon, state biologists collect extensive information and statistics for management decisions. Alaska also has very important, but often less closely monitored, sport and subsistence fisheries for salmon, char, and trout. Many Alaskan Native populations still depend heavily on subsistence-caught salmon for food and cultural purposes. State law gives top priority to the subsistence use of fish resources, which is reflected in BOF-approved FMPs. Around Alaska there are a number of exceptions to the rule of “fixed escapement goals.” Along the South Alaska Peninsula in June, there is an important fishery for sockeye salmon that is regulated by restricting the harvest to a fraction of a preseason forecast for Bristol Bay sockeye salmon. The troll fishery for chinook salmon in Southeast Alaska is controlled by a complicated series of caps based on the abundance of a suite of large stocks. Some fisheries in Western Alaska are regulated by restriction of fishing times. Harvests in sport fisheries are usually controlled by bag

limits, and restrictions on when fishing can take place. The harvest rate is usually low in these fisheries that are not managed for fixed escapement goals (usually far below 10%), and the fisheries are monitored by analysis of fishery performance data.

5.2.3 Fishing Gear

By far, most salmon in Alaska are caught in gillnet, purse seine and troll fisheries (Table 5.1) in which participation is restricted by a limited entry system that has been in place since 1975. Troll gear works by dragging baited hooks through the water. Gillnet gear works by entangling the fish as they attempt to swim through the net. Purse seines work by encircling schools of fish with nets that are drawn up to create giant “purses” that hold the school until it can be brought aboard. Fish wheels, which scoop fish up as the wheel is turned by currents, also have limited use on the Upper Yukon River. While not legal gear outside of the Metlakatla Indian Community on Annette Island in Southeast, fish traps have limited use within the legal confines of the reservation. In general, fish traps were banned from commercial fishing at Statehood in 1959 under Alaska Statute Sec. 16.10.100.

By law, all salmon fisheries using net gear to harvest fish must be operated within 3 miles of the shore, with few exceptions. Gill-netters in CI, the South Alaska Peninsula (South Unimak), and Copper River can operate gear beyond the 3-mile limit, under a Fisheries Management Plan established by the NPFMC. This is also true for salmon trolling. While net gear (purse seine, beach seine, and gillnet) is legal in most areas of the state, trolling is only permitted in the Southeast Alaska.

In Alaska, pink salmon are commercially harvested primarily by purse seine fleets. Chum salmon are harvested primarily by gillnet and purse seine fleets. Most sockeye salmon are harvested by gillnets, or in some cases, seine gear in limited-entry fisheries. Coho and king salmon are caught in the troll and net fisheries.

5.2.4 Fishery Status in 1999

In 1999, commercial fishermen in Alaska harvested a total of 404 thousand metric tons of salmon. This is the second largest volume of salmon commercially harvested in Alaska’s history (1995 was 451 thousand metric tons). The value of the harvest varies both with the size of the runs and with foreign currency exchange rates. For the years 1997, 1998, and 1999, fishermen were paid approximately \$297 million, \$263 million, and \$383 million for their catch, respectively. In 1999, the near record harvest was driven by record pink salmon returns in both Southeast Alaska and PWS. Healthy catches of sockeye salmon also occurred in PWS, CI, Kodiak, the Alaska Peninsula and Bristol Bay fisheries. Record catches of sockeye occurred in the Chignik seine fisheries. Chum salmon catches were very large in Southeast Alaska, but poorer in the Arctic-Yukon-Kuskokwim areas.

A listing of the managed stocks for which stock assessment program with escapement goals are in place are provided in Table 5.1. The status of the salmon stocks in the Copper River, PWS, Lower CI, Upper CI, Kodiak, Chignik, South Alaska Peninsula, North Alaska Peninsula, and

Bristol Bay areas are all healthy. A determination of healthy status is based on the recent 3-5 year average escapement being within the escapement goal range.

Fishing seasons for salmon in Alaska depend on species and particular run timing. Generally, chinook salmon are caught in May and June, although a Southeast Alaska winter troll fishery operates from October 11 through April 14. Sockeye salmon are generally harvested from mid-June to mid-July, but the earliest commercial salmon fishery occurs on the Copper River in mid-May. Coho salmon fisheries typically occur from late July to mid-September, but some limited effort may extend through early October. Pink salmon are harvested from late July to late August. Summer chum salmon runs are harvested in June through early August and fall chum runs are harvested from early August through mid-September. Taking all Alaskan commercial salmon fisheries together, the largest portion of the statewide catch occurs during the month of August (over 50%) when pink salmon are abundant, followed by catches in July (38%) which contain large numbers of sockeye salmon.

Salmon catches in PWS (Figure 5.7), Kodiak (Figure 5.9), and South and North Alaska Peninsula areas (Figure 5.11 – 5.12) are dominated by landings in July and August. Harvests in July dominate the CI (Figure 5.8) and Bristol Bay areas (Figure 5.13), whereas the landings in the Chignik area (Figure 5.10) are more evenly dispersed among June through August.

The spatial distribution of sockeye salmon harvests is highly aggregated in terminal areas in close proximity to natal lake and river systems. For the coastal purse seine fisheries targeting pink and chum salmon, the spatial distribution of the harvest tends to be in the migratory corridor, near terminal areas, and areas near hatcheries. Heaviest catches in PWS come from statistical areas in the northern and southwestern portion of the management area (Figure 5.7). In CI, most catches are taken in the upper portion of the inlet (Figure 5.8), whereas catches along the western side of Kodiak Island dominate the salmon catches in that management area (Figure 5.9). In the Chignik area, statistical areas in the bay and south of the bay dominate the catch (Figure 5.10), and in the South Alaska Peninsula area, heaviest catches come from the Shumagin Islands and statistical areas to the southwest (Figure 5.11). In the North Alaska Peninsula the catches are dispersed throughout the area (Figure 5.12). Finally, harvests from Bristol Bay are tightly aggregated in association with principal river systems flowing into the bay (Figure 5.13). The distribution of these harvests with respect to Steller sea lion critical habitat are discussed in greater detail in section 5.3 of this report.

In Alaska, with few exceptions, salmon runs are in excellent shape. Good fisheries management and a pristine environment have allowed Alaska's salmon populations to make the most of favorable ocean conditions. The status of Alaskan salmon populations stand in stark contrast to wild salmon populations in the southerly extent of their range in the Pacific Northwest where they are declining, at disastrously low levels, or even extinct. In those areas, poor fisheries management and adverse effects of hatcheries on wild salmon have combined with water-use conflicts, land-use development, dams, agriculture, and logging to create an environment adverse to salmon survival.

Health of the salmon fishing industry in Alaska depends largely on external forces. Alaska is one of the last places in the world with large wild salmon populations. But even with continued good

management, the run sizes will largely be determined by oceanographic conditions that are poorly understood and impossible to manage. Excellent ocean conditions of the last two decades will surely end sometime in the future. The economic health of the salmon industry is strongly affected by price that is largely depressed by the worldwide supply of farmed salmon originating outside of Alaska. Even so, Alaska's economy, culture, and even identity will continue to be shaped by salmon because of the size and history of its salmon fisheries.

5.3 Interactions with Steller Sea Lions

5.3.1 Predation

Salmon are often predated by Steller sea lions (see chapter 3 of this report). During 1945-1978, salmon were among the top 10 most frequent prey found in sea lions about half of the time – in three out of four studies conducted in the GOA, one of two studies in Southeast Alaska, and in none of three studies conducted in the BS (Hoover 1988). There appears to be considerable regional, seasonal, and interannual variations in the occurrence of salmon in sea lion diets in Alaska (Table 3.2 in this report, Hoover 1988).

5.3.2 Overlap of Fisheries and Sea Lion Critical Habitat

With few exceptions, current Alaska statutes and regulations allow the use of net gear to harvest salmon only within 3 miles of the shore. Under the current federal FMP, commercial salmon trolling is only permitted in the Southeast Alaska, and accounts for only about 1% of the statewide catch. Because most commercial salmon fisheries are prosecuted within close proximity to the coast, many occur within Steller sea lion critical habitat zones in both the Central and Westward Regions of Alaska (Figure 5.7 – 5.13).

Several exceptions occur in small areas of PWS (Figure 5.7), CI (Figure 5.8), Chignik (Figure 5.10) the South Alaska Peninsula (Figure 5.11), and North Alaska Peninsula (Figure 5.12). In PWS, the Valdez Narrows produce sizeable purse seine catches of pink salmon returning to the Solomon Gulch Hatchery (3-8 million fish). While these waters are outside critical habitat areas, these pinks would migrate through areas of sea lion abundance. Also in the PWS Management Area, the Copper River flats produce large drift gillnet catches of sockeye salmon (0.75-1.5 million fish). In the CI area, the Upper CI drift and set gillnet salmon fisheries fall outside Steller sea lion critical habitat areas. These are largely sockeye salmon fisheries harvesting 1-3.5 million fish. The fishery occurs only after sea lions have an opportunity to feed on these salmon as they pass through critical habitat areas. All fish entering Upper CI pass through sea lion habitat from Shelikof Strait to the waters of Lower CI on their way to various spawning systems. In Chignik, large catches of sockeye salmon near the lagoon by purse seine also fall outside Critical Habitat Areas (1-3 million fish). Here too, fish returning to both Chignik and Black Lakes would be passing through critical habitat areas all along the South Peninsula Management Area, where sea lions would have access to include them in their diet. Along the Alaska Peninsula, mostly on the northern shores, there are also several areas outside critical habitat areas that have salmon fisheries. These can account for notable gillnet catches of sockeye salmon (0.5 –1.0 million fish). In Bristol Bay, most salmon catches are taken outside of sea lion critical habitat.

5.3.3 Direct Fishery Interactions

In the salmon troll fishery, gear and catch loss is considered minor (Hoover 1988). However, sea lions cause significant catch loss and gillnet gear damage by taking fish from nets and by swimming through nets, tearing large holes (Hoover 1988). Sea lions cause the most damage to purse seine gear when they swim inside nets to eat salmon before the nets are closed. If enclosed, sea lions tear holes in the nets, leaving escape routes for fish (Hoover 1988). Prior to the mid-1990s the only quantitative study conducted on sea lion-salmon gillnet fishery interactions in Alaska has been on the Copper and Bering River deltas and the Coghill district in southcentral Alaska (Matkin and Fay 1980). In the Copper River district, the presence of sea lions coincided with the spring eulachon run. Matkin and Fay (1980) found that during the 3-week spring salmon season, sea lions damaged 1.7-4.9% of the weekly catch. Although 458 boats operated in the spring fishery most of the damage occurred in outside waters where relatively few boats fished. Sea lions were infrequently seen in the Coghill District and were absent during the fall Copper River district season. Observers also monitored the PWS salmon drift gillnet (Copper River) fishery in 1990 and 1991. No mortalities were observed in 1990, and only 2 were recorded in 1991. When extrapolated, it leads to a mean kill rate of 14.5 per year for 1990 and 1991. The Alaska Peninsula and AI salmon drift gillnet fishery was also monitored during 1990 and no Steller sea lion mortalities were observed. The incidental mortality in the Cook Inlet salmon drift gillnet fishery has been estimated at 0.5 animals annually, and for Bristol Bay the yearly number is thought to be 3.5 (Ferrero et al. 2000).

The time duration that nets are fished could affect the likelihood of sea lion interactions with the gear. In all areas of Alaska, the department takes a cautious approach to weekly open period durations for net gear. Most fisheries begin the season with 24-72 hour open periods per week, as initial run assessments are made. When returns further develop, and an appreciation of run strength is better understood, modifications to fishing times can be made to better harvest surplus quantities or conversely to slow interceptions to allow increased escapements. Only rarely do fisheries remain open for 24 hours per day, 7 days per week effort. Additionally, when the fleet is not fishing, it generally is not waiting on the grounds for the next weekly period to begin. Interactions with sea lions would not occur at these times.

Table 5.1 Summary of stock status, assessment method, and gear type for state-managed salmon fisheries in 1999.

Managed Stock	Gear	Escapement Assessment	Stock Status
Upper Copper River Chinook	Drift Gillnet	Aerial Survey	Healthy
Upper Copper River Sockeye	Drift Gillnet	Sonar	Healthy
Bering River Sockeye	Drift Gillnet	Aerial Survey	Healthy
Copper River Delta Sockeye	Drift Gillnet	Aerial Survey	Healthy
Copper River Delta Coho	Drift Gillnet	Aerial Survey	Healthy
<u>Prince William Sound Pink Salmon</u>			
Eastern District	Purse Seine	Aerial Survey	Healthy
Southeastern District	Purse Seine	Aerial Survey	Healthy
Montague District	Purse Seine	Aerial Survey	Healthy
Southwestern District	Purse Seine	Aerial Survey	Healthy
Eshamy District	Set Gillnet/Drift Gillnet	Aerial Survey	Healthy
Northwestern District	Purse Seine	Aerial Survey	Healthy
Coghill District	Purse Seine/Drift Gillnet	Aerial Survey	Healthy
Northern District	Purse Seine	Aerial Survey	Healthy
Unakwik District	Purse Seine/Drift Gillnet	Aerial Survey	Healthy
<u>Prince William Sound Chum Salmon</u>			
Eastern District	Purse Seine	Aerial Survey	Healthy
Southeastern District	Purse Seine	Aerial Survey	Healthy
Montague District	Purse Seine	Aerial Survey	Healthy
Southwestern District	Purse Seine	Aerial Survey	Healthy
Eshamy District	Set Gillnet/Drift Gillnet	Aerial Survey	Healthy
Northwestern District	Purse Seine	Aerial Survey	Healthy
Coghill District	Purse Seine/Drift Gillnet	Aerial Survey	Healthy
Northern District	Purse Seine	Aerial Survey	Healthy
Unakwik District	Purse Seine/Drift Gillnet	Aerial Survey	Healthy
<u>Prince William Sound Sockeye Salmon</u>		Aerial Survey	Healthy
Eshamy	Set Gillnet/Drift Gillnet	Weir	Healthy
Coghill	Purse Seine/Drift Gillnet	Weir	Healthy

Table 5.1 (Continued)

Managed Stock	Gear	Escapement Assessment	Stock Status
<u>Lower Cook Inlet Sockeye</u>			
Chenik Lake	Purse Seine	Aerial Survey	Management Concern ¹⁾
Desire Lake	Purse Seine	Aerial Survey	Healthy
Delight Lake	Purse Seine	Aerial Survey/Weir	Healthy
English Bay	Set gillnet	Aerial Survey/Weir	Healthy ²⁾
Mikfik Creek	Purse Seine	Aerial Survey/Video	Healthy
<u>Lower Cook Inlet Pink Salmon</u>			
Eastern District	Purse Seine	Aerial/Ground Surveys	Healthy
Outer District	Purse Seine	Aerial/Ground Surveys	Healthy
Kamishak District	Purse Seine	Aerial Survey	Healthy
Southern District	Purse Seine/Set Gillnet	Aerial/Ground Surveys	Healthy
<u>Lower Cook Inlet chum Salmon</u>			
Eastern District	Purse Seine	Ground Surveys	Yield Concern
Outer District	Purse Seine	Aerial/Ground Surveys	Yield Concern
Kamishak District	Purse Seine	Aerial Survey	Yield Concern
Southern District	Purse Seine/Set Gillnet	Aerial/Ground Surveys	Yield Concern

¹⁾ Chenik Lake was enhanced during the 1980's and early 90's using a non-Chenik brood source. Enhancement was discontinued in the late '90's. The system appears to be extremely susceptible to the IHN virus, which is theorized to be a major factor in suppressing the system's current production.

²⁾ English Bay Lakes are presently enhanced using its own wild stock as brood source.

Table 5.1 (Continued)

Managed Stock	Gear	Escapement Assessment	Stock Status
<u>Kodiak Area Pink Salmon</u>			
Afognak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Northwest Kodiak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Southwest Kodiak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Alitak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Northeast Kodiak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Eastside Kodiak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Mainland Kodiak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
<u>Kodiak Area Chum Salmon</u>			
Northwest Kodiak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Southwest Kodiak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Alitak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Northeast Kodiak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Eastside Kodiak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Mainland Kodiak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
<u>Kodiak Area Sockeye Salmon</u>			
Karluk	Purse Seine/Set Gillnet	Weir	Healthy
Ayakulik	Purse Seine/Set Gillnet	Weir	Healthy
Upper Station	Purse Seine/Set Gillnet	Weir	Healthy
Frazer	Purse Seine/Set Gillnet	Weir	Healthy
Litnik	Purse Seine/Set Gillnet	Weir	Healthy
Saltery	Purse Seine/Set Gillnet	Weir	Healthy
Pauls	Purse Seine/Set Gillnet	Weir	Healthy
Buskin	Purse Seine/Set Gillnet	Weir	Healthy
Akalura	Purse Seine/Set Gillnet	Weir	Healthy
Portage	Purse Seine/Set Gillnet	Weir	Healthy
Malina	Purse Seine/Set Gillnet	Weir	Healthy
Minor Systems	Purse Seine/Set Gillnet	Aerial Survey	Healthy

Table 5.1 (Continued)

Managed Stock	Gear	Escapement Assessment	Stock Status
<u>Kodiak Area Coho Salmon</u>			
Karluk	Purse Seine/Set Gillnet	Weir	Healthy
Ayakulik	Purse Seine/Set Gillnet	Weir	Healthy
Upper Station	Purse Seine/Set Gillnet	Weir	Healthy
Dog Salmon	Purse Seine/Set Gillnet	Weir	Healthy
Horse Marine	Purse Seine/Set Gillnet	Weir	Healthy
Litnik	Purse Seine/Set Gillnet	Weir	Healthy
Saltery	Purse Seine/Set Gillnet	Weir	Healthy
Pauls	Purse Seine/Set Gillnet	Weir	Healthy
Buskin	Purse Seine/Set Gillnet	Weir	Healthy
Akalura	Purse Seine/Set Gillnet	Weir	Healthy
Big Bay	Purse Seine/Set Gillnet	Weir	Healthy
Bear Creek	Purse Seine/Set Gillnet	Weir	Healthy
Penerosa	Purse Seine/Set Gillnet	Aerial/Ground Survey	Healthy
Northeast District Non-Weired	Purse Seine/Set Gillnet	Aerial Survey	Healthy
<u>Kodiak Area Chinook Salmon</u>			
Karluk	Purse Seine/Set Gillnet	Weir	Healthy
Ayakulik	Purse Seine/Set Gillnet	Weir	Healthy
Dog Salmon	Purse Seine/Set Gillnet	Weir	Healthy
<u>Chignik Area Sockeye Salmon</u>			
Black Lake	Purse Seine	Weir	Healthy
Chignik Lake	Purse Seine	Weir	Healthy
<u>Chignik Area Pink Salmon</u>			
Eastern District	Purse Seine	Aerial Survey	Healthy
Central District	Purse Seine	Aerial Survey	Healthy
Chignik Bay District	Purse Seine	Aerial Survey	Healthy
Western District	Purse Seine	Aerial Survey	Healthy
Perryville District	Purse Seine	Aerial Survey	Healthy

Table 5.1 (Continued)

Managed Stock	Gear	Escapement Assessment	Stock Status
<u>Chignik Area Chum Salmon</u>			
Eastern District	Purse Seine	Aerial Survey	Healthy
Central District	Purse Seine	Aerial Survey	Healthy
Chignik Bay District	Purse Seine	Aerial Survey	Healthy
Western District	Purse Seine	Aerial Survey	Healthy
Perryville District	Purse Seine	Aerial Survey	Healthy
<u>South Alaska Peninsula Pink Salmon</u>			
Southeastern District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
SouthCentral District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Southwestern District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Unimak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
<u>South Alaska Peninsula Chum Salmon</u>			
Southeastern District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
SouthCentral District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Southwestern District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
Unimak District	Purse Seine/Set Gillnet	Aerial Survey	Healthy
<u>South Alaska Peninsula Sockeye Salmon</u>			
Orzinski River	Purse Seine/Set Gillnet	Aerial Survey/Weir	Healthy
<u>North Alaska Peninsula Sockeye Salmon</u>			
Bear River	Drift Gillnet/Purse Seine	Weir	Healthy
Nelson Lagoon	Drift Gillnet	Weir	Healthy
Ilnik Lagoon	Drift/set Gillnet	Weir	Healthy
Sandy River	Drift Gillnet	Aerial Survey/Tower/Weir	Healthy
Urilia Bay Lagoon	Drift Gillnet	Aerial Survey	Healthy
Port Heiden	Drift Gillnet	Aerial Survey	Healthy
Swanson's Lagoon	Drift Gillnet	Aerial Survey	Healthy
Thin Point Lake	Drift Gillnet	Aerial Survey	Healthy

Table 5.1 (Continued)

Managed Stock	Gear	Escapement Assessment	Stock Status
<u>North Alaska Peninsula Pink Salmon</u>			
Northwestern District	Drift Gillnet/Purse Seine	Aerial Survey	Healthy
<u>North Alaska Peninsula Chum Salmon</u>			
Northwestern District	Drift Gillnet/Purse Seine	Aerial Survey	Healthy
Northern District	Drift Gillnet/Purse Seine	Aerial Survey	Healthy
<u>Aleutian Islands Pink Salmon</u>			
Unalaska District	Purse Seine	Aerial Survey	Healthy
<u>Bristol Bay Sockeye Salmon</u>			
Ugashik River	Drift Gillnet/Set Gillnet	Tower	Healthy
Egegik River	Drift Gillnet/Set Gillnet	Tower	Healthy
Naknek River	Drift Gillnet/Set Gillnet	Tower	Healthy
Alagnak Rvier	Drift Gillnet/Set Gillnet	Tower	Healthy
Kvichak River	Drift Gillnet/Set Gillnet	Tower	Yield Concern, for offcycle run
Wood River	Drift Gillnet/Set Gillnet	Tower	Healthy
Nushagak/Mulchatna River	Drift Gillnet/Set Gillnet	Sonar Count	Healthy
Igushik River	Drift Gillnet/Set Gillnet	Tower	Healthy
Togiak River	Drift Gillnet/Set Gillnet	Tower	Healthy
<u>Bristol Bay Chum Salmon</u>			
Nushagak River	Drift Gillnet/Set Gillnet	Sonar Count	Healthy
Togiak River	Drift Gillnet/Set Gillnet	Aerial Survey	Healthy
<u>Bristol Bay Chinook Salmon</u>			
Nushagak River	Drift Gillnet/Set Gillnet	Sonar Count	Healthy
Togiak River	Drift Gillnet/Set Gillnet	Aerial Survey	Healthy
Naknek River	Drift Gillnet/Set Gillnet	Aerial Survey	Healthy

Table 5.1 (Continued)

Managed Stock	Gear	Escapement Assessment	Stock Status
<u>Bristol Bay Coho Salmon</u>			
Nushagak River	Drift Gillnet/Set Gillnet	Sonar Count	Healthy
Togiak River	Drift Gillnet/Set Gillnet	Aerial Survey	Healthy
Kulukak River	Drift Gillnet/Set Gillnet	Aerial Survey	Healthy

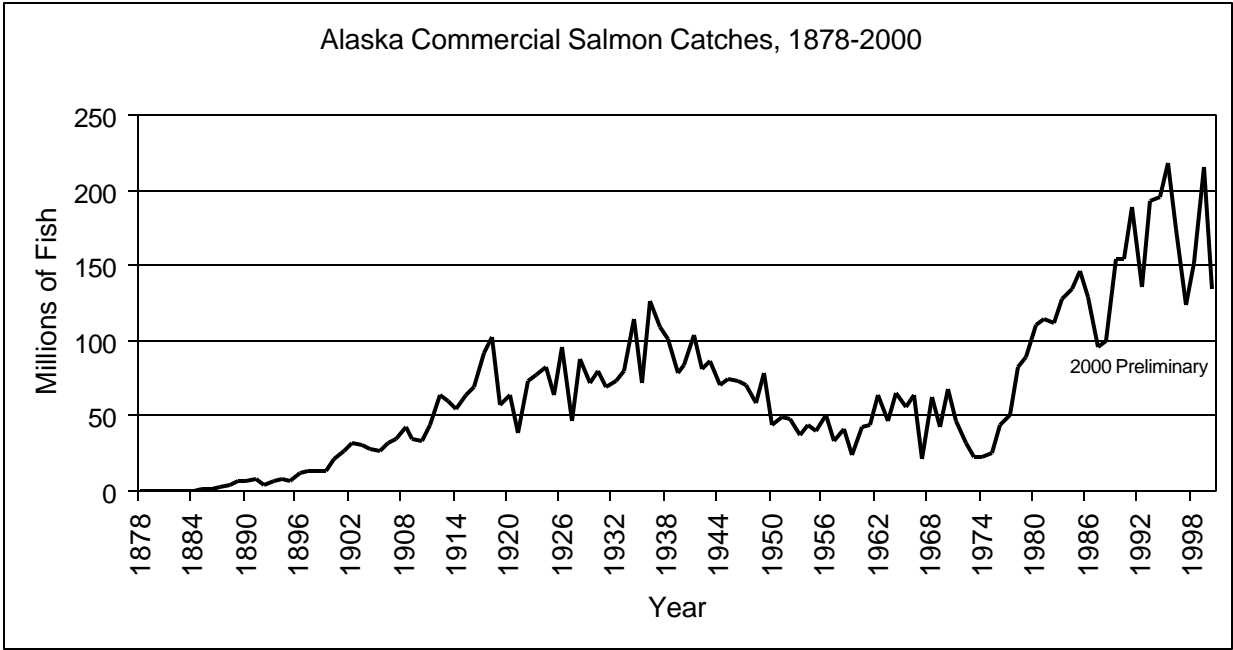


Figure 5.1. Commercial catches of Pacific salmon in Alaska during 1878-2000.

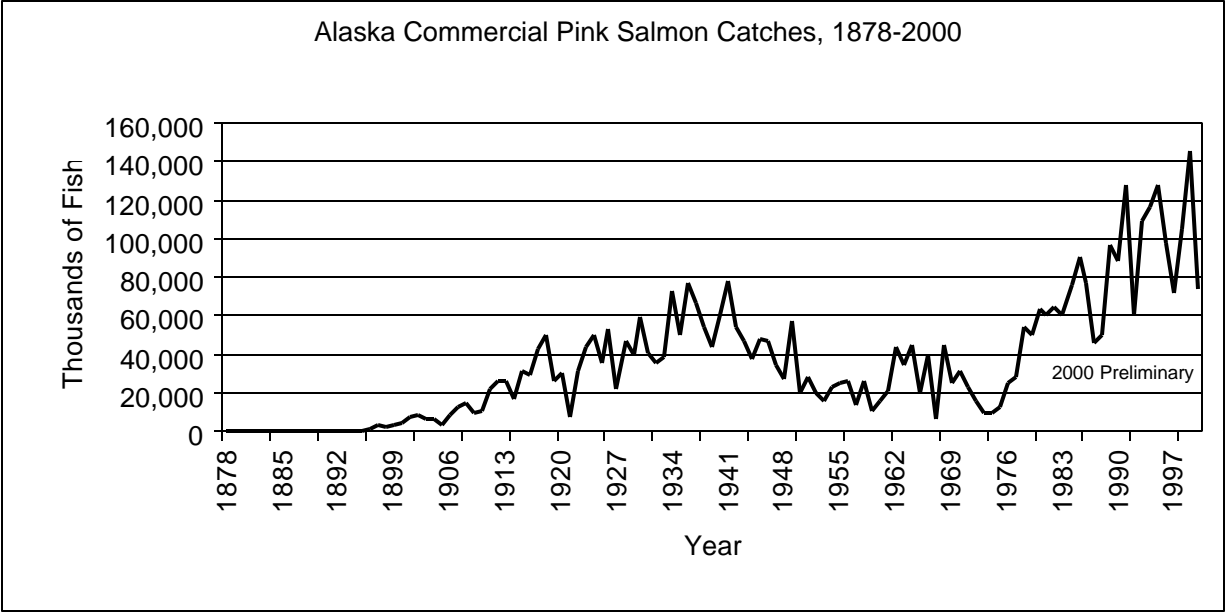


Figure 5.2. Commercial catches of pink salmon in Alaska during 1878-2000.

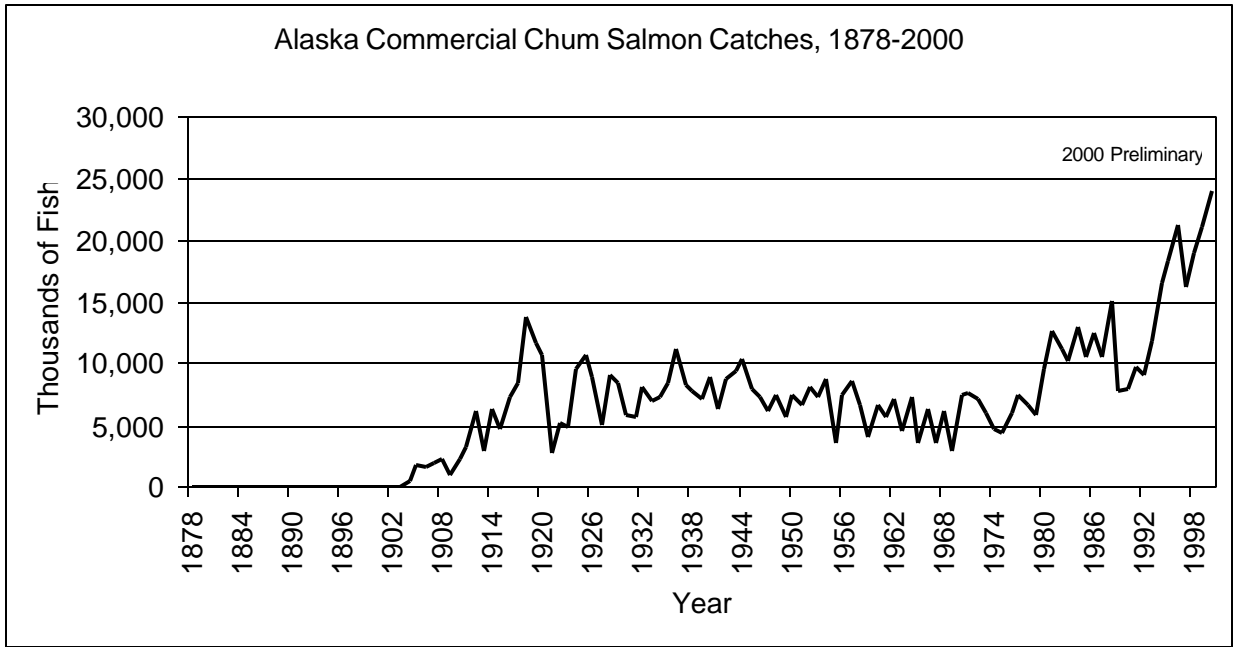


Figure 5.3. Commercial catches of chum salmon in Alaska during 1878-2000.

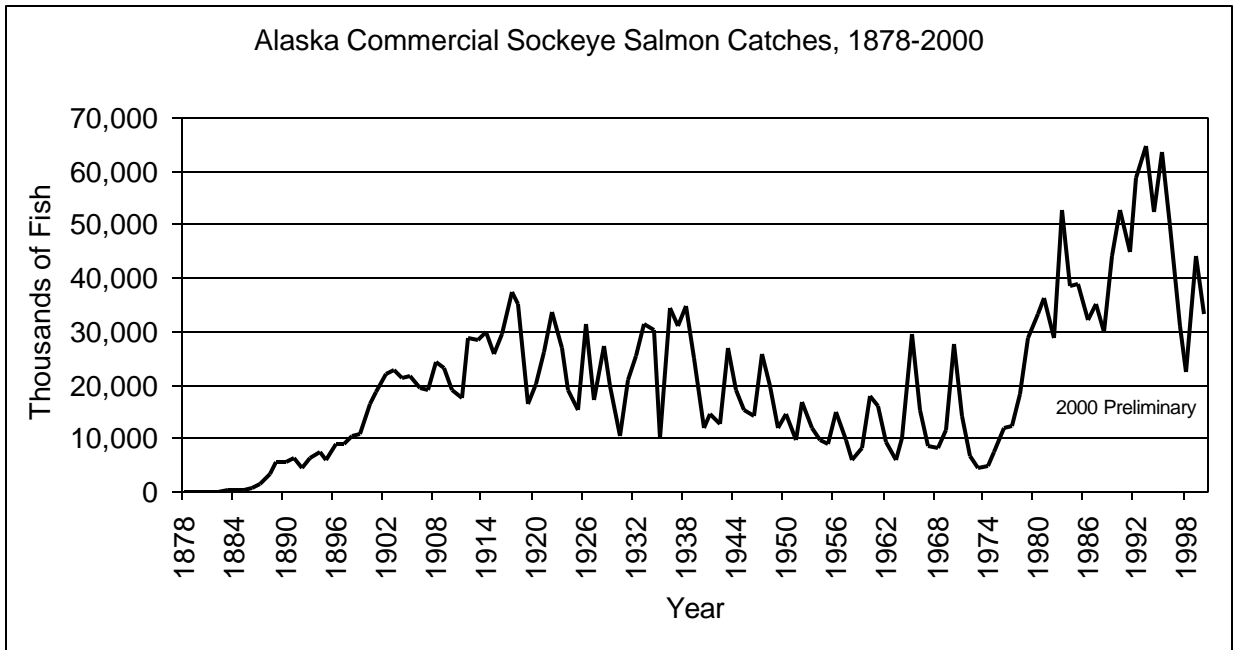


Figure 5.4. Commercial catches of sockeye salmon in Alaska during 1878-2000.

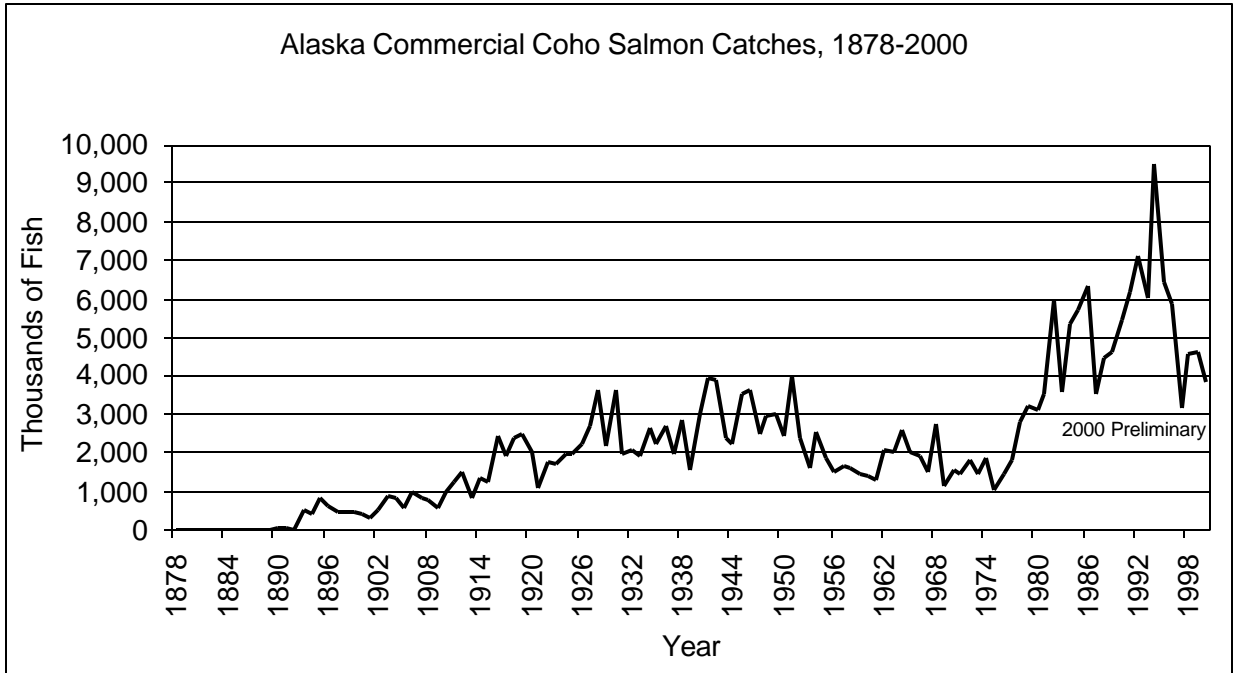


Figure 5.5. Commercial catches of coho salmon in Alaska during 1878-2000.

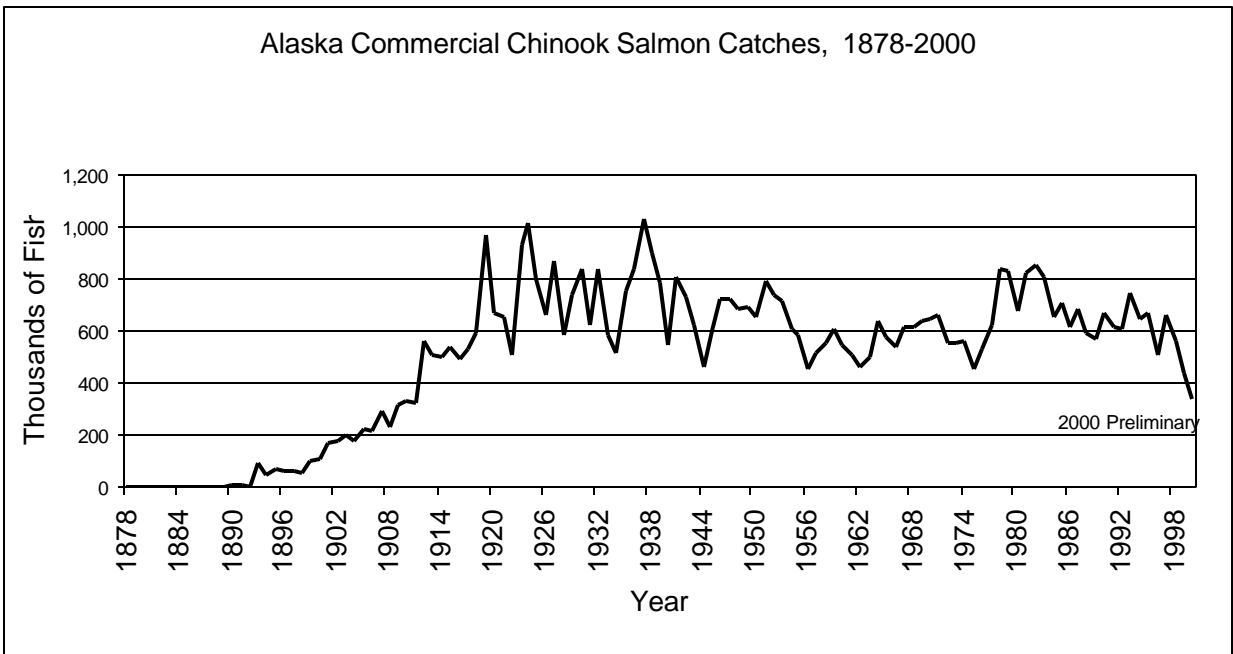


Figure 5.6. Commercial catches of chinook salmon in Alaska during 1878-2000.

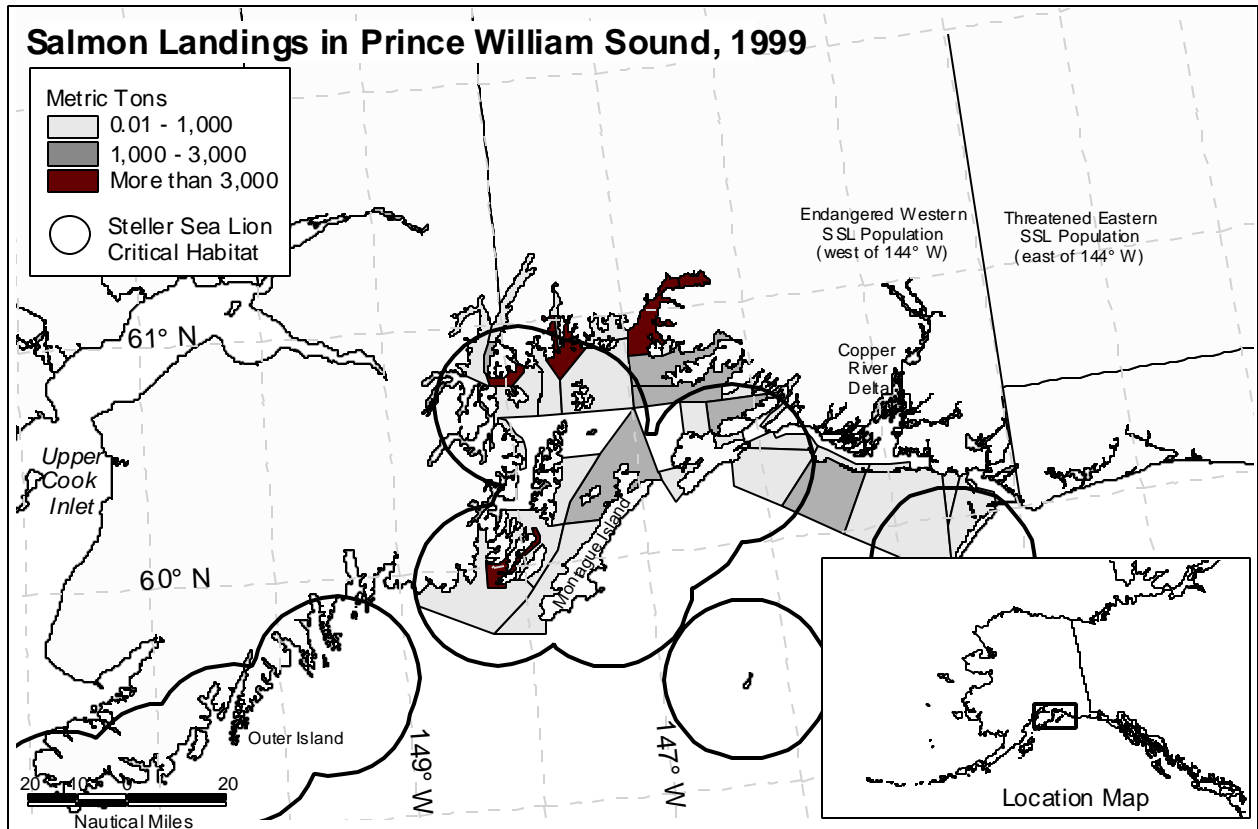
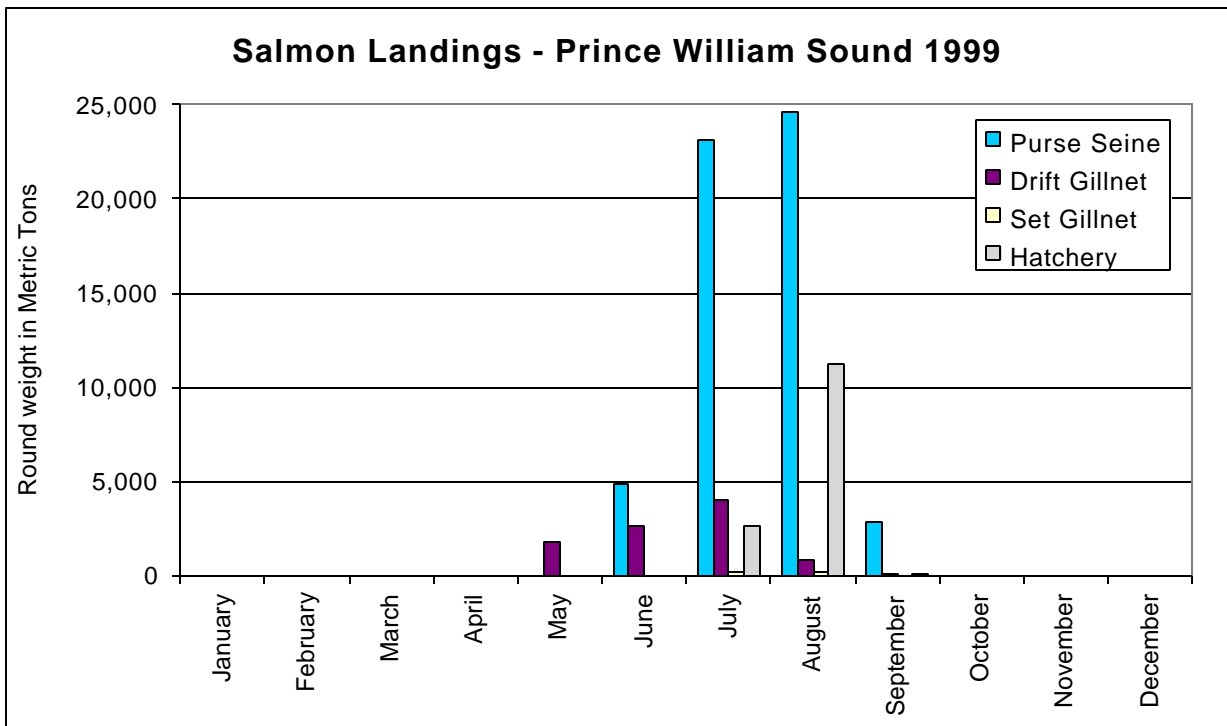


Figure 5.7 Monthly distribution of salmon landings in Prince William Sound, 1999 (top), and Spatial distribution of salmon landings in Prince William Sound, 1999 (bottom).

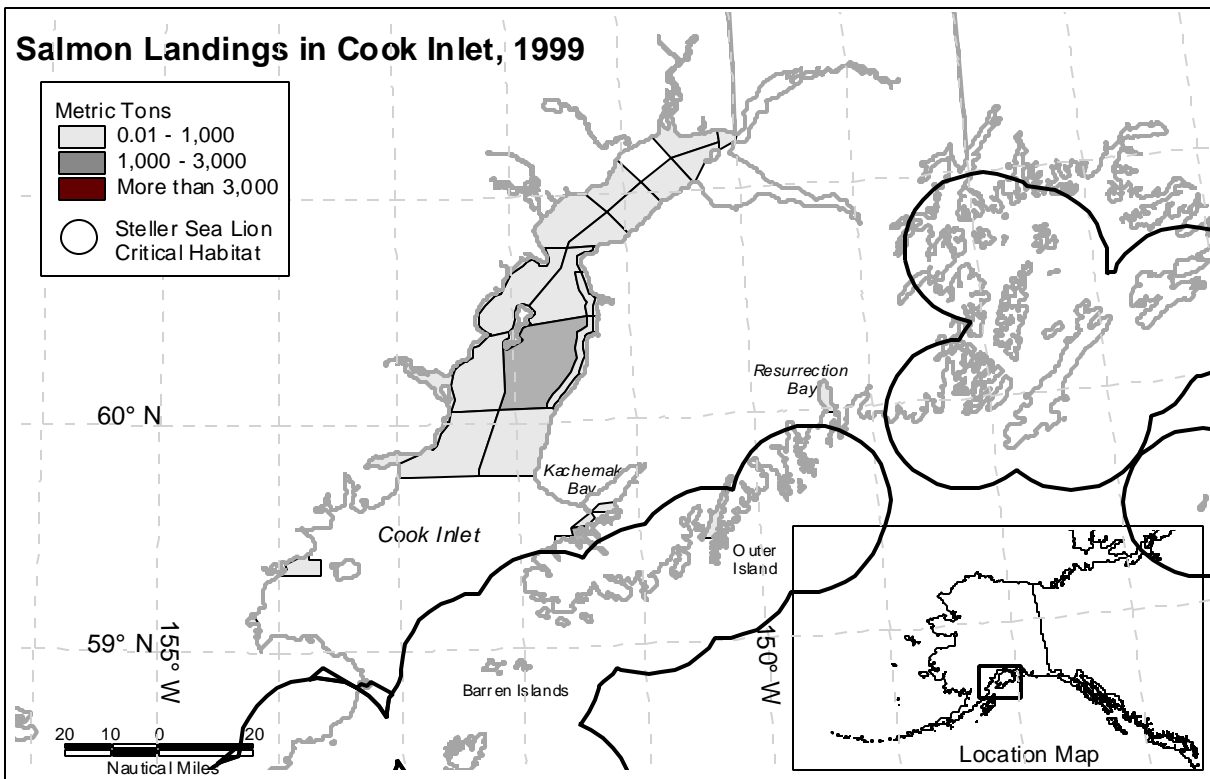
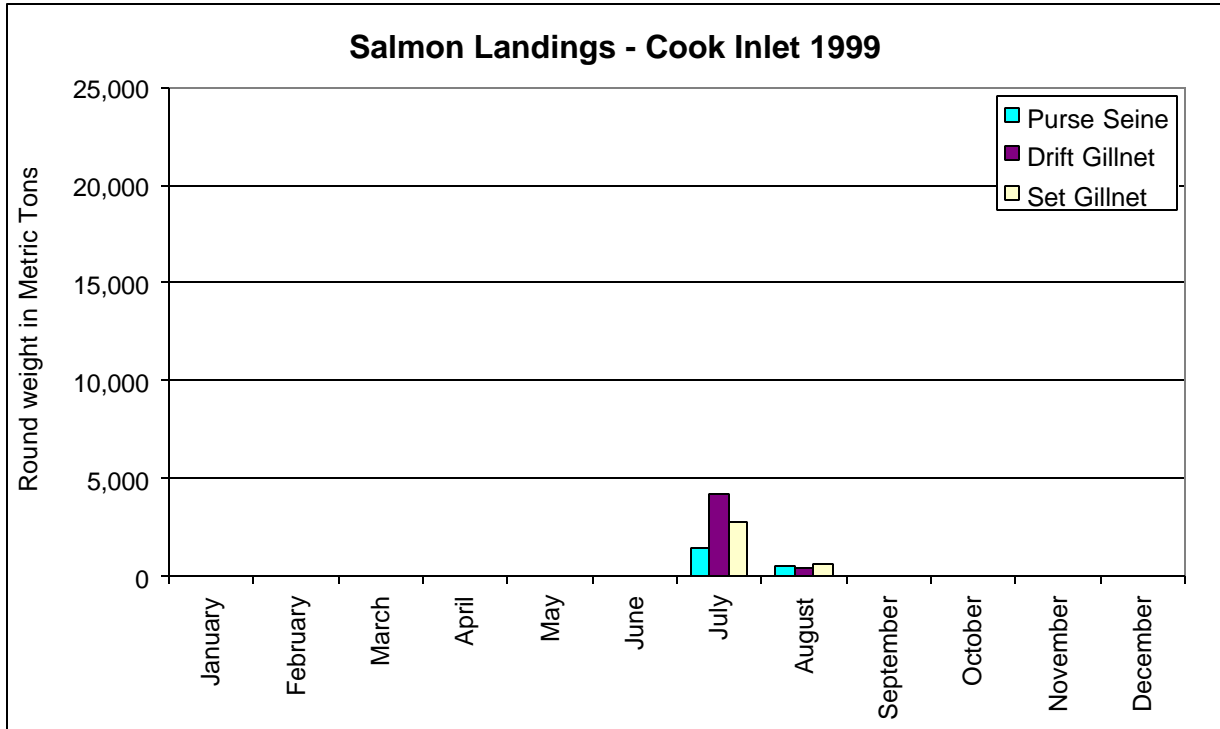


Figure 5.8 Monthly distribution of salmon landings in Cook Inlet, 1999 (top), and Spatial distribution of salmon landings in Cook Inlet, 1999 (bottom).

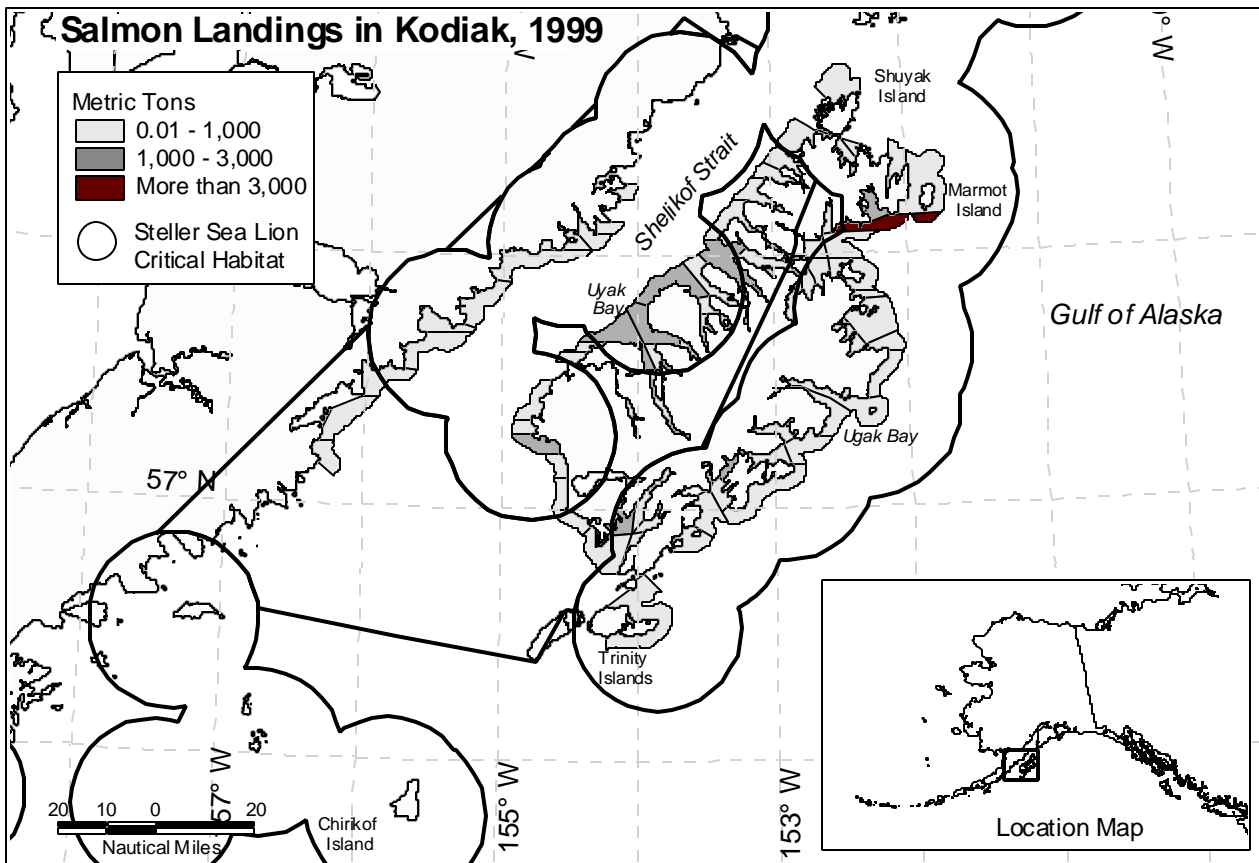
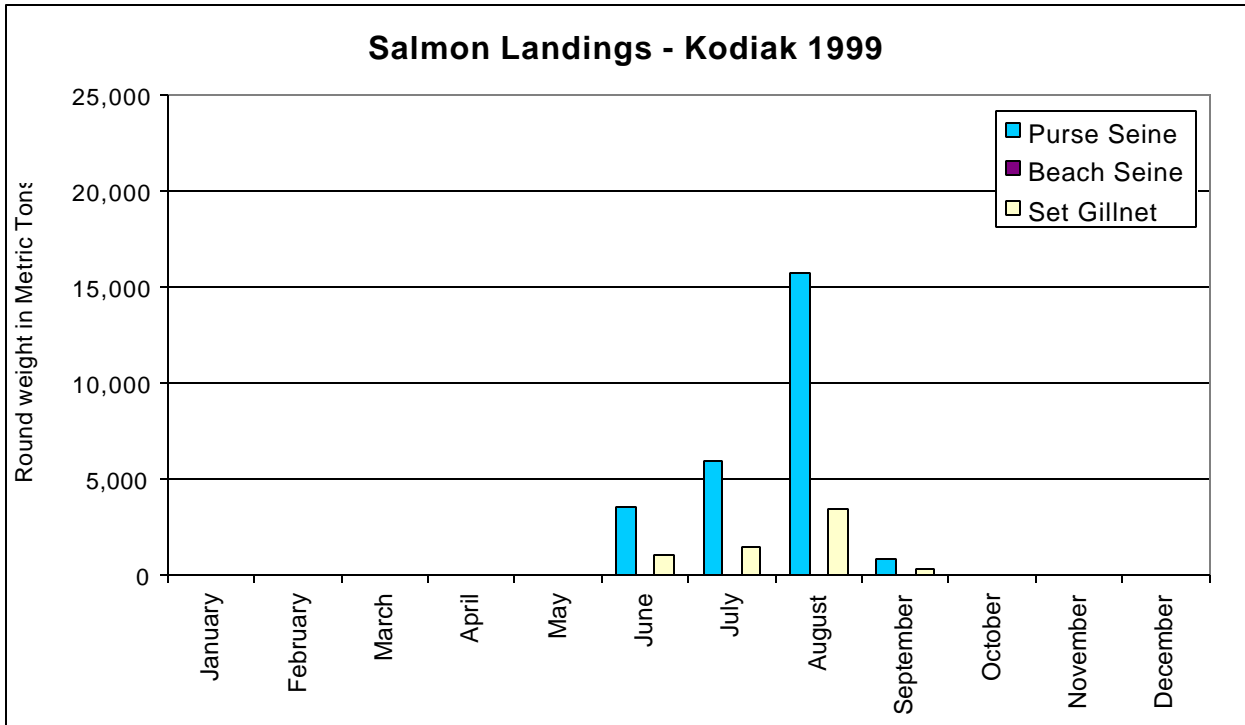


Figure 5.9 Monthly distribution of salmon landings in Kodiak, 1999 (top), and Spatial distribution of salmon landings in Kodiak, 1999 (bottom).

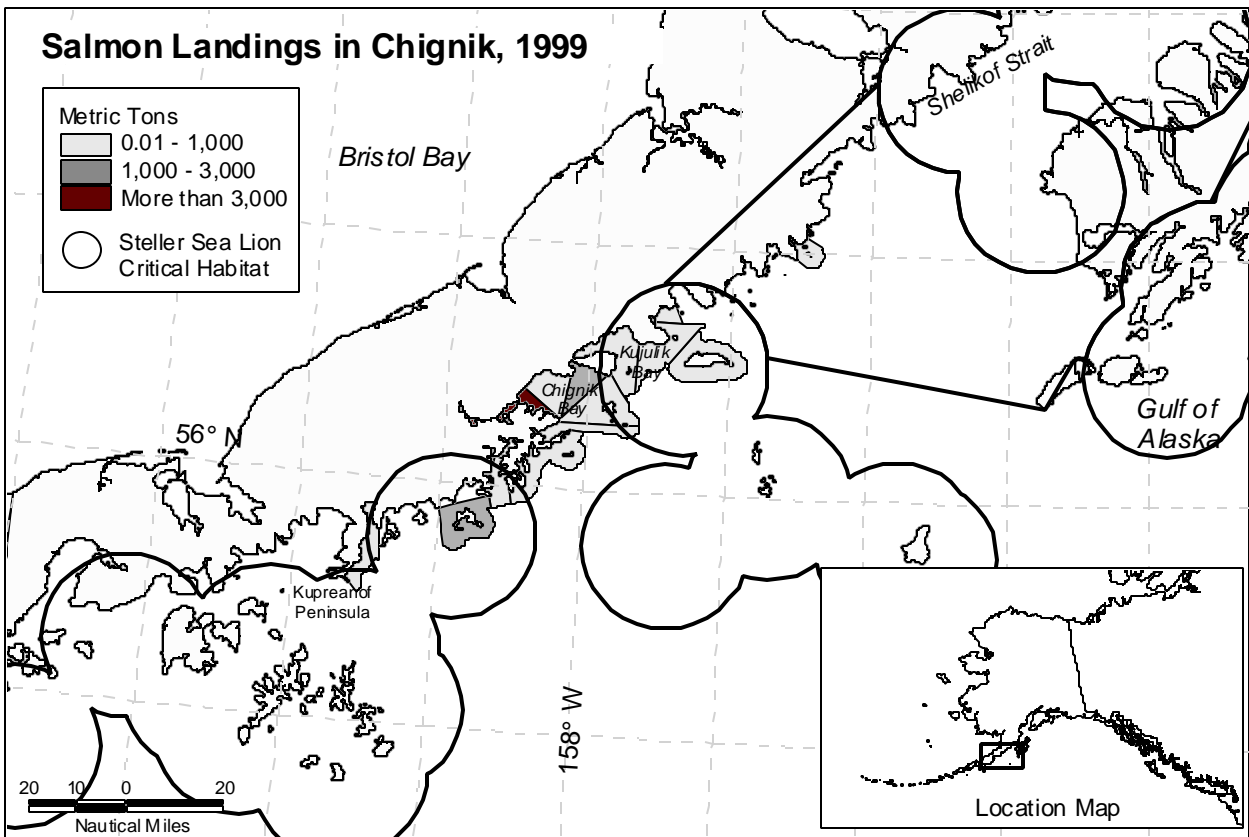
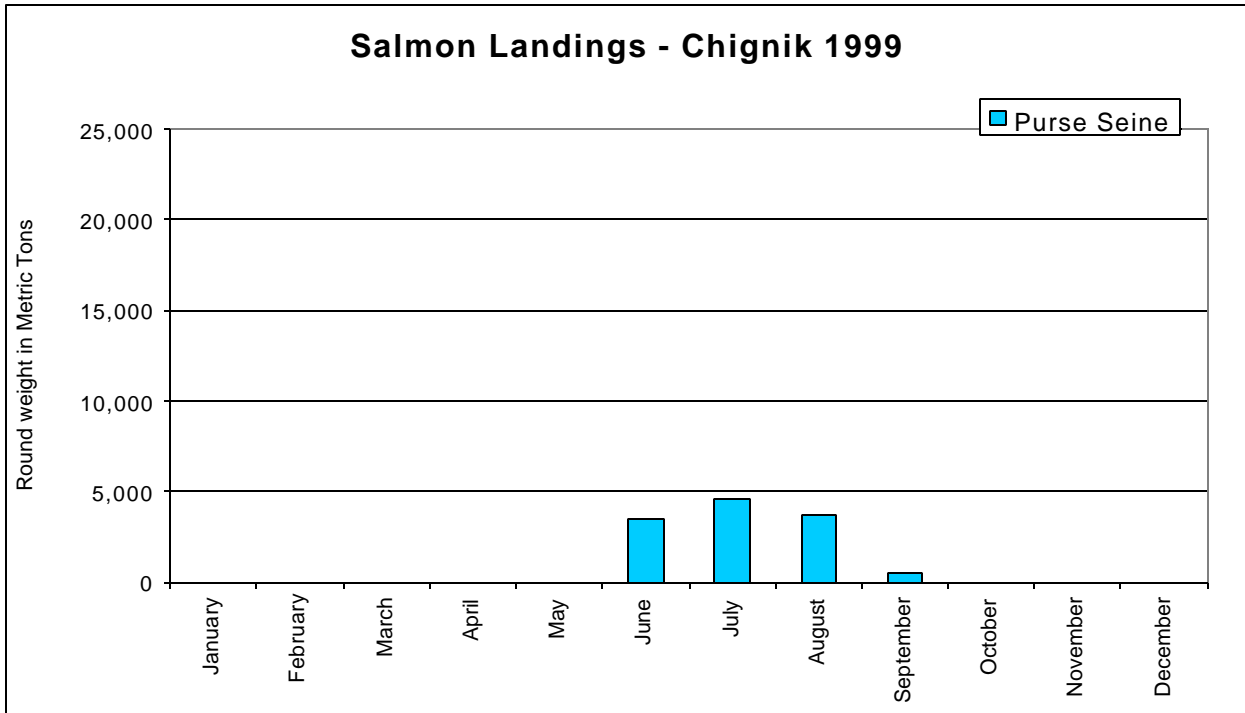


Figure 5.10 Monthly distribution of salmon landings in Chignik, 1999 (top), and Spatial distribution of salmon landings in Chignik, 1999 (bottom).

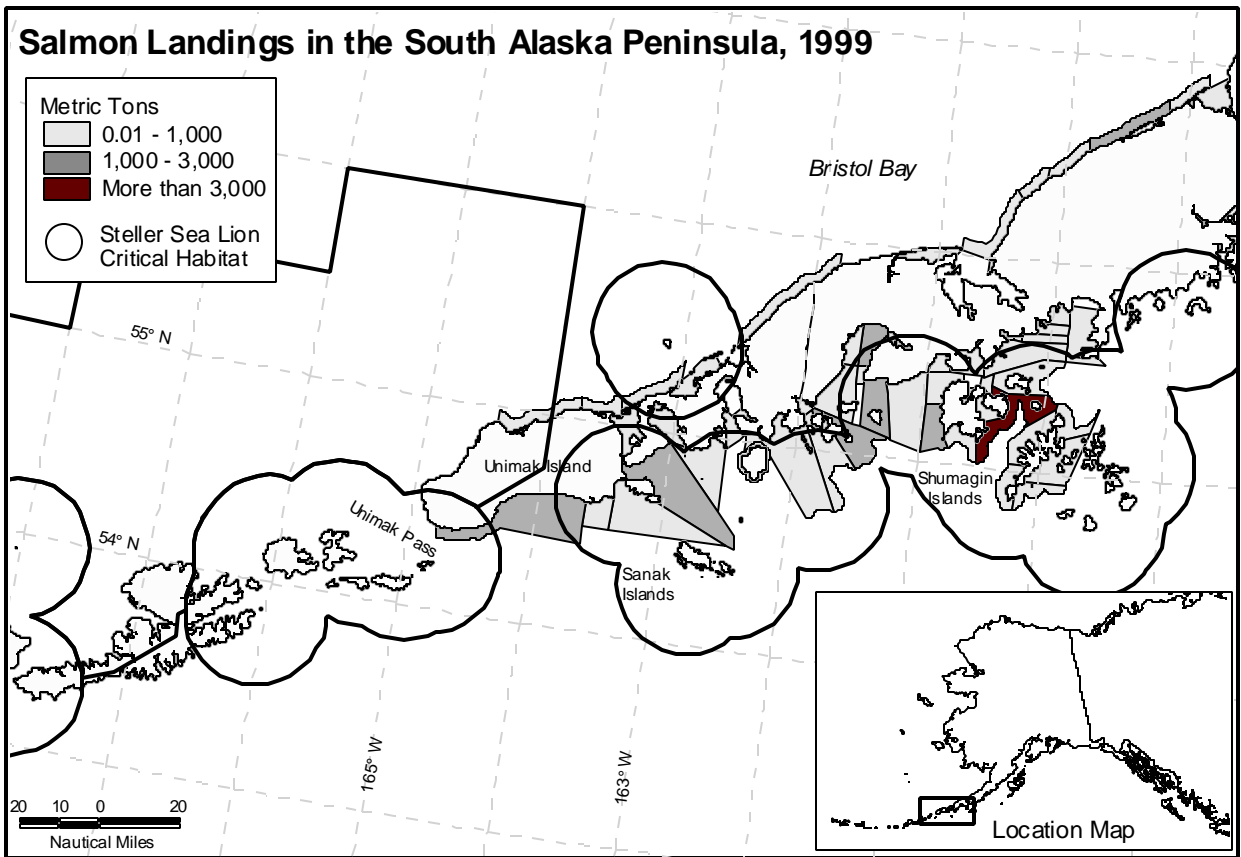
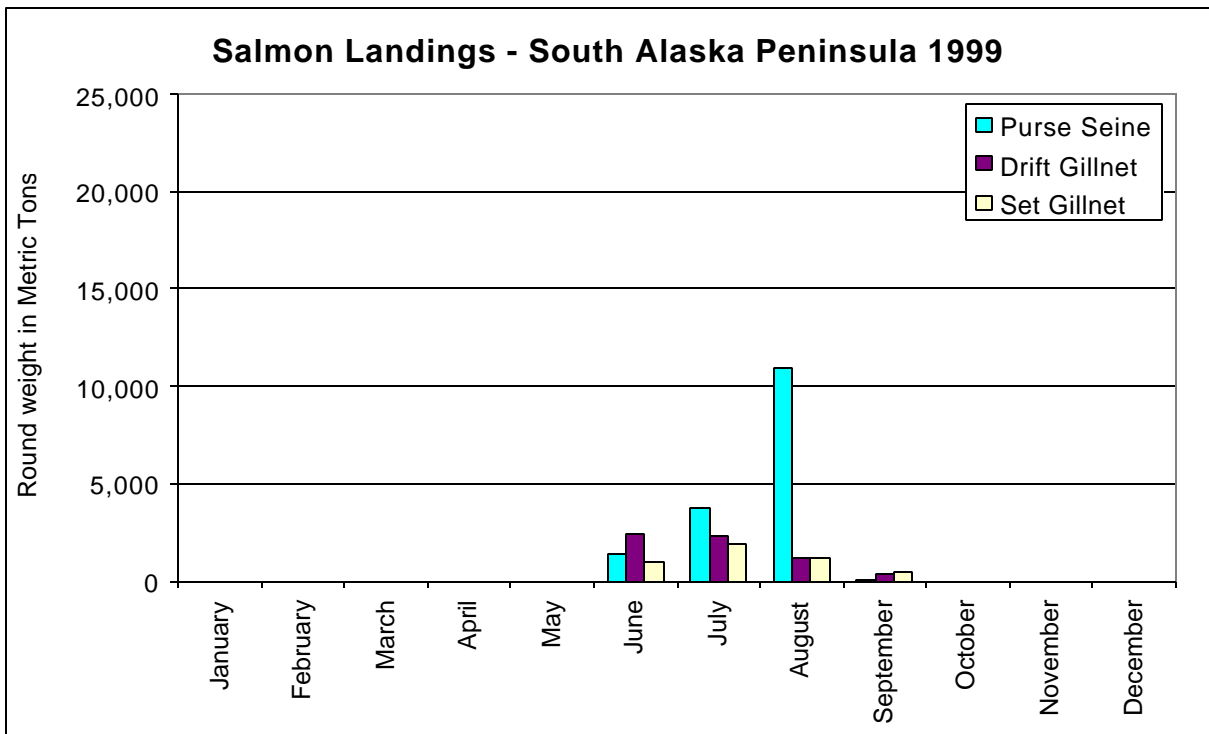


Figure 5.11 Monthly distribution of salmon landings in the South Alaska Peninsula, 1999 (top), and Spatial distribution of salmon landings in the South Alaska Peninsula, 1999 (bottom).

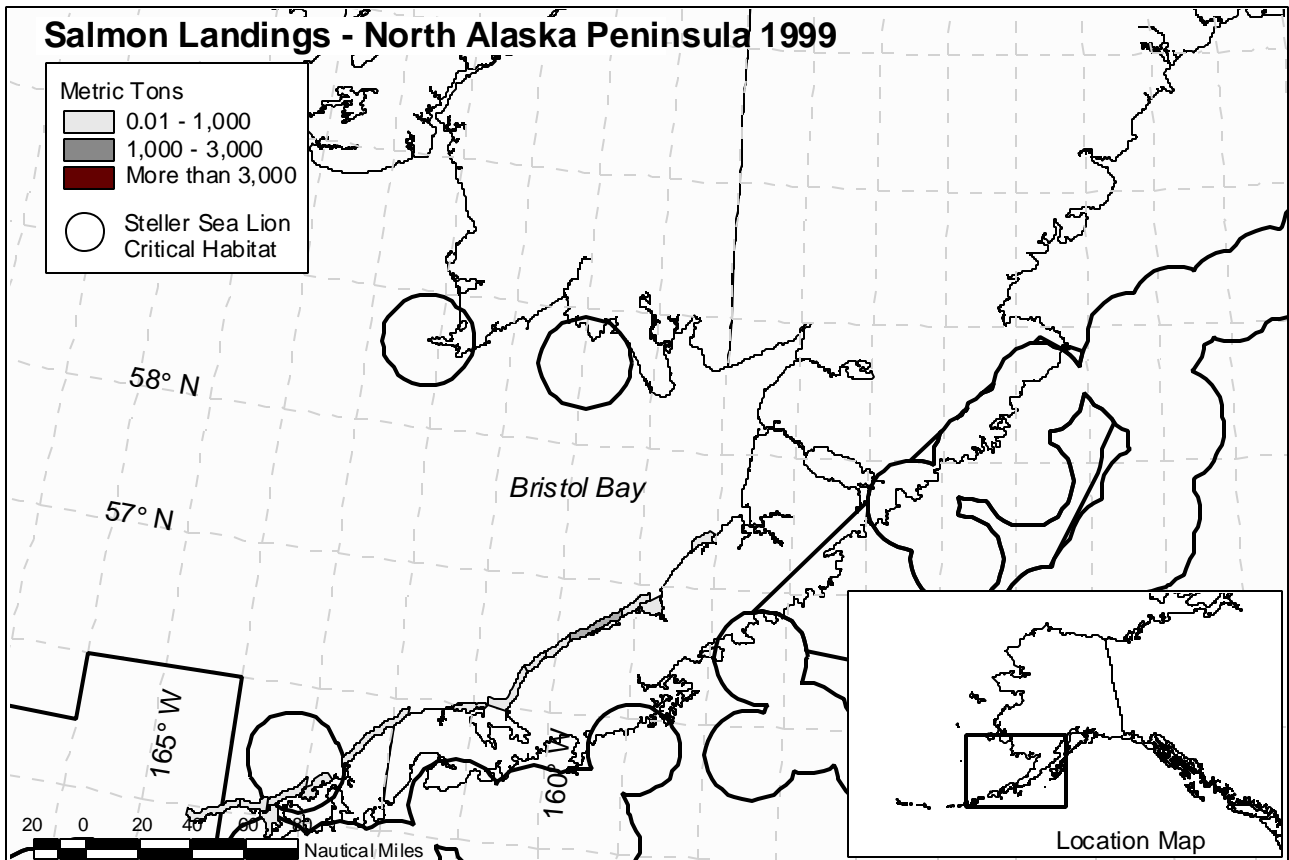
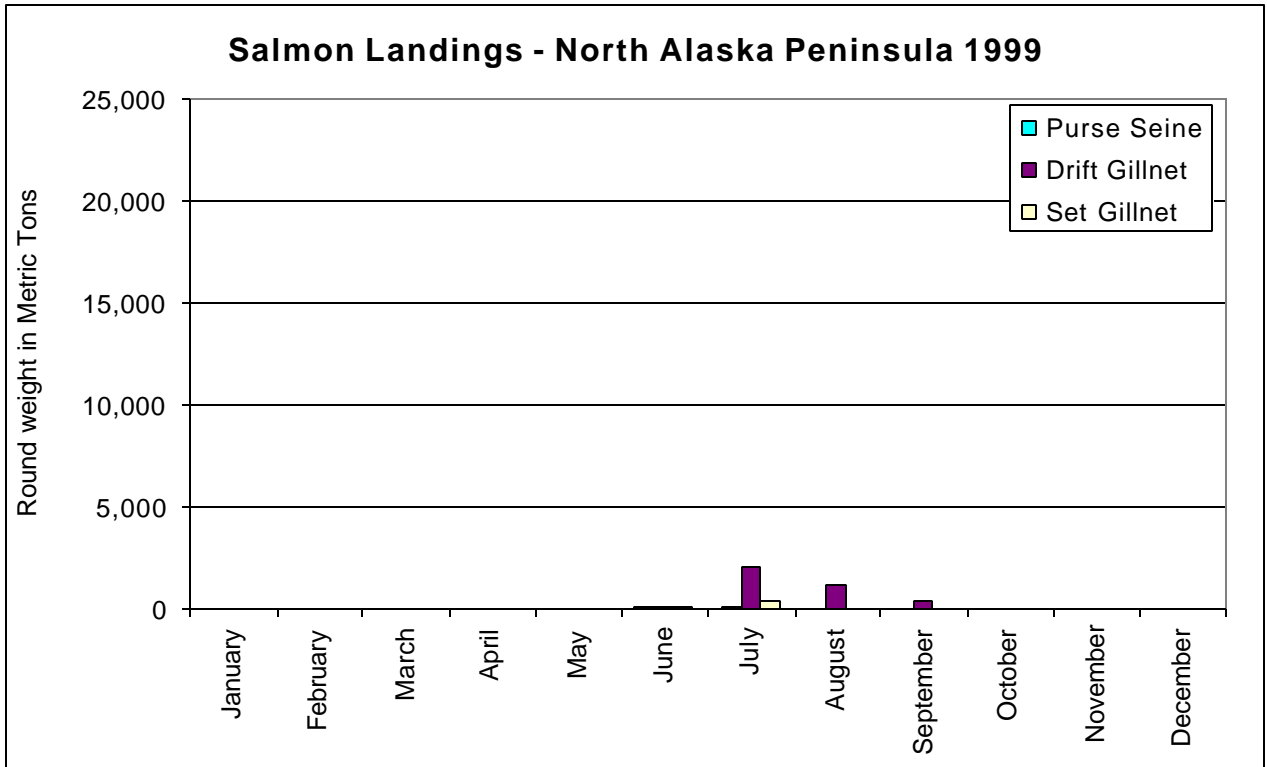


Figure 5.12 Monthly distribution of salmon landings in North Alaska Peninsula, 1999 (top), and Spatial distribution of salmon landings in North Alaska Peninsula, 1999 (bottom).

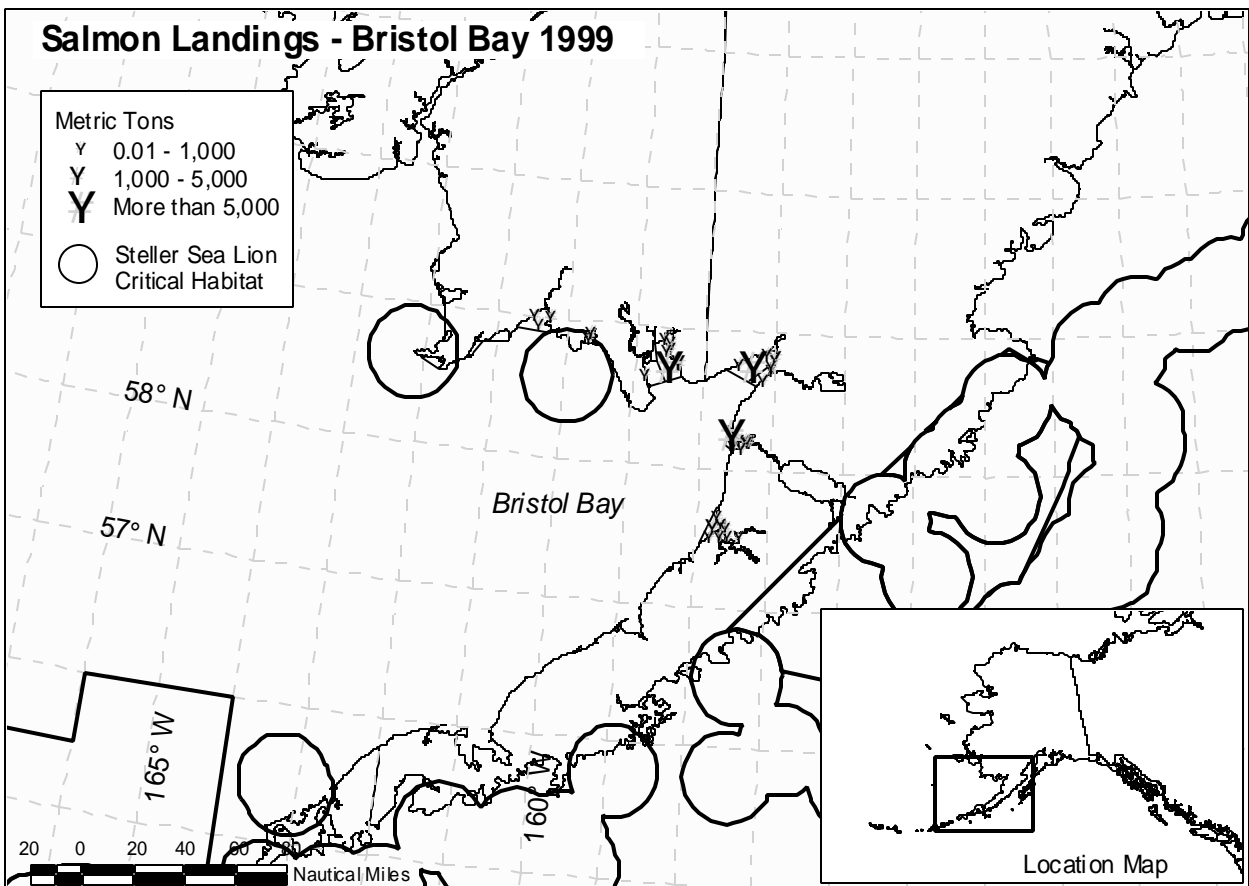
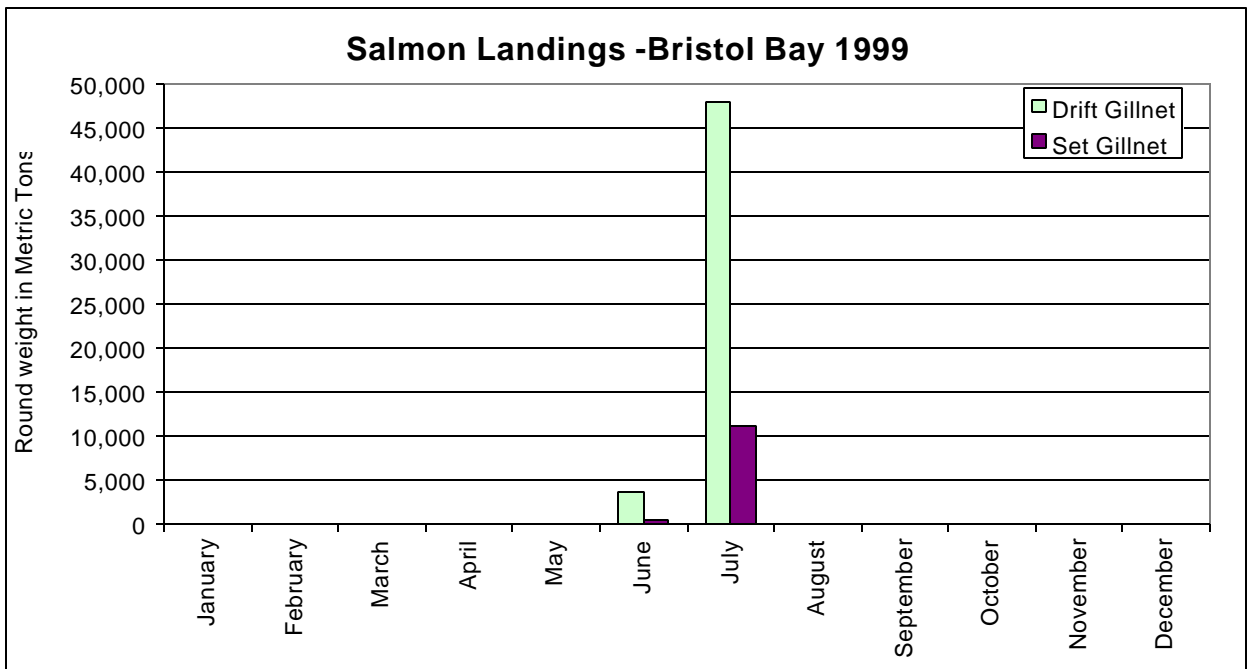


Figure 5.13 Monthly distribution of salmon landings in Bristol Bay, 1999 (top), and Spatial distribution of salmon landings in Bristol Bay, 1999 (bottom).

6. INVERTEBRATE FISHERIES

6.1 Fishery History

Crab and other invertebrate fisheries considered in this report include major commercial fisheries in state (0-3 nm) and federal waters (3-200 nm) west of 144° W longitude (Cape Suckling), covering the central and western GOA, AI, and eastern BS.

6.1.1 Crab

Commercially important crab fisheries developed in the central GOA, BS, and AI since the entry of Japanese crab vessels in the BS in the 1930s and early explorations by the United States (U.S.) off the Alaska coast in the 1940s. Seven species of crabs (red king crab, *Paralithodes camtschaticus*; blue king crab, *P. platypus*; golden king crab, *Lithodes aequispinus*; Tanner crab, *Chionoecetes bairdi*; snow crab, *C. opilio*; Korean hair crab, *Erimacrus isenbeckii*; and Dungeness crab, *Cancer magister*) have supported major commercial fisheries in the last three decades while three species (scarlet king crab, *L. couesi*; grooved Tanner crab, *C. tanneri*; and Triangle Tanner crab, *C. angulatus*) have contributed insignificant amounts, mostly as incidental catch in the major crab fisheries. Besides commercial fisheries, subsistence fisheries by Alaskan natives primarily for food and sport fishery occur in many areas, but their contributions to total harvest are small. In the past, foreign (mostly Japanese and Russian) fleets exploited BS crab resources. The enactment of the Magnuson Fishery Conservation and Management Act, now revised as the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), in 1976 severely curtailed foreign participation in crab fisheries in the U.S. EEZ.

6.1.1.1 Red King Crab

Although red king crab fisheries existed in many regions of the central and western GOA, AI, and BS (Tables 6.1 and 6.2); historically, CI, Kodiak, AI, and Bristol Bay (BB) fisheries contributed the largest volumes to the total landings. CI red king crab have been harvested since late 1930s, but catch records are available only from the 1960/61 season. The crab fishery occurred either in the Southern or the Kamishak/Barren Islands districts with very little fishing activity recorded in the Outer district and none in the Eastern district. Catch peaked at 3,908 metric tons (mt) (Figure 6.1) in 1962/63 and declined in the latter half of 1960 primarily due to lack of facilities available for processing as a result of 1964 earthquake damage to major plants in Seldovia. Although catches improved in the 1970s, stock abundance declined drastically in the early 1980s, perhaps due to heavy fishing (17-89 vessels), and the commercial fisheries in the Southern district, and Kamishak/Barren and Outer districts have been closed since the 1982/83 and 1984/85 seasons, respectively. The 1983/84 season produced only 87 t by 17 vessels. Kodiak red king crab has been harvested since 1936. Proper catch records, however, are available only since the 1960/61 season. Catch peaked in 1965/66 at 42,834 mt (Figure 6.1) with 177 vessels and systematically declined to 3,960 mt by the final season, 1982/83, despite a number of management measures, such as minimum legal crab size and pot limits, taken in between to arrest the decline. The AI fishery was prosecuted in

two registration areas: Adak (area west of 171° W long.) and Dutch Harbor (east of 171° W long.). Domestic fisheries for red king crab in both areas started in 1961. The Adak Island area harvest reached a peak of 9,613 mt (Figure 6.1) with 18 vessels in 1964/65, while peak production in Dutch Harbor area occurred in 1966/67 with a yield of 14,902 mt by 27 vessels. The catch in both areas fluctuated over the years and the Dutch Harbor fishery declined to a low harvest level of 195 mt by 1982/83 and this area has been closed since then. The Adak area fishery occurred annually until the 1995/96 season when only 18 mt was landed. In order to obtain information on red king crab abundance, the Alaska Department of Fish and Game (ADF&G) opened a limited commercial fishery in two areas of the AI in 1998/99 with a guideline harvest level (GHL) of 7 mt. Closed waters included Petrel Bank. Out of three vessels registered for fishing, only one reported any landings, which are confidential. On the other hand, the BB red king crab fishery, the largest of all, has persisted since Japanese began harvesting crab in the BS in 1930. Although the continuity was punctuated by a number of fishery closures due to low abundance, landings peaked at a record high of 58,944 mt from 236 vessels in 1980. Since then, stock size declined sharply through the early 1980s and remained depressed in the 1990s (Figure 6.1) although the number of vessels participating in the fishery remained high, 89-302 vessels.

6.1.1.2 Blue King Crab

The St. Matthew and Pribilof Islands districts are the two major blue king crab fishing areas. In 1965 the Japanese developed a blue king crab fishery in the Pribilof district. The U.S. fleet first participated in this fishery in 1973, when they fished in the vicinity of St. George and St. Paul Islands. In the 1970s blue king crab were primarily taken as bycatch in the snow and Tanner crab fisheries. The catch peaked in 1980/81 at 4,976 mt by 110 vessels. The effort peaked at 126 vessels in 1983/84. Thereafter, the catch and effort sharply declined until the fishery was closed in 1988/89 due to very low abundance (Figure 6.2). Some of the landing records in the 1990s were mixed with red king crab catches; therefore, the blue king crab catches were underestimated during this period. A commercially viable blue king crab resource was discovered around St. Matthew Island in the 1970s and U.S. vessels started exploiting this population in 1977 and the harvest peaked at 4,288 mt with an effort of 164 vessels in 1983. The catch declined thereafter, and stabilized at two low levels: during 1986 to 1990 at a low catch range of 455-783 mt with an effort range of 31-69 vessels and during 1991 to 1998 at a slightly higher catch range of 1,122-2,109 mt (Figure 6.2) with 68-174 vessels. Escalation of effort has been checked by concurrently opening St. Matthew and the Pribilof Islands crab fisheries and enforcing pot limits (Morrison et al. 2000; Zheng et al. 1997).

6.1.1.3 Golden King Crab

Following the collapse of red king crab interest emerged to exploit other species, such as golden king crab. Golden king crab were landed in many areas either as bycatch in red and blue king crab fisheries or as catch in a directed fishery. Fisheries in AI registration areas (Adak and Dutch Harbor) accounted for most of the landings (Figure 6.3), whereas PWS fishery produced small catches (Figure 6.3). Golden king crab inhabit deeper waters

than red or blue king crab. In central and western PWS, king crab catches have been recorded since 1960, but species-specific catch recording started only in 1979/80. With the decline in red and blue king crabs landings, a directed fishery for golden king crab started in the 1980s. However, the golden king crab stock in PWS is small. Catch and effort peaked at 67 mt (Figure 6.3) and 31 vessels, respectively in 1982/83; thereafter, they declined rapidly. Only 2 vessels fished in the last season, 1991/92. Since then, the fishery occurred sporadically in some seasons, but because of a few vessels involved the catches are confidential. A directed fishery for golden crab started in AI registration areas in the 1981/82 season. Between 1981 and 1995, an average of 49 vessels in Adak and 18 vessels in Dutch Harbor participated in the fishery. Peak harvest occurred in Adak in the 1986/87 season (5,805 mt by 62 vessels) and in Dutch Harbor during 1995/96 (904 mt by 17 vessels).

6.1.1.4 Tanner Crab

Tanner crab resources were exploited in many areas (Table 6.2), but PWS, CI, Kodiak, Alaska Peninsula (Chignik and South Peninsula), and BS fisheries are historically most important. The Tanner crab fishery in PWS and adjoining GOA waters began in 1968 and was the main shellfish fishery in that region before it collapsed. The fishery peaked at 6,318 mt in 1972/73 and declined to 215 mt in 1988 before it was closed. During 1976/77 to 1988, the effort ranged from 14 to 51 vessels. Despite closure of the commercial fishery, sport, personal use, and subsistence Tanner crab fisheries persisted at a low level until 1999 when they were closed due to continued low crab abundance. A number of reasons were given for the collapse of PWS fishery (Trowbridge 1996): overexploitation of immature and legal males, illegal harvest of females, lengthy fishing season (7 months during 1974-1981) and warm seawater temperatures. The Tanner crab fishery in CI occurred in six districts: Southern, Kamishak, Barren Islands, Central, Outer, and Eastern (Trowbridge 1996). Catch recording began in 1968 and the catch peaked at 3,614 mt in 1973/74. Landings from the Eastern district were smaller compared to those of the other districts. The total number of vessels in all districts ranged from 7 to 137. Because of the decline in abundance the commercial fishery has been closed since 1995. However, sport and personal use fisheries occur in the Southern District, which harvest up to 10% of legal male crabs. With the decline of the red king crab stock in Kodiak waters fishermen targeted Tanner crabs among other crabs. The domestic fishery commenced in 1967. Development of this fishery was slow due to a number of reasons (ADF&G 2000), the most important one being low consumer acceptance. By 1972, market conditions improved and the fishery grew to a peak of 15,096 mt (Figure 6.4) harvested by 148 vessels in the 1977/78 season. The harvest began to decline in the late 1970s and early 1980s with increasing effort (148-348 vessels), which prompted the BOF to enforce a number of management regulations including pot limits and exclusive fishing areas. Due to the persistent decline of crab stocks around Kodiak area, the commercial fishery has not been open since the 1993/94 season. Tanner crab fisheries in the Peninsula area were prosecuted in two districts: Chignik and South Peninsula. The fishery in Chignik district started in 1968. The harvest peaked in 1975/76 at 3,142 mt (Figure 6.4) from 35 vessels. The number of vessels engaged in the fishery ranged from 6 to 48. As observed in other GOA crab fisheries, the harvest progressively declined to historic low (147 mt) in 1989

and the commercial fishery has remained closed since 1989. The South Peninsula fishery started in 1967 and developed to produce a maximum yield of 3,939 mt (Figure 6.4) with an effort of 48 vessels. Thereafter, harvests declined systematically to a low of 479 mt in 1989 and no fishery has occurred since then. The number of vessels engaged in this fishery ranged from 17 to 74. The BS Tanner crab registration area includes all waters of the BS north of the latitude of Cape Sarichef at 54° 36' N lat., which included BB and Pribilof Islands areas, as well. Tanner crab have been harvested since 1969, but the directed fishery started in 1974/75 with 28 vessels. The catch peaked in 1977/78 to 30,232 mt harvested by 120 vessels. The catch declined to a low level of 1,430 mt in 1985 and the fishery was closed during 1986 and 1987. The fishery picked up from 1989 onwards with 109-296 vessels, but the stock declined again due to poor recruitment. Despite implementation of a number of management regulations commercial harvest continued to decline in the 1990s. Finally, due to poor fishery performance in 1996, the fishery was closed before the GHL was reached and has remained closed since then.

6.1.1.5 Snow Crab

Snow crab, being a more northerly species, were harvested only in the BS and have been fished since 1977, initially incidental to Tanner crab harvest. The directed fishery started in 1981 with the decline of Tanner crab harvest. In terms of landed weight, this was by far the largest crab fishery in Alaska waters. The fishery grew progressively with increasing catch and effort and the catch peaked in 1991 at 149,073 mt (Figure 6.5) harvested by 220 vessels. Thereafter, the catch started to decline and picked up in 1998 to reach a harvest of 110,379 mt by 229 vessels. The number of vessels operating in this fishery ranged from 52 to 273 during 1978 to 1999.

6.1.1.6 Korean Hair Crab

Historically, the Korean hair crab fishery in the BS occurred in the Pribilof district. Japanese fleets exploited this fishery in the 1960s and the U.S. fleet entered in 1978. Throughout the 1980s they were caught as bycatch in Tanner crab fisheries. As the interest increased on this population in the 1990s, ADF&G began to manage this fishery under conditions of a commissioner's permit. During the historical development of this fishery, effort and harvest reached a maximum of 67 vessels and 1,107 mt in 1980. Effort reduced during 1987 to 1990 as a result of stock decline, and in the 1990s, harvest reached a peak of 1,059 mt in 1993/94 (Figure 6.6). The number of vessels operated in this fishery ranged from 2 to 99, but it was less than 10 in nearly half of the seasons. Since 1995, both effort and GHL have declined as a result of stock decline.

6.1.1.7 Dungeness Crab

Historically, Dungeness crab harvests have been reported from PWS, CI, Kodiak, Alaska Peninsula and AI districts, but the former four areas have the long history of landings. The Dungeness crab fishery in PWS occurred in two regions: Inside and Outside districts. The major fishery occurred within Orca Inlet of the Inside district, and Copper River delta and Controller Bay areas of the eastern section of the Outside district. In 1987, split

regulatory seasons were adopted in the Outside District with open seasons from March 20 to May 20 and July 25 to December 31 to protect soft shell males. The total PWS catch peaked at 931 mt (Figure 6.7) by 63 vessels in 1978. Peak catches in the Inside and Outside Districts occurred in 1960 and 1981, respectively (Berceli and Brannian 2000). Historically, the total PWS effort ranged from 2 to 67 vessels. Because of depressed stock levels the fishery has been closed since 1980 and 1993 in the Inside and the Outside districts, respectively. Besides overfishing, sea otter predation (only on the Orca Inlet stock) and adverse climatic change were likely causes identified for non-recovery of PWS stocks (Berceli and Brannian 2000). Cook Inlet Dungeness crab catches have been recorded since 1961 and the major portion of catches came from the Southern district. Split fishing seasons in the Southern District (Kachemak Bay), from July 15 through December 31, and from January 15 or the beginning of the Tanner crab fishing season, whichever is later, through March 15, were designed to protect softshell crab. The catch peaked at 967 mt by 72 vessels (Figure 6.7) in 1979. Effort varied from 1 to 108 vessels during the history of this fishery. The commercial fishery in the Southern District has been closed since 1991 and in all other districts since 1997 because of low stock levels. Sport and personal use fisheries continued through mid-1998 when they were closed due to low stock levels. Most non-commercial harvest occurred in Kachemak Bay east of Homer Spit with little effort in other districts (Trowbridge et al. 2000). Part of the Kodiak district and the northern area have an open season from May 1 to January 1 and the southern area has an open season from June 15 to January 1 (Ruccio and Worton 2000). The Dungeness crab fishery in Kodiak started in 1962 and the maximum catch of 3,098 mt was harvested by 43 vessels in 1968. The number of vessels participating in this fishery varied from as low as four to as high as 125, but less than 25 vessels have been operating since 1995. Stock abundance fluctuated with the change in effort and recruitment. Lower market value contributed to low effort in many years in the late 1990s. Dungeness crab harvest along the Alaska Peninsula have been recorded since 1968, but landings have been sporadic. The highest landing was 571 mt achieved in 1968. In the 1980s, catch and effort increased as a result of the decline in king crab harvest and stronger market for Dungeness crab and the harvest peaked to 545 mt (Figure 6.7) with 132 vessels in 1983. The numbers of vessels operated during 1990s were low, varied from less than 3 to 24. Few seasons recorded confidential landings (years in which fewer than four vessels made landings), which included 1999 (Table 6.4), because less than three vessels reported landings.

6.1.1.8 Grooved Tanner Crab, Triangle Tanner crab, and Scarlet King Crab

Since the 1990s, grooved Tanner crab and triangle Tanner crab were harvested in the Alaska Peninsula, AI, and BS areas, mostly as bycatch in the crab fisheries. Triangle Tanner crab were caught as incidental catch in the grooved Tanner crab fisheries in the three areas (Table 6.2). The grooved Tanner crab harvests in the Alaska Peninsula, AI, and BS areas ranged from 25 mt to 456 mt. Few (3-8) vessels were involved in this fishery in each area and there were no landings since 1997 although fisheries were open. As an example of the size of this fishery, four vessels reported a 22 mt harvest in 1995 in the BS area. Scarlet king crab were harvested as bycatch in the golden king crab and

deep-water Tanner crab fisheries in the AI area. Since 1992, annual harvest has ranged from 3 mt to 29 mt and 2-8 vessels engaged in this fishery.

6.1.1.9 Summary

In summary, all crab stocks have fluctuated over the years perhaps due to fishing and environmental causes. Some stocks have collapsed and shown no signs of recovery (e.g., Kodiak red king crab) while others declined to low stock levels in the 1990s triggering recent fishery closures and drastic GHL reductions (e.g., PWS, CI, Kodiak, AI, and BS Tanner crab, St. Matthew and Pribilof districts blue king crab, and BS snow crab) (Tables 6.1 and 6.2). Some remaining fisheries do not attract much interest by crab fishers because of small stocks (e.g., grooved and triangle Tanner crab).

6.1.2 Other Invertebrates

Other commercially and recreationally harvested invertebrates include species of shrimp, scallop, sea cucumber, clams, octopus, squid, and sea urchins. The historical development of commercial fisheries of the important first three groups are described in this section.

6.1.2.1 Shrimp

Five species supported Alaska shrimp fisheries: northern (formerly, pink) shrimp, *Pandalus borealis*; sidestriped shrimp, *Pandalopsis dispar*; coonstriped shrimp, *Pandalus hypsinotus*; spot shrimp, *Pandalus platyceros*; and humpy shrimp, *Pandalus goniurus*. In 1999, northern and sidestriped shrimp contributed to almost all the landings from the areas west of 144° W long.: PWS, CI, Kodiak, AI coasts, and BS (the Pribilof Islands and St. Matthew Island) (Table 6.1).

Shrimp resources in Alaskan waters have been exploited since 1915, but catch records are available for less than five decades only. A trawl fishery for northern shrimp in the CI Southern District has been documented since the 1950s. The trawl harvest peaked at 2,802 mt by 15 vessels in 1980/81. The effort ranged from 3 to 23 vessels. Trawl surveys indicated declines of all shrimp species in the Kachemak Bay portion of the Southern District from levels in the 1970s and the fishery has been closed since 1987/88 (Trowbridge 2000). The shrimp trawl fishery outside CI proper and along the outer Kenai Peninsula was small compared to that of the Southern District. Catches were recorded since 1977/78 and peaked at 888 mt by 11 vessels in 1984/85. Catches prior to 1987 were predominantly northern shrimp while more recent fisheries targeted sidestriped shrimp (Trowbridge 2000). Effort ranged from 1 to 4 vessels in the fishery except for the 1982/83 and 1983/84 seasons, during which 7 and 11 vessels, respectively, were operated. The fishery has been closed since 1997/98 due to low abundance. In Kodiak, trawl and pot gear have been used to harvest shrimp, but pot gear has been used only in few areas. The Kodiak trawl shrimp fishery began in 1958 and the harvest consisted of primarily northern shrimp (95% by weight). Other species landed included sidestriped, coonstriped, spot, and humpy shrimp. The 1964 earthquake and tidal wave destroyed

most of the Kodiak fishing infrastructure, including the shrimp fishery. The fishery developed thereafter, and the trawl harvest peaked to 37,265 mt in 1971 and effort peaked to 75 vessels in 1974. Catch and effort declined in the 1980s and 1990s due to stock decline, and only three vessels landed 3 mt during the 1998/99 season (June 15, 1998 to February 28, 1999).

The shrimp trawl fishery in the Alaska Peninsula and Chignik districts started in 1968. Northern shrimp was the main component of the catches. The catch levels remained low until the early 1970s and catch and effort peaked at 32,440 mt and 98 vessels, respectively, in 1977/78. Catches started to decline thereafter in both areas with the decline in stock abundance and the fishery in south Peninsula closed since 1980. Although only offshore areas in Chignik district have been open for fishing since 1982, no commercial harvests have been reported since 1982/83.

Shrimp fishing in the AI and BS started in 1960s with Russian and Japanese participation. Most harvest occurred northwest of the Pribilof Islands. A domestic trawl fishery began in 1972, targeting northern shrimp near Unalaska Island. As the fishery developed in AI and BS, catch peaked to 3,085 mt by seven vessels in 1977/78. Precipitous decline in shrimp catches after 1978 resulted in reduction in the season and no shrimp activities between 1983 and 1992. Since 1992, shrimp fishing activities have been very low and the first commercial harvest after 1992 occurred only in 1999 with two vessels, hence the catch is confidential. At the start of the fishery, catch consisted primarily of northern shrimp, however as the season progressed, sidestriped shrimp became dominant in the catch.

In PWS, the pot fishery targeted spot shrimp and to a limited extent coonstriped shrimp, while trawl fishery harvested sidestriped shrimp and northern shrimp. The primary spot shrimp harvest area encompassed northern and western PWS. Commercial shrimp landings (2 mt) were first reported in 1960. The pot fishery expanded rapidly after 1978 with increases in catch and effort. During 1982-1984, the open season was reduced to April 1 through November 30 and a regulatory GHL adopted. Despite these measures, catch and effort increased and reached a maximum of 132 mt in 1986 and 86 vessels in 1987. Thereafter, catch dropped drastically and the fishery lasted only 46 days in 1991 with 8 mt taken by 15 vessels (Berceli and Brannian 2000). The fishery has been closed since 1992 due to low stock abundance. The PWS trawl fishery targeting northern shrimp began in 1972 with 2 mt of landings and occurred in all but the eastern portion of the PWS Inside District (Berceli and Brannian 2000). Northern shrimp landings increased gradually through the late 1970s but experienced a dramatic increase in 1983 and 1984 when Kodiak- based trawlers harvested shrimp in the southwest portion of the Sound. A small portion of this increased harvest was sidestriped shrimp. Northern shrimp catch and effort peaked at 586 mt and 14 vessels respectively in 1984. Thereafter, the catch dropped and by 1987 the fishery targeted sidestriped shrimp. The sidestriped shrimp harvest peaked in 1992 at 89 mt by five vessels. By 1999, the northern shrimp catches had approached zero with only three vessels and sidestriped shrimp catch dropped to 26 mt with three vessels.

Overall trends in total shrimp catch in the central and western GOA reveal a prominent rise and fall (Figure 6.8). High yields, 48,822 mt to 66,683 mt, were obtained during 1973 to 1977, with the major peak of 66,683 mt in 1973 and the minor peak of 59,091 mt in 1977. The total yield sharply declined after 1977.

6.1.2.2 Weathervane Scallop

The weathervane scallop, *Patinopecten caurinus*, supported a sporadic commercial fishery in Alaska waters from Yakutat west to the eastern AI and into the BS. They aggregate in elongated beds parallel to the bathymetry and inhabit sand, gravel, and rock bottoms at depths 35 to 200 m. Most dredge fishing occurs between 70 and 110 m. Alaska's commercial scallop fishery began in Kodiak in 1967. The fishery developed through several phases of rise and fall as virgin scallop beds were identified and harvested (Shirley and Kruse 1995). The fishery expanded in the early 1990s with an influx of scallop boats from the east coast of the U.S. During this period, the scallop fishery changed from one characterized by short trips with numerous deliveries each season to one of long trips with few deliveries as the fleet converted from icing to freezing of products. By 1996, all vessels were converted to catcher-processors capable of producing frozen products at sea (Barnhart 2000).

In central and western Alaska waters, scallops were harvested in PWS, Lower CI, Kodiak, Alaska Peninsula, Dutch Harbor, and BS. The PWS commercial fishery started in 1992 with exploitation of scallop beds at Kayak Island. The fishery was closed in 1996 because of illegal fishing by a single boat at Kayak Island in the previous year. Since 1997, the fishery has been opened with a GHL. The PWS fishery is small with few boats and the catches are typically confidential. On the other hand, the Lower CI, Kodiak, Alaska Peninsula, and BS fisheries have been important in recent years.

The commercial scallop fishery in Lower CI area began in 1983. Catches were sporadic and a single scallop bed near Augustine Island in the Kamishak District has produced virtually all catches since 1983 (Trowbridge et al. 2000). The fishery GHL is set by regulation at 9 mt, however crab bycatch allowances are set annually. Catch and effort peaked at 13 mt and 5 vessels, respectively in 1996.

The Kodiak fishery began in 1967 when two vessels delivered 0.4 mt of scallop-shucked meat harvested from waters along the east coast of Kodiak Island. The harvest peaked to 643 mt with seven vessels in 1970 and the effort peaked to 15 vessels in 1981. Catches declined to zero in 1977 and 1978. Since 1980, landings fluctuated between 21 mt and 313 mt. Since the 1960s, a number of scallop beds in Kodiak have been closed for fishing because of the concern of high king and Tanner crab bycatch rate.

Commercial scallop fishing activities in the Alaska Peninsula area have been documented since 1975. Closed areas included waters within three miles of shore and the offshore waters of Unimak Bight (to protect king crab stocks) and around Mitrofanina Island (to protect Tanner crab stocks). The fishery has been sporadic and most catches prior to 1993

are confidential because too few boats fished in the area. Harvest peaked in 1982 when six vessels delivered 93 mt.

The BS scallop fishing area encompasses all waters of BS from the latitude of Cape Sarichef to 171° W long., and north to 50° 30' lat. and west to U.S.-Russian boundary line. Although the BS scallop fishery has been documented since 1987, significant commercial harvests have occurred since 1993. Harvest peaked at 229 mt in 1994/95 with eight vessels.

Total scallop catches in the areas discussed above and Dutch Harbor fluctuated widely revealing the sporadic nature of this fishery (Figure 6.9). Highest yield of 643 mt shucked-meat was reported in 1970 when Kodiak contributed all of the harvest.

6.1.2.3 Red Sea Cucumber

The red sea cucumber, *Parastichopus californicus*, lives in shallow waters and is harvested by hand by divers. In the region west of 144° W longitude, the main dive fishery occurred in Kodiak and Chignik areas. An exploratory fishery began in 1991, but the commercial fishery developed since 1993. The number of diver permits issued during 1993 to 1999 ranged from 16 to 86. Maximum harvest of 256 mt was reached at the start of the large-scale commercial fishery in 1993 by 50 permit holders. The harvest drastically dropped since 1993 and remained at a low level (53-60 mt) during the last three years due to severe management restrictions (Figure 6.10).

6.1.2.4 Other Invertebrates

Among the other invertebrates, Pacific razor clams, *Siliqua patula*, are exploited in both commercial and recreational fisheries using shovels near Cordova, on the west and east sides of CI, and Swikshak Beach on the Alaska Peninsula. In CI, hard-shell clams (i.e., Pacific littleneck clam, *Protothaca staminea* and butter clam, *Saxidomus giganteus*) are also harvested using rakes in commercial and recreational fisheries. The majority of hard-shell clams harvested were littlenecks from beds in Kachemak Bay. The giant Pacific octopus, *Octopus dofleini*, is harvested in all Alaskan waters primarily as bycatch in groundfish pot (in particular Pacific cod), trawl, and longline fisheries. The squid, *Berryteuthis magister*, is also found in all Alaskan waters and taken as bycatch in shrimp and fish (bottom and mid water) trawl fisheries. The green sea urchin, *Strongylocentrotus droebachiensis*, is harvested for their roe by divers in Kodiak waters. The fishery began in 1980 and the number of permit holders varied from 7 to 29 during 1980 to 1999.

6.2 Fishery Description

6.2.1 Crab

6.2.1.1 Overview

As evident from the fishery history section of this chapter, crab fisheries have been prosecuted throughout Alaska on a number of species. Fisheries in the GOA tend to be predominated by small vessels home ported in Alaskan coastal communities. Many vessels are configured for participation in other coastal fisheries for salmon, herring, halibut, and groundfish. Fisheries in the BS/AI tend to be predominated by larger vessels, many of which are home ported in Washington and Oregon and in large Alaskan fishing communities, such as Dutch Harbor and Kodiak. These large vessels are designed to withstand poor conditions of high-seas fisheries in winter. Many of these vessels are highly specialized for participation in crab and groundfish pot fisheries only, while others are also capable of trawling for groundfish.

Crab harvest from BS and AI are sold alive to catcher-processor vessels, floating-processor vessels, or shore-based processors. In Kodiak, processing is done exclusively in shore processing facilities except isolated processing of Tanner crab aboard floating-processor vessels to prevent spread of bitter crab disease. King, Tanner, and snow crabs are cleaned and either cooked and brined or left raw and the final products are marketed in the form of crab clusters, claws, and meat in the U.S. and Asian countries. Hair crab are cooked whole whereas Dungeness crab are marketed live or are cooked and processed as frozen whole or sectioned products. Small percentages of king crab and Dungeness crab are also shipped live to Asian markets.

Some crab fisheries in federal waters in BS and AI are managed jointly by ADF&G and NMFS under species-specific fishery management plans (FMPs), while the rest are managed by state with its own FMPs developed in accordance with federal FMPs. An observer program for vessels that process crab at sea ensures adherence to crab fishing regulations and also gathers scientific information for management.

6.2.1.2 Fishery Management Strategy

King, snow, and Tanner crab stocks in the EEZ (3-200 nm) of the BS and AI regions are managed under the federal FMP for king and Tanner crab fisheries in the BS and AI (BSAI). The FMP covers BB red king crab, BS Tanner and snow crabs, the Pribilof Islands red and blue king crabs, and St. Matthew Island blue king crab. All other crab stocks are managed solely under state regulations (Tables 6.1-6.4). The FMP was developed by the North Pacific Fishery Management Council (NPFMC) under the MSFCMA and became effective in 1989. The FMP defines the arrangement for cooperative state-federal management of the crab fisheries. Management measures are classified as category 1: fixed in the FMP and require a federal plan amendment to change, category 2: frameworked: those that the state may change within certain limits, and category 3: those that the state may freely change. Most of the routine fishery

management activities are deferred to the state. One important exception is recent provisions required under National Standard 1 of the recently revised MSFCMA.

The National Standard 1 requires prevention of overfishing while achieving optimal yield from each fishery on a continuing basis. The technical implementation of the National Standard 1 (Restrepo et al. 1998) proposed a Maximum Sustainable Yield (MSY) rule to use in judging the status of a stock as well as to rebuild an overfished stock. Under this rule a maximum fishing mortality threshold (MFMT) and a minimum spawning stock threshold (MSST) were defined as benchmarks for determining the status of a stock and developing a management plan to rebuild an overfished stock to the MSY producing level. The MFMT was equated to MSY producing fishing mortality (F_{MSY}) and the MSST was defined as half of MSY producing biomass. Because of lack of reliable F_{MSY} estimates for crab stocks, instantaneous natural mortality (M) was used as surrogate for F_{MSY} . Furthermore, because of lack of plausible M estimate for each crab stock, a M of 0.2 for king crab and a M of 0.3 for Tanner and snow crab have been adopted.

Because the federal FMP delegates most management of BSAI crab fisheries to the state and because there is no federal FMP for the GOA, the BOF has developed management plans, in accordance with BOF policy on crab management, that describe specific harvest strategies and other management measures implemented by ADF&G to regulate crab fisheries off the coast of Alaska. The harvest strategies strive to keep sufficient spawning biomass for stock productivity by controlling the removal of mature males. Harvest rate and GHL are determined for each exploitable stock. Minimum stock size thresholds have been determined only for those stocks having sufficient fisheries and biological data and adequate stock assessment analysis (see Tables 6.1-6.4). If the preseason standing stock size falls below threshold, and in some fisheries if the preseason estimate of GHL is lower than minimum acceptable GHL, the fishery is closed for the entire season. If the stock is above threshold levels, then harvest rate is calculated by a stair step or linearly increasing function of standing stock size up to a maximum rate (see ADF&G 1999a). To avoid disproportionate harvest of legal males within the GHL, legal male harvest rate is capped at 50% in most fisheries. Incidental mortality of crab in other fisheries (trawl, groundfish pot, and dredge) is limited by bycatch caps as a percentage of the crab abundance and closed areas.

Annual trawl surveys are conducted in the eastern BS by the National Marine Fisheries Service (NMFS) and in Norton Sound and several areas of the central and western GOA by ADF&G to determine crab stock abundance by sex, size, maturity, and shell age. Historically, abundance has been estimated using an area swept method of analysis (ASA). ADF&G has developed population models for crab stocks, and more and more stocks are estimated each year with these advanced techniques. Because NMFS trawl surveys for St. Matthew and the Pribilof Islands king crab are prone to large measurement errors associated with untrawlable or inaccessible areas, catch-survey analysis (CSA) is used to obtain better stock abundance estimates. For those stocks, such as BB red king crab and BS Tanner crab, having long time series of length frequency and trawl abundance data, length-based analysis (LBA) is used for more precise stock abundance estimates. The abundance estimates are used to compare the status of

standing stock size with the federal overfishing and state threshold levels for opening the fishery and to determine GHL on annual basis. Some crab stocks are not surveyed annually (e.g., Norton Sound red king crab stock is surveyed triennially using trawl gear), while some others are not surveyed at all (e.g., golden king crab and deepwater grooved and triangle Tanner crabs). For those stocks having no annual stock abundance estimates, GHLS are determined based on either the most recent abundance estimates or historical average harvests. In addition, the current status of unsurveyed stocks is determined by fisheries performance analysis (FPA). The FPA involved examining catch-per-unit-effort (CPUE), size, sex, maturity, and shell age compositions, amount of sublegal crab discards, and amount of other crab bycatch in the recently concluded fisheries (Tables 6.1-6.4).

Most crab fisheries are managed by sex, size, and season regulations and a GHL determined from either stock biomass estimates or long-term mean harvests except Dungeness crab, which is managed by sex, size, and season (3S) regulations only (Tables 6.1-6.4). In addition, fisheries performance within a season is monitored and, if the fishery is expected to exceed the GHL before the declared season closure date, then the season is closed by an ADF&G commissioner's emergency order. Only male crab above the minimum legal size are allowed to be retained for marketing and sublegal crab are required to be released unharmed as soon as possible. Single sex harvest has been in force since late 1940s to protect reproductive potential of mature females. Specific fishing seasons are set to avoid crab mating and molting periods and to optimize meat recovery and price (Tables 6.1-6.4).

6.2.1.3 Fishing Gear

Crab pots are the legal gear allowed to harvest crab in commercial and non-commercial fisheries. However, crab rings are also allowed in Dungeness and some Tanner crab fisheries. Harvest for personal use employs crab pots or scuba gear. Incidental catch of crabs occurs in trawl, dredge, and groundfish pot fisheries. However, this bycatch cannot be legally retained.

Crab pot design differs by species, but all pot gear must have biodegradable seam, panel, or other device that renders the pot incapable of holding the catch for more than 30 days (six months in the case of Dungeness crab) if the gear is lost at sea. In addition, pots must have the required number of escape rings at specified heights from the base to allow sublegal crabs to escape. Dungeness crab pots are rounded (1.1 to 1.5 m diameter) while king and Tanner crab pots are typically larger and rectangular in shape (1.8 m by 1.8 m to 2.4 m by 2.4 m with height 0.8 to 0.9 m). King crab pots are often modified for use in Tanner crab fisheries by reducing the tunnel size to suit the entry of smaller size legal crab (ADF&G 1999a). Pots are baited with chopped herring or other fish and deployed on a single buoyed line, except in the golden crab fishery in the AI where a minimum of 10 pots are longlined together owing to strong ocean currents. Single-line pots are placed in the water using a hydraulic pot launcher and set in rows that may run from dozens to more than 100 pots. Longlined pots are set using a ramp over the stern of the vessel. The depth fished varies with target species. Pot soak time has declined over the years from as

high as three days to 12 hours as the duration of fishing season length has shortened and pot limits have been imposed. Pots are hauled using a hydraulic crab block mounted near the gunnel. Once aboard, the pot's contents are sorted and female and sublegal male crabs returned to the sea. Legal crabs are retained in live tanks with continuous flow of seawater. In the case of catcher-processor vessels that have no live tanks, crabs are processed immediately aboard the vessel.

6.2.1.4 Fishery Status in 1999

Most westward crab stocks were not healthy in 1999. All major red king crab stocks, except those in Norton Sound, BB, perhaps the Pribilof Islands, were very low in abundance. Consequently, fisheries have been closed for sometime (Tables 6.1 and 6.2). BS Tanner crab has been declared overfished and closed since 1997. St. Matthew and the Pribilof Islands blue king crab fisheries have been closed since 1999 due to low stock abundance (Table 6.2). The BS snow crab GHL was drastically reduced in 1999 because of stock decline (Table 6.1).

Crab species harvested in 1999 included red king, golden king, scarlet king, snow, Dungeness, and Korean hair crabs. Approximately 96,302 mt of crab with an exvessel value of approximately \$255 million was landed with BS snow crab dominating the total harvest (Table 6.1). The 1999 harvest consisted of snow crab 91.5%, red king crab 5.6%, golden king crab 2.5%, Dungeness crab 0.3%, Korean hair crab 0.1%, and scarlet king crab <0.0001%. Exvessel prices were high for BB and AI king crabs due to stable Asian economies, increased domestic demand for crab, decreased Russian production, and closures of the Pribilof Islands and St. Matthew Island king crab fisheries (ADF&G 2000).

In 1999, 5,369 mt of red king crab was caught in BB and 14 mt in Norton Sound (Table 6.1). In BB, most of the catches were taken in October from a widely scattered area (Figures 6.11 and 6.12). On the other hand, Norton Sound red king crab catches were spread over two seasons with high landings reported in the summer fishery during July and August (Figure 6.12) and the winter ice fishery was comparatively small. The catches were taken from a limited area (Figure 6.12). St. Matthew Island and the Pribilof Islands blue king crab fisheries were closed in 1999 due to low abundance (Table 6.2). In 1998/99, a total of 2,457 mt golden king crab was harvested from Adak & West AI, Dutch Harbor, and the Pribilof Islands (Table 6.1). Dutch Harbor landings peaked in the first month of the season and the fishery was closed in the very next month (October) because the GHL was reached (Figure 6.13). Catches were taken from a restricted area around Dutch Harbor (Figure 6.13). On the other hand, Adak catches progressively decreased from September to December 1999 (Figure 6.14) and the fishery was also widespread (Figure 6.14). Due to poor fishery performance in 1996, the Tanner crab fishery was closed before the GHL was reached and it remained closed since then. The largest fishery of all, the BS snow crab fishery produced 88,088 mt in 1999 (Table 6.1). February recorded the highest landing and catches declined thereafter (Figure 6.15). The area of fishing was widespread (Figure 6.15). In 1999, 101 mt of hair crab was harvested from the Pribilof district. The catch peaked in November (Figure 6.16). The hair crab

fishing area was smaller compared to other crab fishing areas (Figure 6.16). In 1999, 272 mt of Dungeness crab was landed from Kodiak and Alaska Peninsula. Kodiak contributed the major share with 250 mt (Table 6.1). The catches spread out over time with a peak in August (Figure 6.17). The fishing areas were also widespread along the east and south coast of Kodiak and east coast of Alaska Peninsula (Figure 6.17). In 1999, deepwater grooved and triangle Tanner crab fisheries were open in BSAI, but there were no landings. On the other hand, only one vessel reported any landings of scarlet king crab, thus harvest information is confidential (Table 6.4).

6.2.2 Other Invertebrates

6.2.2.1 Overview

A number of invertebrates, other than crab, are commercially and recreationally exploited in the waters of the central and western GOA, AI, and eastern BS. They include shrimp, weathervane scallop, red sea cucumber, hard-shell clam (especially littleneck clam), octopus, squid, and green sea urchin. In 1999, 1,054 mt, worth approximately \$ 5.5 million, of these invertebrates were commercially harvested. Very few stock assessment surveys have been carried out on these stocks except for shrimp and weathervane scallop. Even these two stocks have not been regularly and comprehensively surveyed. FMPs have been developed for shrimp management by the state and, in the case of scallop, joint state and federal management because of the importance of scallops in federal and state waters. Most shrimp resources have declined to very low levels and fisheries have been closed for decades. Declines in shrimp abundance have been linked to a climate regime shift that may have triggered a large increase in groundfish abundance. However, fishing effort was quite high in many areas before the fishery collapse. Stocks lacking regular surveys and stock assessments are managed by adjusting harvest levels based on stock status indicators obtained from CPUE and change in age and size compositions.

Most northern shrimp are shelled by mechanical peelers and processed into frozen products at sea or shore-side processors while a large portion of the catch of spot, coonstriped, and sidestriped shrimp are sold as live or fresh product to local and foreign markets. Scallops are processed at sea and most sold as frozen meats to domestic markets. Sea cucumbers are eviscerated at sea or kept alive and delivered to shore-based processors. At the plant, they are hand processed into frozen meats and dried skins for domestic and Asian markets. Green sea urchins are delivered live to shore-based processors and shipped live to Japan.

6.2.2.2 Fishery Management Strategy

Because of sparse information on stock abundance for many shrimp populations, different management strategies have been adopted in different areas. For example, in the western region (especially, Kodiak and Alaska Peninsula), a minimum acceptable biomass index (MABI) has been established for each stock under the Western Region Management Plan (WRMP). The objective of this plan is to maintain stocks at a level known as representative biomass index (RBI) determined by trawl surveys, while

allowing a small fishery to continue during rebuilding periods (Ruccio and Worton 2000). When the trawl estimated biomass is below MABI, the fishery is closed. When it is above MABI, a GHL is estimated based on abundance estimate and fishing logbook information. There is, however, no regulation for offshore shrimp fisheries. In the PWS trawl fishery for sidestriped shrimp, onboard observer data are used to estimate stock abundance by the area-swept method and a 20% harvest rate is applied to determine GHL. In addition, closed areas (primarily to avoid crab bycatch), minimum codend mesh size, and spring and fall open seasons (to avoid harvest of egg bearing females and molting shrimp, respectively) are enforced as management measures in the PWS trawl fishery. In the PWS pot fishery for spot shrimp, CPUE and sex ratio from the annual pot survey will ultimately be used to develop a management plan for the fishery.

The weathervane scallop fishery was declared a high impact emerging fishery in 1993 and a state FMP was developed to prevent overharvest. An interim fishery management plan included 100% observer coverage, a ban on automatic shucking machines on scallop vessels, a maximum crew size of 12, crab bycatch caps (1 or 0.5% of the crab stock size), dredge gear specification, and limitation on number of units per vessel (a maximum of two), and establishment of a scallop guideline harvest range (GHR). Until 1995 fishing in both state waters and federal EEZ was managed solely under state jurisdiction. Since 1996, a federal FMP frameworked a cooperative state-federal jurisdiction with nearly all management measures being delegated to the state of Alaska. Assessment surveys have been limited to two stocks: off Kayak Island southeast of PWS and Kamishak Bay in lower CI. Elsewhere, attempts to estimate abundance from commercial catch data by area-swept and Leslie depletion methods have been inconclusive. Consequently, a MSY of 562 mt shucked meats was determined by averaging the landings from 1990 to 1997 (excluding 1995 when the fishery was closed). An overall optimum yield was determined as a catch between 0 and 562 mt. In PWS, GHRs are determined by applying a conservative exploitation rate of 5-7.5% to scallop abundance estimates derived from fishery independent surveys. Size and age compositions of both surveyed and harvested age groups are monitored and GHRs are reduced, if a narrow age range is harvested. In all other areas, a separate GHR for each fishing area is determined based on historical mean catch (HMC) for traditional fishing areas and historic high catch (HHC) for non-traditional fishing areas adjusted to meet within the overall total (Table 6.1). A maximum annual harvest rate of 9% (Table 6.4) is determined under the precautionary management approach as 75% of F_{MSY} (= M of 0.13 given in annual rate of 12%, Kruse and Funk 1995). ADF&G may close any fishing area at any appropriate level within the GHR for various reasons, including exceeding crab bycatch limits, declining CPUE, localized depletion, and lack of recruitment to the fishery.

No stock assessment surveys have been conducted on the Kodiak sea cucumber population. As a result, individual area dive fisheries are managed by setting a GHL based on historical catch and fishery performance. Tanner crab fishing districts are utilized in an attempt to disperse fishing effort and prevent localized depletion. Harvest rates in each area are closely monitored to detect any localized depletion. An area could be closed if localized depletion is detected.

Annual stock assessment surveys are conducted to determine hard-shell clam biomass in Kachemak Bay fishing areas. A 5% exploitation rate is applied to the biomass estimate to determine the annual GHL. There are no survey estimates or rigorous stock assessment of other invertebrates, razor clam, octopus, squid, and sea urchin. However, based on historical maximum catch, conservative GHRs have been established for sensitive sedentary stocks, such as razor clam and green sea urchin (Table 6.4). A fishery management plan was recently developed for octopus in CI with an annual GHL as bycatch not to exceed 15.9 mt. There was no GHR set for squid. A 20% cap on the pot catch has been enforced for octopus.

6.2.2.3 Fishing Gear

Spot shrimp and coonstriped shrimp were historically harvested by pot gear at depths of 9 m and deeper in CI and 37 m and deeper in PWS. Northern, sidestriped, and humpy shrimp are caught almost exclusively by bottom (otter and a few beam) trawl gear. In the PWS trawl fishery, the sidestriped shrimp are harvested at depths of 330 m and deeper, and the minimum required codend mesh size is 48 mm and must be hung square to the mouth of the trawl. In Kodiak, Alaska Peninsula and BSAI, otter trawls are used at 20 m and deeper depths to harvest primarily northern shrimp.

Weathervane scallops are caught by vessels towing a pair of New Bedford-Style dredges mostly at depths 70 to 110 m. The gear requirements included 102 mm rings, no chafing gear, 4.6 m maximum width of opening of the dredge, and a maximum of two dredges per vessel. The only exception is the Kamishak District of Lower CI where vessels are limited to a single 1.8 m-wide dredge.

In the fisheries for sea cucumbers and sea urchins, divers are required to hand pick their catches and dive logs are required to be submitted with fish tickets.

6.2.2.4 Fishery Status in 1999

Most of the other invertebrates, except octopus and squid, have limited distribution and abundance. Many are sedentary (e.g., spot shrimp, hard-shell clam, red sea cucumber, and green sea urchin). Thus, they are susceptible to local depletion. A number fisheries remained closed during 1999 as a result of low stock abundance, perhaps due to overfishing. Examples include the PWS shrimp pot fishery, Lower CI shrimp pot and trawl fisheries, green sea urchin fishery, and sea cucumber fishery.

In 1999, a total of 219 mt of shrimp was harvested from various fishing grounds west of 144° W longitude (Table 6.1). The catches spread over different months and are confidential (Figure 6.18) because very few vessels participated in the fishery. Fishing areas were wide spread, but small in PWS, Kodiak, AI, the Pribilof Islands and St. Matthew Island (Figure 6.18).

Sporadic weathervane scallop fishing is apparent from Figure 6.9. In 1999, 214 mt was harvested from all areas considered in the figure. In 1999/2000, the weathervane scallop

fishery in the Kodiak district was opened from July 1, 1999 to February 15, 2000, but no fishing occurred after September 1999. The fishery harvested 121 mt. Monthly catches were spread from July to September and confidential (Figure 6.19). The scallop fishing areas included northeast of Kodiak, and northeast and southeast of Alaska Peninsula (Figure 6.19). The South Alaska Peninsula fishing season occurred during July 1, 1999 to February 15, 2000; however, waters between 160° and 161° W long. were closed early on September 29, 1999. The 1999/2000 scallop catch was 34 mt. Monthly catches were spread from August to October and confidential (Figure 6.20). Major scallop fishing areas were near Shumagin Islands and Sanak Islands (Figure 6.20).

In 1999, red sea cucumber fishing occurred only in Kodiak and most of the permit holders stopped fishing by October 31 even though the season was open from October 1 to April 30. The 1999 harvest was low (53 mt, Table 6.1). ADF&G managed this fishery by opening selected areas for three-day of fishing per week during the season. If catch rates decline sharply in an area, it is immediately closed. During the fishing season, October produced the highest catch (Figure 6.21). The dive fishery occurred all along the coast of Kodiak (Figure 6. 21).

A number of other fishing grounds produced other invertebrate catches in 1999. They included, 160 mt razor clam and 9 mt weathervane scallop in Lower CI, 9 mt weathervane scallop in PWS, 3 mt weathervane scallop in Dutch Harbor, 75 mt weathervane scallop in BS (Table 6.4), 9 mt littleneck clam in Lower CI (Table 6.3), 178 mt octopus and 184 mt squid in the central and west Alaska waters (Table 6.1), and 0.9 mt green sea urchin in Kodiak (Table 6.3).

6.3 Interactions with Sea Lions

6.3.1 Predation

Steller sea lions eat a number of invertebrates, including squid, octopus, clams, mussels, shrimp and crabs (Table 3.2 in this report). Among these, the cephalopods (squid and octopus) are most commonly eaten; they were among the top 10 most frequent prey found in sea lion stomachs in 6 of 9 studies conducted off Alaska during 1945-1978 (Hoover 1988). Shrimp (1 of 9) and crabs (2 of 9) were rare in the top 10. Other invertebrates (e.g., sea urchins, sea cucumbers, scallops) were never mentioned as prey in the NMFS review of sea lion diet studies (Table 3.2). Often, the species was not identified, so it is not possible to determine whether the prey were commercial or non-commercial species. Occasionally, species are sufficiently identified so as to indicate whether the prey were commercial (e.g., Tanner crab) or non-commercial (e.g., Gonatid shrimp, spider crabs) species (Table 3.2).

6.3.2 Overlap of Fisheries and Sea Lion Critical Habitat

The centers of distribution of Steller sea lions are in the GOA and AI. The western population of Steller sea lions was listed as endangered species under the Endangered Species Act and therefore designated as depleted under the Marine Mammal Protection

Act. Minimal mortality rate incidental to commercial fisheries during 1990-99 was 30 sea lions per year and mean subsistence harvest during 1993-95 was 412, mainly by Aleut hunters in the Aleutian and the Pribilof Islands. Thus, the total average annual removal (442) exceeded the potential biological removal (234) based on observer, fishing vessel logbook, or stranding data.

Spatial overlap of different crab and other invertebrate fisheries with that of sea lions vary. In 1999, most of the red king crab catches in BB were taken from a widely scattered area with a very small portion overlapping with the Steller sea lion critical habitat areas (Figure 6.11). The Norton Sound red king crab fishing area in 1999 did not cover any sea lion critical habitat areas even though the fishing took place over a number of months in the summer and the winter (Figure 6.12). On the other hand, in 1999, golden king crab fishing in the Dutch Harbor (Figure 6.13), and Adak and west Aleutian Islands (Figure 6.14) areas overlapped a substantial portion of sea lion critical habitat areas. Although the 1999 BS snow crab fishing area was widespread, the fishing grounds included only a small portion of sea lion critical habitat (Figure 6.15). In 1999, the hair crab fishing area covered a small portion of sea lion critical habitat areas (Figure 6.16). In 1999, Kodiak Dungeness crab fishing occurred in a large portion of sea lion critical habitat (Figure 6.17). The entire state's shrimp fishery was very small and most of the landings are confidential. The 1999 shrimp landings for the whole area of consideration were reported throughout the year. However, only the fisheries in PWS, Kodiak, and Dutch Harbor included a part of sea lion critical habitat areas (Figure 6.18). In 1999, the Kodiak weathervane scallop fishery occurred largely in sea lion critical habitat areas (Figure 6.19). In 1999, south Alaska Peninsula scallop fishing areas covered a part of sea lion critical habitat areas (Figure 6. 20). Kodiak sea cucumber fishing areas in 1999 included a significant part of sea lion critical habitat areas (Figure 6.21). Because quite a number of other invertebrate fisheries (e.g., weathervane scallop in PWS, Dutch Harbor, and BS; razor clam, weathervane scallop, and littleneck clam in Lower CI; octopus and squid in the central and west Alaska waters) coincide with other invertebrate fishing areas, they may have included some part of sea lion critical habitat.

6.3.3 Direct Fishery Interactions

Despite the spatial overlap of some invertebrate fisheries with Steller sea lion critical habitat, there is no documentation of any incidental harvest of Steller sea lions in any of the invertebrate fisheries discussed in this report (Hoover 1988). However, sea lions have been reported to interfere with king crab pot fishery by biting and sinking inflated buoys (Mate 1980, as cited in Hoover 1988).

Table 6.1. Status of invertebrate fisheries in the central and westward regions of Alaska west of 144° W longitude) for which landings were available in 1999.

Fishery	Gear	Assessment Method	Stock Definition	Stock Biomass (mt)	Stock Status		Federal Overfishing Definition		Harvest Rate Policy		State Fishery Threshold (mt/no)	Season	Catch (mt)	Remarks (GHL & GHR in mt)
					Level	Trend	F _{MSY}	Biomass MSST (mt)	Framework	1999				
Crabs:														
Norton Sound RKC	Pot	SSA&ASA	LM > 121 mm CW	1,905 LM	Aver.	Incr.	None		0-10% LM	<2% LM	680 LM for summer fishery	July1-Sep.3; Nov15-May15	14	Summer and Winter open fisheries, CDQ: 7.5% of open harvest, HRV
Bristol Bay RKC	Pot	LBA&ASA	MMF	50,667 MMF, ESB 20,230	Low	Stable	0.2	22,136 MMF	0-15% MM>120 mm CL	10% MM	8.4 million MF > 89 mm CL crabs, ESB 6,577	Oct15-20	5,369	Open fishery GHL: 4,581 & CDQ:242, HRV, 50% cap on LM harvest, Bering Sea PSC limit
Bering Sea SC (Bristol Bay, Pribilof Is., St. Matthew Is.)	Pot	ASA	MMF	128,504 MMF	Low	Decline	0.3	209,018 MMF	0-58% MM>65 mm CW	58% MM	Min. GHL 11,340	Jan15-Mar22	88088	GHL: 88,905 & CDQ:4,386 (5% of open harvest), 50% cap on LM harvest
Adak & W Aleutian GKC	Pot	FPA	LM >140 mm CW	No est.	Aver.	Stable	None		0-20% LM	18% LM	None	Sep1-open	1,567	GHL:1,225 set as long term mean (MSY) level
Dutch Harbor GKC	Pot	FPA	LM > 140 mm CW	No Est.	Aver.	Stable	None		0-20% LM	18% LM	None	Sep1-Oct25	810	GHL:1,361 set closer to long term mean (MSY) level of 1,452
Pribilof Is. GKC	Pot	FPA	LM > 140 mm CW	No Est.	Aver.	Stable	None		0-20% LM	18% LM	None	Jan1-Jun10	80	GHL:91 based on historical catch
Pribilof Is. KHC	Pot	ASA	LM >82.5 mm CW	644 LM	Low	Decline	None		0-40 LM	20 LM	None	Oct30-Dec 7	101	GHL:128
Kodiak DC	Pot	FPA	LM > 165 mm CW	No Est.	Low	Stable	None		3S	3S	None	May1-Jan1 in all areas, Jun15-Jan1 in the south	250	

Table 6.1 continued.

Fishery	Gear	Assessment Method	Stock Definition	Stock Biomass (mt)	Stock Status		Federal Overfishing Definition		Harvest Rate Policy		State Fishery Threshold (mt/no)	Season	Catch (mt)	Remarks (GHL & GHR in mt)
					Level	Trend	F _{MSY}	Biomass MSST (mt)	Framework	1999				
Other Invertebrates:														
Kodiak Red Sea Cucumber	Diving	CPUE	Undefined	No Est.	UK	Stable	None			Permit		Oct1-Apr30	53	GHL:68, 3days per week opening
Kodiak Scallop	Dredge	CPUE	Undefined	No Est.	Aver.	Stable	0.13		0-HMC			July1-Feb15	121	GHR:0-136 shucked meat, 0-562 (entire region)
Peninsula Scallop	Dredge	CPUE	Undefined	No Est.	Low	Decline	0.13		0-HHC			July1-Feb15	34	GHR:0-91 shucked meat, 0.5 or 1% crab bycatch cap, 0-562 (entire region)
Shrimp (Northern & Sidestriped) (Dutch Harbor, PWS, Adak & W Aleutian Is., Pribilof Is., Kodiak, St. Matthew Is.)	Otter Trawl, Beam Trawl, Pot	ASA& FPA	Undefined	No Est. for all regions	Low	Stable	None				Various MABI for different areas	Various time periods (e.g., trawl: Apr15-Aug15, Oct1-Dec31 in PWS)	219	GHL: in PWS: 0-23 for each season, spring and fall, 10% cap on northern and pandalid shrimp
Kodiak Octopus	Pot, LL, trawl	None	Undefined	No Est.	UK	Stable	None		None	None	None	Year round	178	Up to 20% of catch in pot
PWS Squid (bycatch only)	Otter Trawl	None	Undefined	No Est.	UK	UK	None		None	None	None	Year round bycatch	184	

LM: legal male; CW: carapace width (including spines); CL: carapace length; MM: mature male; MF: mature female; MMF: mature male and female; CPUE: catch-per-unit-effort; F_{MSY}: Maximum fishing mortality threshold; MSST: minimum stock size threshold; Harvest Rate: percentage of the estimated mature or legal male biomass; HMC: historical mean catch; HHC: historical high catch; HRV: stair-step harvest rate on molting mature male at other higher stock size levels; RKC: red king crab; BKC: blue king crab; TC: Tanner crab; SC: snow crab; GKC: golden king crab; KHC: Korean hair crab; DC: Dungeness crab; SSA: length-based stock synthesis analysis; LBA: length-based analysis; ASA: area swept analysis; CSA: catch survey analysis; FPA: fishery performance analysis; PSC: prohibited species catch limits for groundfish trawlers; MABI: minimum acceptable biomass index; 3S: sex, size, season; GHL: guideline harvest level; GHR: guideline harvest rate; CDQ: community development quota; ESB: effective spawning biomass-successfully mating mature female biomass; UK: unknown; PWS: Prince William Sound; No Est.: no estimation; Aver.: average level; Incr.: increase.

Table 6.2. Status of non-active invertebrate fisheries in the central and westward regions of Alaska (west of 144° W longitude).

Fishery	Gear	Assessment Method	Stock Definition	Stock Size in 1999 (mt/no)	Stock Status		Federal Overfishing Definition		Harvest Rate Policy		State Fishery Threshold (mt/no)	Season	Catch (mt)	Remarks (GHL in mt)
					Level	Trend	F _{MSY}	Biomass MSST (mt)	Framework	1999				
Crabs:														
PWS RKC	Pot	FPA	LM>178 mm CW		Low	Decline	None	None		0	None	Oct1-Dec20, Jan15-Mar15	0	Closed since 1992/93
Lower Cook Inlet RKC	Pot	FPA	LM>178 mm CW		Low	Decline	None	None		0	None		0	Closed since 1984/85
Kodiak RKC	Pot	ASA	MM	7,053 fertilized female crabs	Low	Decline	None	None	0-20% MM > 130 mm CL	0	5.12 million fertilized female crabs	No	0	Closed since 1983/84, 60% cap on LM harvest
Dutch Harbor RKC	Pot	ASA	LM > 190 mm CW	No Est.	Low	Decline	None	None	0-20% LM	0	None	No	0	Closed since 1983/84, subsistence fishery in 1999
Peninsula RKC	Pot	ASA	LM > 190 mm CW	23,675 crabs	Low	Decline	None	None	0-20% LM	0	None	No	0	Closed since 1983/84
Pribilof Is. RKC	Pot	ASA&CSA	MMF	5,806 MMF, small stock	High	Stable	0.2	1,497 MMF	0-20% MM > 120 mm CL	0	None	Sep15-28 (1998)	466 (1998) RKC&BKC	Closed in 1999 because no BKC fishery, low precision biomass estimate
PWS BKC	Pot	FPA	LM>150 mm CW	No Est	Low	Decline	None	None		0		Oct1-Dec20, Jan15-Mar15		Closed since 1992/93
Pribilof Is. BKC	Pot	ASA&CSA	MMF	4,173 MMF	Low	Decline	0.2	2,994 MMF	0-20% MM > 120 mm CL	0	0.77 million MM crabs, no min. GHL	Sep15-28 (1998)	466 (1998) RKC&BKC	Closed in 1999, 60% cap on LM harvest
St. Matthew Is. BKC	Pot	ASA&CSA	MMF	1,905 MMF	Low	Decline	0.2	4,990 MMF	0-20% MM > 105 mm CL	0	1,315 MM, min. GHL 1,134	Sep15-26 (1998)	1,301 (1998)	Closed in 1999, 40% cap on LM harvest
PWS GKC	Pot	FPA	LM>178 mm CW	No Est	Small Low	Decline	None				None	Oct1-Dec20, Jan15-Mar15	0	Closed since 1992/93, confidential catch in 94/95, GHL 18-27
Peninsula GKC	Pot	None	LM > 165 mm CW	No Est.	UK	UK	None		None	None	None		0	
Kodiak GKC	Pot	None	LM > 165 mm CW	No Est.	UK	UK	None		None	None	None		0	
PWS TC	Pot	FPA	LM>135 mm CW	No Est	Low	Decline	None		None	None	None	Jan15-Mar31	0	Closed since 1989

Table 6.2 continued.

Fishery	Gear	Assessment Method	Stock Definition	Stock Size in 1999 (mt/no)	Stock Status		Federal Overfishing Definition		Harvest Rate Policy		State Fishery Threshold (mt/no)	Season	Catch (mt)	Remarks (GHL in mt)
					Level	Trend	F _{MSY}	Biomass MSST(mt)	Framework 1999					
Cook Inlet TC	Pot	FPA	LM>140 mm CW	No Est	Low	Some areas incr.	None		None		395,000 MM, GHL 100,000 in south		0	Closed since 1995
E. Aleutian TC	Pot	ASA	MMF	No Est.	Low	Incr.	Bering Sea Tanner crab definitions apply		0-40% MM > 112 mm CW	0	Eastern Bering Sea thresholds apply	No	0	Closed since 1995, subsistence fishery in 1999
Adak & W Aleutian TC	Pot	None	LM > 140 mm CW	No Est.	UK	UK	None		None		None	Nov1-July31 (1998/99)	0	Bycatch from RKC fishery
Bering Sea TC	Pot	ASA&LBA	MMF	31,797 MMF	Low	Stable	0.3	43,001 MMF	0-40% MM > 112 mm CW	0	Eastern Bering Sea 9,526 MF, 1,814 LM	No	0	Closed since 1997, 50% cap on LM harvest, HRV, Bering Sea PSC limit
Peninsula TC	Pot	FPA	LM > 140 mm CW	4,082 LM	Low	Stable	None	None	0-30% LM	0	1375000 MM crabs, min. GHL 91	No	0	Closed since 1990, HRV
Kodiak TC	Pot	ASA	LM > 140 mm CW	2,309,240 million LM	Low	Stable	None	None	0-30% LM	0	6,877,000 MM crabs, min. GHL 181	No	0	Closed since 1994/95, HRV
Bering Sea & Aleutian Is. TTC>C	Pot	FPA	LM > 127 mm CW	No Est.	UK	UK	None		Permit		None		0	No activity or some areas closed since 1997, TTC as bycatch in GTC
PWS DC	Pot	FPA	LM > 165 mm CW	No Est.	Low	Decline	None	None	3S	3S	None	No	0	Orca Inlet fishery closed since 1980, Copper River fishery closed since 1993,
Lower Cook Inlet DC	Pot	FPA	LM > 165 mm CW	No Est.	Low	Decline	None	None	3S	3S	None	No	0	Southern district closed since 1991, others since 1997

LM: legal male; CW: carapace width (including spines); CL: carapace length; MM: mature male; MMF: mature male and female; MF: mature female; HRV: stair-step harvest rate on molting mature male at other higher stock size levels; F_{MSY}: Maximum fishing mortality threshold; Harvest Rate: percentage of the estimated legal male biomass; MSST: minimum stock size threshold; RKC: red king crab; BKC: blue king crab; GKC: golden king crab; TC: Tanner crab; TTC: triangle Tanner crab; GTC: grooved Tanner crab; DC: Dungeness crab; LBA: length-based analysis; ASA: area swept analysis; FPA: fishery performance analysis; UK: unknown; No Est.: no estimation; Incr.: increase.

Table 6.3. Status of invertebrate fisheries in the central and westward regions of Alaska (west of 144° W longitude) for which landings were insignificant (<10 mt) in 1999.

Fishery	Gear	Assessment Method	Stock Definition	Stock Biomass (mt)	Stock Status		Federal Overfishing Definition		Harvest Rate Policy		State Fishery Threshold (mt/no)	Season	Catch (mt)	Remarks (GHR in mt)
					Level	Trend	F _{MSY}	Biomass MSST (mt)	Framework 1999					
Crabs:														
Dutch Harbor SKC	Pot	FPA	Undefined	No Est.	Small, UK	UK	None	None	Permit		None	Sep1-Oct25	0.04	Bycatch in the GKC fishery
Other Invertebrates:														
Cook Inlet Littleneck Clam	Rake	ASA	Legal Size > 38 mm SL	Estimates. for some areas	UK	Variable	None	None	Alternate opening area, 5% harvest		None	Quarterly (Temperature dependent) Mar, May, Nov	9	GHR:18 commercial and 73 recreational
Kodiak Green Sea Urchin	Diving	None	Undefined (market prefers > 51-57 mm diameter)	Small, UK	UK	UK	None	None	Permit		None	Oct1-Jan31	0.9	

F_{MSY}: Maximum fishing mortality threshold; MSST: minimum stock size threshold; Harvest Rate: percentage of the estimated legal male biomass; SKC: scarlet king crab; GKC: golden king crab; ASA: area swept analysis; FPA: fishery performance analysis; PWS: Prince William Sound; LL: longline; UK: unknown; GKC: golden king crab, GHR: guideline harvest rate; No Est.: no estimation.

Table 6.4. Status of invertebrate fisheries in the central and westward regions of Alaska (west of 144° W longitude) for which landings were confidential (*) in 1999.

Fishery	Gear	Assessment Method	Stock Definition	Stock Biomass (mt)	Stock Status Level Trend		Federal Overfishing Definition		Harvest Rate Policy		State Fishery Threshold (mt/no)	Season	Catch (mt)	Remarks (GHR in mt)
							F _{MSY}	Biomass MSST (mt)	Framework 1999					
Crabs:														
Peninsula DC	Pot	FPA	LM > 165 mm CW	No Est.	UK	UK	None	3S	3S	None		May1-Dec31	*	
Adak &W Aleutian SKC	Pot	FPA	Undefined	No Est.	Small, UK	UK	None	None		Permit	None	Sep1-no closure	*	Bycatch in the GKC & deepwater Tanner crab fisheries
Adak RKC	Pot	ASA	LM > 190 mm CW	No Est.	Low	Decline	None	None	0-20% LM		None	Nov1-July31 (1998/99)	*	Closed during 1996/97-1997/98, limited fishery in 1998/99 with a GHL:7
Other Invertebrates:														
Upper Cook Inlet Razor Clam	Shovel	None	LS > 114 mm SL	No Est.	Aver.	Stable	None	None	None		None	May-August	*	GHR: 159-181 limit
PWSScallop	Dredge	ASA	Undefined	1,930	Low	Stable	None	None	0-10%	3%	None	July1-3 East & July1-4 West of Kayak Is.	*	GHR: 0-23 shucked meat, 0.5 or 1% Tanner crab bycatch cap
Lower Cook Inlet Scallop	Dredge	ASA	Undefined	4,263	UK	Stable	None	None	0-10%	5%	None	Aug15-23	*	GHR: 0-9 shucked meat, 0.5 or 1% Tanner and king crab bycatch cap
Dutch Harbor Scallop	Dredge	CPUE	Undefined	No Est.	Low	Decline	0.13	562 (entire region)	0-9%	UK	None	July 1-Oct 1	*	Bycatch cap of 1% or 0.5% crab stock , GHR:0-50 shucked meat
Bering Sea Scallop	Dredge	CPUE	Undefined	No Est.	Aver.	Stable	0.13	562 (entire region)	0-9%	UK	None	July1-Aug 30	*	Bycatch cap of 1% or 0.5% crab stock , GHR:0-181shucked meat

LS: legal size; F_{MSY}: Maximum fishing mortality threshold; MSST: minimum stock size threshold; Harvest Rate: percentage of the estimated legal male biomass; ASA: area swept analysis; CPUE: catch-per-unit-effort; PWS: Prince William Sound; SL: shell length; UK: unknown; GHR: guideline harvest rate; No Est.: no estimation; Aver.: average level.

Red King Crab

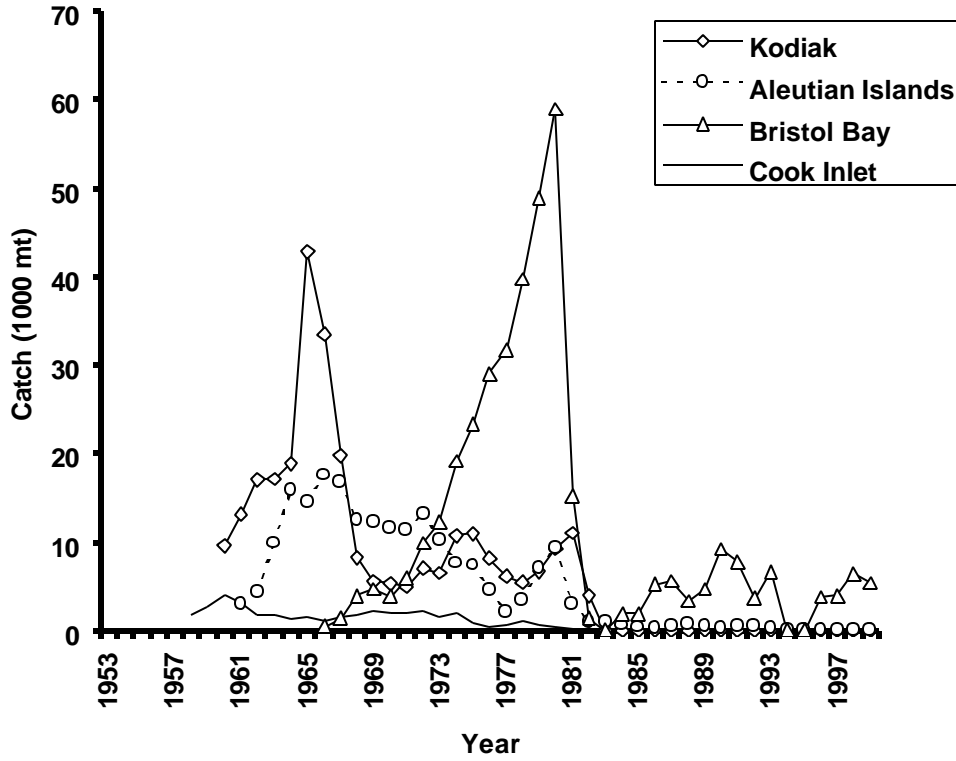


Figure 6.1. Historical red king crab catch (in 1000 mt) in Cook Inlet, Kodiak, Aleutian Islands, and Bristol Bay. Cook Inlet, Kodiak, and Aleutian Islands catches are given per season (for example, 1960 refers to the 1960/61 season).

Blue King Crab

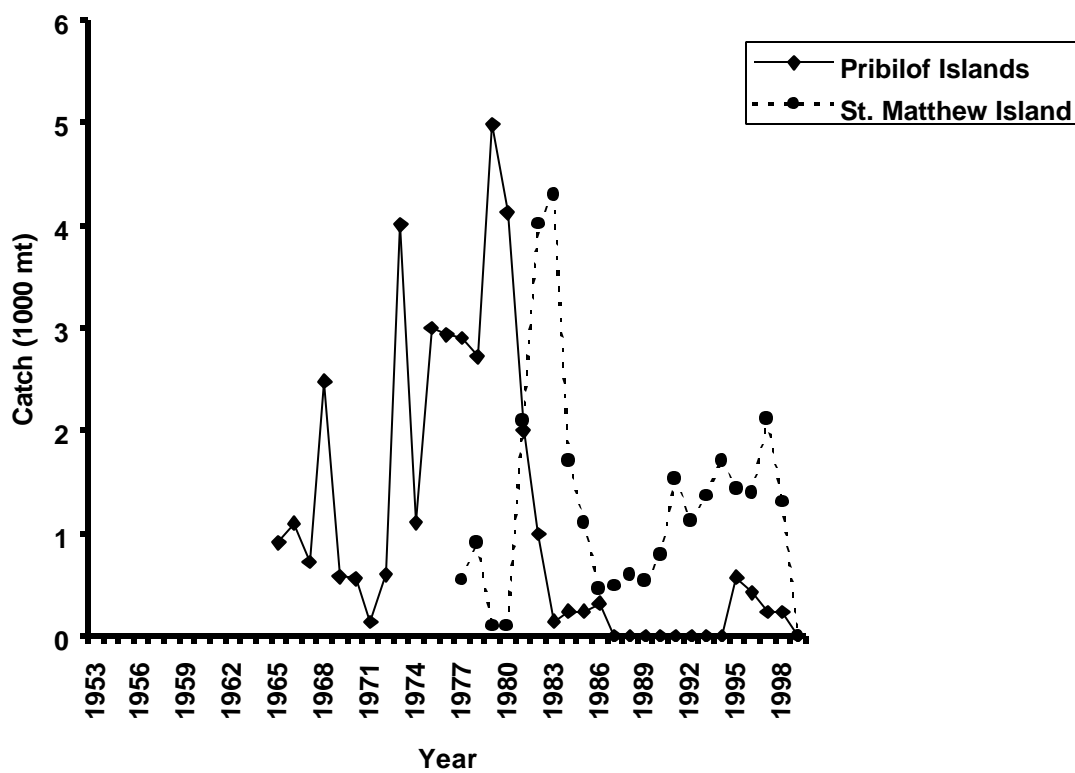


Figure 6.2. Historical blue king crab catch (in 1000 mt) in the Pribilof Islands and St. Matthew Island. The Pribilof Islands catches are given per season (for example, 1972 refers to the 1972/73 season).

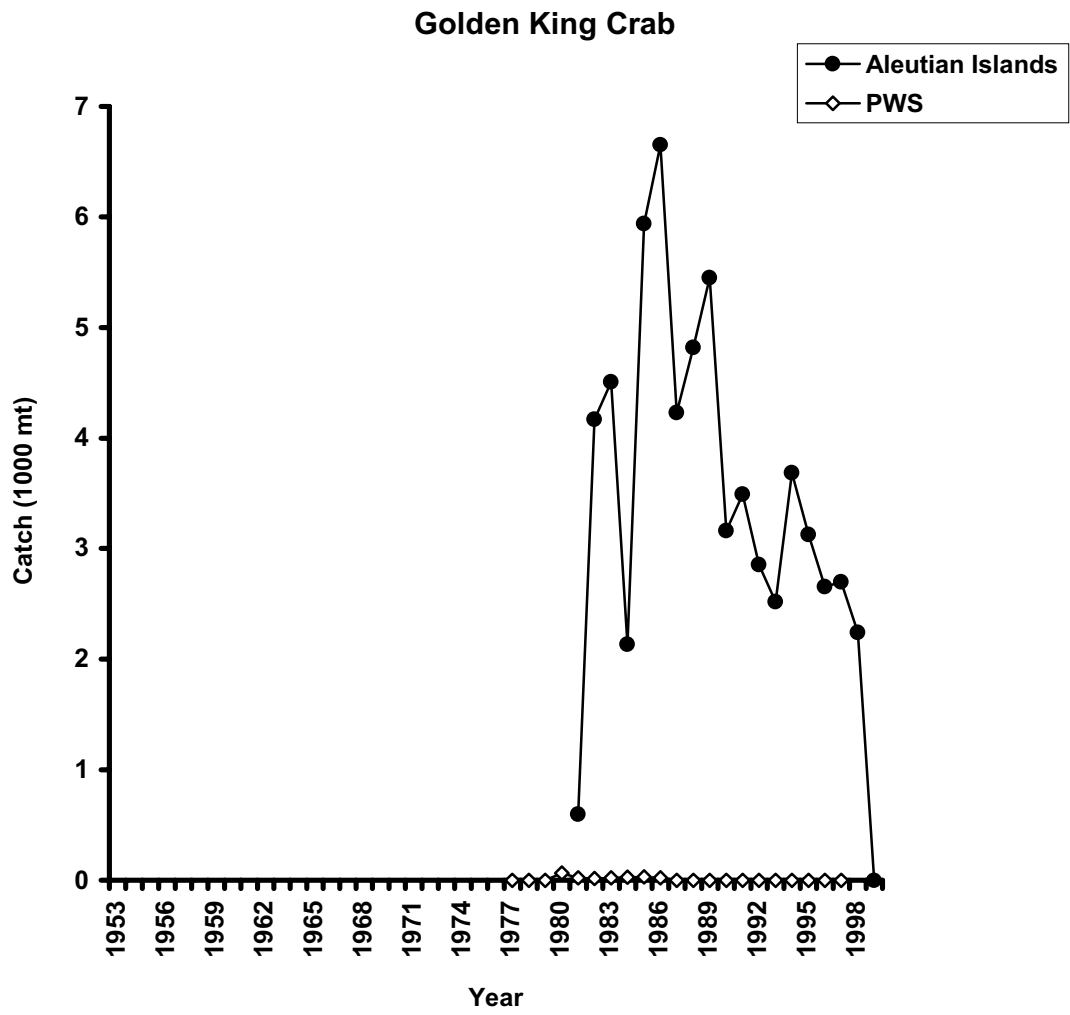


Figure 6.3. Historical seasonal golden king crab catch (in 1000 mt) in PWS and Aleutian Islands. Catches are given per season (for example, 1981 refers to the 1981/82 season).

Tanner Crab

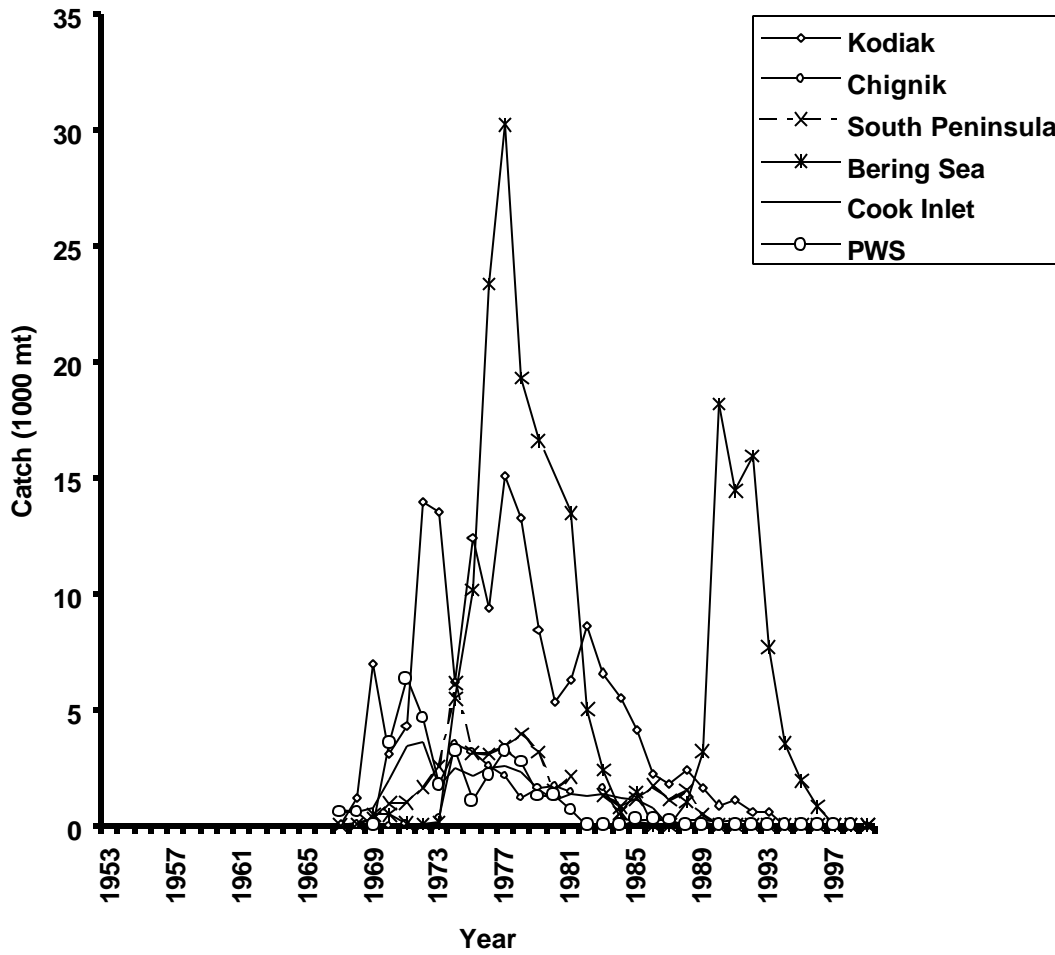


Figure 6.4. Historical Tanner crab catch (in 1000 mt) in PWS, Cook Inlet, Kodiak, Chignik, Southern Peninsula, and Bering Sea areas. Some catches are given per season (spanning two calendar years), whereas others per calendar year.

Snow Crab

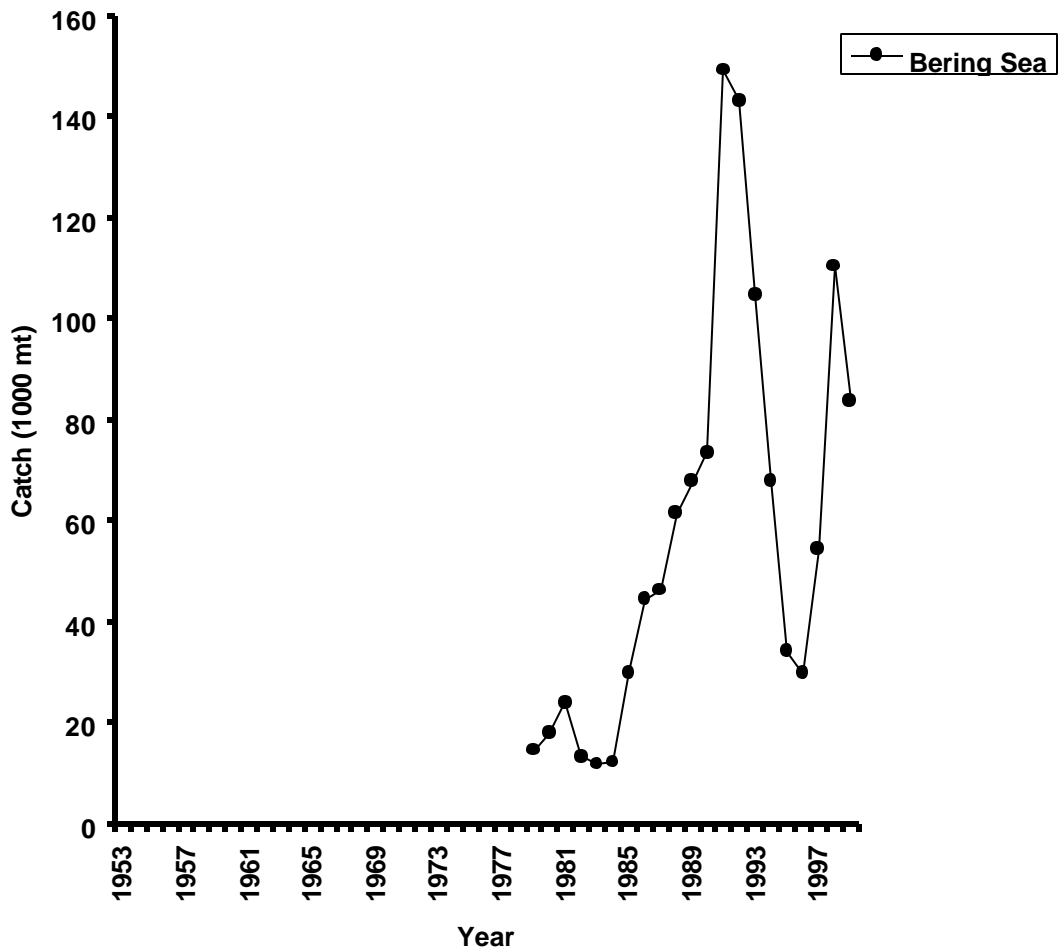


Figure 6.5. Historical snow crab catch (in 1000 mt) in Bering Sea. Some catches are given per season (spanning two calendar years), whereas others per calendar year.

Korean Hair Crab

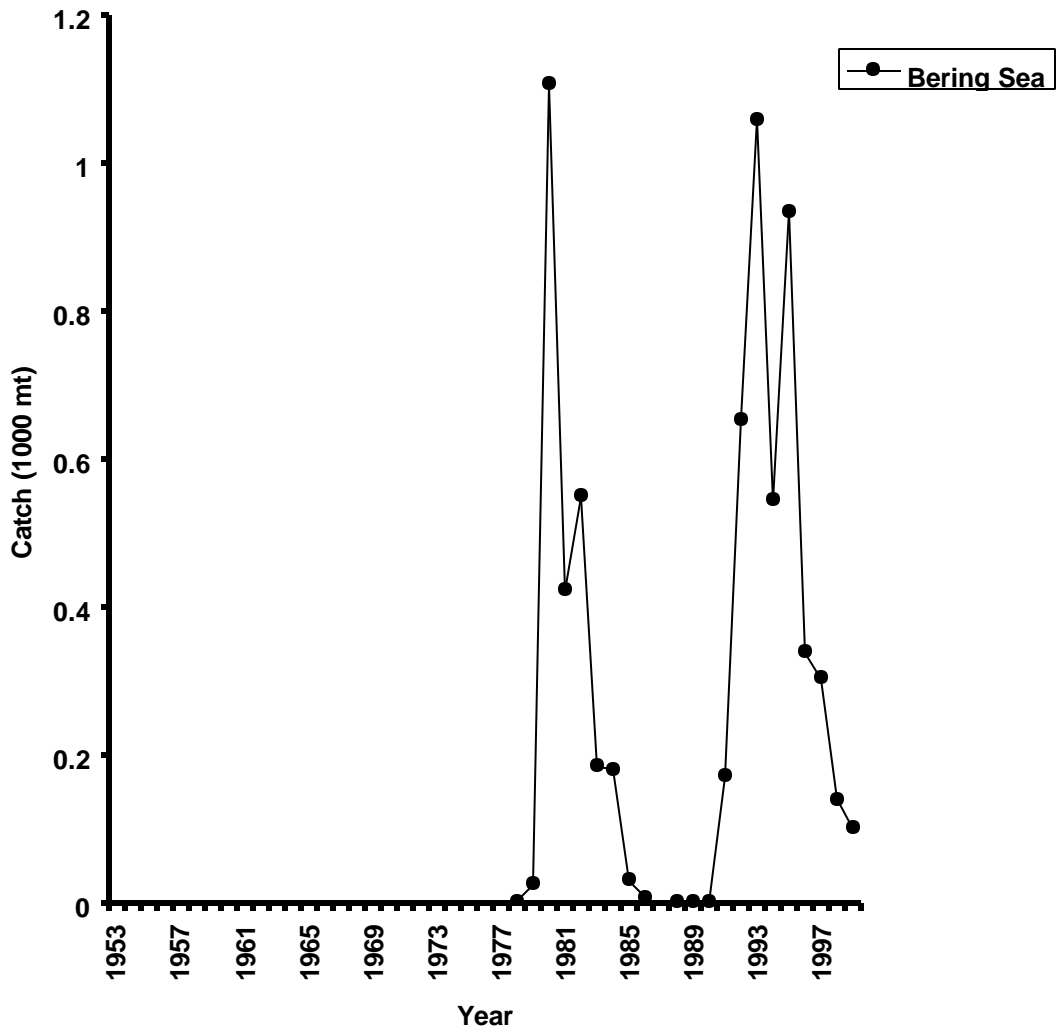


Figure 6.6. Historical Korean hair crab catch (in 1000 mt) in Bering Sea. Some catches are given per season (spanning two calendar years), whereas others per calendar year.

Dungeness Crab

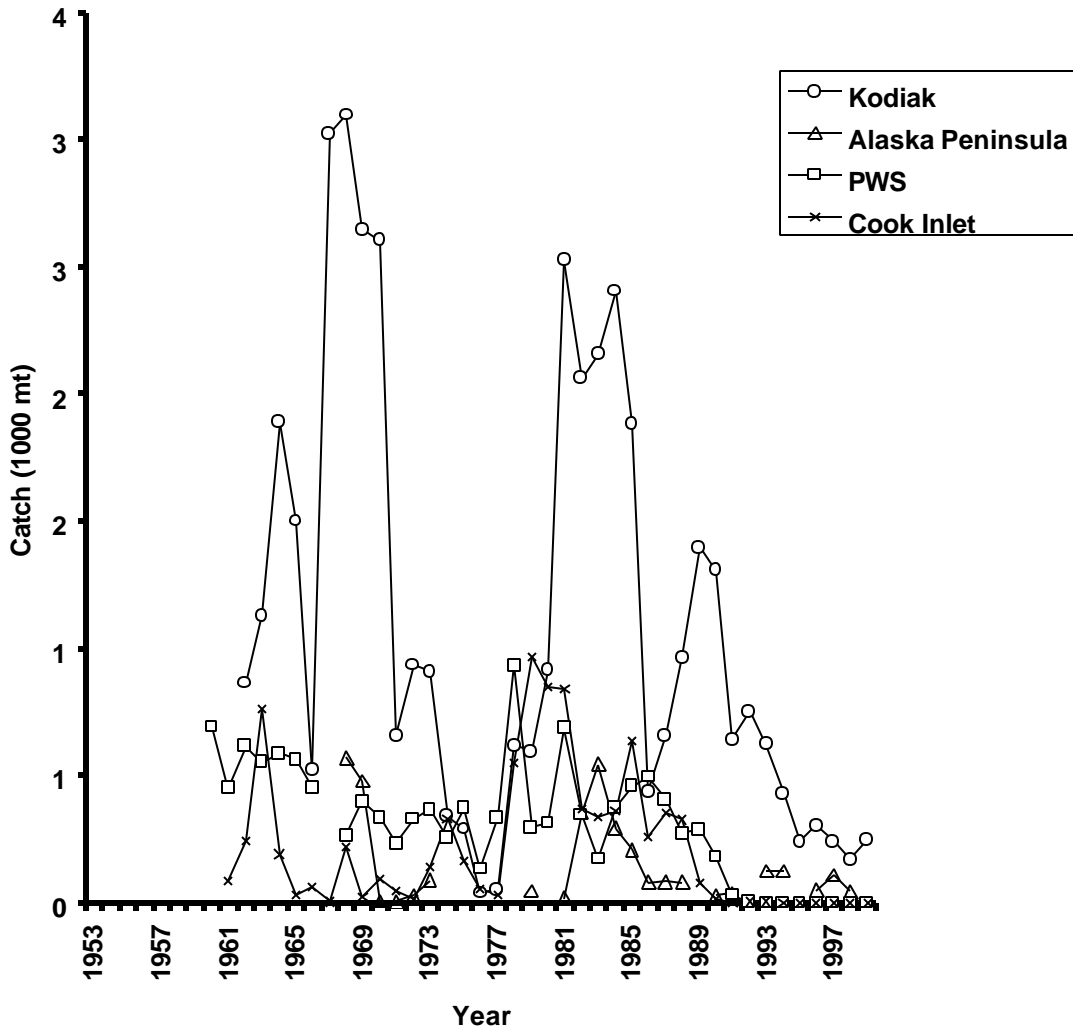


Figure 6.7. Historical annual Dungeness crab catch (in 1000 mt) in PWS, Cook Inlet, Kodiak and Alaska Peninsula districts.

Shrimp

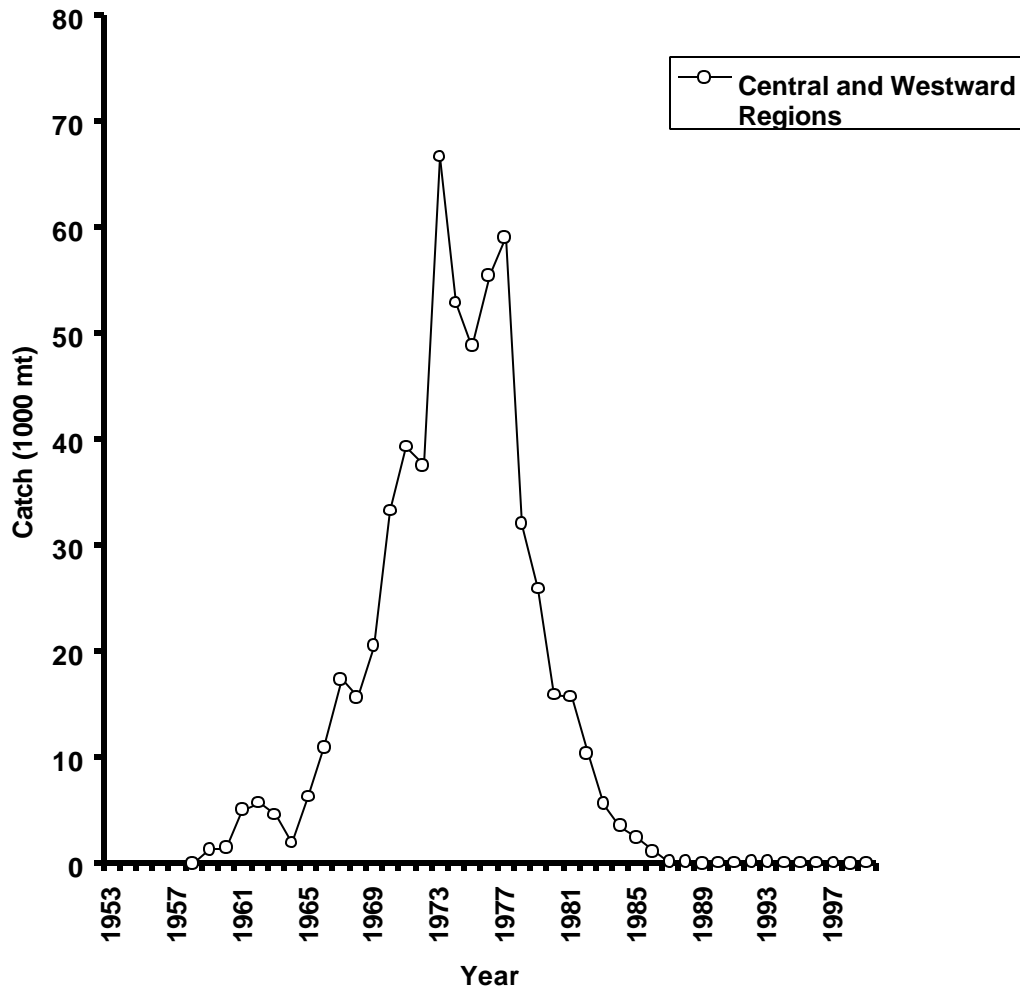


Figure 6.8. Historical annual shrimp catch (in 1000 mt) in the central and westward regions (west of 144° W). Landings from PWS, Cook Inlet, Kodiak, Alaska Peninsula, Chignik, Aleutian Islands, and Bering Sea contributed to the total catch.

Weathervane Scallop

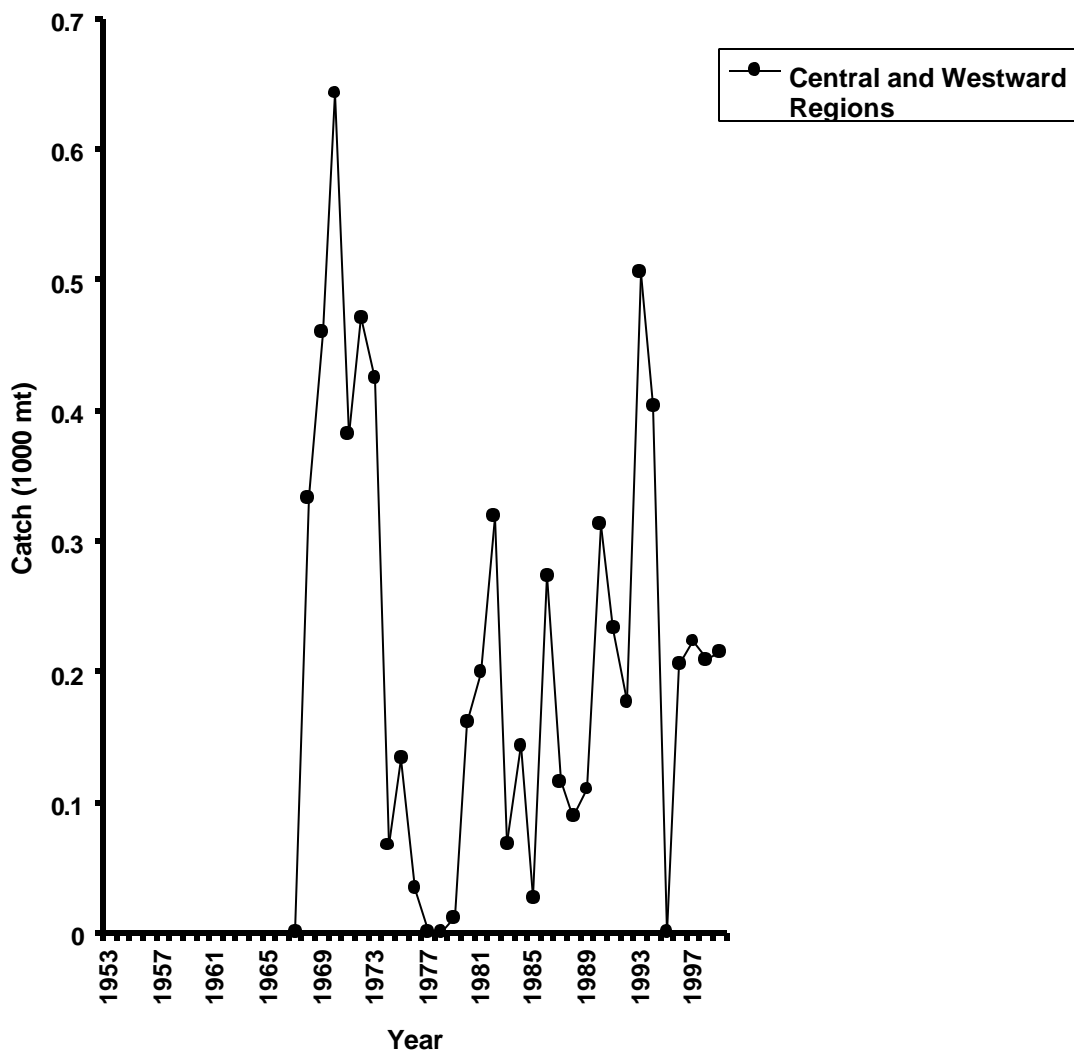


Figure 6.9. Historical total annual catch (in 1000 mt) of weathervane scallop for Lower Cook Inlet, Kodiak, Alaska Peninsula, Dutch Harbor, and Bering Sea.

Red Sea Cucumber

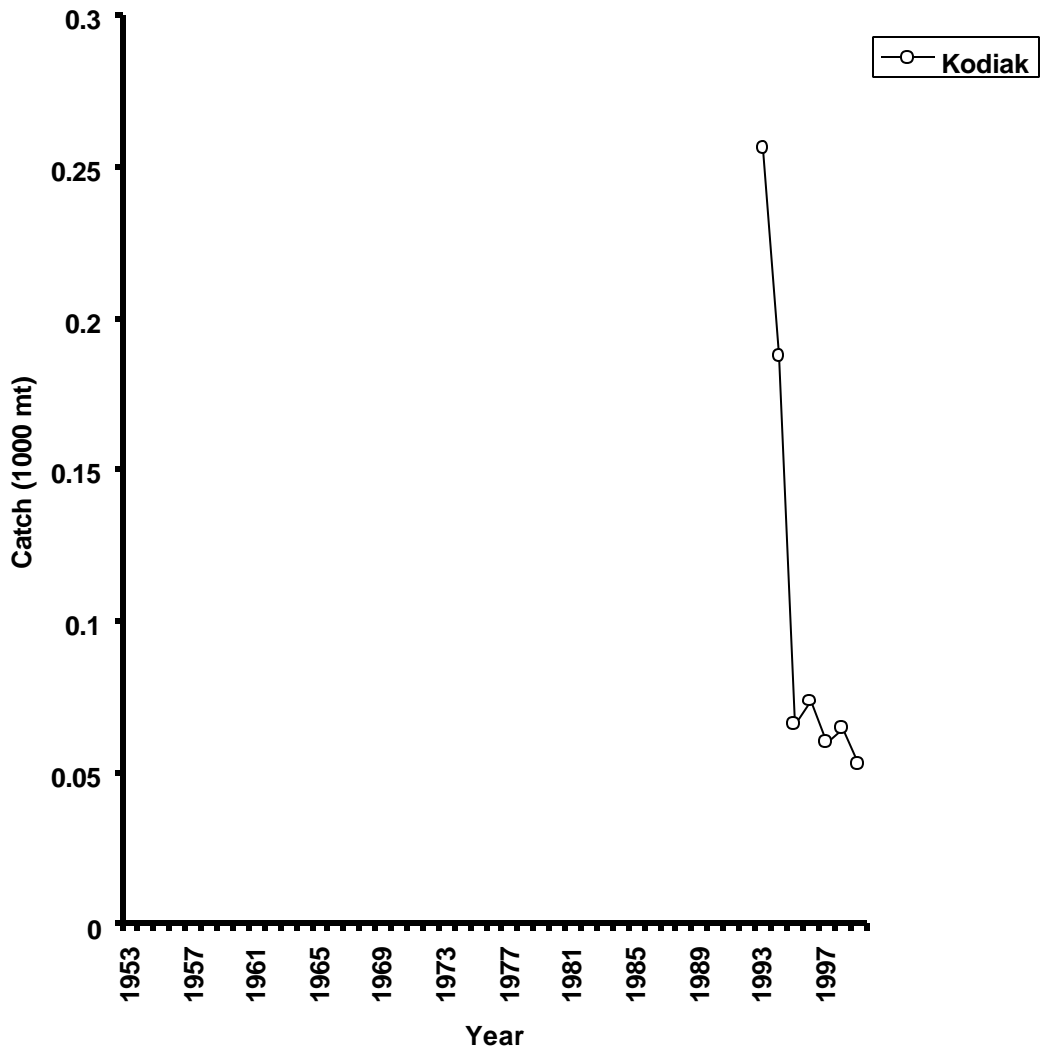


Figure 6.10. Historical annual catch (in 1000 mt) of red sea cucumber in Kodiak and Chignik waters.

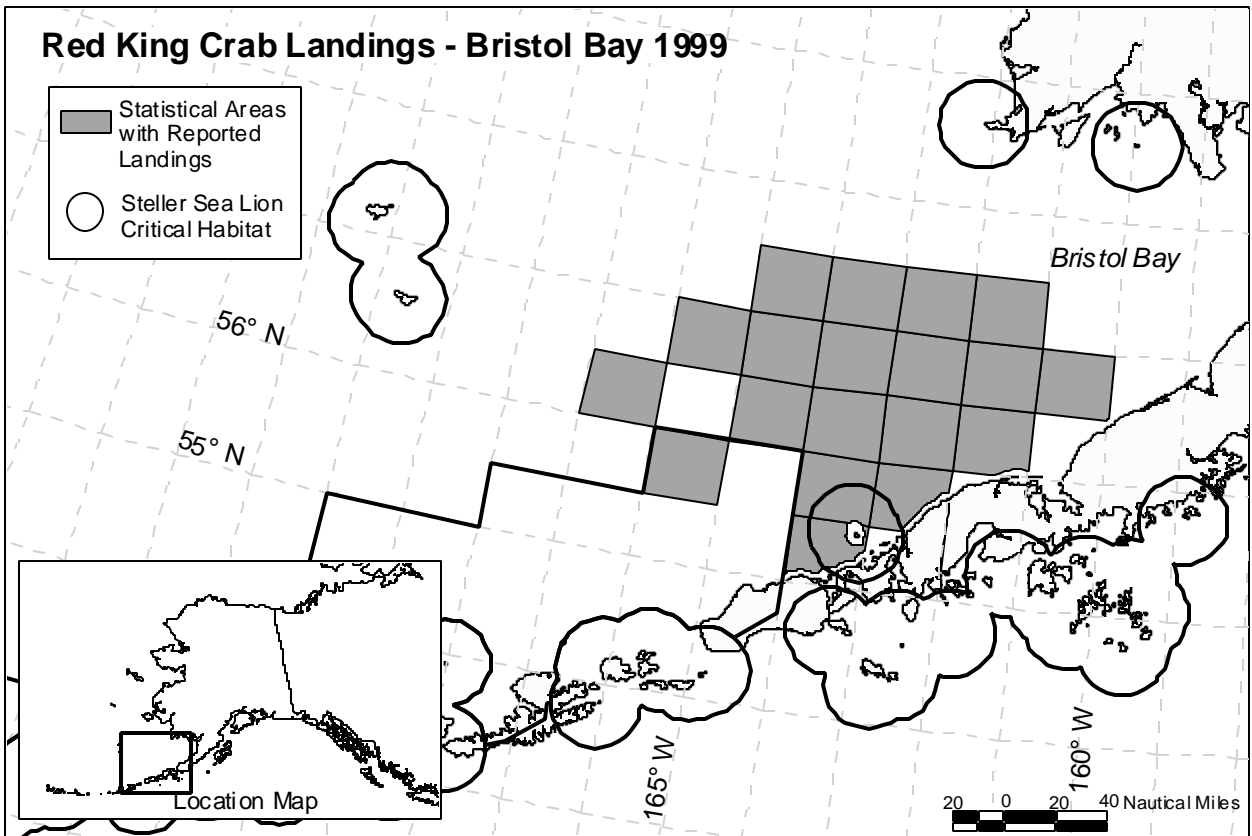
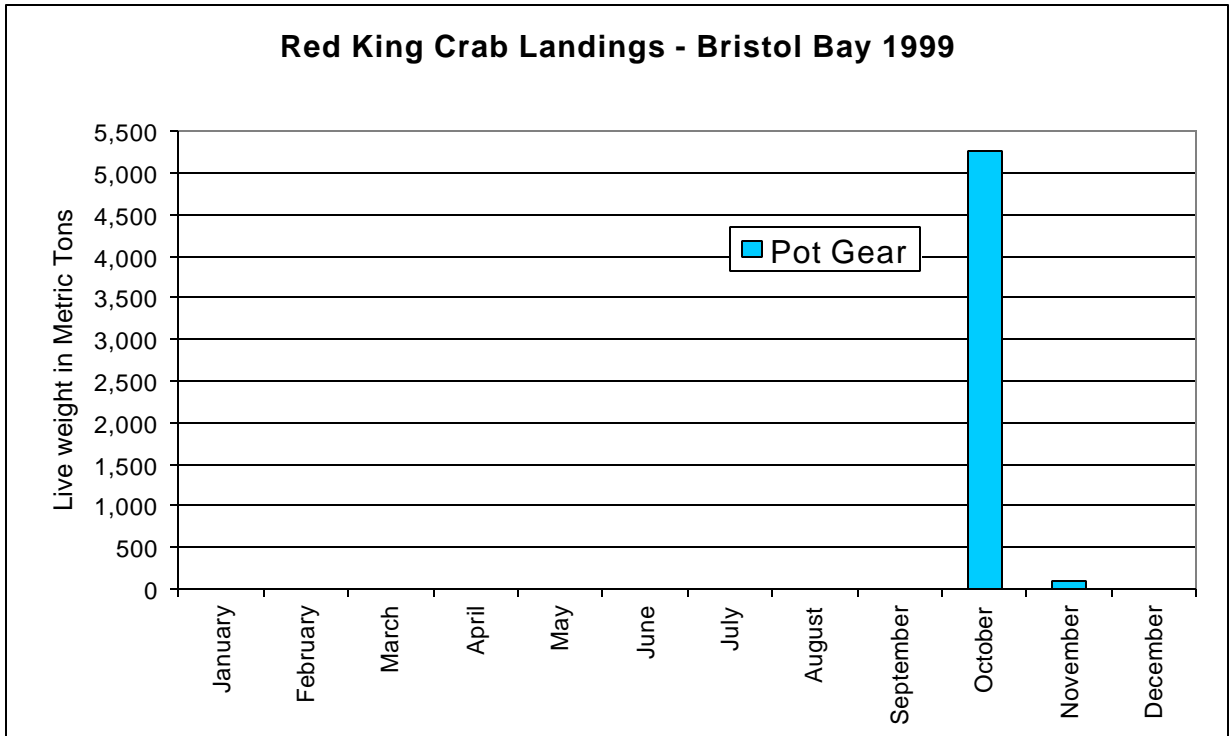


Figure 6.11 Monthly distribution of red king crab landings in Bristol Bay, 1999 (top), and Spatial distribution of red king crab landings in Bristol Bay, 1999 (bottom).

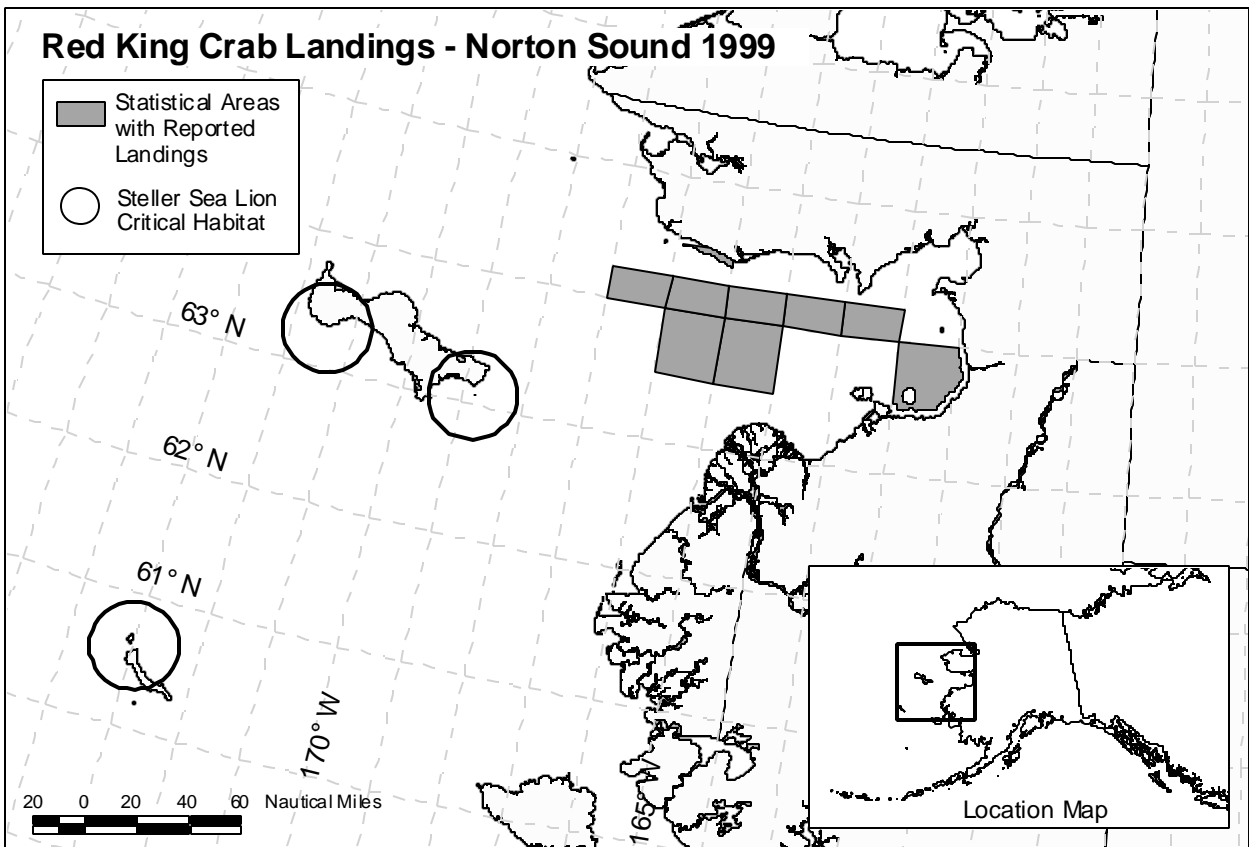
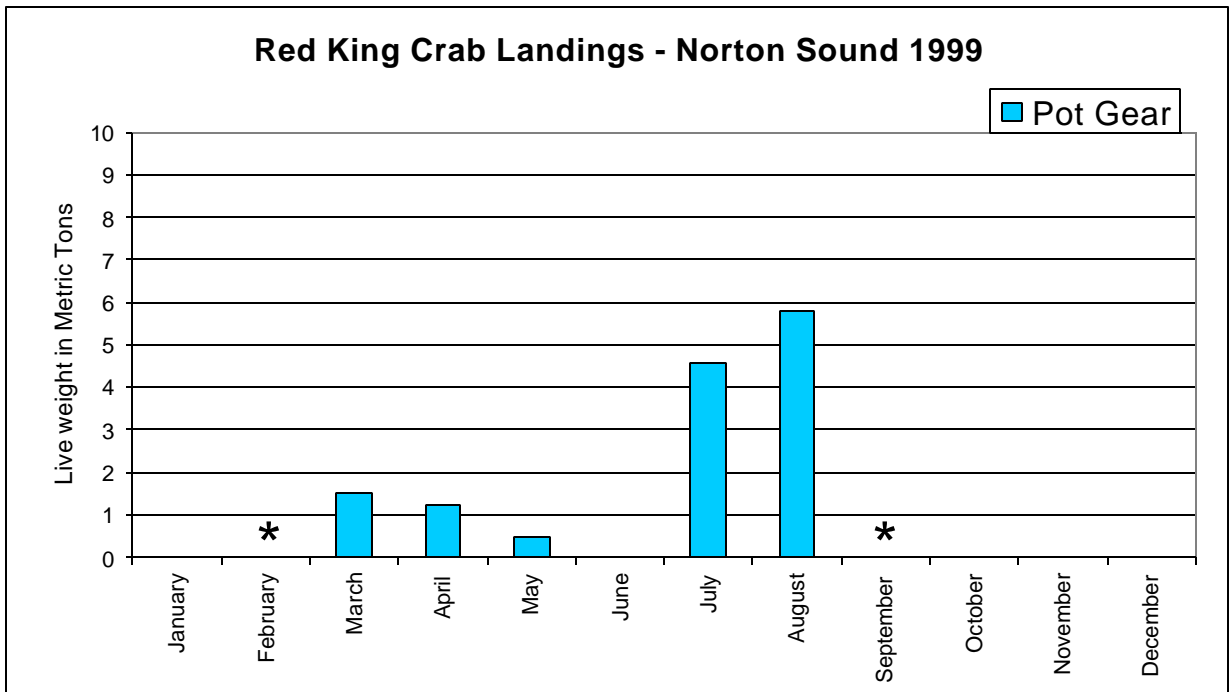


Figure 6.12 Monthly distribution of red king crab landings in Norton Sound, 1999 (top), and Spatial distribution of red king crab landings in Norton Sound, 1999 (bottom). * indicates confidential catch.

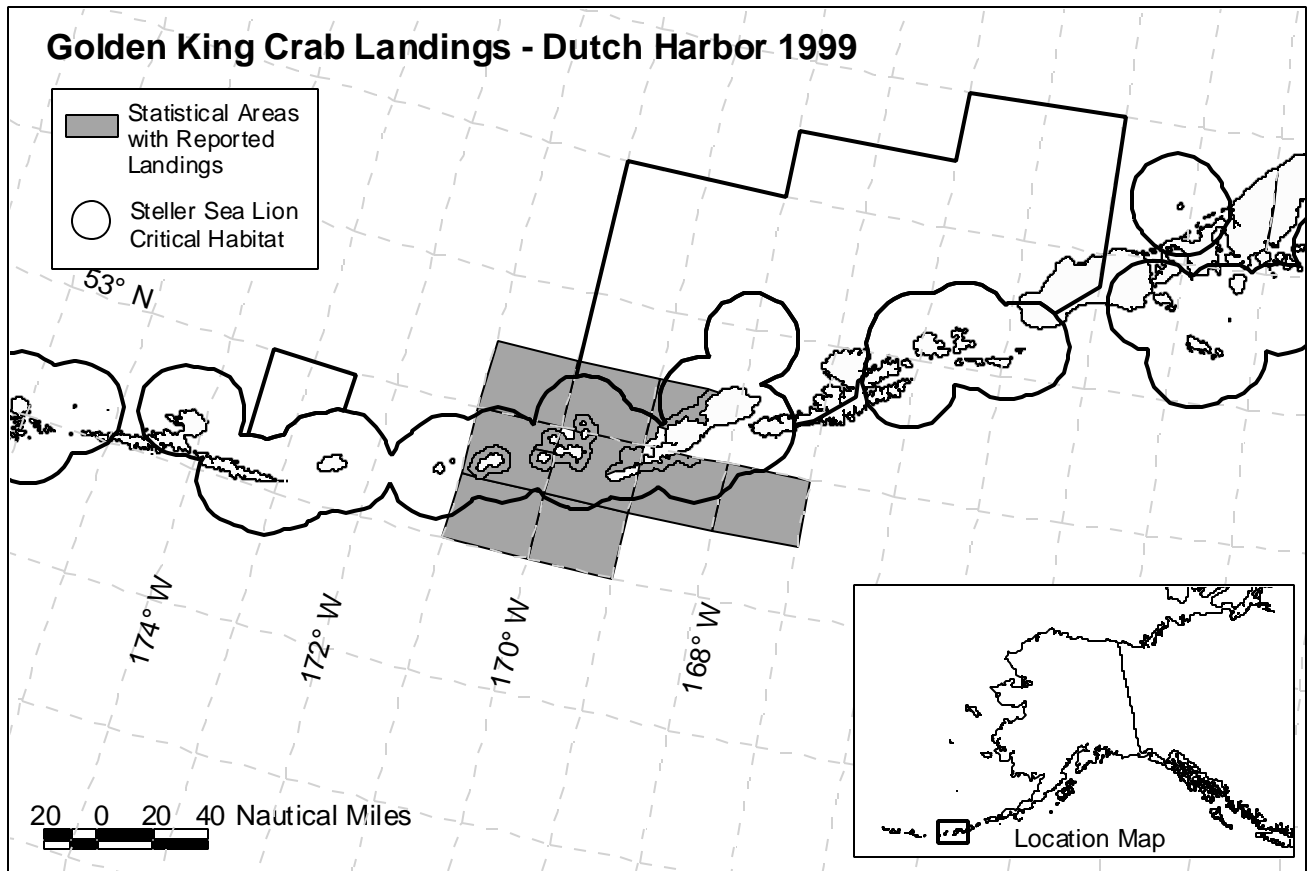
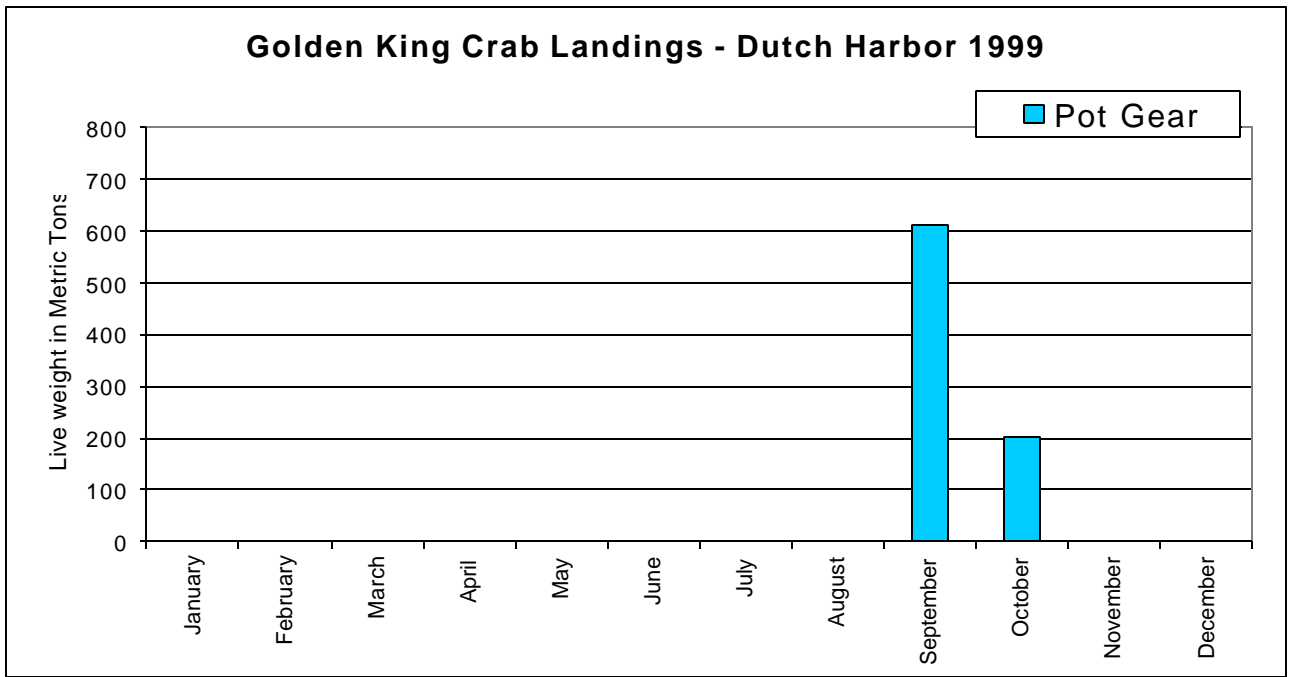


Figure 6.13 Monthly distribution of golden king crab landings in Dutch Harbor, 1999 (top), and Spatial distribution of golden king crab landings in Dutch Harbor, 1999 (bottom).

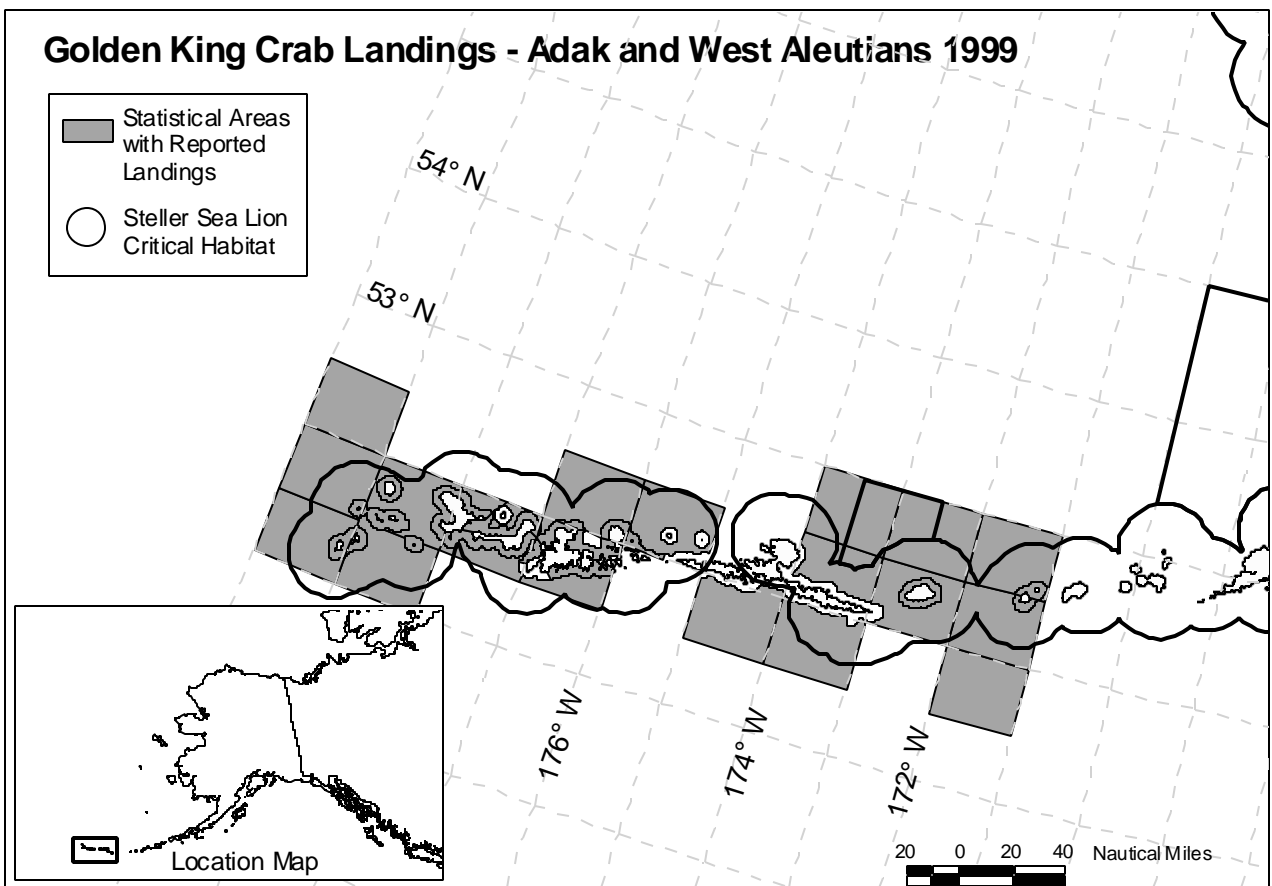
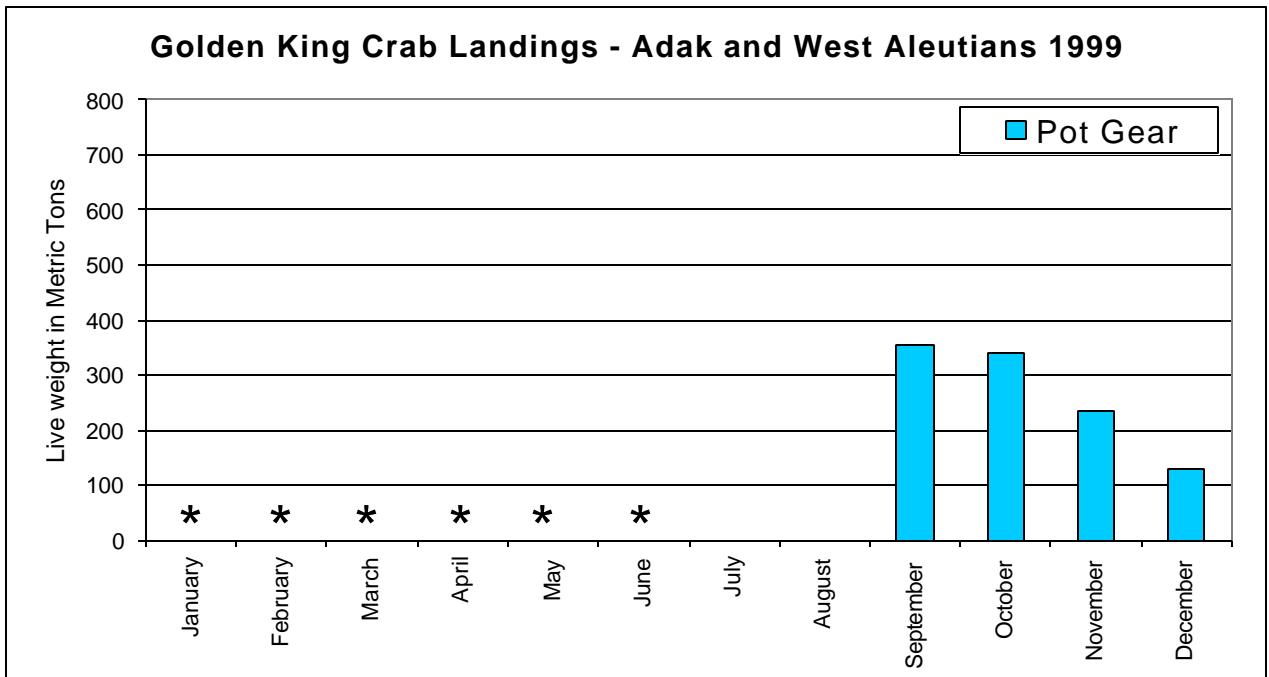


Figure 6.14 (top) Monthly distribution of golden king crab landings in Adak, 1999. Spatial distribution of golden king crab landings in Adak, 1999 (bottom). * indicates confidential catch.

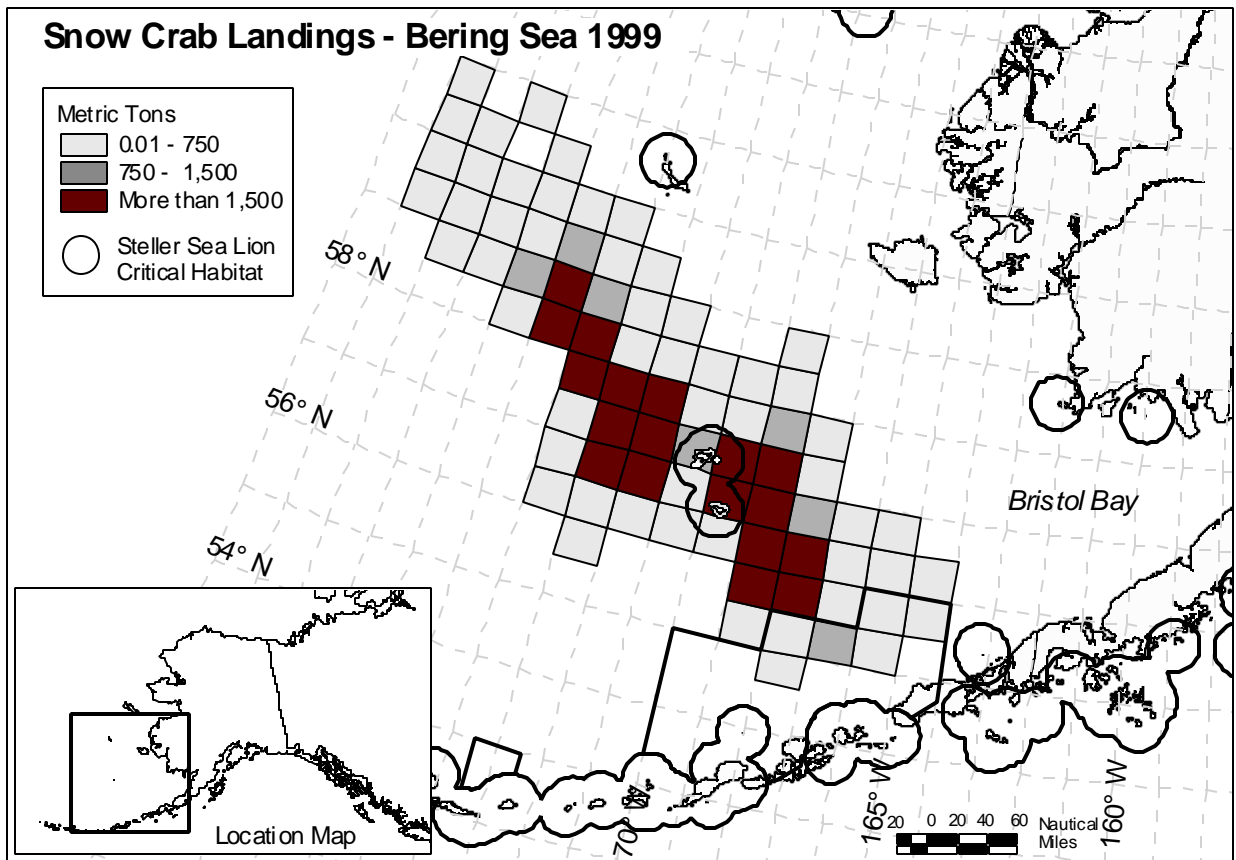
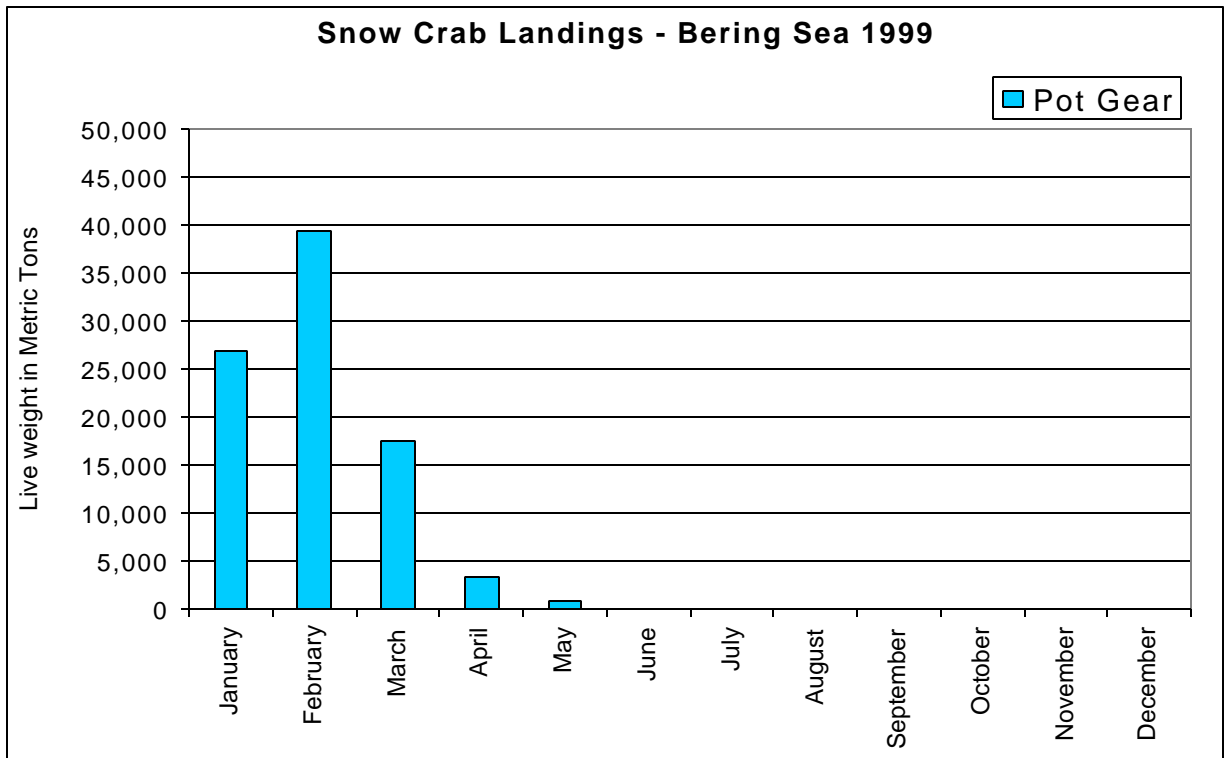


Figure 6.15 Monthly distribution of snow crab landings in the Bering Sea, 1999 (top), and Spatial distribution of snow crab landings in the Bering Sea, 1999 (bottom).

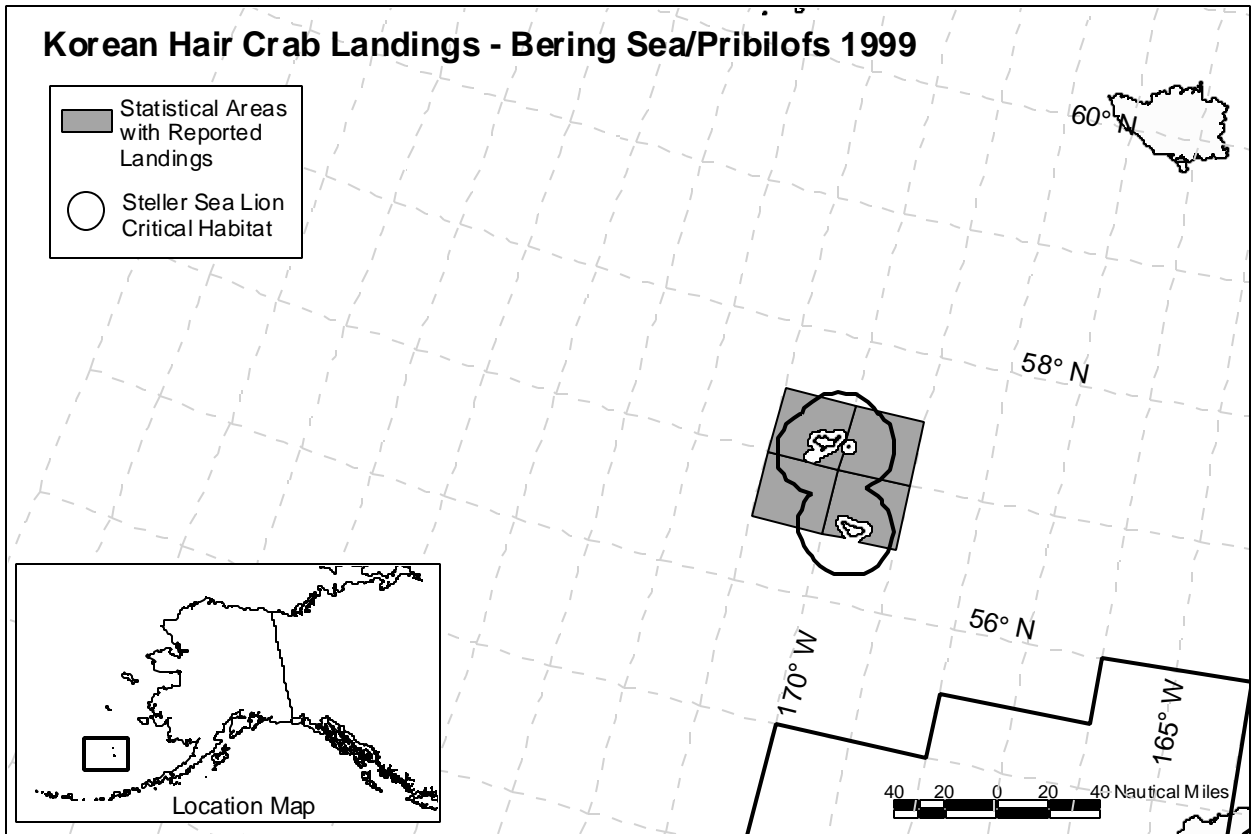
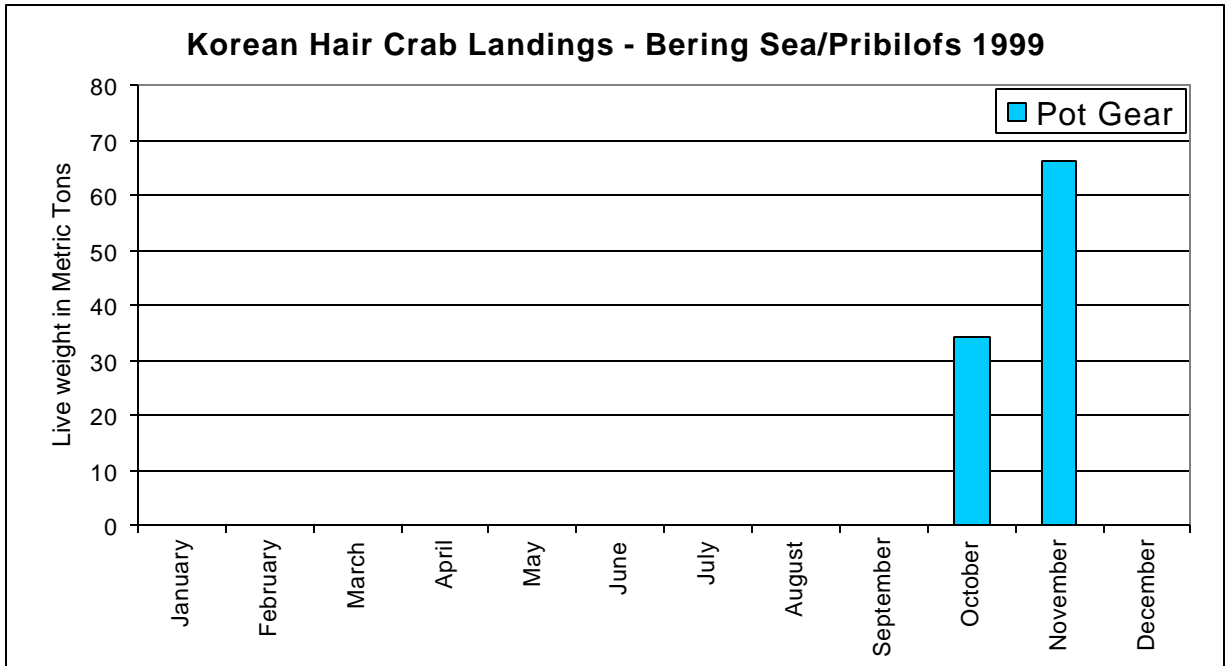


Figure 6.16 Monthly distribution of Korean hair crab landings in the Bering Sea, 1999 (top), and Spatial distribution of Korean hair crab landings in the Bering Sea, 1999 (bottom).

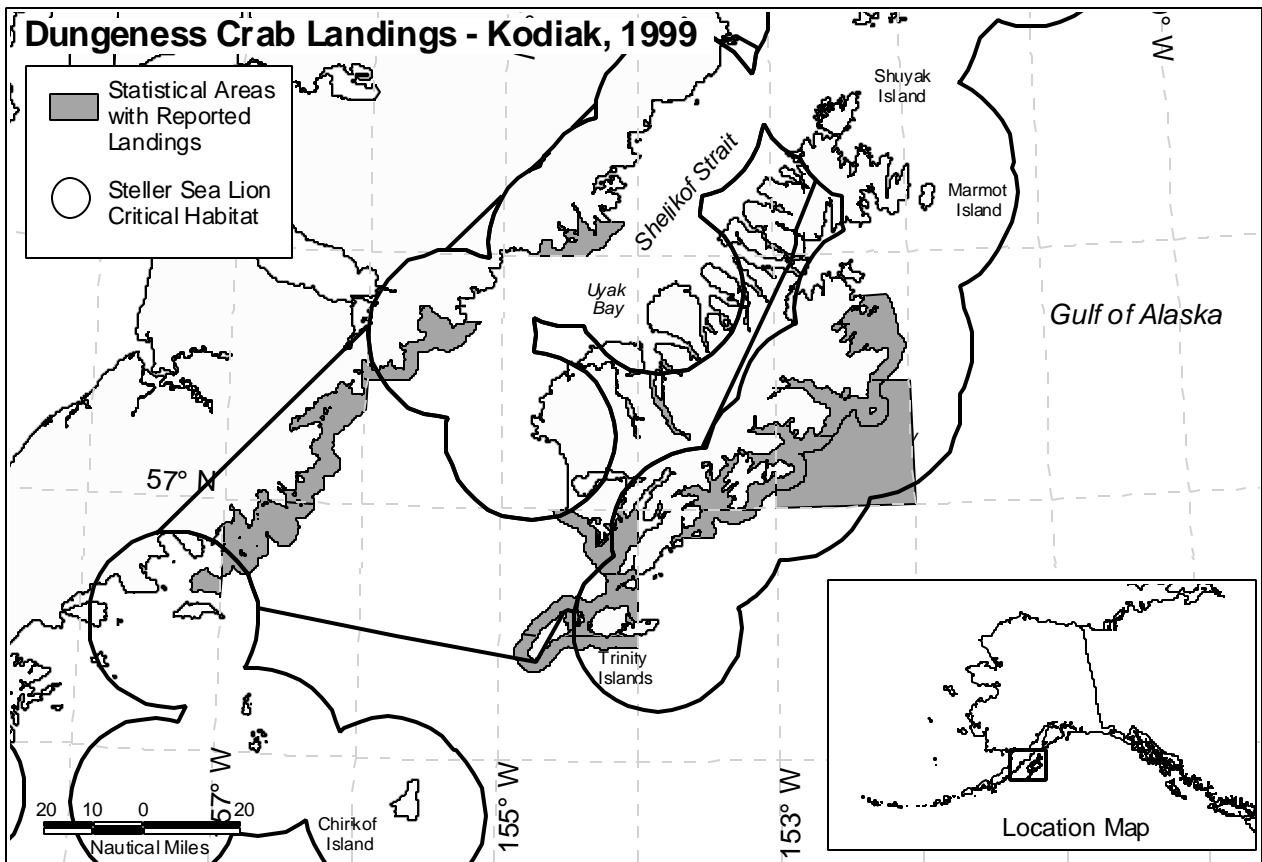
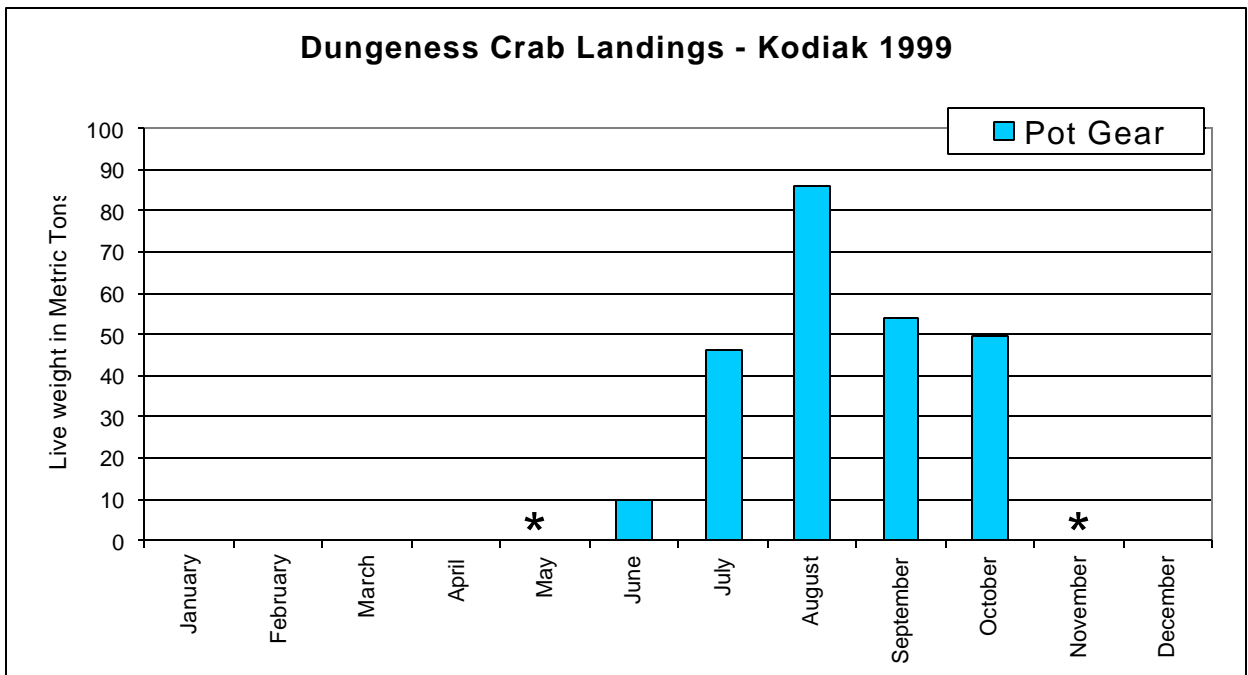


Figure 6.17 Monthly distribution of dungeness crab landings in Kodiak, 1999 (top), and Spatial distribution of dungeness crab landings in Kodiak, 1999 (bottom). * indicates confidential catches.

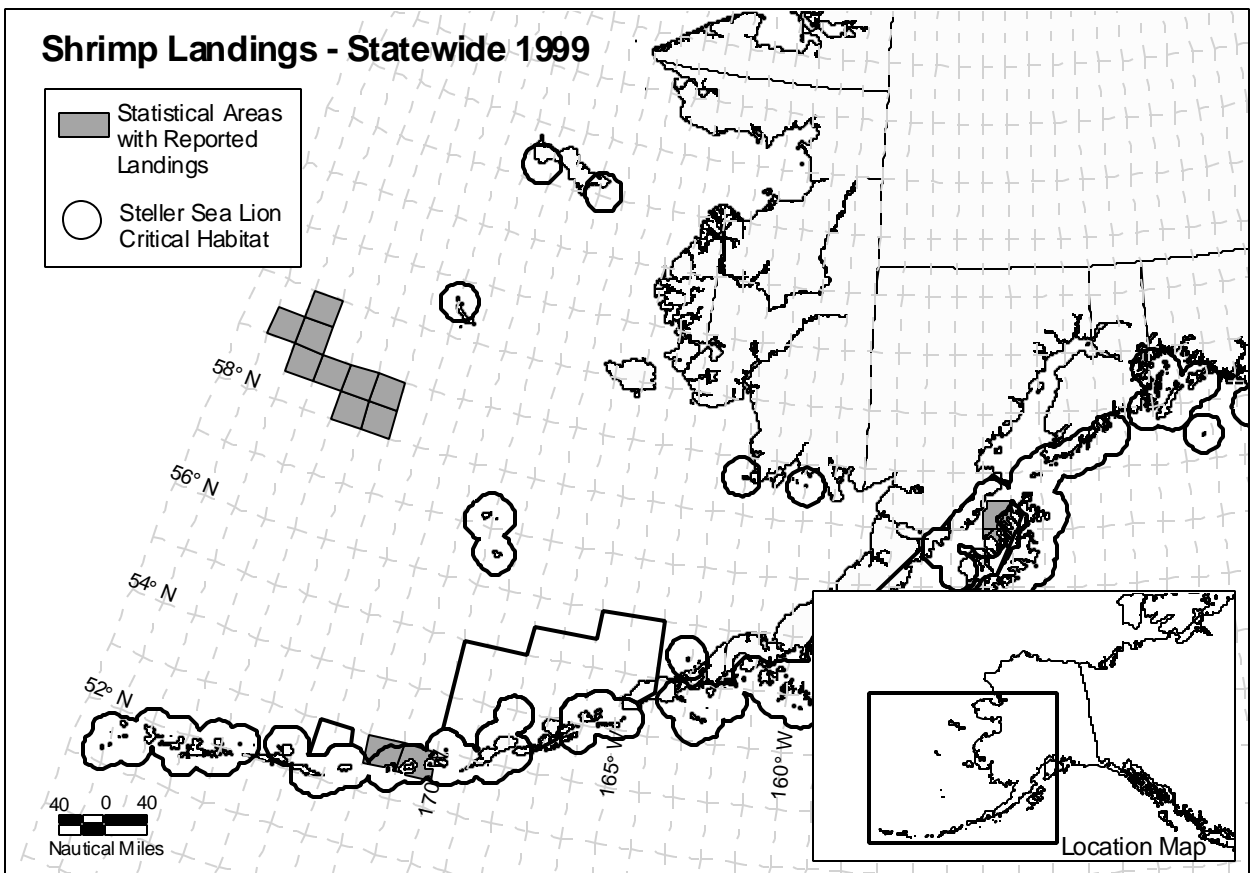
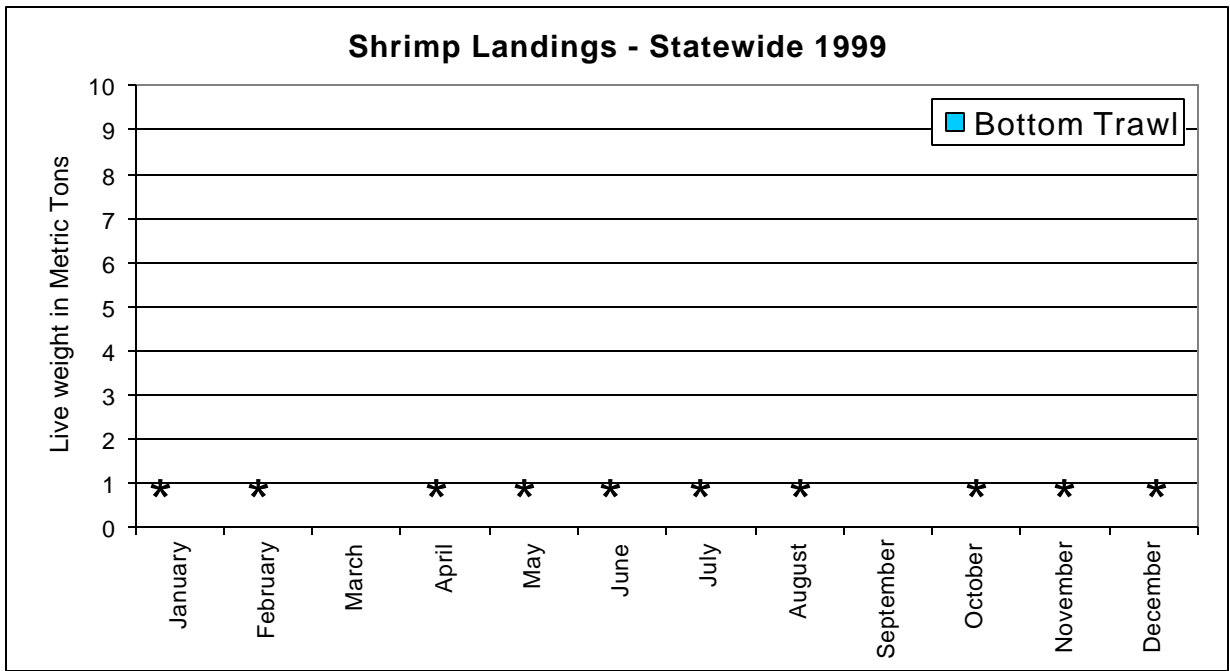


Figure 6.18 Monthly distribution of statewide shrimp landings, 1999 (top), and Spatial distribution of statewide shrimp landings, 1999 (bottom). * indicates confidential catches.

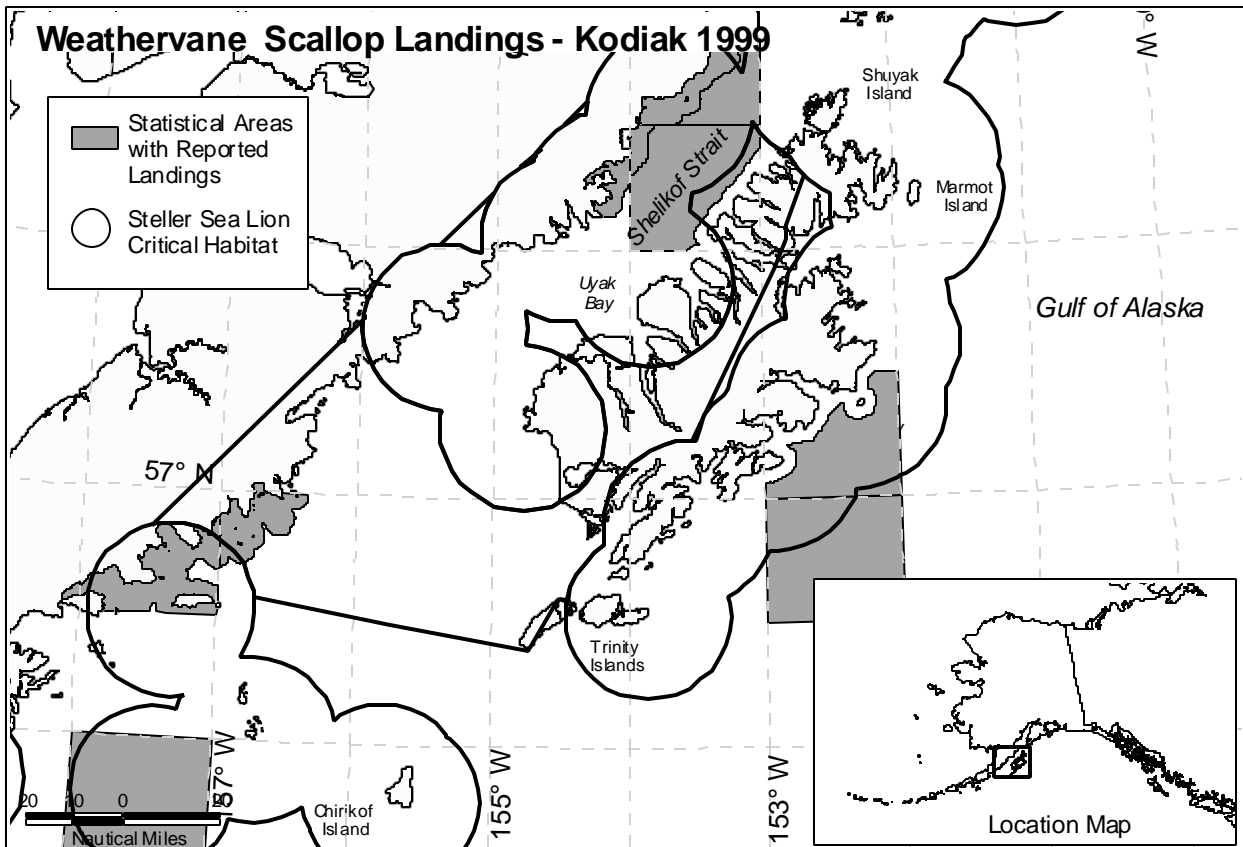
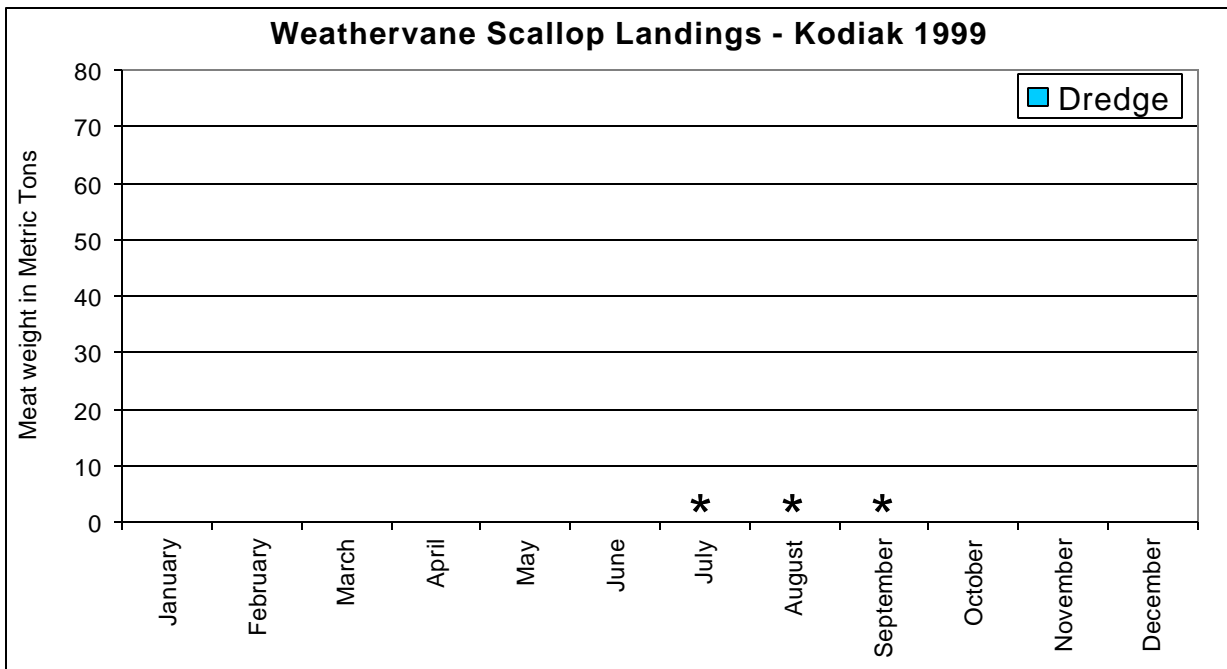


Figure 6.19 Monthly distribution of scallop landings in Kodiak, 1999 (top), and Spatial distribution of scallop landings in Kodiak, 1999 (bottom). * indicates confidential catches.

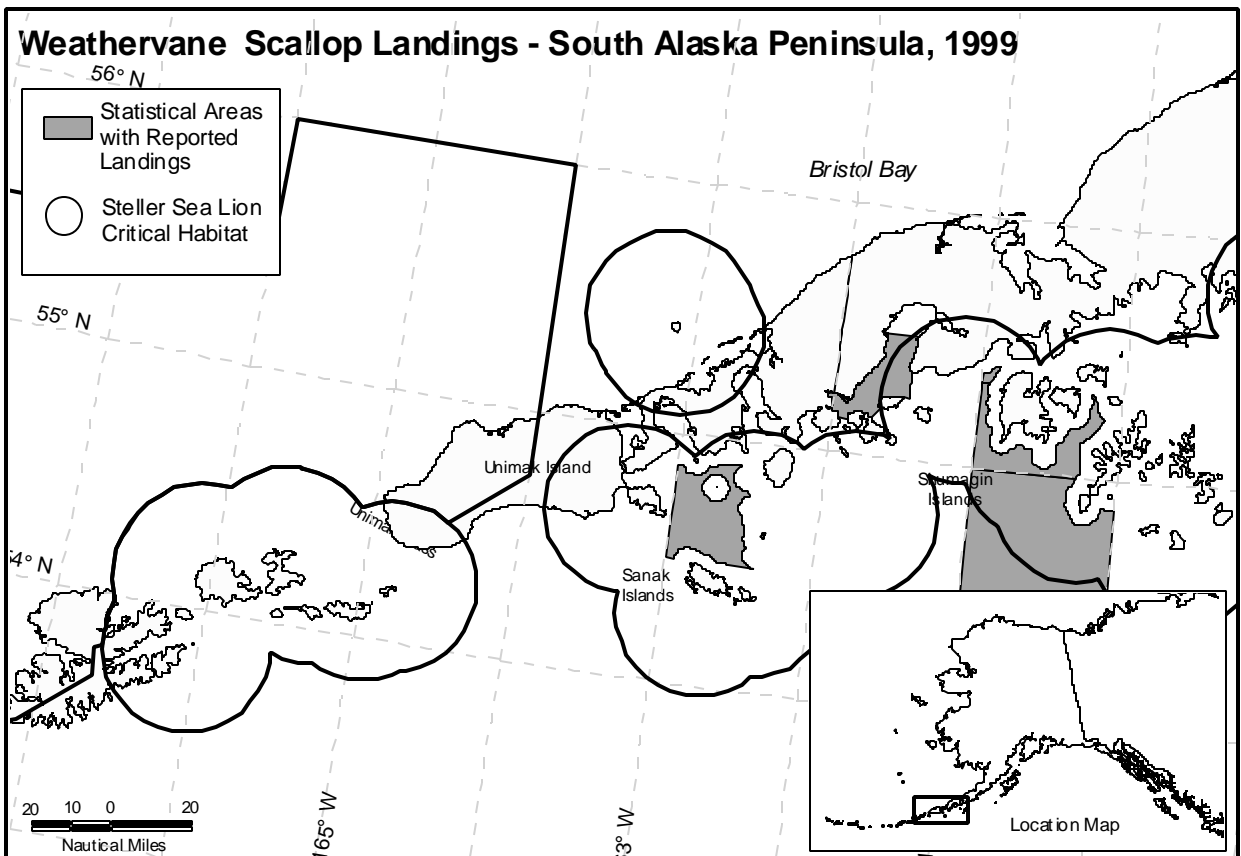
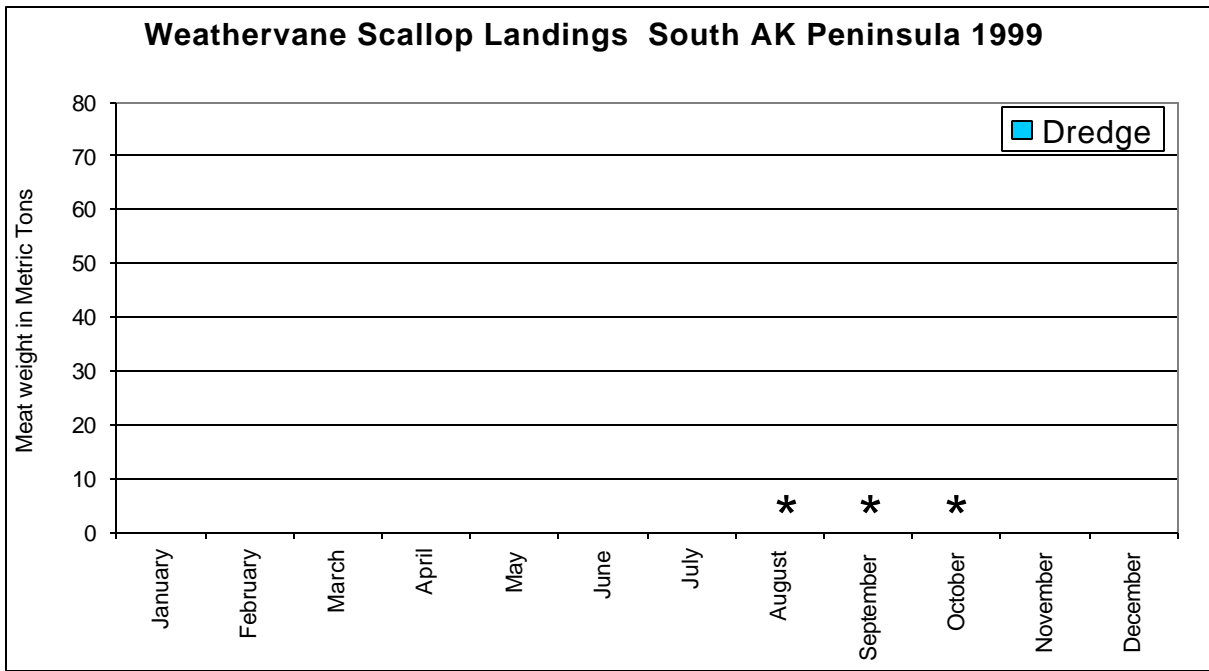


Figure 6.20 Monthly distribution of scallop landings in the South Alaska Peninsula, 1999 (top), and Spatial distribution of scallop landings in the South Alaska Peninsula, 1999 (bottom). * indicates confidential catches.

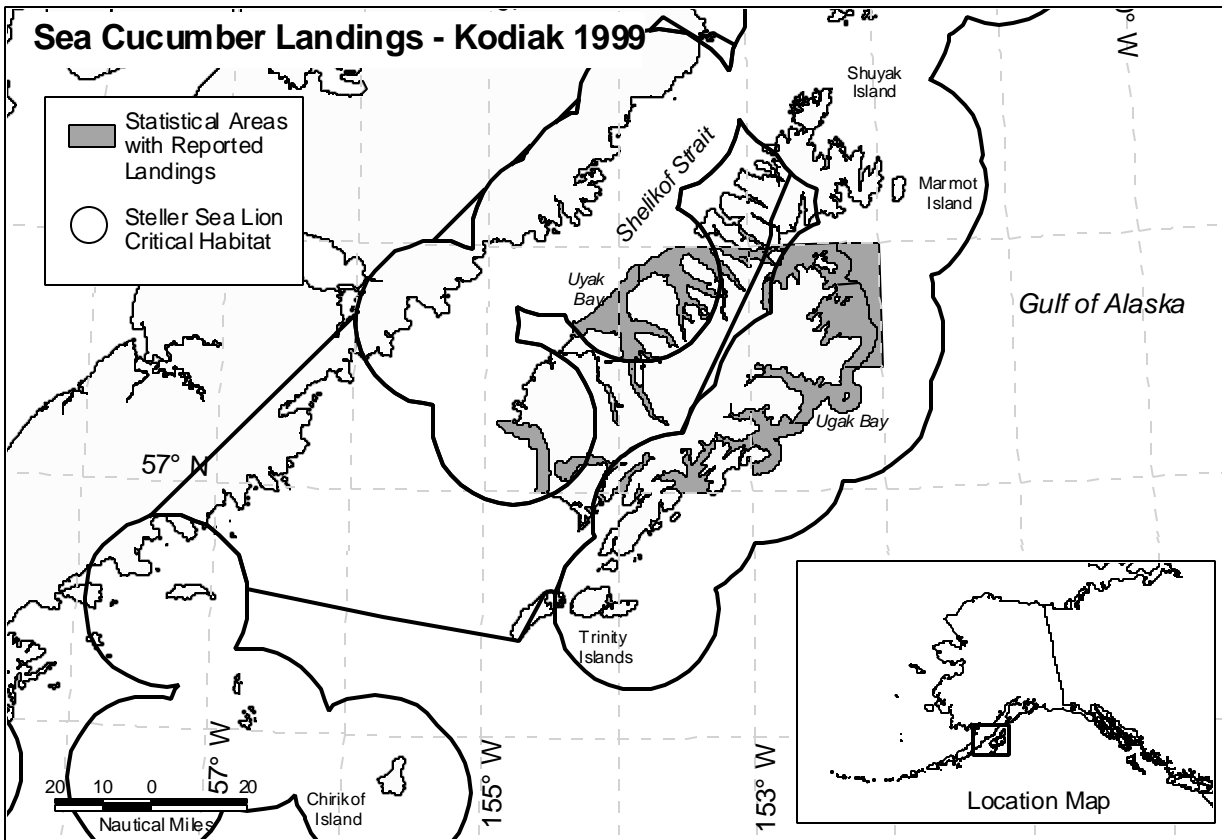
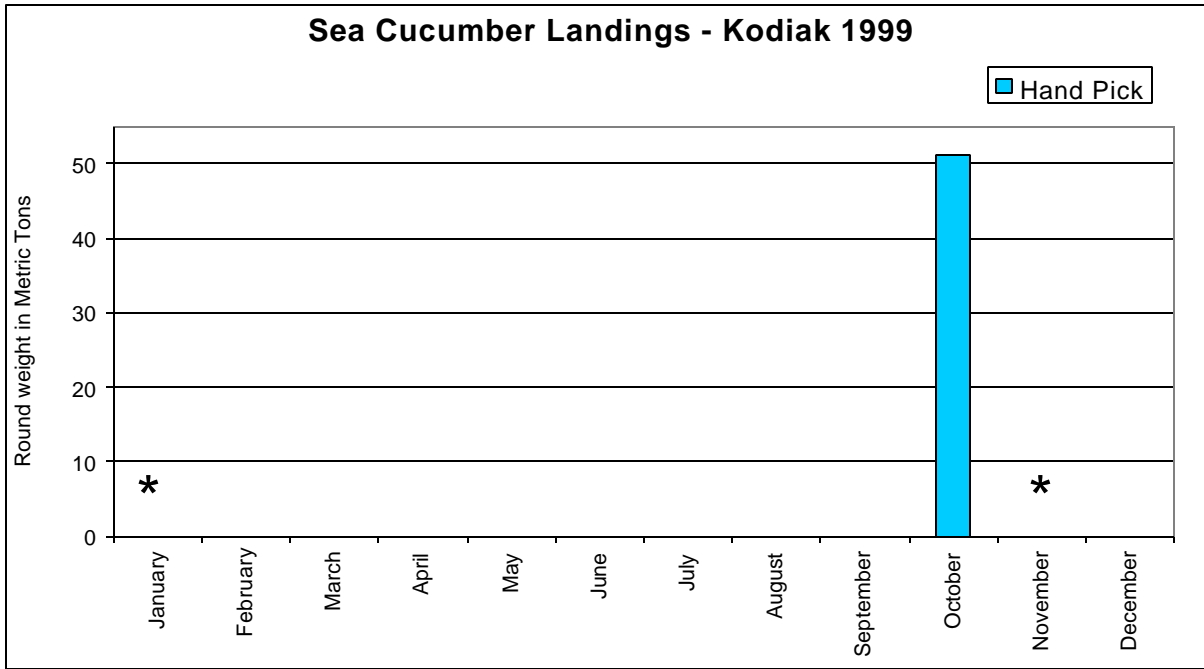


Figure 6.21 Monthly distribution of sea cucumber landings in Kodiak, 1999 (top), and Spatial distribution of sea cucumber landings in Kodiak, 1999 (bottom). * indicates confidential catches.

7. GROUND FISH FISHERIES

7.1 Fishery History

Groundfish fisheries in Alaska underwent several stages: (1) limited exploration by North Americans, (2) extensive exploration by foreign countries, (3) unregulated overfishing by foreign trawlers coupled to gear conflicts with domestic fixed gear fishers, (4) transition to Americanization of the fisheries, and (5) development of an overcapitalized U.S. fleet. As the history of state-managed groundfish fisheries in Alaska is short, state-managed fisheries are described in section 7.1, *Fishery Description*. The following historical description of foreign and federally managed domestic groundfish fisheries off the coast of Alaska is based on a review by Rigby et al. (1995).

The oldest groundfish fishery off Alaska targets Pacific cod (*Gadus macrocephalus*). In 1865 the schooner *Alert* made the first fishing expedition into the BS. The developing fishery peaked during 1916 - 1920 and steadily declined to 1950. In the 1880s a commercial fishery began for halibut (*Hippoglossus stenolepis*) and sablefish (*Anoplopoma fimbria*) in the inside waters of Southeast Alaska. Besides U.S. fishermen, Canadians regularly fished for halibut off Alaska.

After an exploratory fishing expedition in the BS in 1930, Japan fished for pollock (*Theragra chalcogramma*) during 1933 - 1937 and yellowfin sole (*Limanda aspera*) in 1940 - 1941. After cessation of fishing during World War II, a fishery for yellowfin sole resumed in 1954. This fishery peaked at 500,000 mt in 1960 and declined with the collapse of yellowfin sole abundance. The Russian fleet, which began fishing in the BS in 1958, contributed to the decline. By the early 1960s Japanese trawlers began targeting pollock. In 1972 Japanese pollock catches in the Bering Sea peaked at over 1.7 million mt. This coincided with peak Russian harvests of over 300,000 mt annually in 1971 and 1973. Fishing effort was extremely high; during 1971 over 450 foreign fishing vessels entered the fishery. With the addition of a small Korean fleet in the BS during the late 1960s and early 1970s, Bering Sea foreign fisheries reached a record 2.2 million mt of pollock, flatfish, rockfish, cod, and other groundfish in 1972. Subsequently, total groundfish harvests dropped sharply in the BS and AI.

The Japanese fleets moved into the GOA in 1960 followed by the Russian trawl fleet in 1962. Their primary target was Pacific ocean perch (POP, *Sebastes alutus*). Catches of this and other red rockfish species peaked at 350,000 mt in 1965. As POP declined from overfishing, flatfish, cod, pollock, and sablefish became alternatives and effort continued to increase. In the 1970s, Japanese, Russian, Korean, and Taiwanese longliners focused on sablefish and cod. Other fishing nations in the GOA included Poland, the then West Germany, and Mexico. The late 1960s and early 1970s represent a period of unregulated overfishing of groundfish resources off Alaska. It was also a time of many gear conflicts between these foreign trawl fisheries and domestic pot fisheries for crab and longline fisheries for halibut. Moreover, bycatch was a major issue. In the GOA, bycatch of halibut by foreign trawlers peaked at 9,000 mt in 1965, roughly one-third of the directed halibut harvest.

In 1976, the U.S. Congress passed an act named the MSFCMA. This important fishery legislation authorized the U.S. to manage its fishery resources out to 200 nm, and it established a

mechanism to “Americanize” the Alaska groundfish fishery. Following its enactment, the years 1978 – 1990 became a transition period typified by foreign-U.S. joint ventures (JVs) in groundfish fisheries. The JV fishery peaked at 1.3 million mt in 1987, which was also the last year of any foreign directed catches. By 1991, only domestic U.S. vessels participated in the groundfish fisheries off Alaska.

7.2 Fishery Description

7.2.1 Overview

7.2.1.1 General Description

Most groundfish fisheries off the Alaskan coast are managed by NMFS under federal FMPs adopted by the NPFMC. The groundfish FMP for the GOA was adopted 1978, and the FMP for the Bering Sea/Aleutian Islands (BS/AI) was approved in 1982. Current FMPs (NPFMC 2000a,b) reflect many amendments since their adoption. DiCosimo (1998) and Witherell (1997) prepared concise summaries of these FMPs. The status of groundfish stocks and federally-managed fisheries in the GOA and BS/AI areas are summarized annually in stock assessment and fishery evaluation reports, such as NPFMC (1999a,b). A description of these federally managed fisheries is beyond the scope of this report.

Whereas fisheries in the EEZ from 3-200 nm fall under federal authority by virtue of the MSFCMA, the State of Alaska has management authority for fishery resources within state territorial (0-3 nm) waters by virtue of the Submerged Lands Act (1953) and further recognized by the MSFCMA. For most groundfish fisheries, ADF&G issues emergency orders (EOs) for state waters that duplicate all NMFS groundfish fishery management actions. These EOs establish parallel fishing seasons such that vessels may fish for groundfish in either state or federal waters. In some other instances, the State of Alaska establishes separate catch quotas, termed GHs in state management, and fishing seasons under state groundfish FMPs. The rest of this chapter addresses state-managed fisheries only. Federal and parallel fisheries in state waters are beyond the scope of this report.

The region covered by this report, waters west of 144° W longitude, include the federal designations of the CGOA and WGOA regulatory areas of the GOA. In the WGOA, the state has established separate GHs and seasons for the following fisheries: sablefish, lingcod (*Ophiodon elongatus*), Pacific cod, black rockfish (*Sebastes melanops*), and blue rockfish (*S. mystinus*). The state-managed fisheries for sablefish and Pacific cod occur within 3 nm of shore, whereas the state has full management authority extending throughout the EEZ for species (e.g., lingcod and black and blue rockfish) not covered by a federal FMP. Lingcod were never covered by the groundfish FMP whereas black and blue rockfish were removed from it recently. In the CGOA, state-managed fisheries in state waters consist of pollock in PWS and Pacific cod, sablefish, and all rockfish species in state waters of PWS and CI. As in the WGOA, the state has full management authority for lingcod and black and blue rockfish fisheries. The rest of this chapter focuses solely on state-managed groundfish fisheries under FMPs established by the BOF.

7.2.1.2 Pacific Cod

Pacific cod, also called gray cod, is a broadly distributed species from about 34° to 63° N latitude throughout the GOA and BS/AI areas. Tagging and genetic studies have failed to demonstrate separate stocks within these areas. They are mostly demersal at depths of 15-550 m and tend to concentrate on the outer continental shelf (100-200 m) where they spawn from January through April. They tend to move to shallower waters (<100 m) in the summer. Cod are opportunistic feeders targeting mostly polychaetes, amphipods, shrimp, and fish. Halibut, sharks, seabirds, and marine mammals such as fur seals (*Callorhinus ursinus*) predate them. Cod enter the fishery about age 7 and may live 19 years or more. Primary products produced from the cod fishery include a headed and gutted (H&G) product, fillets, and to a lesser extent salted, whole fish, and roe. A state-managed cod fishery was first implemented in 1997.

7.2.1.3 Walleye Pollock

Walleye pollock have a broad geographic distribution in the North Pacific Ocean and eastern and western BS. In the GOA, pollock are considered as a single stock separate from those in the BS and AI regions. They are semidemersal (i.e., semi-bottom dwelling) with a depth distribution from near the surface to depths of 500 m. In late winter/early spring pollock form huge spawning aggregations in Shelikof Strait with smaller schools in the Shumagin Islands, in the entrance to PWS, and near Middleton Island. In summer, large aggregations have been found on the east side of Kodiak Island, nearshore along the southern Alaska Peninsula, and other areas. Pollock undergo seasonal migrations between spawning and feeding areas. Pollock feed on copepods, euphausiids, and fish (including other pollock), and are predated by other fish, marine mammals, and seabirds. Pollock begin to enter the fishery around age 3 and live to 15 years or more. Primary products from the Alaskan pollock fishery include surimi, minced product, fillets, meal, oil and roe. In 1995, a state-managed directed pollock fishery was initiated in PWS, and harvests have averaged 2,259 mt annually.

7.2.1.4 Sablefish

Sablefish, also called blackcod, are distributed throughout the GOA, and BS/AI areas off the coast of Alaska. Adults generally live in deep waters of 150-1,500 m, but they are primarily concentrated at 400-1,000 m along the continental slope. Juveniles tend to be pelagic or semi-pelagic, living in shallower, nearshore waters; they move deeper with age. As with many groundfish species in Alaska, sablefish spawn during late winter to early spring. Sablefish are highly migratory and substantial migration among the GOA and BS/AI areas has been documented. Sablefish are often considered to be a single population along the west coast of the U.S. and into Alaska, but they are managed as four stocks. They are opportunistic feeders, and prey include fish, such as pollock, arrowtooth flounder (*Atheresthes stomias*), herring, capelin (*Mallotus villosus*), and others, as well as crustaceans, and cephalopods. Juvenile sablefish are eaten by a wide variety of fish, such as coho and chinook salmon, and by sea birds and pinnipeds. Pacific halibut, cod, lingcod, hagfishes (*Eptatretus* sp.), sharks, and killer whales (*Orcinus orca*) reportedly eat adults. Sablefish are very long-lived with maximum age of 62 years in Alaska. They are a highly prized fish well known for their oily flesh. In the CGOA and WGOA, ADF&G actively manages commercial fisheries for sablefish in the PWS, CI and

Aleutian Islands Management Areas. The primary product is a H&G product for Japanese markets, but small amounts are distributed in specialty domestic markets.

7.2.1.5 Lingcod

Belonging to the family Hexagrammidae, lingcod are greenlings, rather than true cods. They are common throughout Southeast Alaska, PWS, the outer Kenai Peninsula, and Kodiak. They occur to 300 m, but more typically they inhabit nearshore rocky reefs from 10-100 m. Most spawning occurs during January through March. They are voracious predators and eat almost anything, including other lingcod. If left unguarded, lingcod egg nests are predated by rockfish, starfish, sculpins, kelp greenling, and cod. Salmon, rockfish, and other lingcod eat Young lingcod. Maximum age is reported to be 25 years. Lingcod appear rather sedentary and are not known to undergo extensive migrations. Their sedentary lifestyle, coupled to their nest-guarding behavior, renders the species particularly sensitive to overfishing. Lingcod, attaining sizes of over 35 kg, are highly prized by commercial and recreational fishers for their high-quality white flesh. Primary seafood products are fresh and frozen fillets. ADF&G manages all lingcod fisheries in territorial and EEZ waters off Alaska.

7.2.1.6 Rockfish

Rockfishes (*Sebastes* sp.) are a diverse group of marine fishes comprising more than thirty species off Alaska. They are broadly distributed throughout the GOA and BS/AI areas, although each species has its own geographic and depth distribution. Those inhabiting the GOA are separated into three ecological groups:

- (1) *demersal shelf rockfish (DSR)*, predominated by yelloweye rockfish (*S. ruberrimus*) in the commercial catch, are those that live in nearshore, shallow waters, on rocky bottoms;
- (2) *pelagic shelf rockfish (PSR)*, include dusky rockfish (*S. ciliatus*), widow rockfish (*S. entomelas*), yellowtail rockfish (*S. flavidus*), black rockfish, and blue rockfish, are those that also tend to live in nearshore waters, but mostly live off the bottom. All five species had been under the jurisdiction of the NPFMC until 1998 when black and blue rockfish were removed from the federal FMP and which placed management jurisdiction with the state of Alaska; and
- (3) *slope rockfish*, those that live on the edge of the continental shelf in depths greater than 150-200 m. From an ecological standpoint, the group includes POP, shortraker rockfish (*S. borealis*), roughey rockfish (*S. aleutianus*), northern rockfish (*S. polyspinus*), and other species. In recent years, for federally managed fisheries, the NPFMC split these rockfishes into four groups to improve its ability to manage each more finely in hopes to avoid overfishing: POP, shortraker/roughey, northern, and other slope rockfish. For state managed fisheries, rockfishes of the genus *Sebastes* are defined as DSR, PSR, and slope rockfish in regulation 5 AAC 39.975.

In general, rockfish feed on a variety of prey. Juveniles eat mostly plankton, such as small crustaceans and copepods, as well as fish eggs. Adults eat fish, such as herring, sand lance, and small rockfish, as well as crustaceans including shrimps. Rockfish are a very long-lived group of

fishes. Predators include sablefish, Pacific halibut and other fish species. Maximum ages differ by species with some species living as long as 140 years or more. Because of their longevity and the fact that most rockfish species are very site-specific and demonstrate minimal migration, rockfish populations are extremely vulnerable to overfishing. Rockfish are valued for high quality white flesh by commercial and recreational fisheries. The primary commercial product for DSR is fresh, whole iced fish. Other rockfish species tend to be marketed as frozen (or fresh) fillets. In addition to management of black and blue rockfish throughout all territorial and EEZ waters off Alaska, the state manages rockfish (all species) in PWS and CI.

7.2.2 Fishery Management Strategy

7.2.2.1 Overview

State regulation 5 AAC 028.89 *Guiding Principles for Groundfish Fishery Regulations* (ADF&G 1999b) specifies that the BOF will, to the extent practicable, consider the following when adopting regulations concerning groundfish fisheries:

- (1) conservation of the groundfish resource to ensure sustained yield, which requires that the allowable catch in any fishery be based upon the biological abundance of the stock;
- (2) minimization of bycatch of other associated fish and shellfish and prevention of the localized depletion of stocks;
- (3) protection of the habitat and other associated fish and shellfish species from nonsustainable fishing practices;
- (4) maintenance of slower harvest rates by methods and means and time and area restrictions to ensure the adequate reporting and analysis necessary for management of the fishery;
- (5) extension of the length of fishing seasons by methods and means and time and area restrictions to provide for the maximum benefit to the state and to regions and local areas of the state;
- (6) harvest of the resource in a manner that emphasizes the quality and value of the fishery product;
- (7) use of the best available information presented to the board; and
- (8) cooperation with the North Pacific Fishery Management Council (NPFMC) and other federal agencies associated with management of groundfish fisheries.

7.2.2.2 Pacific Cod

In 1996, the BOF adopted Pacific cod FMPs for state waters fisheries in PWS, CI, Chignik, Kodiak, and the South Alaska Peninsula consistent with their recently adopted *Guiding Principles for Groundfish Fishery Regulations*. All five FMPs have some common elements that include: only pot or jig gear is permitted, pot vessels are limited to no more than 60 pots, jig vessels are limited to no more than five jigging machines, and exclusive area registration

requirements. Vessels participating in the South Alaska Peninsula and Chignik areas are limited to no more than 58 feet in length. Catches are allocated to users as: 85% pot and 15% jig in South Alaska Peninsula and Chignik areas, 60% pot and 40% jig in PWS, and 50:50 in Kodiak and Cook Inlet areas. If target gear allocation percentages are not met by late in the season, then the unattained GHL becomes available to all gear types. Because cod are assumed to be one stock in the GOA, state GHLS are set as a percentage of the federal acceptable biological catch (ABC, Table 7.1). State GHLS for PWS are set at 25% of the federal for the eastern GOA (EGOA), leaving 75% for the federal EGOA TAC. Similarly, up to 25% of the CGOA ABC is allocated among Chignik (up to 8.75%), Kodiak (up to 12.5%) and Cook Inlet (up to 3.75%). Finally, the state GHL for the South Alaska Peninsula fishery is set at 25% of the WGOA ABC.

7.2.2.3 Walleye Pollock

The PWS pollock fishery is based on a harvest rate strategy. Because reliable estimates of biomass and natural mortality are available, the PWS pollock stock falls into Tier 5 (DiCosimo 1998). The GHL is calculated as the product of the biomass estimate, instantaneous natural mortality rate (0.3) and a safety factor of 0.75 (Table 7.1; Bechtol 1999). Biomass is estimated by bottom trawl surveys in summer and hydroacoustic surveys of spawning aggregations in winter. In 1999 the BOF directed the ADF&G to file an emergency regulation (effective for 90 days) establishing a PWS pollock trawl fishery management plan to reduce potential impacts on the endangered population of Steller sea lions. The plan, which was subsequently adopted into regulation, divides the Inside District of PWS into three management sections. The management plan also specifies that no more than 40% of the GHL may be taken from any one section. To implement this plan, ADF&G managed the fishery to target 30% of the GHL from any one area. The remaining 10% of the GHL was intended to insure against overharvest that could occur from an unforeseen increase in harvest rate or as result of incorrect inseason haul weights. Although pollock in the GOA are considered to be one stock, pollock in PWS appear not to be assessed by NMFS surveys in the GOA. Therefore, ADF&G surveys of pollock in PWS are used to set the GHL, rather than setting the GHL in PWS as a fraction of the federal TAC for the GOA.

7.2.2.4 Sablefish

Sablefish fisheries managed by ADF&G in management areas west of 144° W longitude include a limited entry fishery in PWS and open access fisheries in the CI and AI areas (Table 7.1). The PWS sablefish fishery is managed for a GHL set as the midpoint of a guideline harvest range derived from the estimated size of sablefish habitat and a yield-per-unit-area model (Berceli et al. 1999). The department sets a fishing season length based on the GHL, estimated number of participants, and past catch rates. Rockfish bycatch is limited to 20%. In CI, the first GHL was set in 1997 based on the recent ten-year average harvest of 43.5 mt (96,000 lb) adjusted up or down annually in proportion to the federal TAC set for the CGOA (Trowbridge 1998). In 1999, the GHL was 28.8 mt (63,400 lb). As with Pacific cod, sablefish are thought to constitute one stock in the GOA, so adjusting the GHL based on TAC changes is thought to be reasonable and conservative. The Aleutian Islands sablefish management area includes all state waters west of Scotch Cap Light (164° 44" W. longitude) and south of Cape Sarichef (54° 36" N. latitude). The fishery opens and closes concurrent with the federal fishery unless closed earlier by emergency order when the state GHL is attained. In the Aleutian Islands the GHL is based on a combination of harvest history, fishery performance, and the federal TAC based on NMFS surveys. In 1999,

the GHL was set at 113 mt (250,000 lb). In January 2001, the BOF will consider the adoption of a formal FMP for the state-managed Aleutian Islands fishery. In all management areas, survival of released sablefish is thought to be high, so there is no bycatch allowance for sablefish after the closure of the directed fisheries.

7.2.2.5 Lingcod

The minimum legal size of lingcod is 35" total length or 28" measured from the front of the dorsal fin to the tip of the tail. The minimum legal size restriction is intended to allow lingcod to spawn at least two years prior to becoming vulnerable to the fishery (Trowbridge 1998). In the PWS Management Area, the lingcod fishery is split among two districts: the Inside District and the Outside District. For each district, a conservative GHL is established based on 75% of the recent 10-year average harvest. For 1999, the GHL for the Inside District was 1.8 mt (4,000 lb), and 10.2 mt (22,500 lb) was set for the Outside District. In PWS lingcod are primarily caught as bycatch mainly by longline vessels. In CI, a GHL was set at 15.8 mt (35,000 lb) as 50% of recent five-year harvest, and only mechanical jig and hand jig (hand troll) gear may be used to target lingcod. During the open fishing season in PWS and CI, lingcod may be retained as bycatch in other directed fisheries in an amount that does not exceed 20% by weight of the directed groundfish species aboard the vessel.

In the WGOA, lingcod are taken largely incidental to other fisheries. Therefore, no GHLS are set and harvests are small. In Kodiak and Chignik areas, there are no gear restrictions and lingcod over the size limit may be retained during July 1 – December 31. The South Alaska Peninsula is the western range limit of the species, so no specific lingcod regulations exist in that area.

Like sablefish, survival of released lingcod is relatively high. Therefore, after the closure of the directed lingcod fishery, they cannot be retained as bycatch in any other fisheries.

7.2.2.6 Rockfish

The PWS rockfish management plan, adopted by the BOF in 1992, includes three main components: (1) a 68-mt (150,000 lb) annual harvest cap for all species, (2) bycatch allowance for low-level retention once the directed fishery is closed, and (3) vessel trip limits. The small trip limit of 1.4 mt (3,000 lb) per 5-day period maintains a slow-paced fishery. Unlike sablefish and lingcod, most rockfish die when discarded at sea. Therefore, a low (10%) bycatch allowance set by EO provides for retention of unavoidable bycatch rockfish while not providing incentive to target rockfish after the closure of the directed fishery. The GHL is set relative to average harvests sustained over time similar to the tier 6 approach summarized by DiCosimo (1998) for groundfish fisheries lacking stock assessment data under federal management. In 1999 the BOF designated PWS as a bycatch-only fishery with full retention. All rockfish above the allowable bycatch rate set for each directed fishery (P. cod: 5%, sablefish: 20%, and all others: 10%) must be donated or sold in the name of the state of Alaska.

The Cook Inlet Area Rockfish Management Plan is virtually identical to the PWS management plan with a 68-mt annual harvest cap and low bycatch allowances. However, in mid-1999 new regulations became effective which restricted gear to jig only and set a season opening date of July 1. Vessel trip limits are set by district. In the Cook Inlet District a fishing vessel may not

land or have onboard more than a total of 0.45 mt (1,000 lb), or 1.81 mt (4,000 lb) in the case of the North Gulf District, of all rockfish species within five consecutive days. When the directed fishery is closed, bycatch limits for rockfish are set at 10% or less.

In the WGOA, only black and blue rockfishes are managed by the state (Table 7.1). As in the CGOA, conservative GHs are set from historical catch data. In the Kodiak area, separate GHs are set for seven fishing districts to disperse harvest and reduce the likelihood of localized depletion. Likewise, separate GHs were established for four fishing subdistricts in the Akutan District and the Unalaska District was split into three subdistricts, one of which was split further into five sections. Once the directed fishery is closed in the WGOA, fishers are allowed to retain up to 5% by weight of black rockfish caught incidentally in other directed fisheries.

7.2.3 Fishing Gear

With some exceptions, groundfish may be taken in state-managed fisheries by trawls, seines, longlines, pots, hand troll gear, dinglebar troll gear, and mechanical jigging machines. However, extensive areas of state waters are closed to non-pelagic trawling. In PWS non-pelagic trawls are illegal for groundfish species other than sablefish. In the PWS and CI areas, regulations provide for retention of groundfish taken as bycatch in drift gillnet fisheries for salmon. In the WGOA, rockfish may not be taken with seines. Lingcod and rockfish may only be taken by mechanical jigging machines and hand troll gear in directed fisheries for these species in CI. Since 1995, a trawl fishery in PWS has targeted pollock, although, historically, they have been landed in small amounts incidental to other fisheries using jig, longline, and pot gear.

Pacific cod are harvested in two fisheries in state waters. During the parallel state-waters fishery open coincident with the federally managed EEZ fishery, cod may be taken by trawl, pot, longline and jig gear, subject to state regulations. Owing to trawl area closures in state waters, the parallel cod fisheries in PWS and CI are dominated by longline and pot catches. During the parallel fishery in the WGOA, catches are taken by all four gear types with trawls and pots accounting for most of the catches in the South Alaska Peninsula area, pots and longlines dominating Kodiak landings, and pots accounting for most of the Chignik catches. In the state-managed cod fisheries, no trawling is allowed; pot catches dominate those by jigs and hand trolling in all of the five state management areas for Pacific cod.

7.2.4 Fishery Status in 1999

In 1999, approximately 14,044 mt of Pacific cod were harvested in state-managed fisheries in the CGOA and WGOA (Table 7.1; Figures 7.1-7.5). These landings represented less than 18% of all cod harvested in combined state and federally managed fisheries in Alaska. The South Alaska Peninsula Management Area accounted for the greatest landings (38%), followed by Kodiak (35%) and Chignik (21%). Landings from PWS and CI combined to account for only 6% of the harvest from the state-managed fishery. Landings in March and April tend to dominate the annual harvests from CI (Figure 7.2) and the South Alaska Peninsula (Figure 7.5). Catches in April and May are largest in the Chignik area (Figure 7.4). In the Kodiak area, landings in late spring and early winter were greatest (Figure 7.3). In all areas, landings were either spread out from spring through summer (Figure 7.4-7.5) or else landings were bimodal with a hiatus in late

summer and early fall (Figures 7.1-7.3). Pot catches tended to dominate in most areas and months, with the main exceptions being the jig fisheries in early summer off Kodiak and all summer off the South Alaska Peninsula. Cod catches are highly spatially aggregated in all areas. Most catches in PWS were taken from areas west of Montague Island and the western sound (Figure 7.1), and in the Cook Inlet area, most catches came from Kachemak Bay and to a lesser extent the Barren Islands and outer coast (Figure 7.2). Catches were most widely dispersed in the Kodiak (Figure 7.3) and Chignik areas (Figure 7.4), but most catches off the South Alaska Peninsula came from the Sanak and Shumagin Islands areas (Figure 7.5).

A GHL of 2,086.5 mt was set for the PWS pollock fishery in 1999 (Berceli et al. 1999). The fishery opened on January 20 and closed on February 25. After the directed fishery closed, the department issued an EO to provide for bycatch retention of pollock to meet regulations for improved retention and improved utilization. Also, ADF&G conducted a test fishery in March. Taken together, all pollock landings totaled approximately 2,120.7 mt in 1999 (Table 7.1), most of which was harvested during February (Figure 7.6). Catches were somewhat dispersed spatially, but the highest catches were taken from the southwestern portions of PWS (Figure 7.6).

In 1999 state-managed sablefish fisheries harvested 253.1 mt, half of which came from the South Alaska Peninsula (Table 7.1). In PWS, just a few statistical areas dominated the harvest (Figure 7.7). Catches from the outer coast dominated the landings from CI (Figure 7.8), and catches in areas southwest of Unimak Island dominated the catches in the South Alaska Peninsula and Adak and west Aleutians areas (Figure 7.9). Directed fisheries lasted from just a few days in PWS (Table 1, Figure 7.7) to months in the case of CI and South Alaska Peninsula (Table 1, Figures 7.7-7.8). Although the CI sablefish fishery opened on March 15, 1999, starting in 2000 the fishery will open on July 15th owing to a regulatory change.

Just 26.5 mt of lingcod were taken in the CGOA and WGOA regions (Table 1). In PWS mostly longline vessels harvested 4.2 mt of lingcod largely as bycatch. The directed fishery lasted just one month (Table 1), but at least one bycatch landing was recorded in all months except February, May, November and December. Catches were spatially dispersed throughout state and federal waters, with highest catches from the southeast side of Montague Island (Figure 7.10). Lingcod catches from CI totaled about 12.6 mt in 1999 (Table 1). Most of the harvest was taken from August through November on the outer coast of the Kenai Peninsula from Resurrection Bay southwest to the Barren Islands by longline, and to a lesser extent jig, vessels (Figure 7.11). Lingcod catches (9.7 mt) were widely dispersed throughout state and federal waters off Kodiak Island, with one statistical area in the EEZ accounting for the largest catch (Table 1, Figure 7.12). Most of the Kodiak harvest occurs incidental to other fisheries during July–December, but some catch has been recorded from most months of the year (Figure 7.12).

About 31.3 mt of rockfish were harvested in the PWS area in 1999 (Table 7.1). The harvest is comprised largely of yelloweye rockfish (58%) and slope rockfish species, such as roughey rockfish. Longline vessels dominate the harvests, but vessels using trawl, mechanical jig, and hand troll gear have recorded some catches. Directed fishery catches occurred in January through March, and bycatches were taken in all months except December with 48% of the harvest taken in January through March, and another 27% taken during May and June (Table 7.1, Figure 7.13). Catches were widely spatially distributed with highest catches north and west of Montague

Island (Figure 7.13). In the CI area about 38.5 mt of rockfish were harvested in the directed fishery (mostly jig) in January through March and as bycatch (mostly longline) in all months except December 1999 (Table 7.1, Figure 7.14). Yelloweye and black rockfish accounted for 47% and 34%, respectively, of the total. Starting in 2000, the directed fishery will open July 1, rather than January 1. Most harvests were distributed along the outer coast of the Kenai Peninsula (Figure 7.14).

Finally, approximately 101.9 mt of black rockfish were harvested from the WGOA with Kodiak accounting for 61% and the South Alaska Peninsula accounting for 25% (Table 7.1). The predominant gear type is jig. In general, the fishery on the eastside of Kodiak Island accounted for the largest harvest from all areas, with the exception of a portion of the Shumagin Islands that reported high catches (Figure 7.15-7.18). Catches extended into the EEZ in all four management areas.

7.3 Interactions with Sea Lions

7.3.1 Predation

Among the groundfish species with fisheries managed by the State of Alaska, Walleye pollock and Pacific cod have been the most common prey of Steller sea lion in recent years (Table 3.2). Interestingly, cod were among the top 10 most common prey of sea lions in only 2 of 9 studies conducted off the coast of Alaska during 1945-1978 whereas pollock were in the top 10 in 6 of 9 studies (Hoover 1988). Rockfishes are not uncommon (Table 3.2), and they were among the top 10 species in the sea lion diet in 4 of 9 studies conducted during 1945-1978. Unfortunately, rockfishes were not identified to species in the NMFS review of previous studies (Table 3.2), so it is not obvious whether sea lions are predating species that are caught in state-managed fisheries. Regarding the remaining state-managed groundfish species, lingcod appear to be eaten occasionally, but apparently not sablefish (Table 3.2).

7.3.2 Overlap of Fisheries and Sea Lion Critical Habitat

Very little information is available on interactions between state-managed groundfish fisheries and Steller sea lions. Observers are not required on vessels participating in state-managed groundfish fisheries. However, some pot and jig vessels fishing for cod in the Kodiak and South Alaska Peninsula areas carried ADF&G observers on a voluntary basis during 1997-1999 (Ruccio and Jackson 2000). No sea lion interactions were reported. Historically, there were reports of sea lions interfering with king crab fisheries by biting and sinking inflated pot buoys (Mate 1980, as cited in Hoover 1988). Similar occurrences are possible for groundfish pot fisheries that also use inflated pot buoys, however we are unaware documented cases. More importantly, no sea lion mortality has been seen by observers in the federal groundfish pot fisheries in the Gulf of Alaska and Bering Sea since 1990 (Ferrero et al. 2000).

7.3.3 Direct Fishery Interactions

No observers have been deployed on state-managed longline fisheries. Hoover (1988) reported that sea lions may follow sablefish longline vessels for hours, and they often remove fish as the

gear is being retrieved. However, observations aboard federally managed longline fisheries suggest that sea lion mortalities associated with longline fisheries are very low. In federally managed longline fisheries (all groundfish target species) in the BS/AI area, only one mortality was recorded (1993) during the period 1990-1998 (Ferrero et al. 2000). For the federally managed longline fisheries in the GOA, just 1 animal was killed during the most recent five-year reporting period (1990-1994).

Incidental rates of sea lion mortality caused by groundfish trawlers were significantly higher than those reported for fixed gear such as pots, longlines, and jigs. In the federally managed trawl fisheries in the GOA and BS/AI areas, mean annual mortality of Steller sea lions was 1.2 and 7.4, respectively, for the five-year period 1994-1998 and higher rates were reported in earlier years (Ferrero et al. 2000). In the GOA, records of animals killed by groundfish trawlers in the federally managed pollock fishery during the 1980s were used to establish a Steller sea lion critical habitat area in Shelikof Strait. Similar data from federal observers led to the establishment of critical habitats in the Bogoslof and Seguam Pass areas of the BS/AI. Most mortalities occurred where trawlers targeted spawning pollock on which sea lions were feeding (NMFS 1999).

Trawl gear is prohibited in most state-managed groundfish fisheries. The only exception is the state-managed pollock trawl fishery in PWS (Table 1) and no observers have been required for this fishery. As discussed in Section 7.2.2.3 of this report, in 1999 ADF&G filed an emergency regulation to divide the Inside District of (PWS) into three management sections to disperse the harvest and reduce the potential for interactions with Steller sea lions.

Table 7.1. Status of state-managed groundfish fisheries in 1999. Catches reflect state managed fisheries only, not necessarily all catches from state waters.

Fishery	Primary Gear Types	Assess. Method	Stock Component	Exploitable Biomass (mt)	Stock Rel. to Mean Status	Three-year Stock Trend	Harvest Rate Policy	Actual Season Length	Catch (mt)
PWS Pacific cod	Pot/jig	LSSM	Age 3+	611,000 ¹	Below	Declining	=25% of EGOA ABC	3/21-12/31	148.6
CI Pacific cod	Pot/jig	LSSM	Age 3+	611,000 ¹	Below	Declining	=3.75% of CGOA ABC	3/21-12/31	688.8
Kodiak Pacific cod	Pot/jig	LSSM	Age 3+	611,000 ¹	Below	Declining	=12.5% of CGOA ABC	3/21-12/31	4,890.6
Chignik Pacific cod	Pot/jig	LSSM	Age 3+	611,000 ¹	Below	Declining	=8.75% of CGOA ABC	3/15-12/31	2,927.6
S. AK Pen. P. cod	Pot/jig	LSSM	Age 3+	611,000 ¹	Below	Declining	=25% of WGOA ABC	3/15-12/31	5,388.8
PWS Pollock	Trawl	Survey	Age 2+	6,304	Below	Declining	0.75 x M = 22.5%	1/20-2/25	2,120.7
PWS Sablefish	Longline	ASA	Age 4+	234,000 ²	Below	Declining	Habitat-yield Model	5/1-5/3	92.6
CI Sablefish	Longline	ASA	Age 4+	234,000 ²	Below	Declining	Hist. catch adjusted by % change in fed. TAC	3/15-5/19	33.4
S. AK Pen. sablefish	Longline	ASA	Age 4+	234,000 ²	Below	Declining	Hist. catch adjusted by % change in fed. TAC	5/3-12/2	127.1
PWS Lingcod	Longline	N/A	--	N/A	Uncertain	Uncertain	75% of 10-year ave.	7/1-7/30	4.2
CI Lingcod	Longline & Jig	N/A	--	N/A	Uncertain	Uncertain	50% of 5-year ave.	7/1-12/31	12.6
Kodiak Lingcod	Jig/other	N/A	--	N/A	Uncertain	Uncertain	Bycatch levels only	7/1-12/31	9.7
PWS Rockfish	Jig & Longline	N/A	--	N/A	Uncertain	Uncertain	Longterm ave. GHL (Now: Bycatch only)	1/1-3/27 (directed)	31.3
CI Rockfish	Longline & Jig	N/A	--	N/A	Uncertain	Uncertain	Conservative GHL	1/1-3/21 (directed)	38.5
Kodiak Black rockfish	Jig	N/A	--	N/A	Uncertain	Uncertain	Conservative GHL	1/1-12/31 ³	61.7
Chignik Black rockfish	Jig	N/A	--	N/A	Uncertain	Uncertain	Conservative GHL	1/1-12/31	5.2
S. AK Pen. Bk. rockfish	Jig	N/A	--	N/A	Uncertain	Uncertain	Conservative GHL	1/1-12/31	25.2
Dutch Hr. Blk. rockfish	Jig	N/A	--	N/A	Uncertain	Uncertain	Conservative GHL	1/1-12/31	9.8

Acronyms: Management Area – Prince William Sound (PWS), Cook Inlet (CI), and South Alaska Peninsula (S. AK Pen.), and eastern, central and western Gulf of Alaska (EGOA, CGOA, WGOA). Assessment method – length-structured Synthesis Model (LSSM), and age-structured separable sequential population analysis (ASA). Harvest rate policy – Total allowable catch (TAC), and guideline harvest level (GHL).

Footnotes: ¹GOA-wide biomass of Pacific cod, ²GOA-wide biomass of sablefish, and ³the Southeast section closed on 5/25, Northeast and Eastside sections closed on 6/22, and the Afognak section closed on 7/25. All remaining Kodiak sections closed by regulation on 12/31.

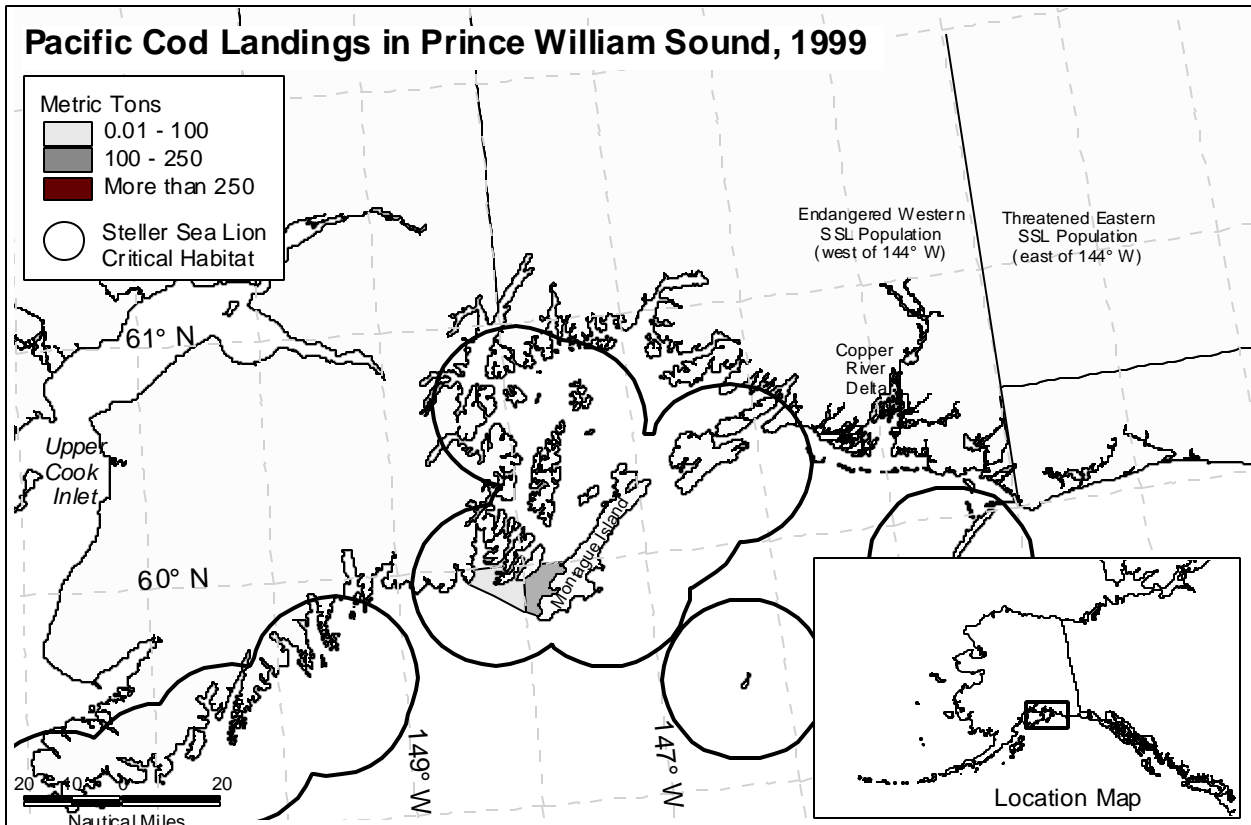
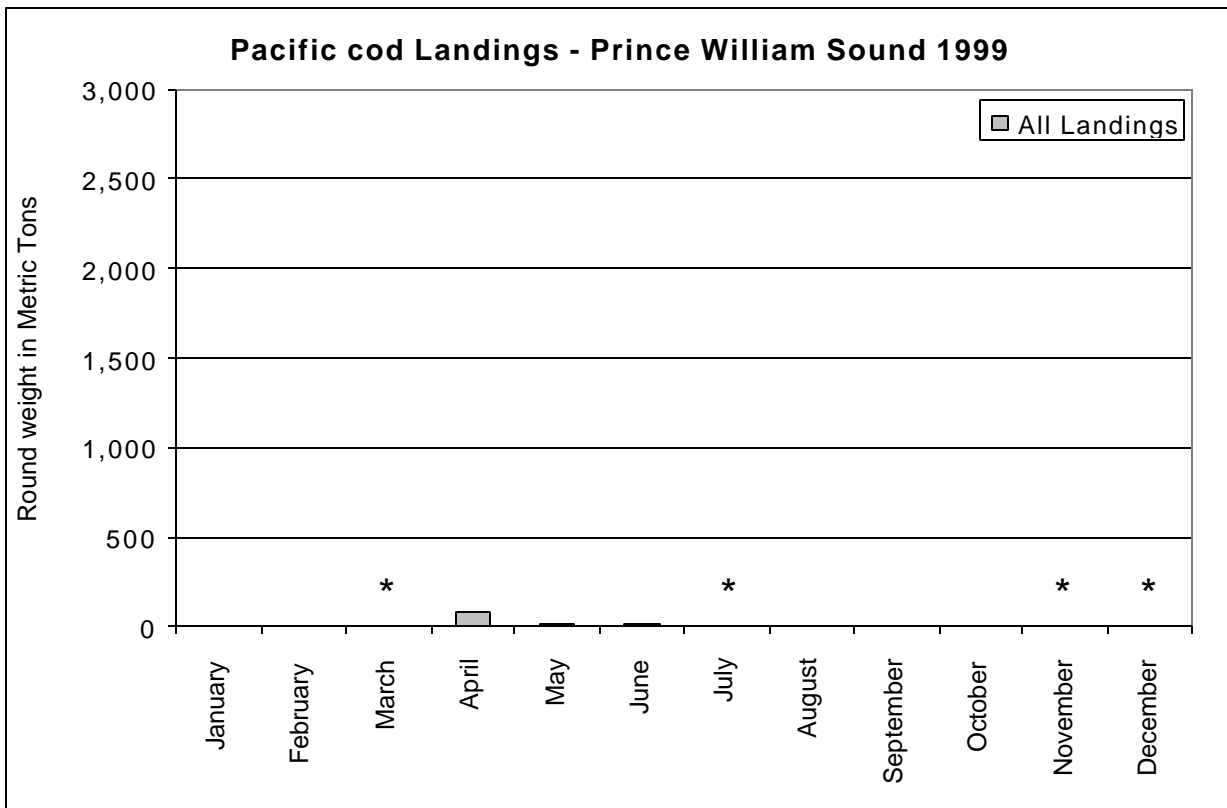


Figure 7.1 Monthly distribution of Pacific cod landings in Prince William Sound, 1999 (top), and Spatial distribution of Pacific cod landings in Prince William Sound, 1999 (bottom). * indicates confidential catch.

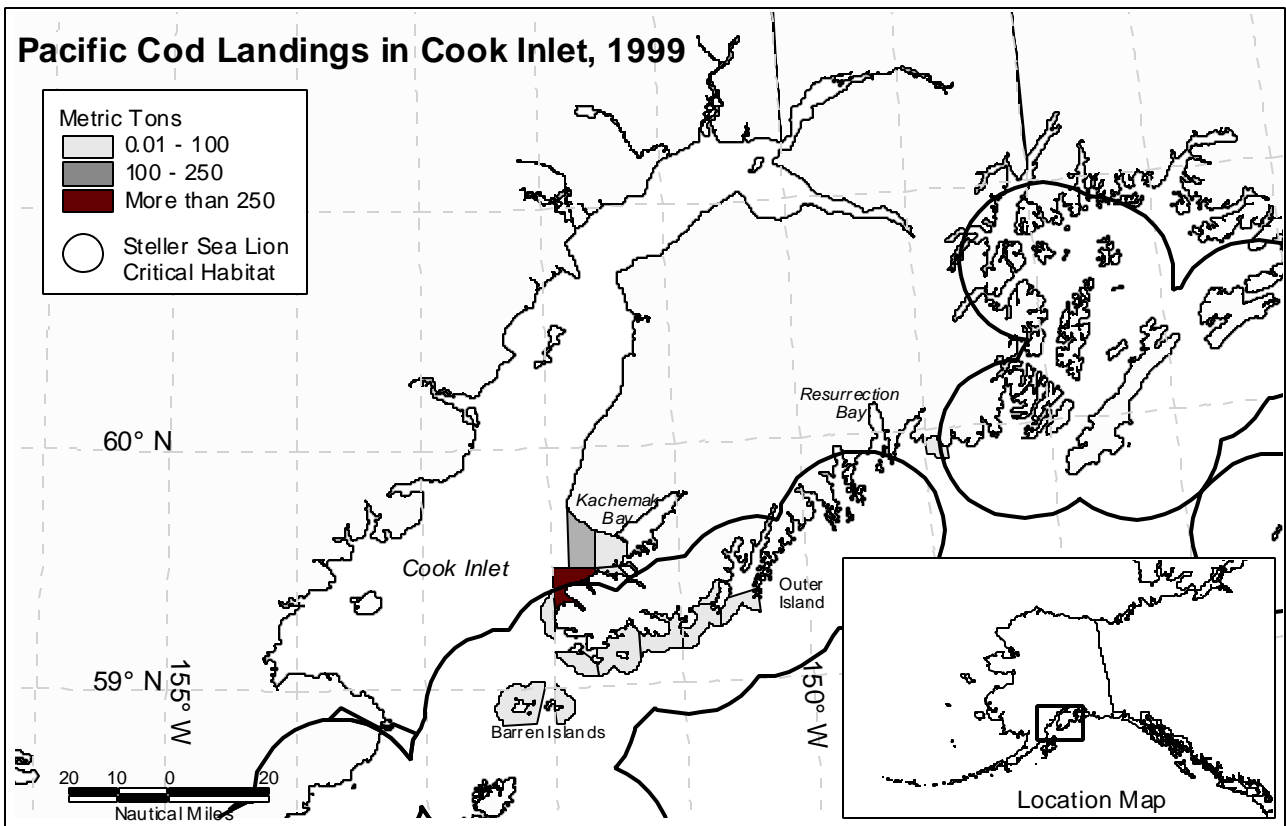
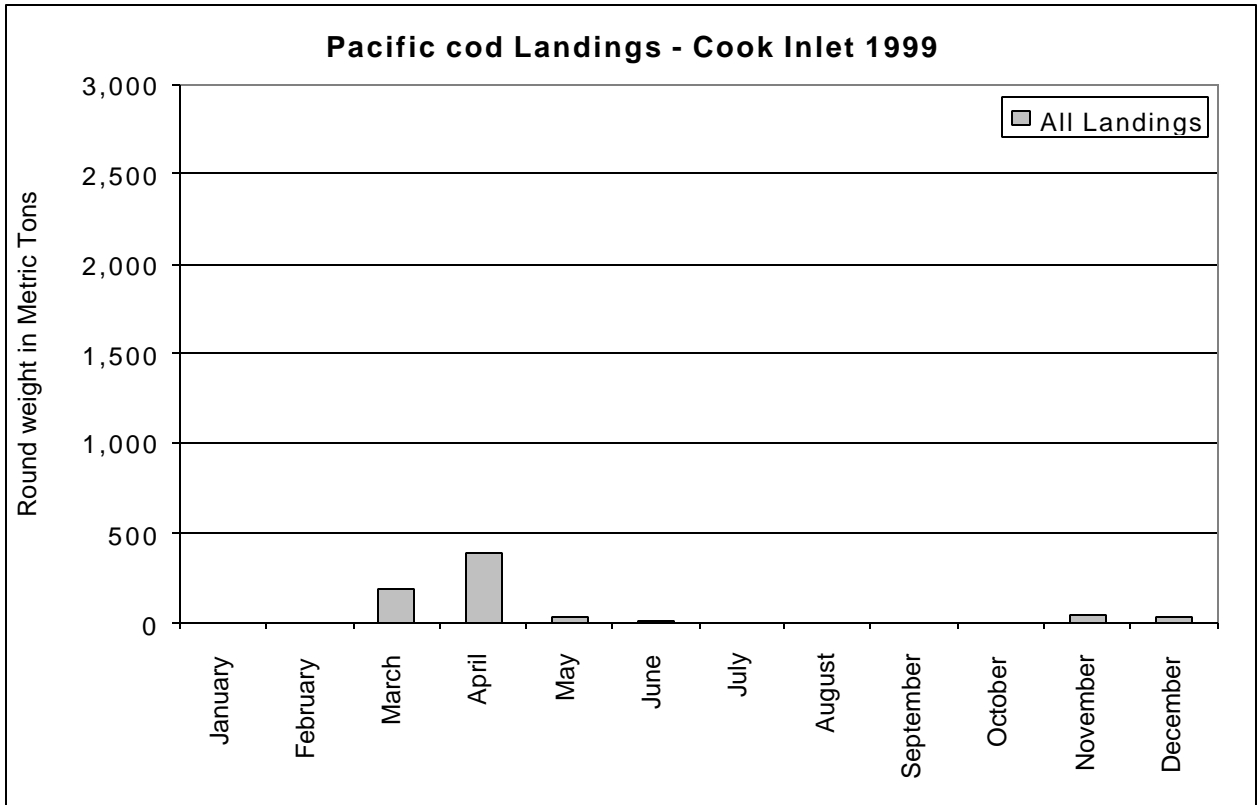


Figure 7.2 Monthly distribution of Pacific cod landings in Cook Inlet, 1999 (top), and Spatial distribution of Pacific cod landings in Cook Inlet, 1999 (bottom).

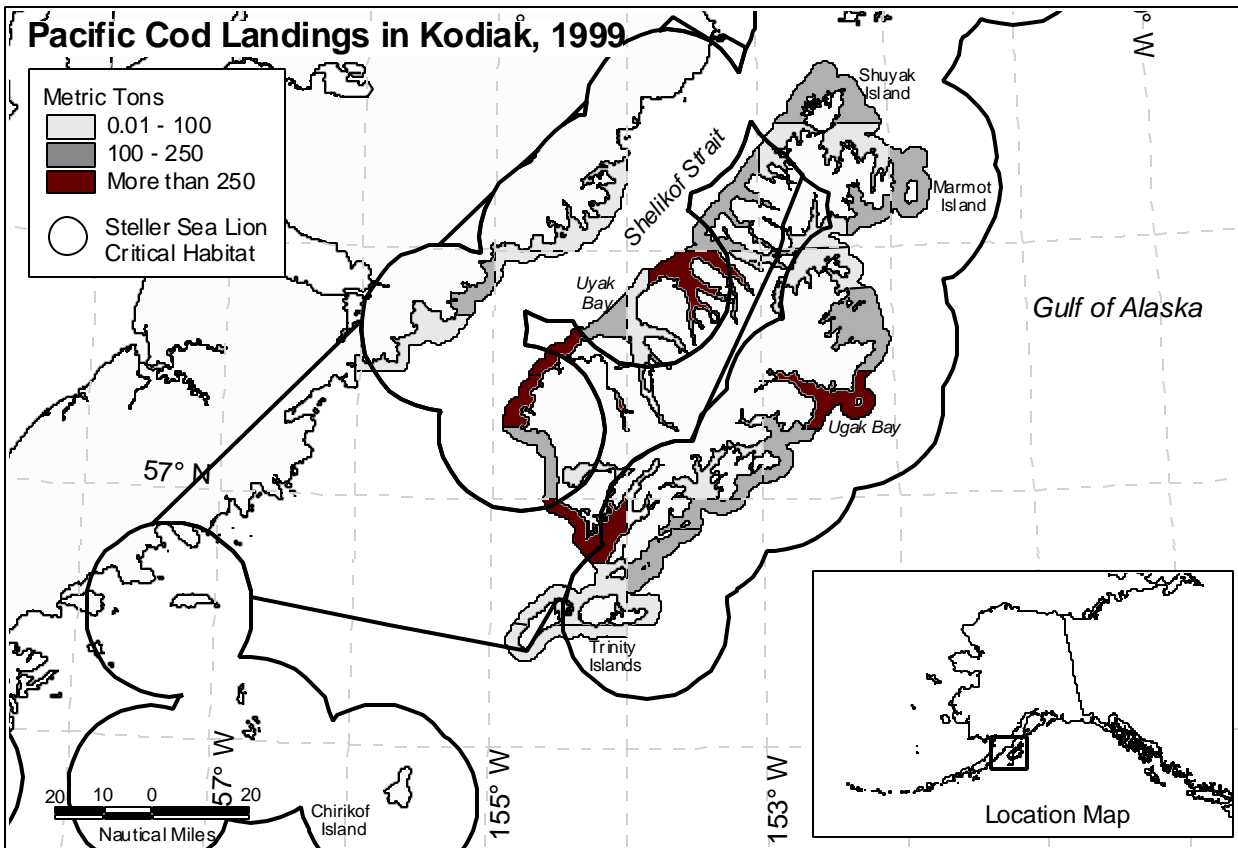
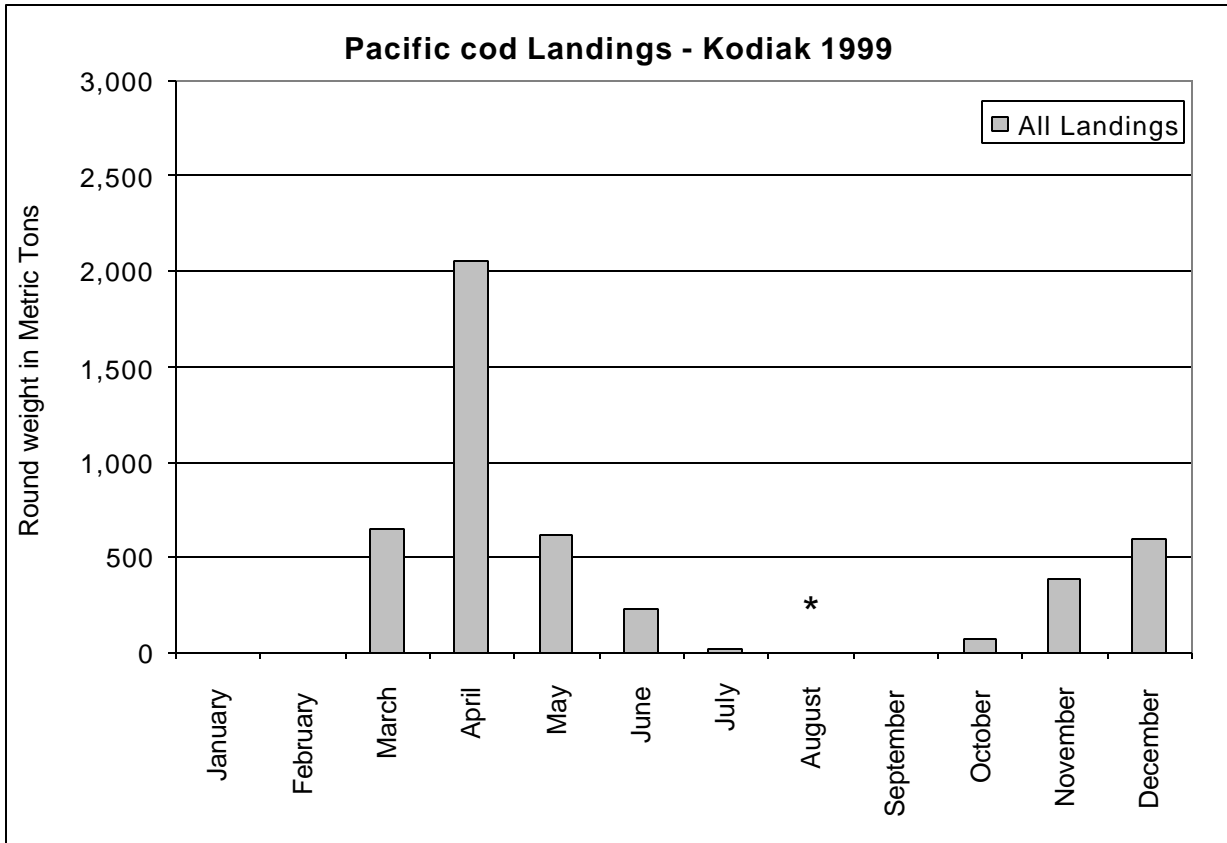


Figure 7.3 Monthly distribution of Pacific cod landings in Kodiak, 1999 (top), and Spatial distribution of Pacific cod landings in Kodiak, 1999 (bottom). * indicates confidential catch.

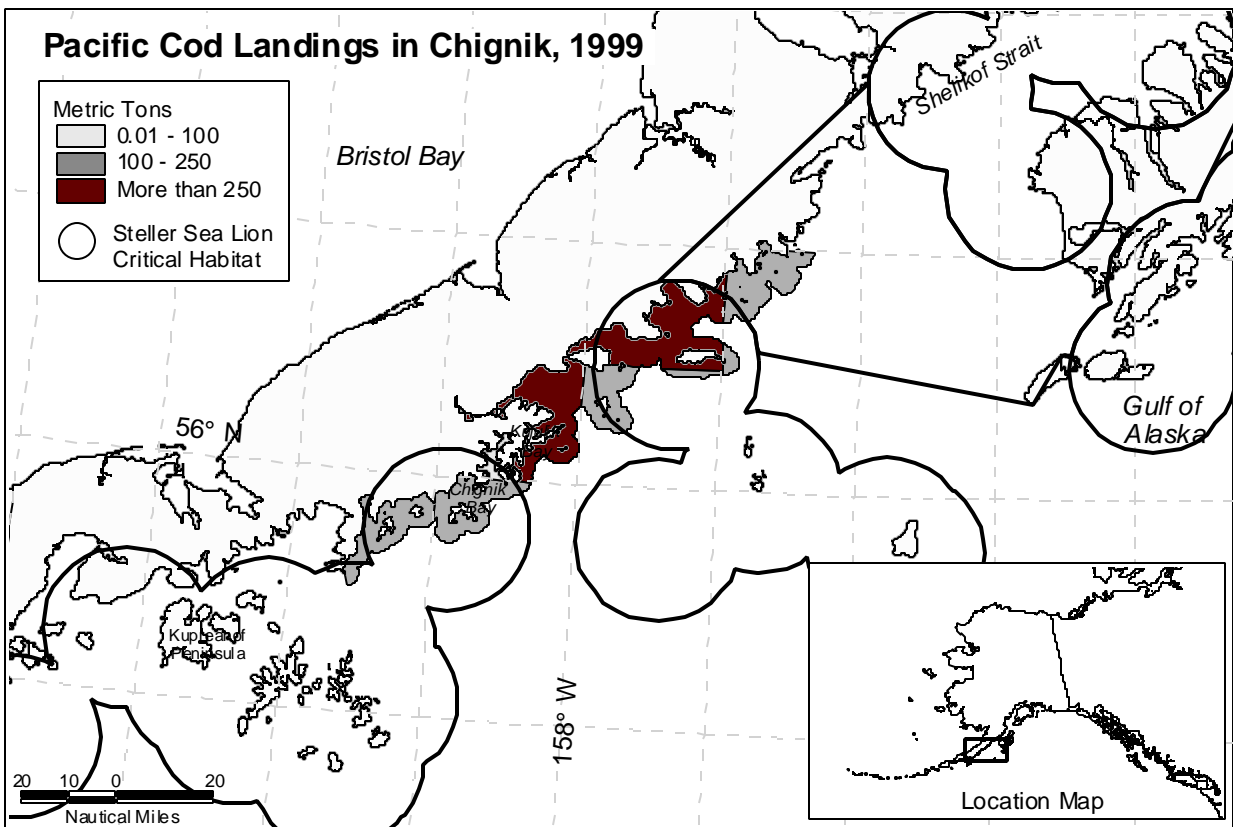
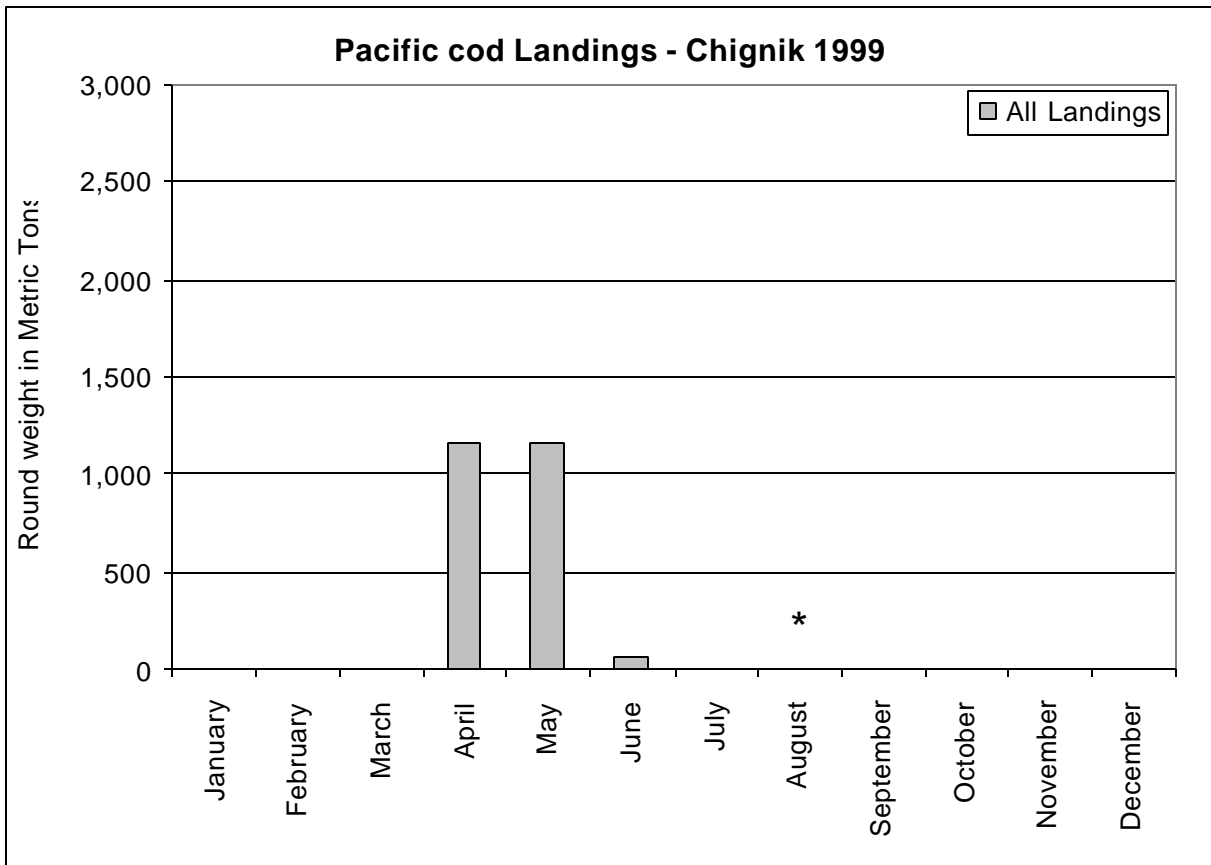


Figure 7.4 Monthly distribution of Pacific cod landings in Chignik, 1999 (top), and Spatial distribution of Pacific cod landings in Chignik, 1999 (bottom). * indicates confidential catch.

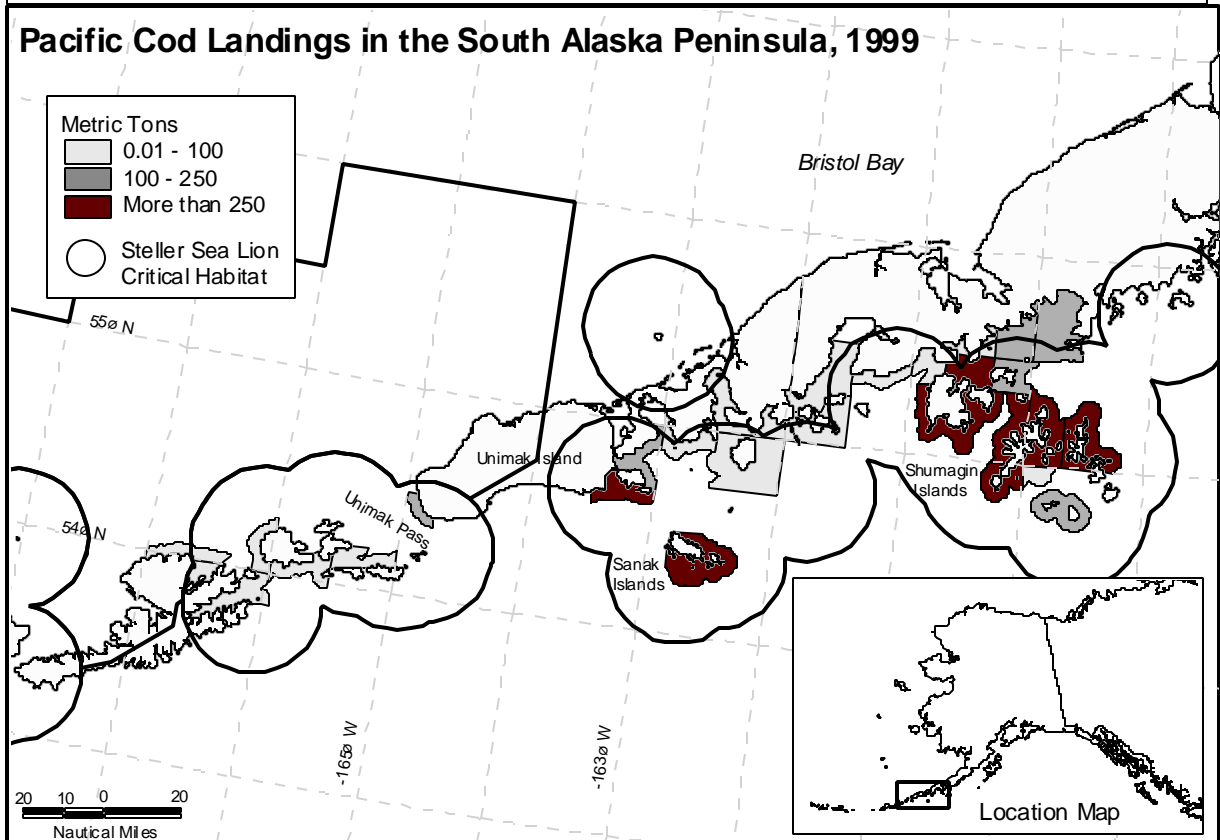
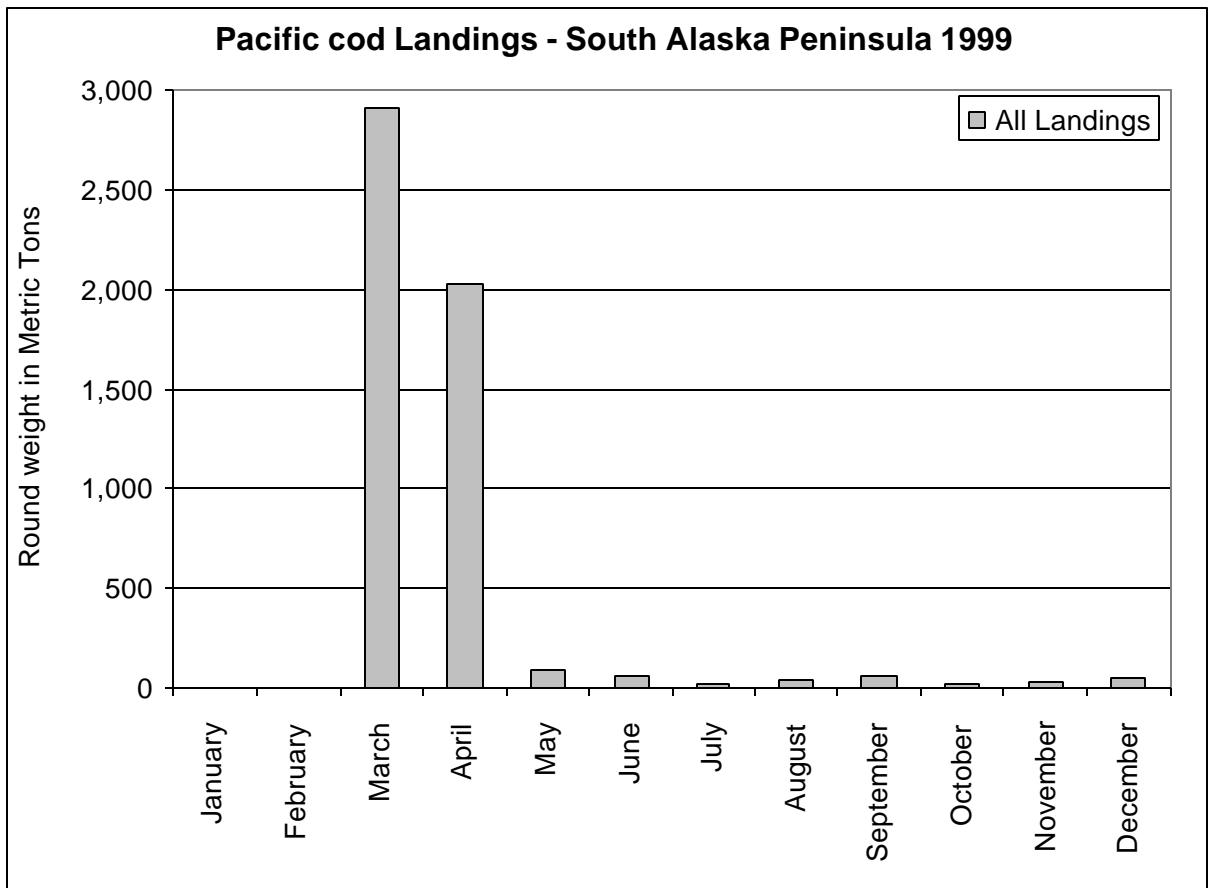


Figure 7.5 Monthly distribution of Pacific cod landings in the South Alaska Peninsula, 1999 (top), and Spatial distribution of Pacific cod landings in the South Alaska Peninsula, 1999 (bottom).

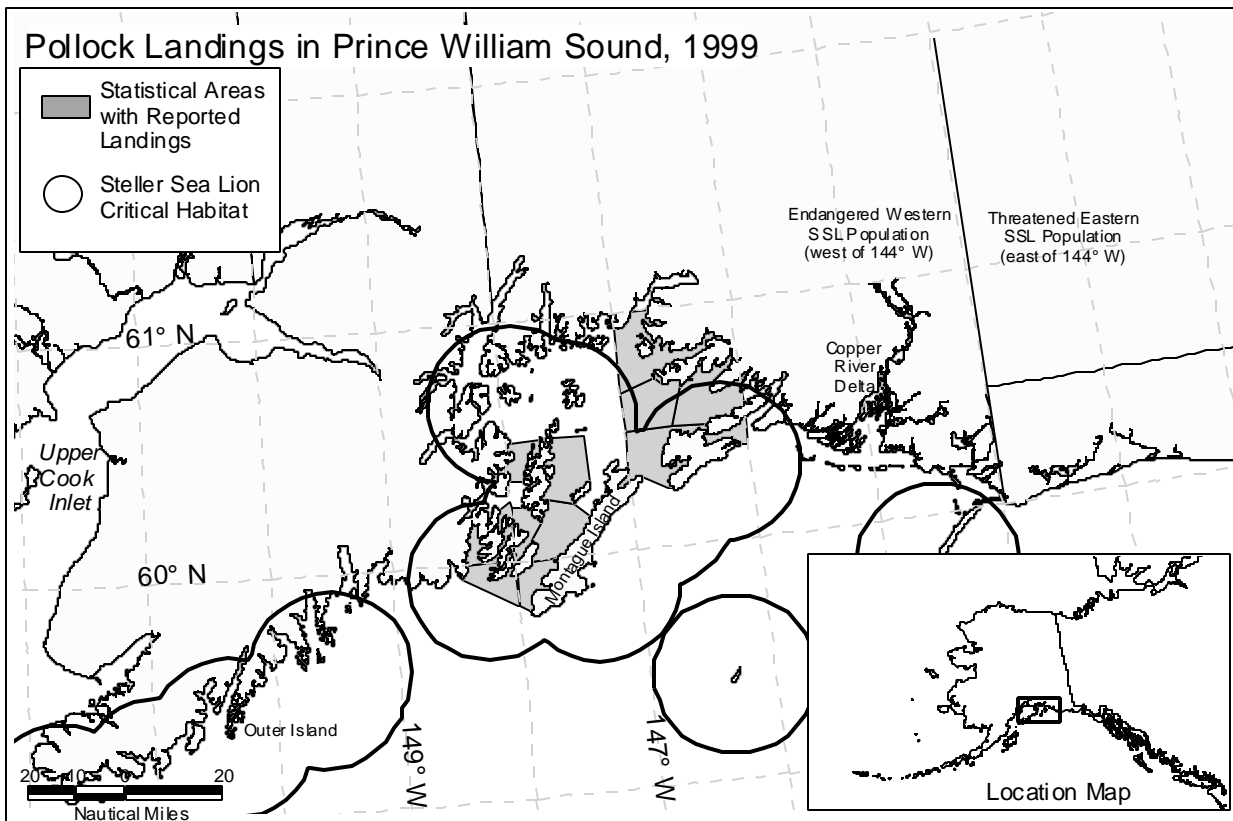
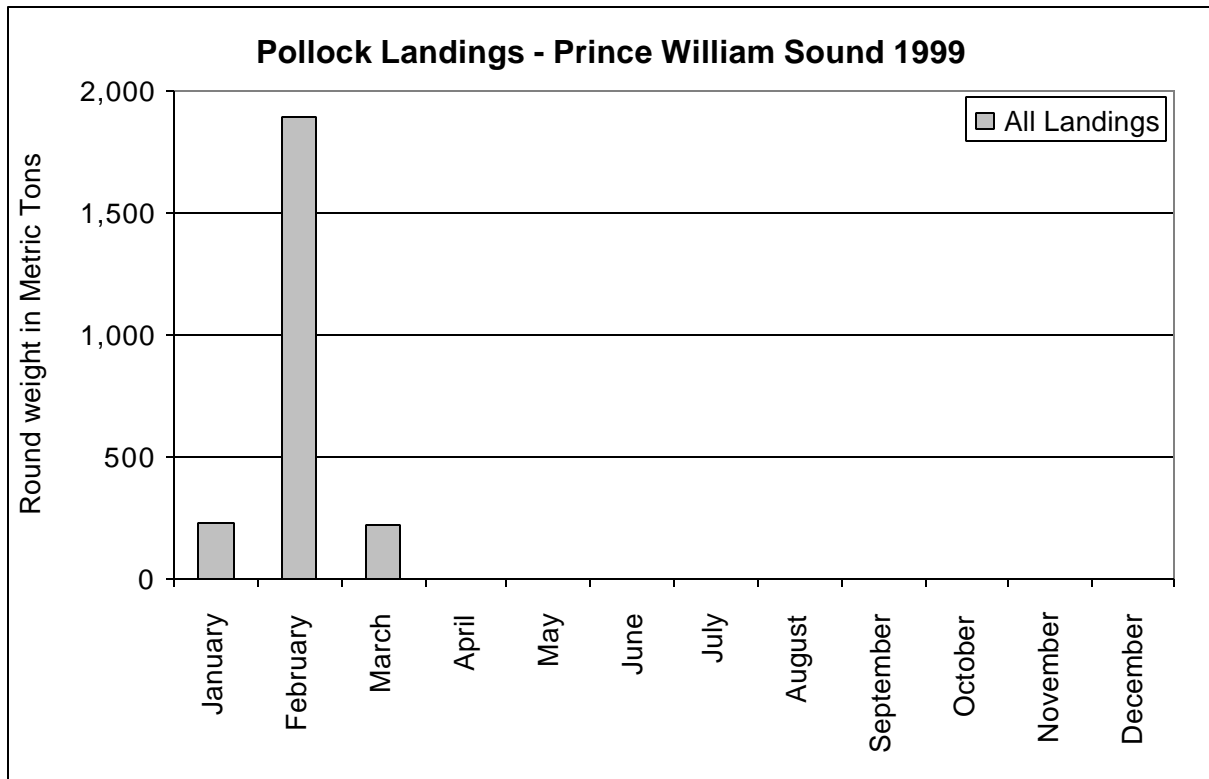


Figure 7.6 Monthly distribution of Pollock landings in Prince William Sound, 1999 (top), and Spatial distribution of Pollock landings in Prince William Sound, 1999 (bottom).

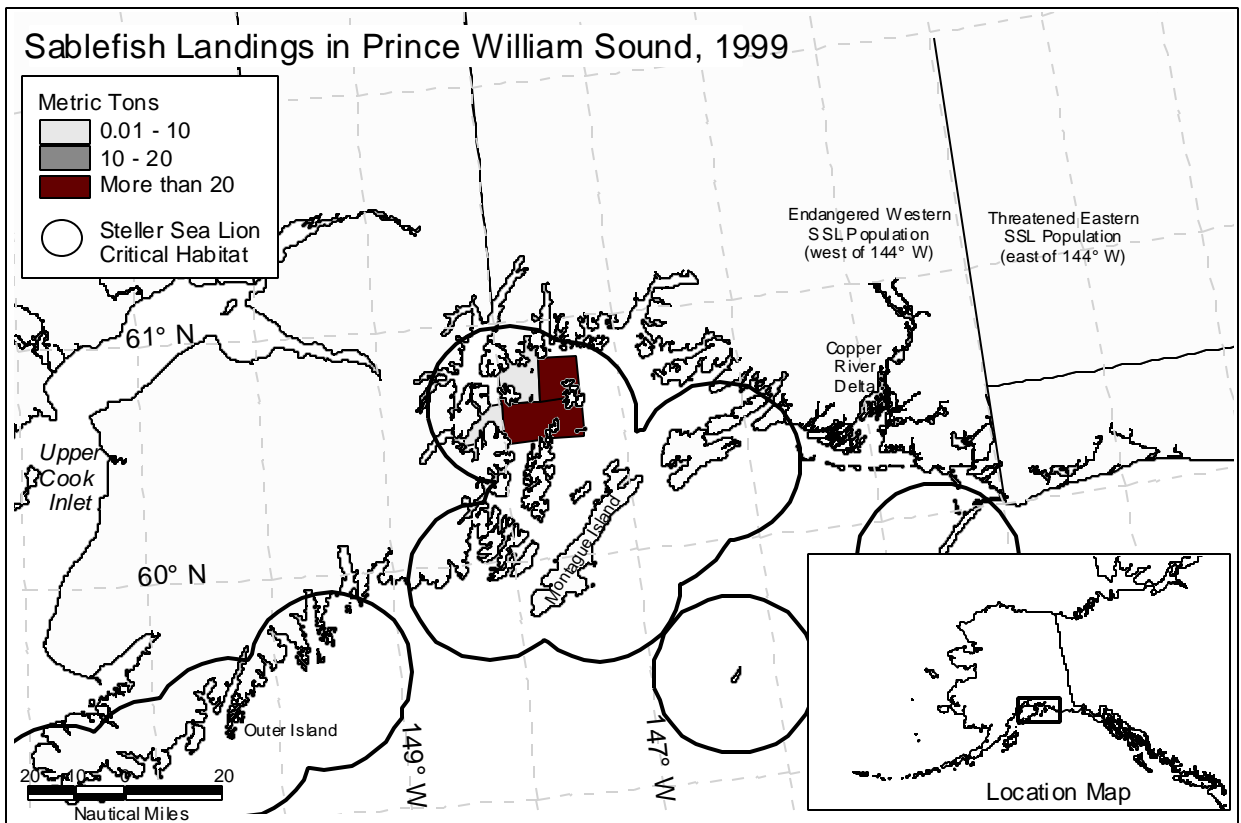


Figure 7.7 Monthly distribution of sablefish landings in Prince William Sound, 1999, cannot be reported for confidentiality reasons. Spatial distribution of sablefish landings in Prince William Sound, 1999 (bottom).

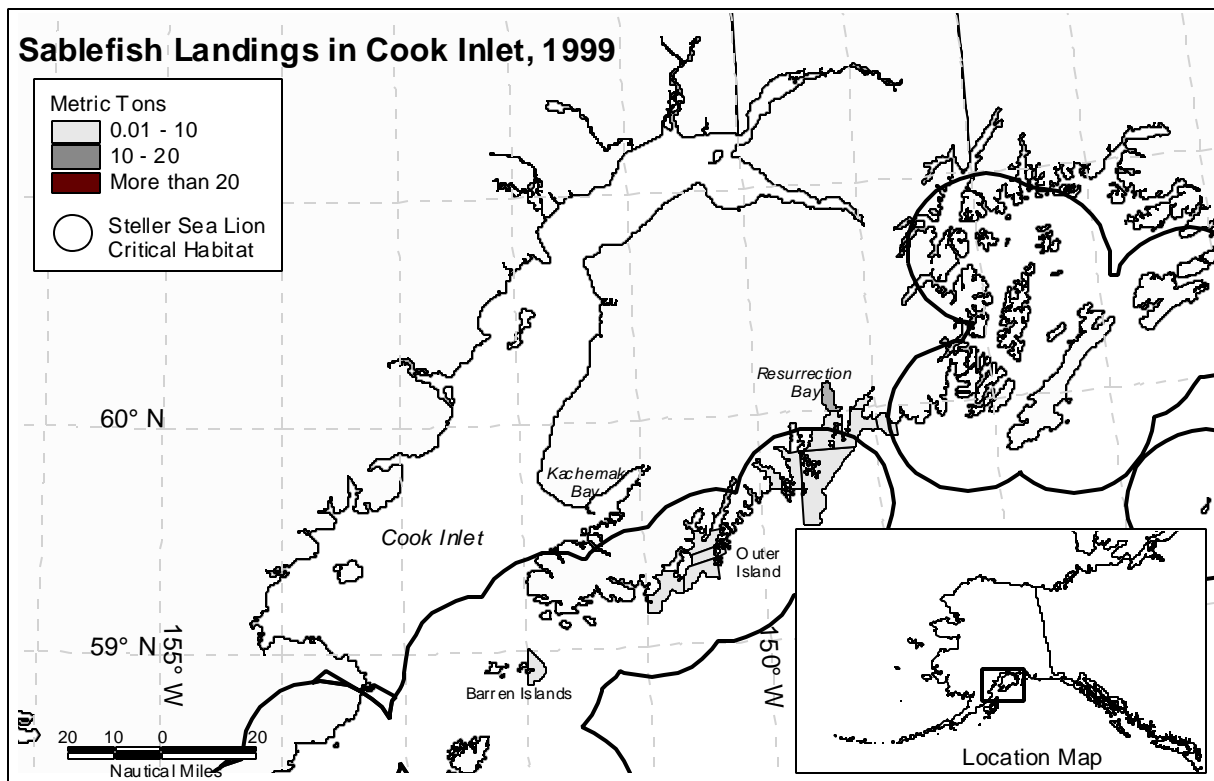
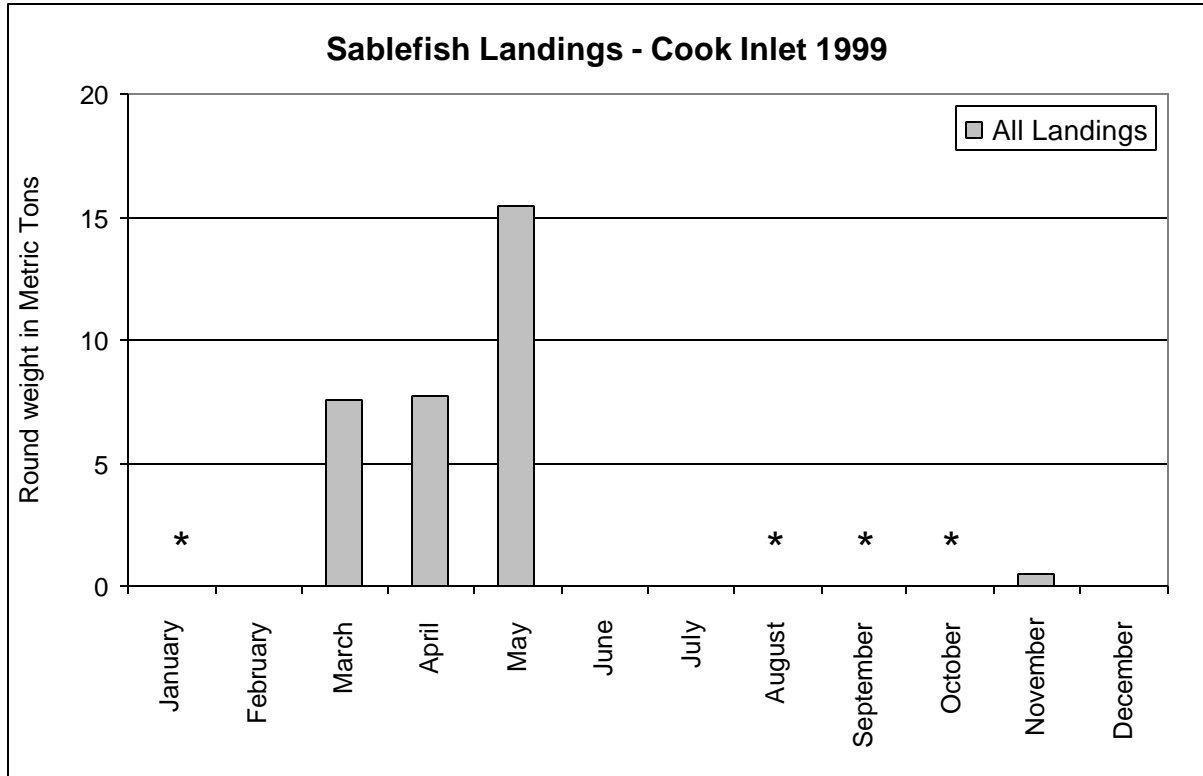
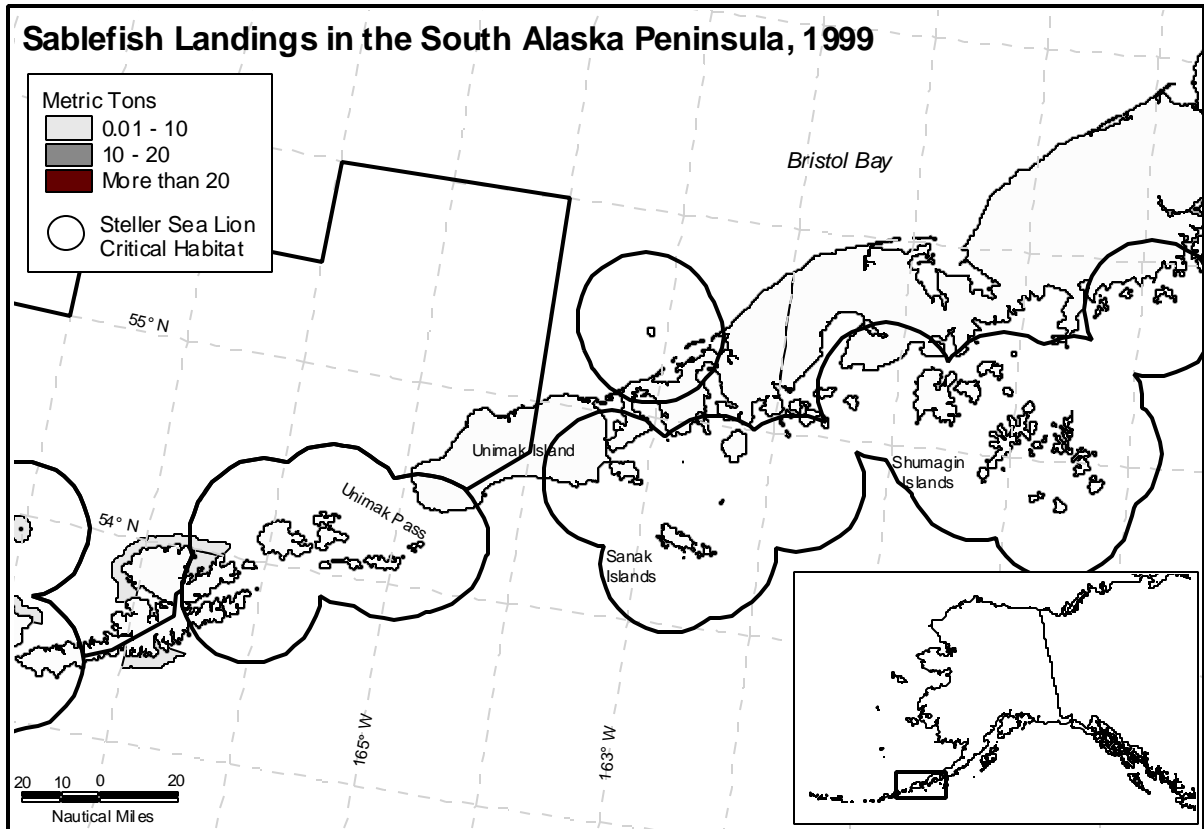
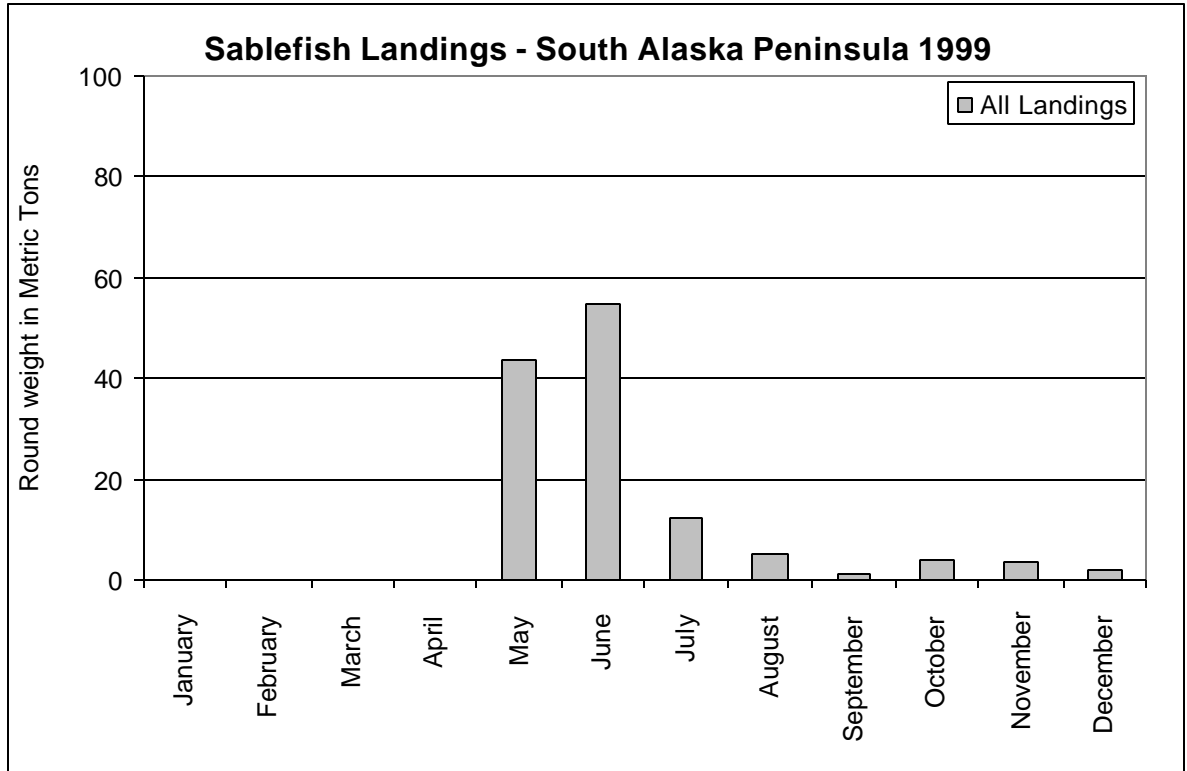


Figure 7.8 Monthly distribution of sablefish landings in Cook Inlet, 1999 (top), and Spatial distribution of sablefish landings in Cook Inlet, 1999 (bottom). * indicates confidential catch.



See Figure 7.9 caption on next page.

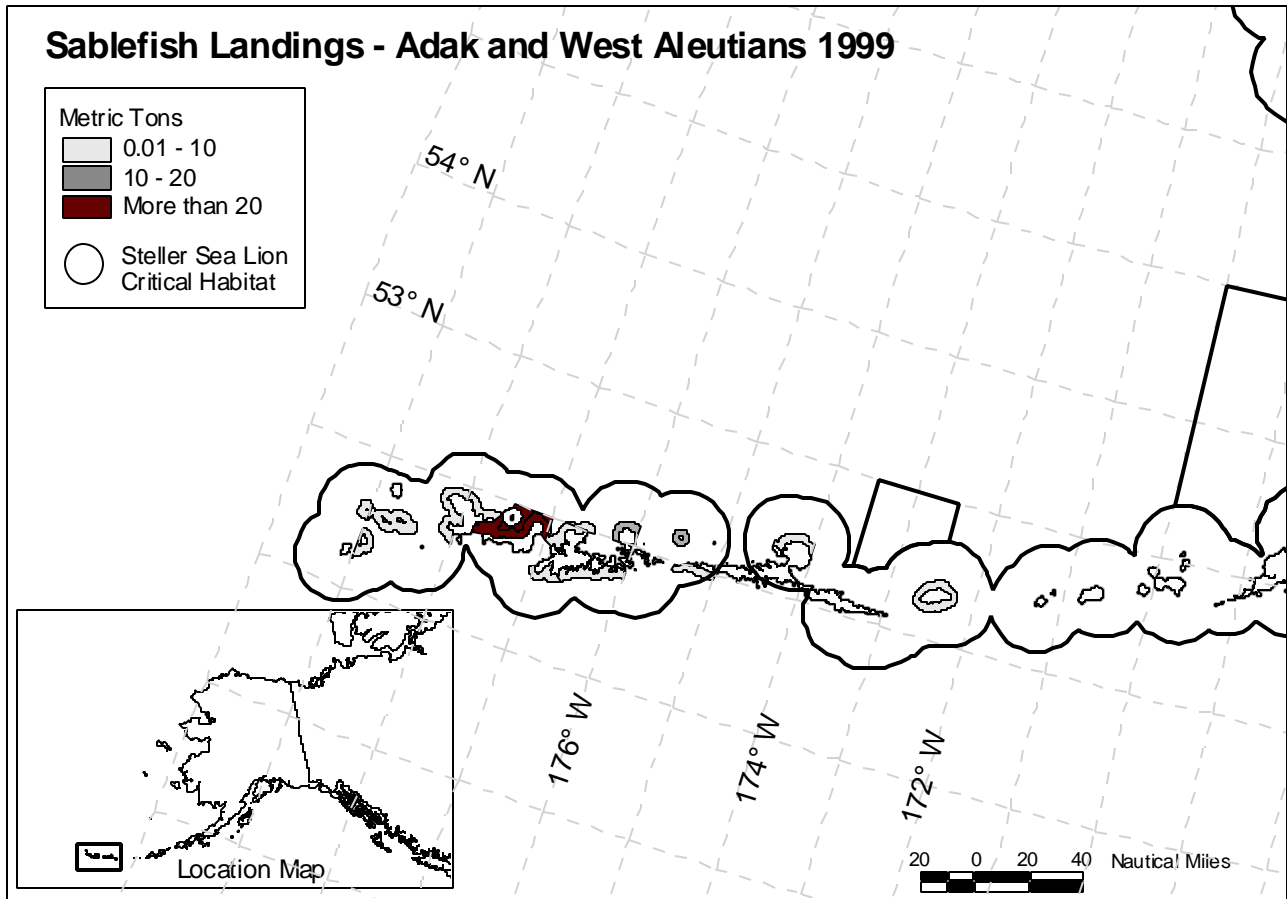


Figure 7.9 Monthly distribution of sablefish landings in the South Alaska Peninsula, 1999 (top), Spatial distribution of sablefish landings in the South Alaska Peninsula, 1999 (bottom), and Spatial distribution of sablefish landings in Adak/Aleutian Islands, 1999 (top of this page).

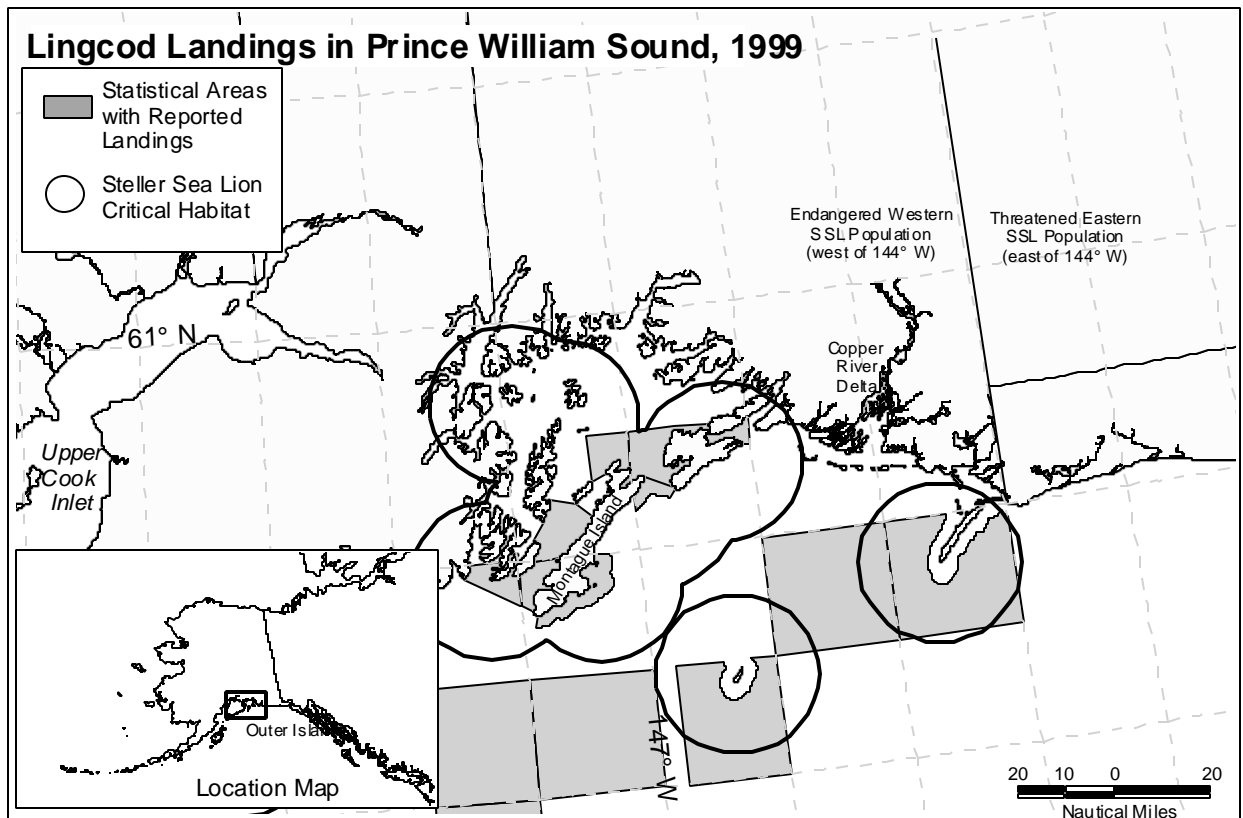
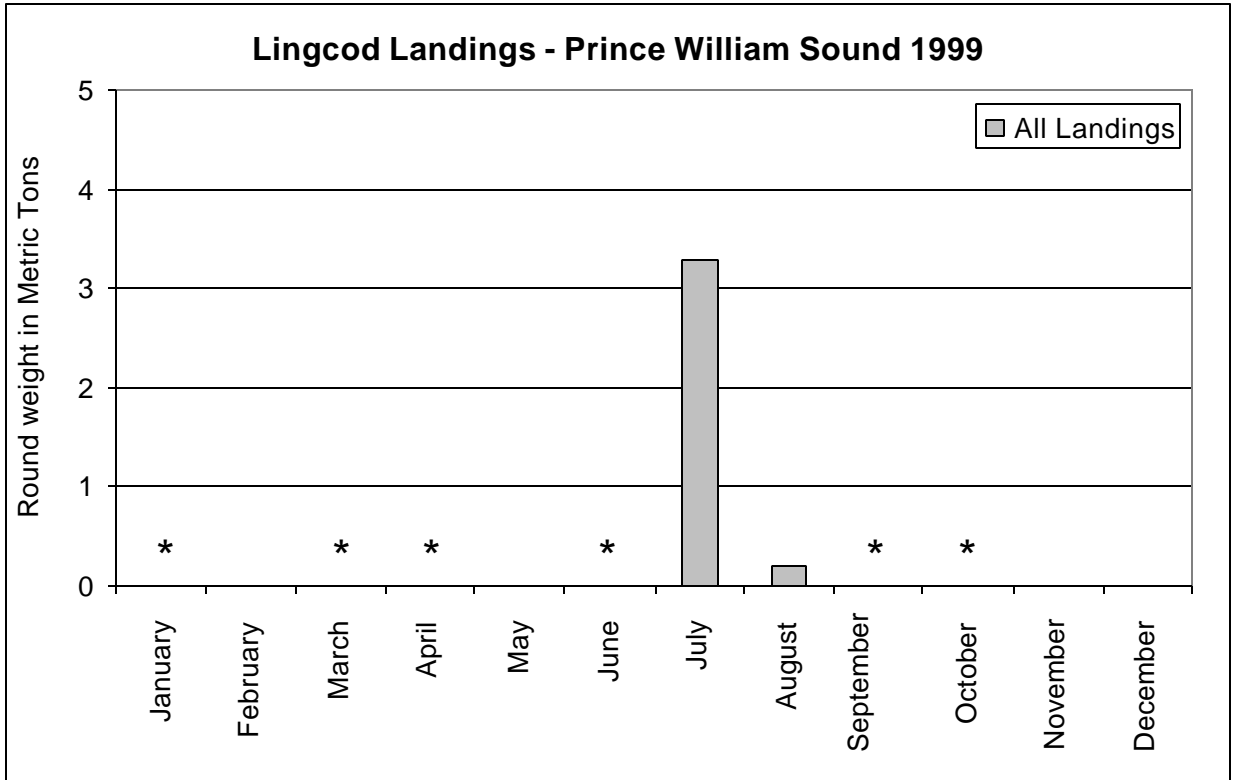


Figure 7.10 Monthly distribution of Lingcod landings in Prince William Sound, 1999 (top), and Spatial distribution of Lingcod landings in Prince William Sound, 1999 (bottom). * indicates confidential catch.

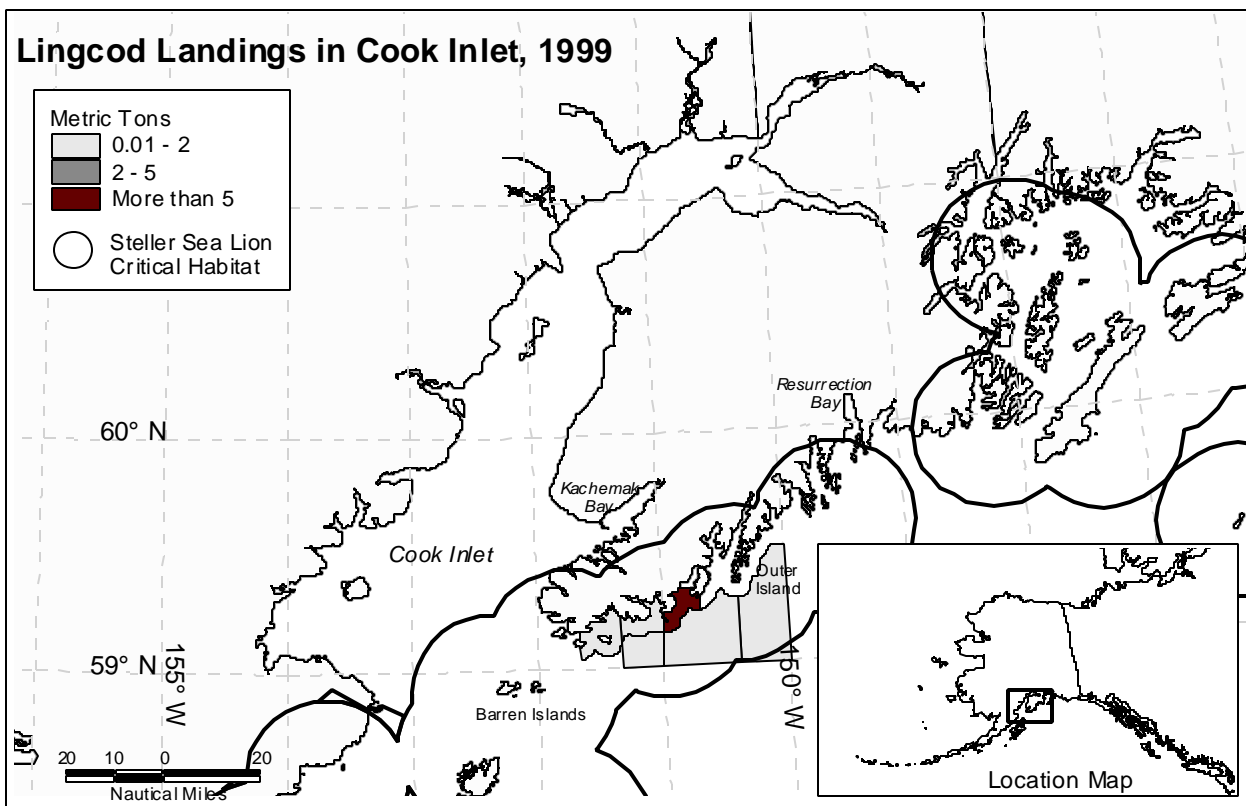
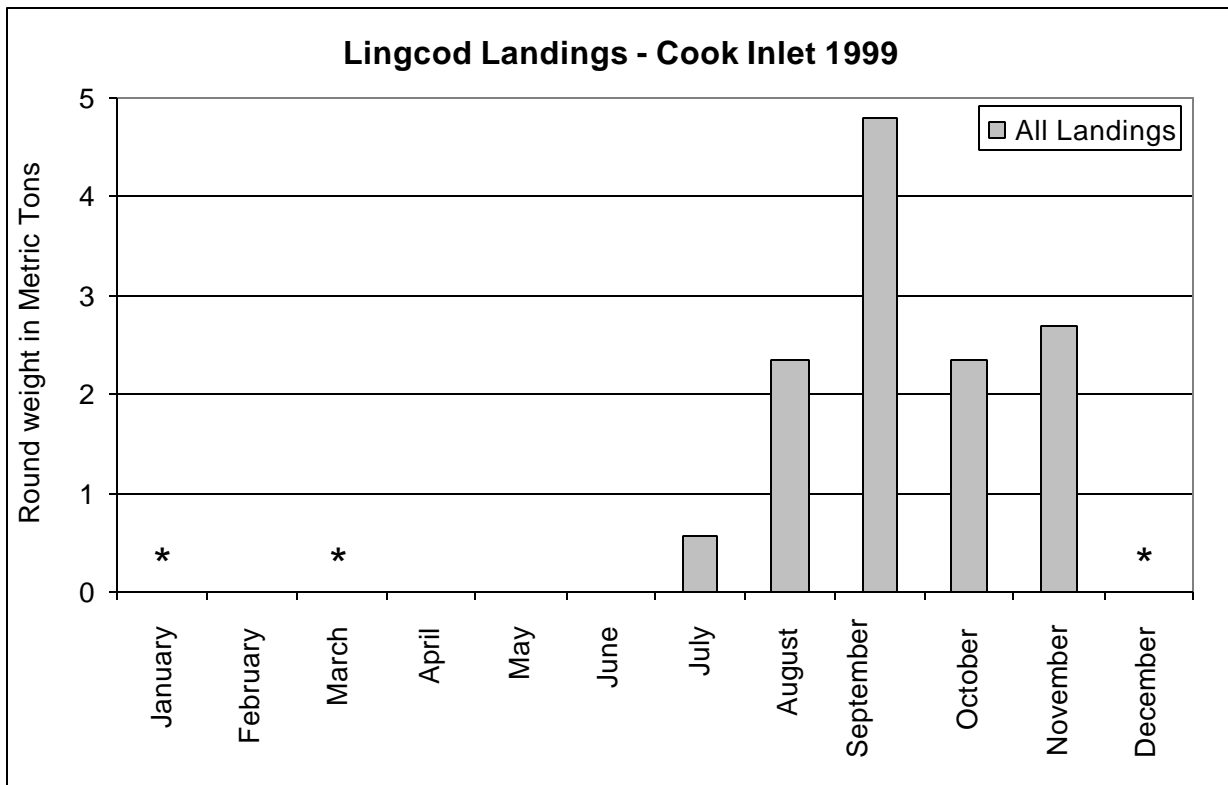


Figure 7.11 Monthly distribution of Lingcod landings in Cook Inlet, 1999 (top), and Spatial distribution of Lingcod landings in Cook Inlet, 1999 (bottom). * indicates confidential catch.

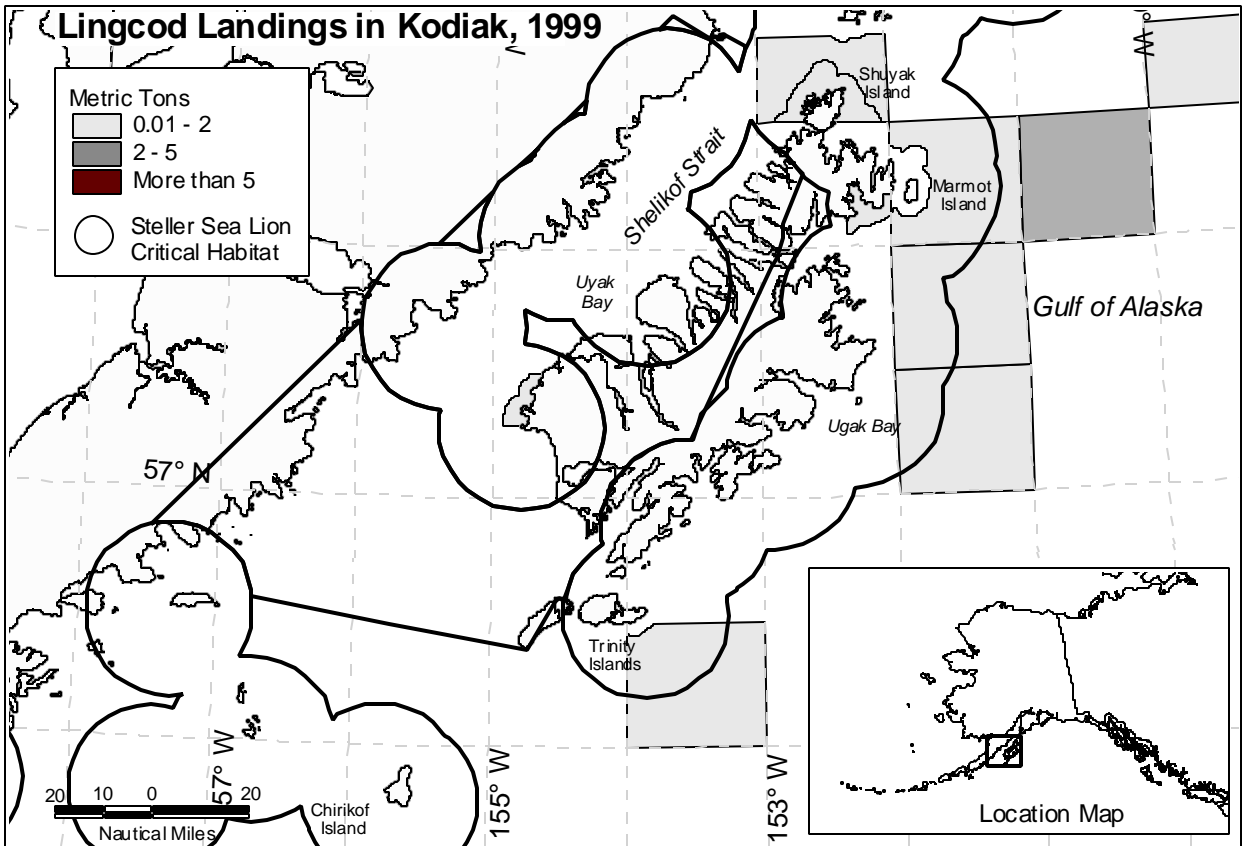
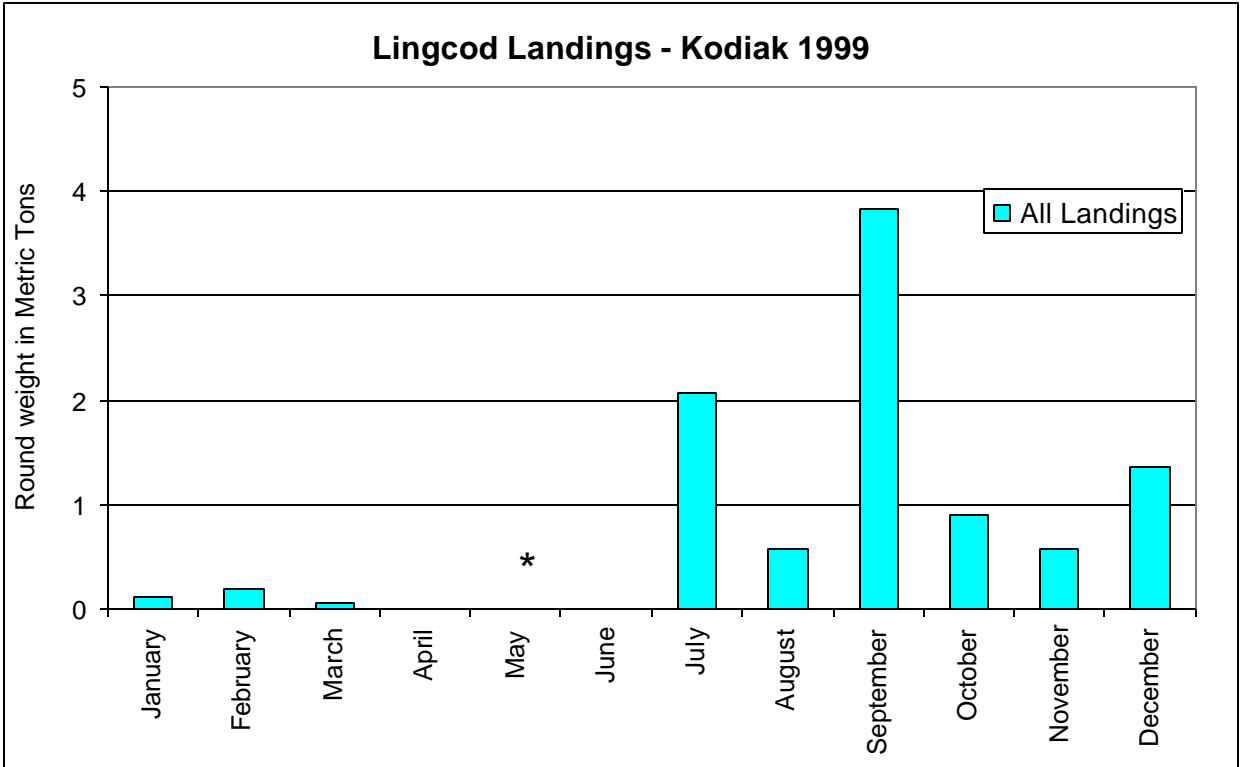


Figure 7.12 Monthly distribution of Lingcod landings in Kodiak, 1999 (top), and Spatial distribution of Lingcod landings in Kodiak, 1999 (bottom). * indicates confidential catch.

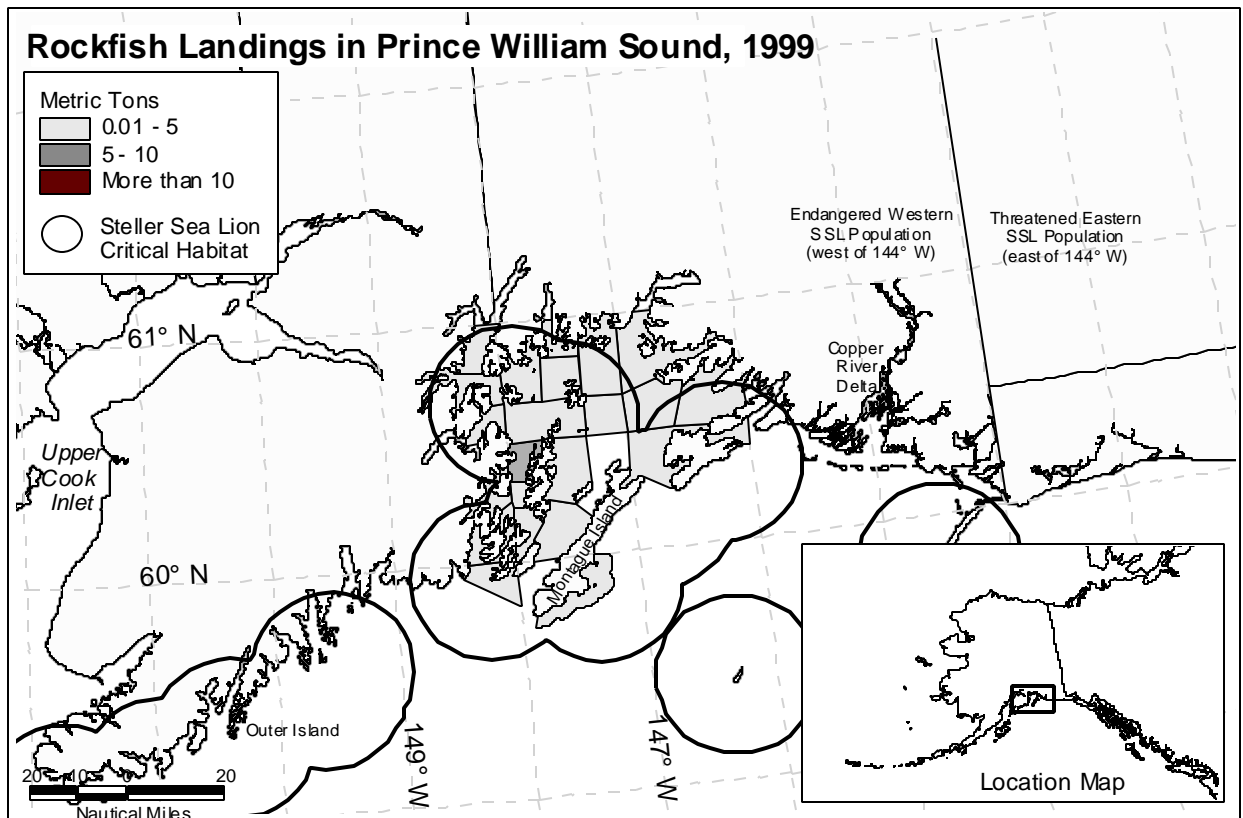
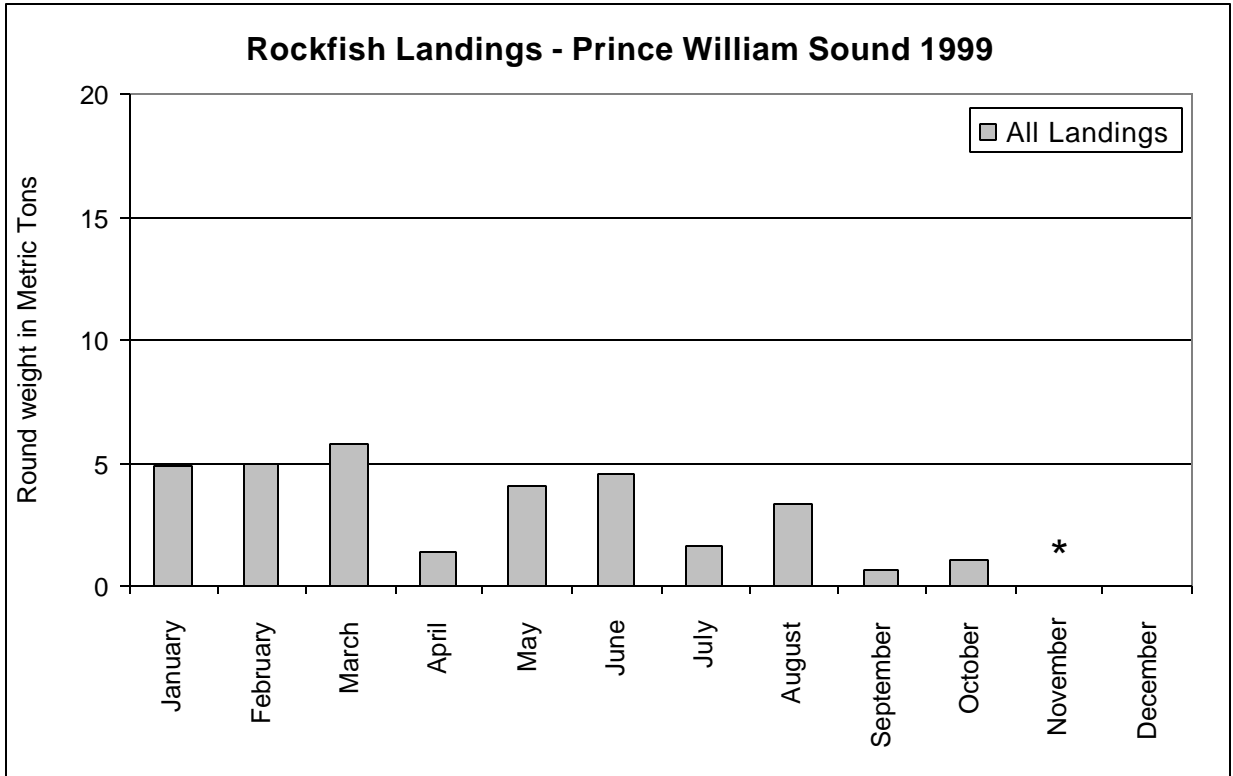


Figure 7.13 Monthly distribution of Black Rockfish landings in Prince William Sound, 1999 (top), and Spatial distribution of Black Rockfish landings in Prince William Sound, 1999 (bottom). * indicates confidential catch.

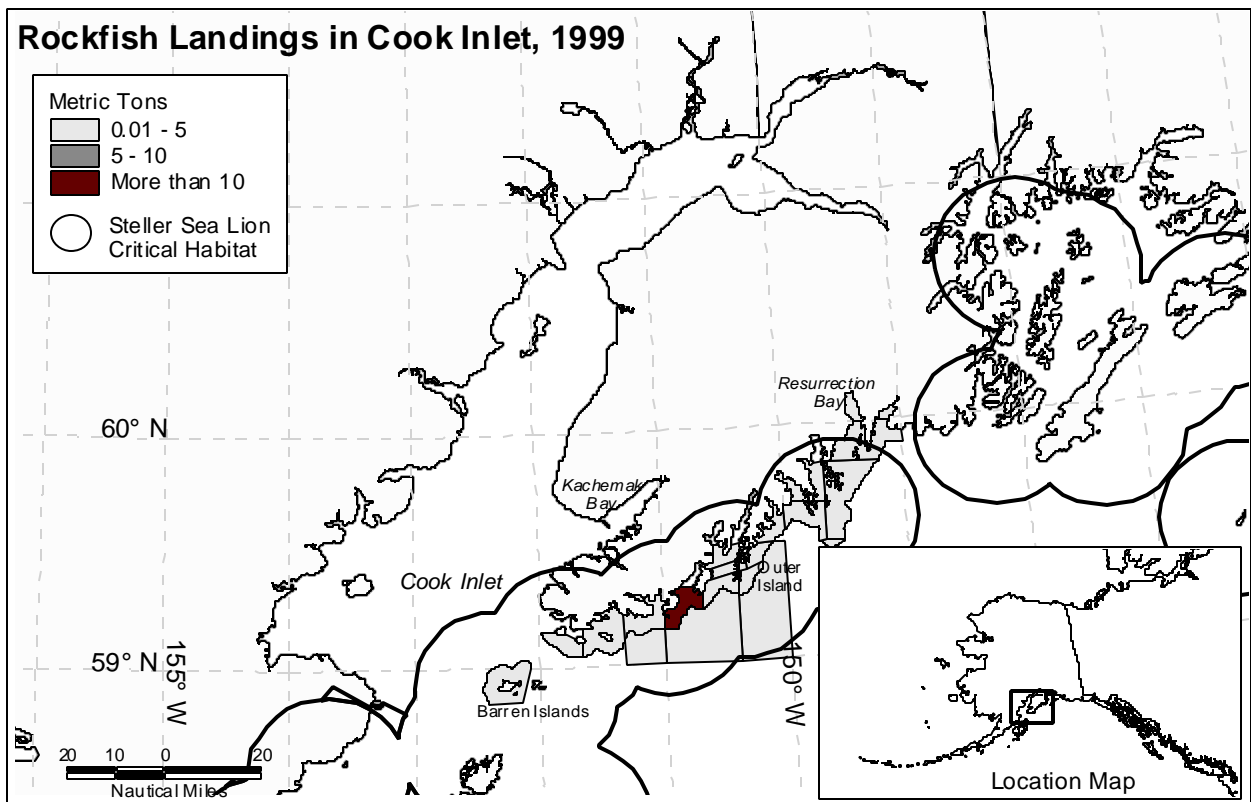
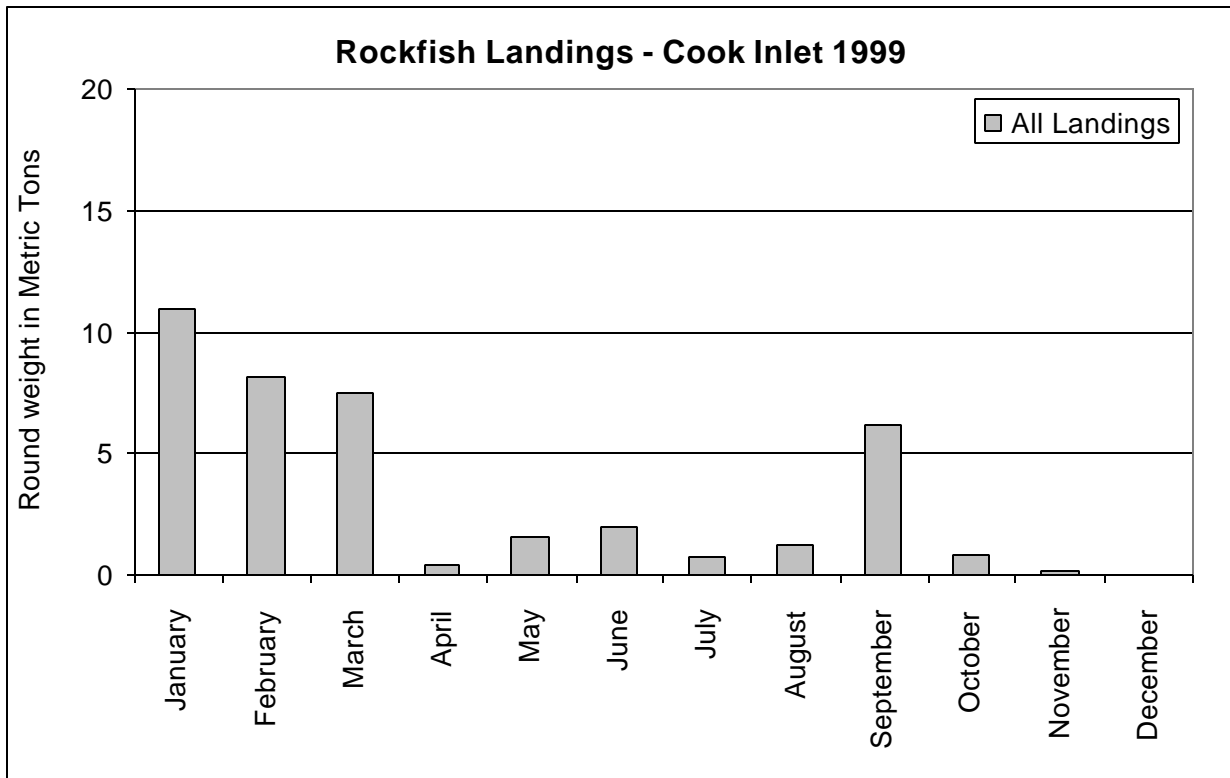


Figure 7.14 Monthly distribution of Black Rockfish landings in Cook Inlet, 1999 (top), and Spatial distribution of Black Rockfish landings in Cook Inlet, 1999 (bottom).

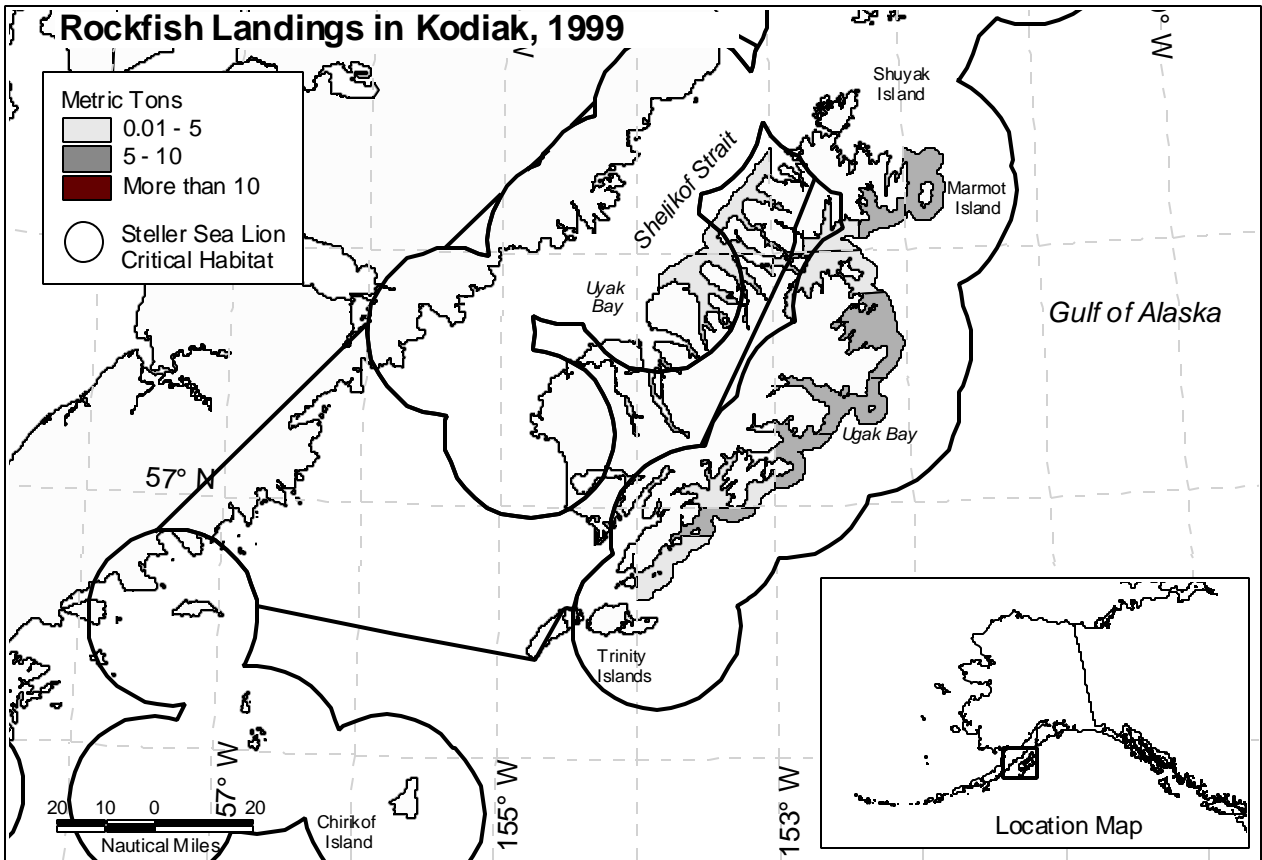
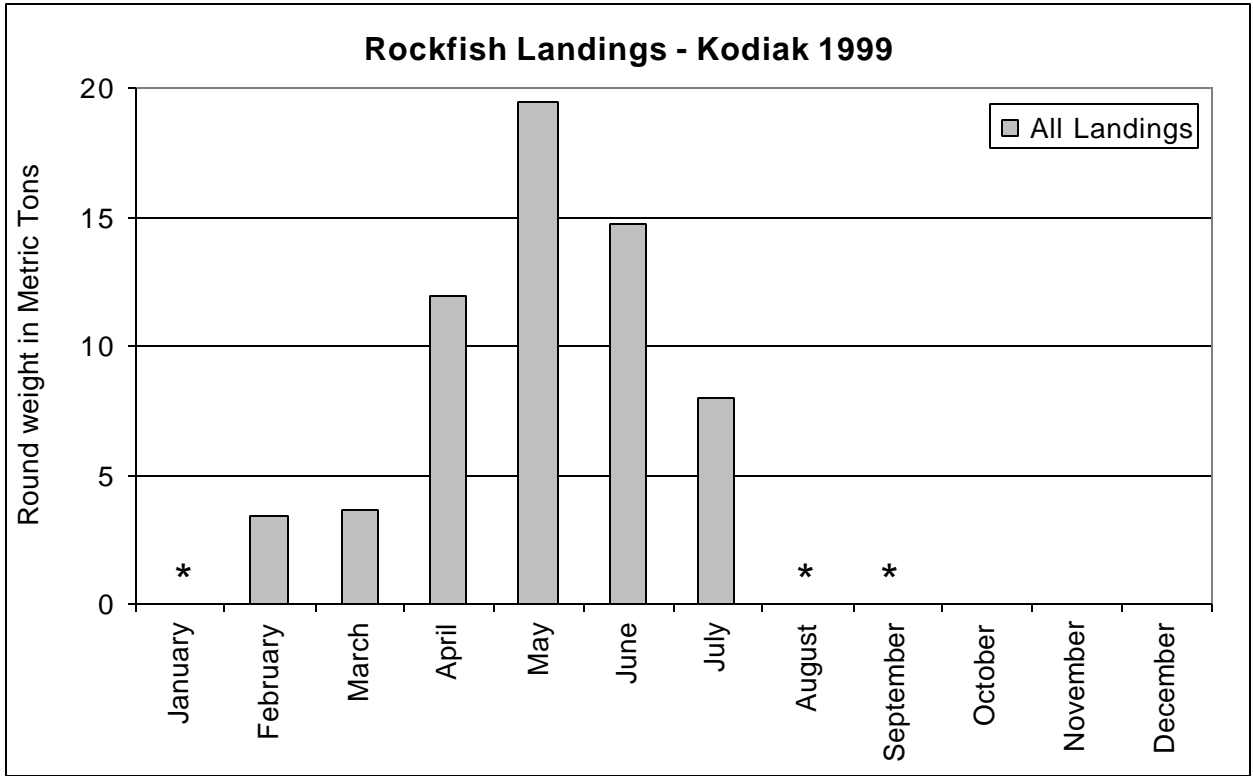


Figure 7.15 Monthly distribution of Black Rockfish landings in Kodiak, 1999 (top), and Spatial distribution of Black Rockfish landings in Kodiak, 1999 (bottom). * indicates confidential catch.

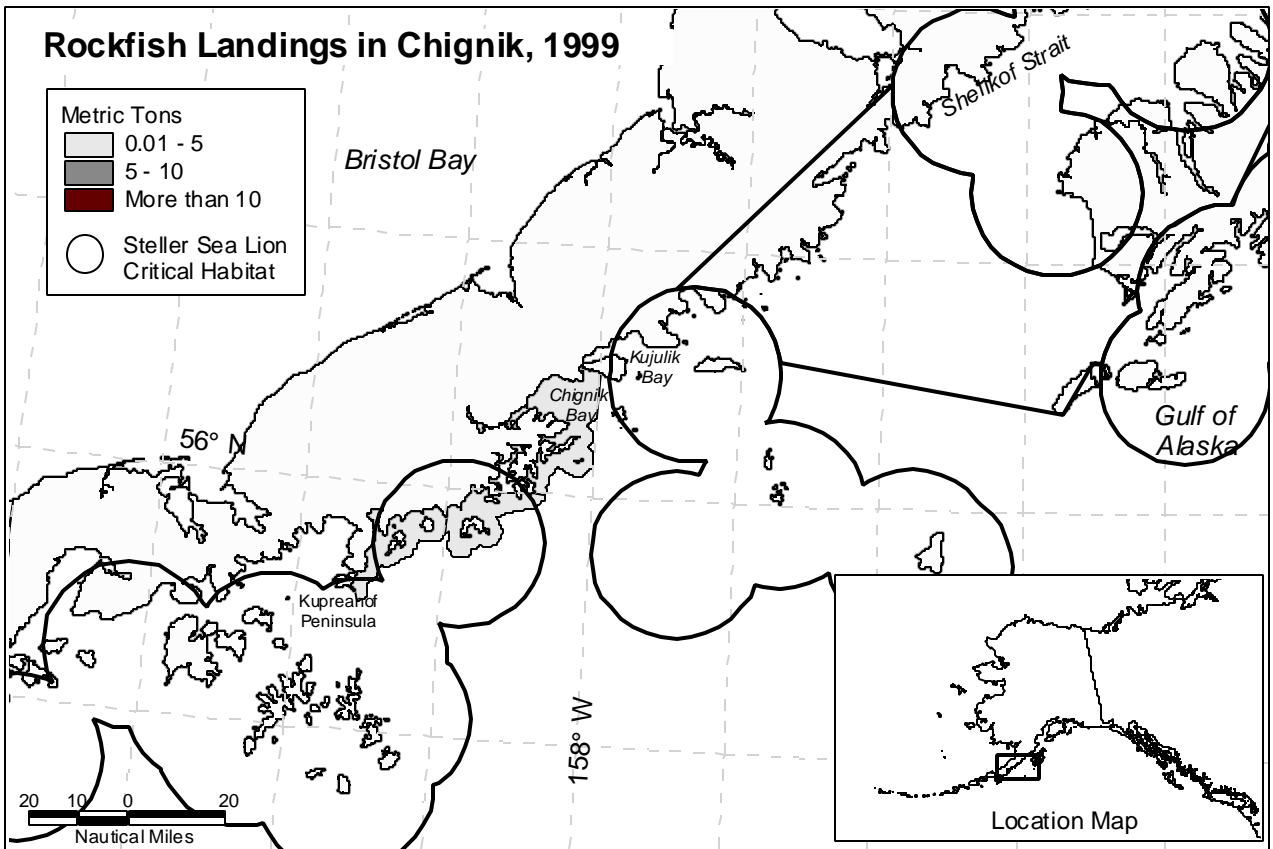
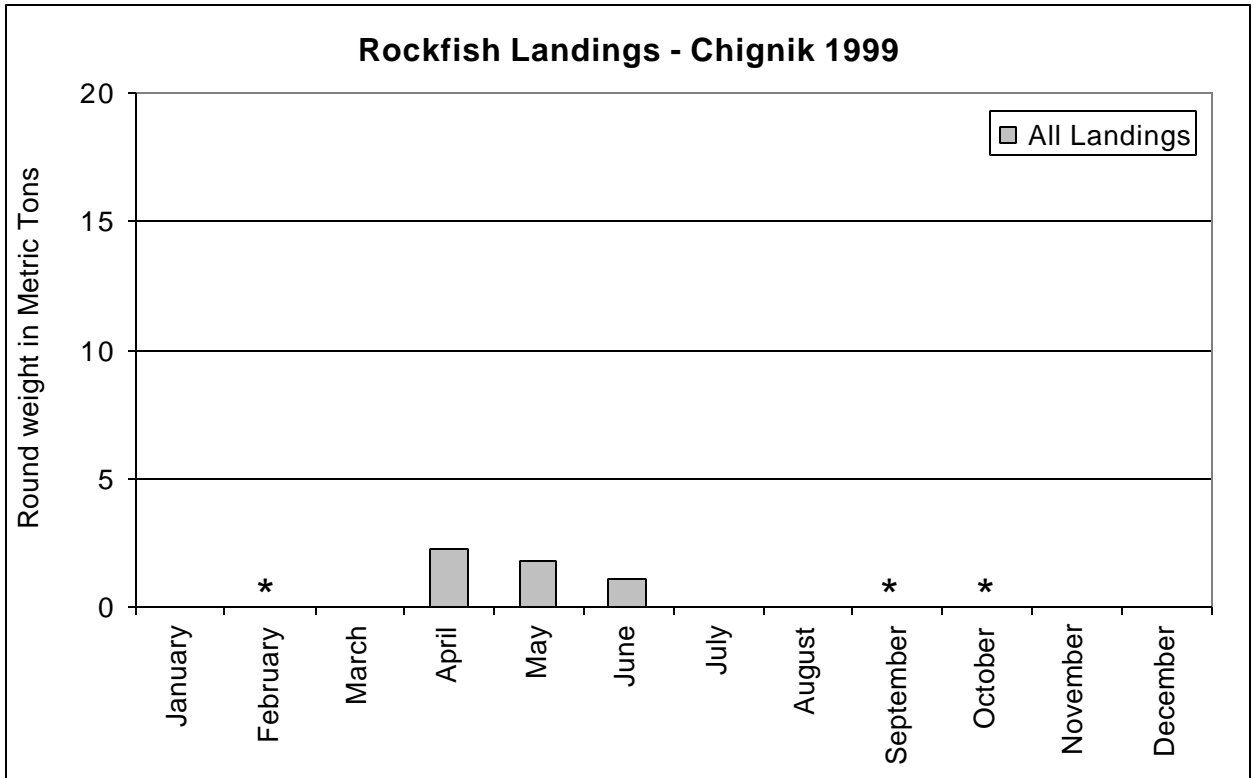


Figure 7.16 Monthly distribution of Black Rockfish landings in Chignik, 1999 (top), and Spatial distribution of Black Rockfish landings in Chignik, 1999 (bottom). * indicates confidential catch.

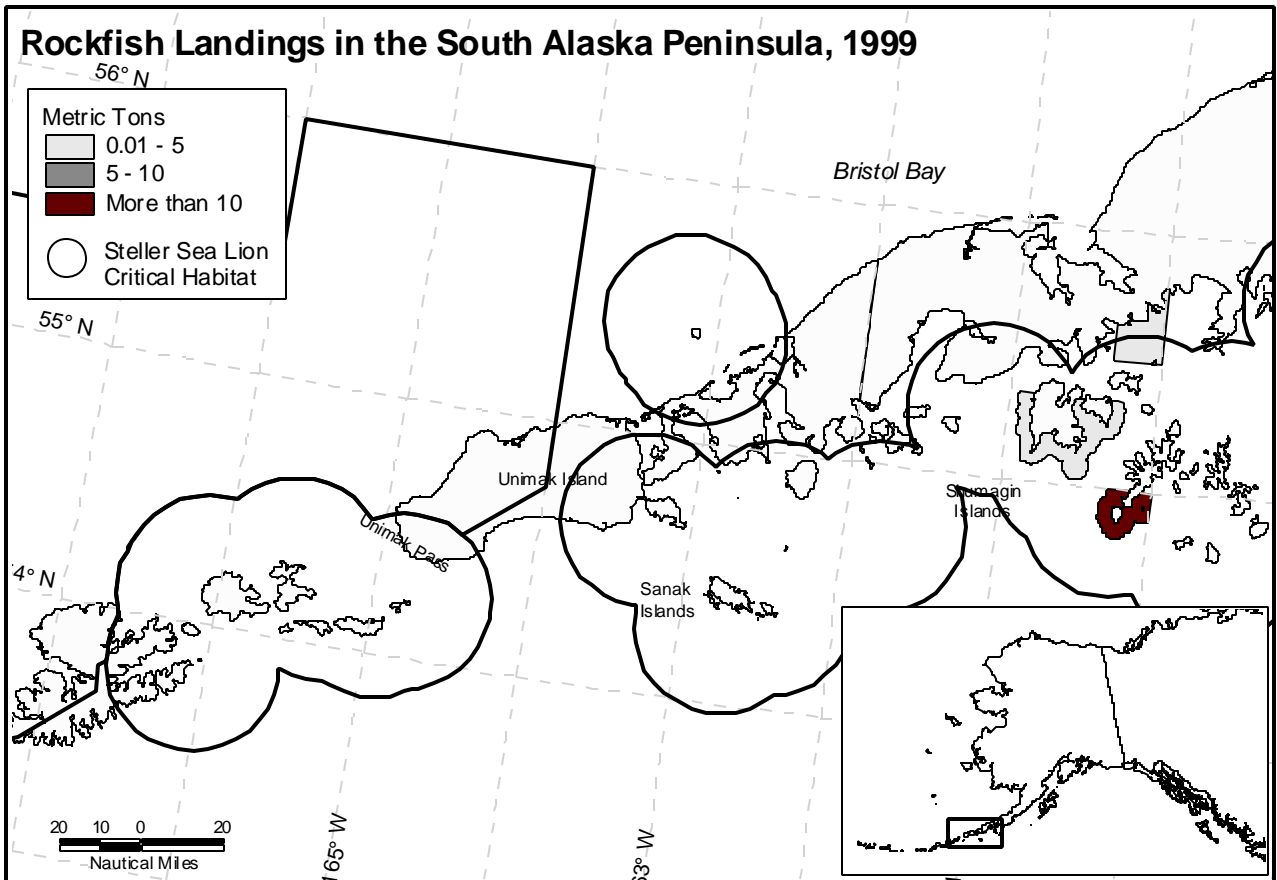
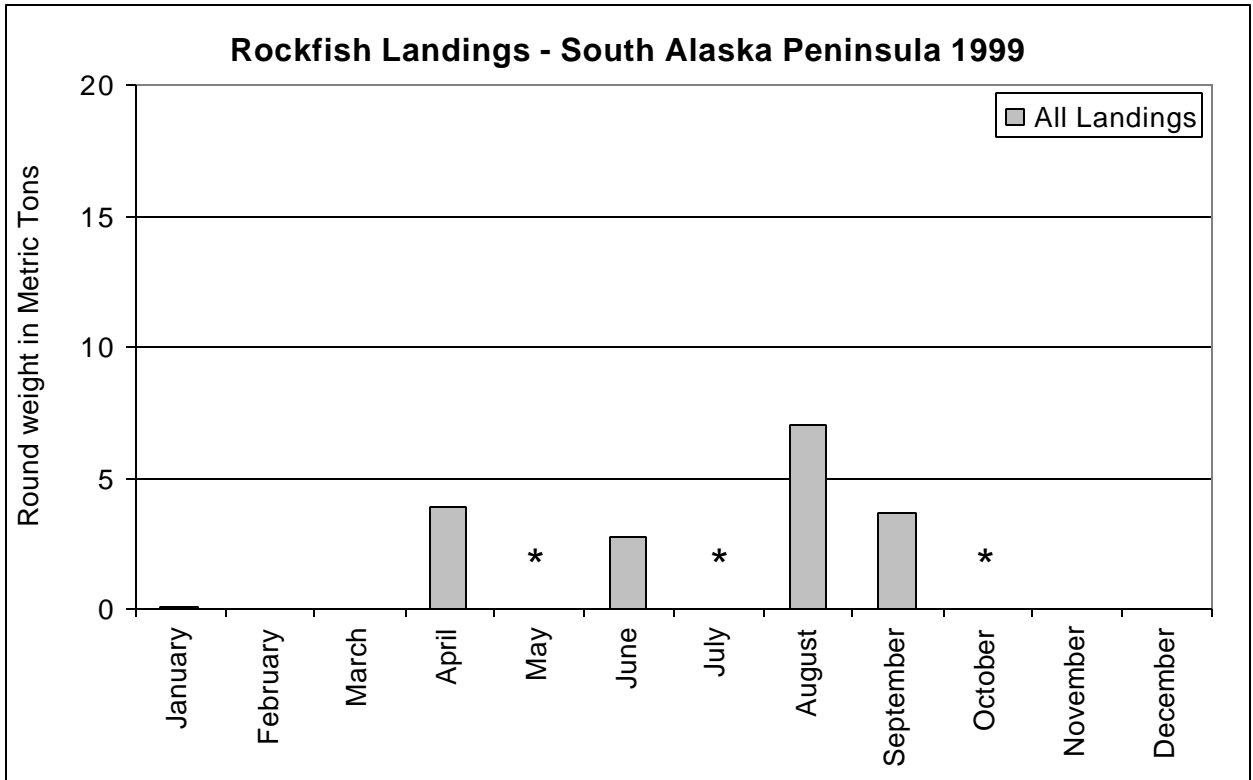


Figure 7.17 Monthly distribution of Black Rockfish landings in the South Alaska Peninsula, 1999 (top), and Spatial distribution of Black Rockfish landings in the South Alaska Peninsula, 1999 (bottom). * indicates confidential catch.

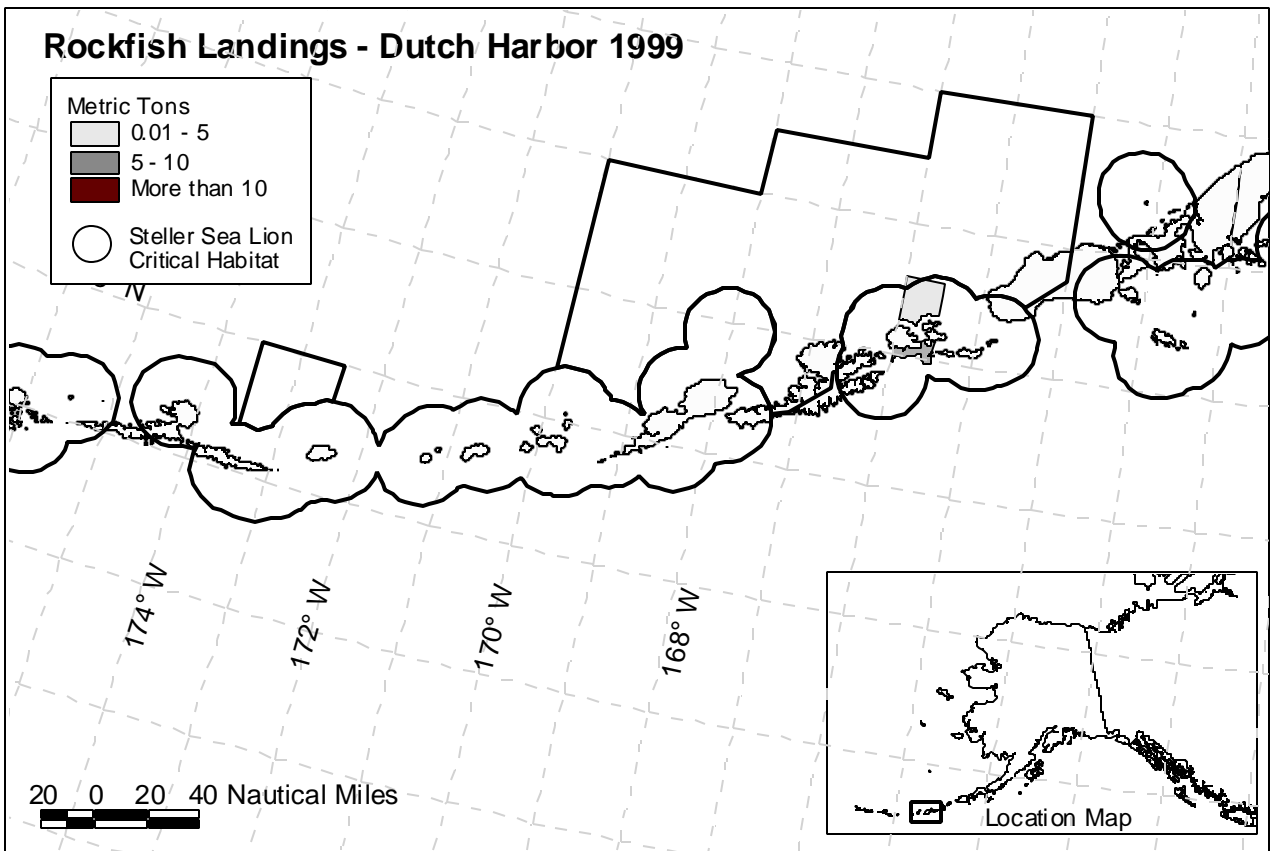
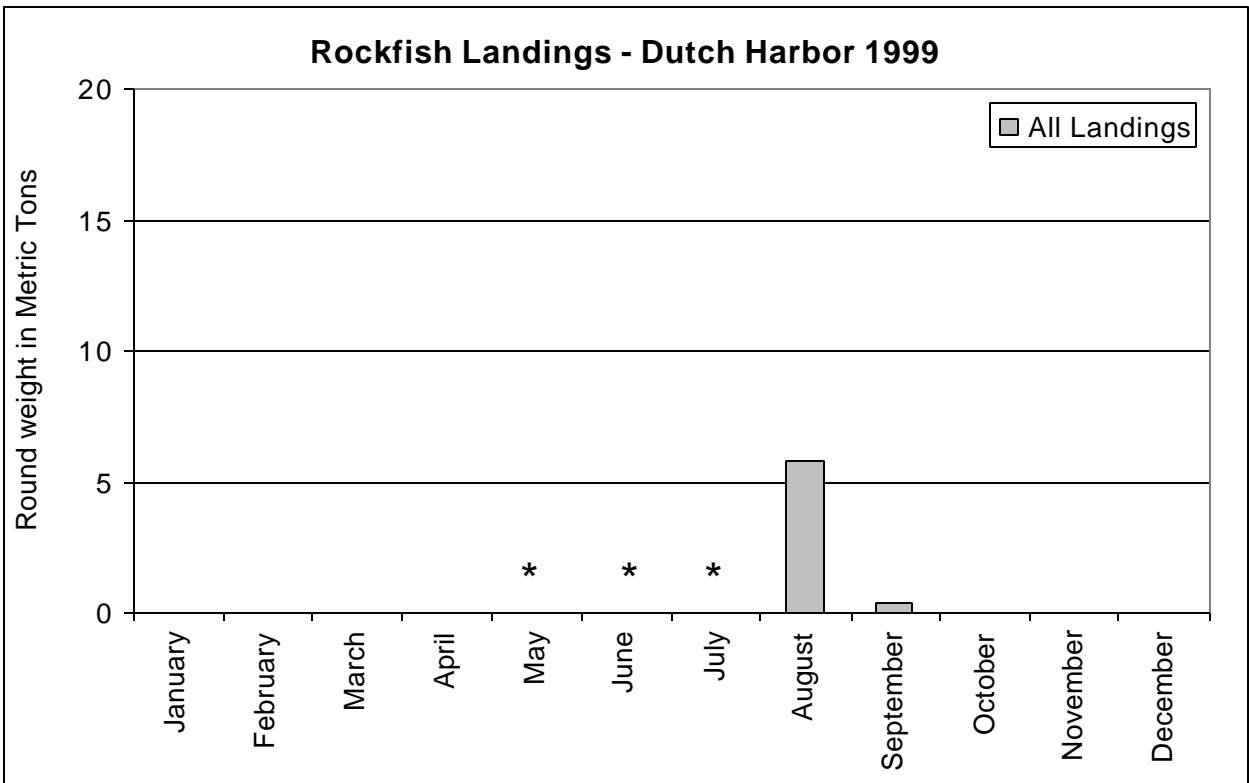


Figure 7.18 Monthly distribution of Black Rockfish landings in Dutch Harbor, 1999 (top), and Spatial distribution of Black Rockfish landings in Dutch Harbor, 1999 (bottom). * indicates confidential catch.

8. EPILOGUE

As indicated in the Introduction, the purpose of this report was to respond to a NMFS information request about state-managed fisheries. At the same time, we hope that this report will serve as a useful reference document to a wide spectrum of individuals interested to learn more about the fisheries of Alaska. We believe that this report represents a rather substantial and unique effort, especially considering the details about spatial and temporal distribution of the fisheries that we have compiled. In so doing, we, in turn, have learned much about the fisheries and our fishery data systems that could lead us in new directions in fishery data collection and perhaps in the use of Geographic Information Systems in fishery management.

Because our goal was information dissemination, we have not attempted to draw any conclusions about the relationships, if any, between state-managed fisheries and the status of the western population of Steller sea lion. To draw any conclusions requires an objective, thorough analysis of all relevant information. Such a task has not been undertaken by ADF&G to date. However, this report could serve as a starting point for subsequent, more in-depth analyses of the attributes of specific fisheries for a number of potential applications, including research into potential causes of Steller sea lion declines.

With respect to sea lions, identification of the causes of their decline is a very difficult problem that remains largely elusive to date. We are optimistic that the problem can be resolved to a substantial degree, but we suspect that explanations are likely to be very complex and unsolvable by superficial analyses. On the one hand, the fact that a species is not harvested, does not rule out the possibility that natural population changes in that species may directly affect the health of sea lion populations. On the other hand, the fact that a particular species is both caught by a fishery and eaten by sea lions does not, in and of itself, lead to conclusions about cause and effect. However, the coincidence of fisheries with sea lion prey species of appropriate size at critical foraging times and locations may bring to light areas where humans could possibly negatively impact sea lions. Such instances should be selected for more in-depth analyses so that any remedial actions have reasonable chances to be effective in promoting sea lion recovery.

In addition to more detailed spatial and temporal analyses of existing ecological and fishery data, we believe that a focused ecological research program, coupled to an innovative experimental management plan, is needed to unravel potential natural and human-induced causes of Steller sea lion declines and their lack of recovery. Experimental management requires creative thinking to design a replicated set of treatments and controls that have a high likelihood of providing statistically significant differences in the experimental outcomes. The experimental management plan requires faithfulness to adhere to the design protocols over the full term of the experiment, and a commitment to an ongoing ecological monitoring program to collect precise data amenable to testing of study results. Moreover, given the relative dearth of knowledge about the population dynamics and ecology of the marine community comprising the sea lion's forage base, an experimental management approach and associated monitoring program may provide vital insights into important ecological relationships that ultimately could lead to ecosystem-based management informed by science rather than by speculation.

9. ACKNOWLEDGMENTS

This report would not have been possible without critical assistance provided by the following individuals. The authors are extremely grateful for all their help. Mo Lambdin, Charlie Trowbridge, Mike Ruccio and Skip Gish provided much of the groundfish fishery data used in this report. Brandee Gerke and Tim Haverland provided digitized statistical area charts for some management areas that were not previously digitized prior to the start of this project. The NMFS—Alaska Regional Office provided permission to use a description of Steller sea lion biology, and Bob Small edited an abridged version that comprises Chapter 3 of this report. Doug Eggers drafted Table 5.1 with assistance from a number of ADF&G regional staff. Finally, many ADF&G staff provided invaluable detailed reviews of draft chapters of this report, and most of them reviewed multiple chapters. They included Linda Brannian, Wayne Donaldson, Doug Eggers, Dennis Gretsich, Lee Hammarstrom, Dave Jackson, Tim Joyce, Denby Lloyd, Ted Otis, Mike Ruccio, Charlie Trowbridge, and Jie Zheng. To all we extend our gratitude.

10. LITERATURE CITED

- ADF&G (Alaska Department of Fish and Game). 1999a. 1999-2000 Commercial Shellfish Regulations: Statewide fisheries regulations. Alaska Department of Fish and Game, Juneau, Alaska.
- ADF&G (Alaska Department of Fish and Game). 1999b. 1999-2000 groundfish fishery: Commercial fishing regulations. Alaska Department of Fish and Game. Juneau.
- ADF&G (Alaska Department of Fish and Game). 2000. Annual management report for the shellfish fisheries of the westward region, 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K00-55, Kodiak.
- Ainley, D.G, C.S. Strong, H.R. Huber, T.J. Lewis, and S.H. Morrell. 1981. Predation by Sharks on Pinnipeds at the Farallon Islands. *Fish. Bull.* 78:941-945.
- Barnhart, J. P. 2000. Annual management report for the weathervane scallop fisheries of the westward region, 1999/00. Pages 262-300 *in* Annual management report for the shellfish fisheries of the westward region, 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Reg. Inform. Rep. 4K00-55, Kodiak.
- Bartholomew, G.A. 1970. A model for the evolution of pinniped polygyny. *Evol.* 24:546-559.
- Bechtol, W.R. 1999. Prince William Sound walleye pollock: Current assessment and 2000 management recommendations. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A99-33, Anchorage.
- Berceli, R., and L. K. Brannian. 2000. Prince William Sound management area: 2000 shellfish report to the Alaska Board of Fisheries, March 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Reg. Inform. Rep. No, 2A00-12, Anchorage.
- Berceli, R., C. Trowbridge, M. Lambdin, and W.R. Bechtol. 1999. Review of groundfish fisheries in the Prince William Sound Management Area: Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A99-30, Anchorage.
- Bickham, J.W., J.C. Patton, and T.R. Loughlin. 1996. High variability for control-region sequences in a marine mammal: Implications for conservation and biogeography of Steller sea lions (*Eumetopias jubatus*). *J. Mammal.* 77(1):95-108.
- Calkins, D.G., and E. Goodwin. 1988. Investigation of the declining sea lion population in the Gulf of Alaska. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518, 76 p.

- Calkins, D.G., and K.W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. U.S. Dep. of Commer., NOAA. OCSEAP Final Report 19 (1983), pp. 445-546.
- Chumbley, K.J. Sease, M. Strick, and R. Towell. 1997. Field studies of Steller sea lions (*Eumetopias jubatus*) at Marmot Island, Alaska 1979 through 1994. NOAA Tech. Mem. NMFS-AFSC-77.
- Daily, M.D. 1975. The distribution and intraspecific variation of helminth parasites in pinnipeds. Rapp. P.-v. Réun. Cons. Int. Explor. Mer 169:338-347.
- Daily, M.D., and R.L. Brownell. 1972. A checklist of marine mammal parasites. Pages 528-589 in S.H. Ridgway (ed.). Mammals of the sea: biology and medicine. Charles C. Thomas, Springfield, Ill.
- DiCosimo, J. 1998. Summary of the Gulf of Alaska groundfish fishery management plan. North Pacific Fishery Management Council, Anchorage, AK.
- Dieterich, R.A. 1981. Alaskan wildlife diseases. Univ. Alaska, Fairbanks.
- Fay, F.H., R.A. Dieterich, L.M. Shults, and B.P. Kelly. 1978. Morbidity and mortality of marine mammals. U.S. Dep. Commer., NOAA, OCSEAP Environ. Assess. Alaska Continental Shelf, Annual Rep. Year ending March 1978, 1:39-79.
- Ferrero, R.C., D.P. DeMaster, P.S. Hill, and M. Muto. 2000. Alaska marine mammal stock assessments 2000. National Marine Fisheries Service, National Marine Mammal Laboratory, Seattle, WA.
- Fiscus, C.H., and G.A. Baines. 1966. Food and feeding behavior of Steller and California sea lions. J. Mammal. 47:195-200.
- Frost, K.J., and L.F. Lowry. 1986. Sizes of walleye pollock, *Theragra chalcogramma*, consumed by marine mammals in the Bering Sea. Fish. Bull. 84:192-197.
- Funk, F. 1990. Migration of Pacific herring in the eastern Bering Sea as inferred from 1983-88 joint venture and foreign observer information. Alaska Department of Fish and Game, Division of Commercial Fisheries, Reg. Inform. Rep. 5J90-04, Juneau.
- Funk, F. 1991. Harvest policy implications of yield per recruit models for Pacific herring in Alaska. Pages 453-462 in Proceedings of the International Herring Symposium, Alaska Sea Grant Report AK-SG-91-01, University of Alaska, Fairbanks.

- Funk, F. and K.A. Rowell. 1995. Population model suggests new threshold for managing Alaska's Togiak fishery for Pacific herring in Bristol Bay. *Alaska Fish. Res. Bull.* 2(2):125-136.
- Gentry, R.L. 1970. Social behavior of the Steller sea lion. Ph.D. thesis, Univ. California, Santa Cruz. 113 p.
- Geraci, J.B. 1979. The role of parasites in marine mammal strandings along the New England coast. Pages 85-90 in J.B. Geraci and D.J. St. Aubin (eds.), *Biology of marine mammals: insights through strandings*. Marine Mammal Commission, Washington, D.C.
- Grant, W.S., and F.M. Utter. 1984. Biochemical population genetics of Pacific herring (*Clupea pallasii*). *Can. J. Fish. Aquat. Sci.* 41:856-864.
- Hill, B.L. 1968. A survey of parasites of sea lions from Año Nuevo Islands. Pages 39-43 in Año Nuevo reports. Vol. 2, 1967-1968. *Scientific studies in Año Nuevo State Reserve, California and Related Investigation*. Univ. California, Santa Cruz.
- Hill, P.S., and D.P. DeMaster. 1998. Draft Alaska marine mammal stock assessments 1998. National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115-0070.
- Hoover, A.A. 1988. Steller sea lion. Pages 159-193 in J.W. Lentfer (ed.). *Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations*, Marine Mammal Commission, Washington, D.C.
- Iverson, S.J. 1993. Milk secretion in marine mammals in relation to foraging: can milk fatty acids predict diet? *Symp. Zool. Soc. London* 66:263-291.
- Iverson, S.J., K.J. Frost, and L.F. Lowry. 1997. Fatty acid signatures reveal fine scale structure of foraging distribution of harbor seals and their prey in Prince William Sound, Alaska. *Mar. Ecol. Prog. Series* 151:255-271.
- Kajimura, H., and T.R. Loughlin. 1988. Marine mammals in the oceanic food web of the eastern subarctic Pacific. *Bull. Ocean Res. Inst.* 26:187-223.
- Kruse, G. H., and F. C. Funk. 1995. Biological reference points for weathervane scallops in Alaska. Poster presented to the North Pacific Symposium on Invertebrate Stock Assessment and Management, Nanaimo, British Columbia, Canada, March 6-10, 1995.
- Lentfer, J. W. editor. 1988. *Selected marine mammals of Alaska: species accounts with research and management recommendations*. Marine Mammal Commission, Washington, D.C.
- Loughlin, T.R. 1997. Using the phylogeographic method to identify Steller sea lion stocks. *Molecular Genetics of Marine Mammals, Spec. Pub.* 3:159-171.

- Loughlin, T., and Nelson Jr., R. 1986. Incidental mortality of northern sea lions in Shelikof Strait, Alaska. *Mar. Mamm. Sci.* 2:14-33.
- Loughlin, T.R., M.A. Perez, R.L. Merrick. 1987. *Eumetopias jubatus*. *Mammalian Species* 283:1-7.
- Mate, B.W. 1980. Workshop on marine mammal-fisheries interactions in the northeast Pacific. Marine Mammal Commission, Washington, DC.
- Matkin, C.O., and F.H. Fay. 1980. Marine mammal-fishery interactions on the Copper River and in Prince William Sound, Alaska, 1978. Marine Mammal Commission, Washington, DC.
- Merrick, R.L., M.K. Chumbley, and G.V. Byrd. 1997. Diet diversity of Steller sea lions (*Eumetopias jubatus*) and their population decline in Alaska: a potential relationship. *Can. J. Fish. Aquat. Sci.* 54:1342-1348.
- Merrick, R.L., and T.R. Loughlin. 1997. Foraging behavior of adult female and young-of-the-year Steller sea lions (*Eumetopias jubatus*) in Alaskan waters. *Can. J. of Zool.* 75 (5):776-786.
- Merrick, R.L., T.R. Loughlin, G.A. Antonelis, and R. Hill. 1994. Use of satellite-linked telemetry to study Steller sea lion and northern fur seal foraging. *Pol. Res.* 13:105-114.
- Merrick, R.L., and A.E. York. 1994. A viability analysis for the southwest Alaskan Steller sea lion population, 1985-94. Draft report, 20 p.
- Morrison, R., F. Bowers, R. Gish, E. Wilson, W. Jones, and B. Palach. 2000. Annual management report for the shellfish fisheries of the Bering Sea. Pages 147-261 in Annual management report for the shellfish fisheries of the westward region, 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Reg. Inform. Rep. 4K00-55, Kodiak.
- NMFS (National Marine Fisheries Service). 1992. Recovery plan for the Steller sea lion (*Eumetopias jubatus*). Prepared by the Steller Sea Lion Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland, 92 p.
- NMFS (National Marine Fisheries Service). 1995. Status review of the United States Steller sea lion, *Eumetopias jubatus*, population. U.S. Dep. Commer., NOAA, National Marine Mammal Laboratory, AFSC, 7600 Sand Point Way NE, Seattle, WA 98115. 61 p.
- NMFS (National Marine Fisheries Service). 1999. Endangered Species Act Section 7 Consultation – Biological Opinion, draft dated December 12, 1999. National Marine Fisheries Service, Alaska Region, Juneau, AK. 199 p.

- NPFMC (North Pacific Fishery Management Council). 1999a. Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pacific Fishery Management Council, Anchorage, AK.
- NPFMC (North Pacific Fishery Management Council). 1999b. Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, Anchorage, AK.
- NPFMC (North Pacific Fishery Management Council). 2000a. Fishery management plan for the groundfish of the GOA. North Pacific Fishery Management Council, Anchorage, AK.
- NPFMC (North Pacific Fishery Management Council). 2000b. Fishery management plan for the groundfish fishery in the BSAI area. North Pacific Fishery Management Council, Anchorage, AK.
- Perez, M.A., and T.R. Loughlin. 1991. Incidental catch of marine mammals by foreign and joint venture trawl vessels in the U.S. EEZ of the North Pacific, 1973-88. NOAA Tech. Rep. NMFS 104, 57 p.
- Pete, M.C. 1990. Subsistence herring fishing in the Nelson Island and Nunivak Island districts, 1990. Alaska Department of Fish and Game, Division of Subsistence, Tech. Pap. 196, Juneau.
- Pitcher, K.W. 1981. Prey of the Steller sea lion, *Eumetopias jubatus*, in the Gulf of Alaska. Fish. Bull. 79:467-472.
- Pitcher, K.W., and D.G. Calkins. 1981. Reproductive biology of Steller sea lions in the Gulf of Alaska. J. Mammal. 62:599-605.
- Porter, B. 1997. Winter ecology of Steller sea lions (*Eumetopias jubatus*) in Alaska. M.S. dissertation, University of British Columbia, 84 p.
- Reid, G.M. 1971. Age composition, weight, length, and sex of herring, *Clupea pallasii*, used for reduction in Alaska, 1929-66. NOAA Tech. Rep. NMFS SSRF 634.
- Restrepo, V. R., G. G. Thompson, P. M. Mace, W L. Gabriel, L. L. Low, A. D. MacCall, R. D. Methot, J. E. Powers, B. L. Taylor, P. R. Wade, and J. F. Witzig. 1998. Technical guidance on the use of precautionary approaches to implementing national standard 1 of the Magnuson-Stevens fishery conservation and management act. Prepared by the National Marine Fisheries Service. NOAA Technical Memorandum NMFS-F/SPO-31, August 1998.
- Rigby, P.W., D.R. Ackley, F. Funk, H.J. Geiger, G.H. Kruse, and M.C. Murphy. 1995. Management of marine fisheries resources of Alaska: A report to the Northern Forum. Alaska Department of

- Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 5J95-04, Juneau.
- Ruccio, M.P., and D.R. Jackson. 2000. Westward region groundfish fisheries, 1999: Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4J00-14, Kodiak.
- Ruccio, M. P. and C. L. Worton. 2000. Annual management report for the shellfish fisheries of the Kodiak area, 1999. Pages 16-61 *in* Annual management report for the shellfish fisheries of the westward region, 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Reg. Inform. Rep. 4K00-55, Kodiak.
- Scheffer, V.B. 1946. Growth and behavior of young sea lions. *J. Mammal.* 26:390-392.
- Sease, J.L., and T.R. Loughlin. 1999. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1997 and 1998. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-100.
- Shirley, S. M. and G. H. Kruse. 1995. Development of the fishery for weathervane scallops, Patinopecten caurinus (Gould, 1850), in Alaska. *J. Shellfish Res.* 14(1):71-78.
- Strict, J.M., L.W. Fritz, and J.P. Lewis. 1997. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) in southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1994. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-71, 55 p.
- Strick, J.M., R.L. Merrick, D.C. McAllister, L.W. Fritz, and K.M. Wynne. In press. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) in sou southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-00.
- Swain, U.G., and D.G. Calkins. 1997. Foraging behavior of juvenile Steller sea lions in the northeastern Gulf of Alaska: Diving and foraging trip duration. Pp. 91-106 *in* Steller sea lion recovery investigations in Alaska, 1995-1996. Alaska Dept. of Fish and Game, Div. of Wildl. Conserv., NOAA Contract Report, Contract NA57FX0256, August 1997.
- Thorsteinson, F.V., and C.J. Lensink. 1962. Biological observations of Steller sea lions taken during an experimental harvest. *J. Wildl. Manage.* 26:353-359.
- Trowbridge, C. 1996. Prince William Sound management area 1995 Shellfish annual management report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Reg. Inform. Rep. 2A96-29, Anchorage.

- Trowbridge, T. 1998. Cook Inlet Area groundfish report to the Alaska Board of Fisheries, 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A98-37, Anchorage.
- Trowbridge, C., N. Szarzi, and W R. Bechtol. 2000. Review of commercial, sport and personal use fisheries for miscellaneous shellfish in Lower Cook Inlet, report to the Alaska Board of Fisheries, March 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Reg. Inform. Rep. 2A00-13, Anchorage.
- Wilke, F., and K.W. Kenyon. 1952. Notes on the Food of Fur Seal, Sea-Lion and Harbor Porpoise. *J. Wildl. Manage.* 16:396-397.
- Witherell, D. 1997. Summary of the Bering Sea and Aleutian Islands groundfish fishery management plan. North Pacific Fishery Management Council, Anchorage, AK.
- York, A.E. 1994. The population dynamics of northern sea lions 1975-85. *Mar. Mamm. Sci* 10:38-51.
- York, A.E., R.L. Merrick, and T.R. Loughlin. 1996. An analysis of the Steller sea lion metapopulation in Alaska. Pages 259-292 in D.R. McCullough (ed.), *Metapopulations and Wildlife Conservation*, Island Press, Washington, D.C.
- Zheng, J., M. C. Murphy, and G. H. Kruse. 1997. Application of a catch-survey analysis to blue king crab stocks near Pribilof and St. Matthew Islands. *Alaska Fish. Res. Bull.* 4(1):62-74.

APPENDIX: COMMON ACRONYMS USED IN THIS REPORT

ABC – Acceptable biological catch
ADF&G – Alaska Department of Fish and Game
AI – Aleutian Islands
BOF – Alaska Board of Fisheries
BS – Bering Sea
CGOA – Central Gulf of Alaska
CI – Cook Inlet
CPUE – Catch per unit effort
EEZ – Exclusive Economic Zone (3-200 nm)
EGOA – Eastern Gulf of Alaska
EO – Emergency order
ESA – Endangered Species Act
FMP – Fishery management plan
GHL – Guideline harvest level
GHR – Guideline harvest range
GOA – Gulf of Alaska
PWS – Prince William Sound
MSFCMA – Magnuson-Stevens Fishery Conservation and Management Act
MFMT – Maximum fishing mortality threshold
MSST – Minimum spawning stock threshold
MSY – Maximum sustainable yield
NMFS – National Marine Fisheries Service
NPFMC – North Pacific Fishery Management Council
TAC – Total allowable catch
WGOA – Western Gulf of Alaska

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