Overview of State-Managed Marine Fisheries in Southwestern Alaska with Reference to the Southwest Stock of Sea Otters

By

Fritz Funk

REGIONAL INFORMATION REPORT NO. [1] 5J03-02

Alaska Department of Fish and Game
Division of Commercial Fisheries
P.O. Box 25526
Juneau, AK 99802-5526

May 2003

[1] The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Division of Commercial Fisheries.

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1. EXECUTIVE SUMMARY

The Southwest stock of sea otters *Enhydra lutris* has been declining over the last two decades. The U.S. Fish and Wildlife Service (FWS) is currently reviewing the status of sea otters and contemplating listing the species under the Endangered Species Act. This purpose of this report is to provide background information to the FWS about the potential for interactions of commercial fisheries and sea otters, both during the period of sea otter decline and for future projections. This report addresses potential interactions in commercial fisheries managed by the State of Alaska, including those for which federal agencies delegate management authority to the State. Potential interactions between fisheries and sea otters include direct entanglement in fishing gear leading to direct mortality and/or serious injury, and competition for prey species. Fisheries with potential for entanglement are considered separately from fisheries with potential for competition in this report. With a few exceptions, fisheries that have potential for competition with sea otters do not use gear that has potential for entanglement.

The National Marine Fisheries Service has determined that the set gillnet fishery for salmon, trawl fisheries for groundfish, and pot fisheries for Pacific cod *Gadus macrocephalus*, king crab *Paralithodes camtshaticus*, and Tanner crab *Chionecetes bairdi* have the potential to entangle sea otters. To evaluate the potential for entanglement in state-managed fisheries, an analysis of trends in fishing effort in state-managed fisheries that use set gillnets, trawls, and pots, and occur in the range of the Southwest stock of sea otters, was conducted over the period 1970 to present.

The FWS has determined that sea otters feed primarily on benthic invertebrates in shallow water (<100 m). Fisheries for benthic invertebrates in the range of the Southwest stock of sea otters include those for Dungeness crab, shrimps, razor and other clams, sea urchins, sea cucumbers, sea urchins, scallops, and octopus. To evaluate the potential for competitive interactions of fisheries and sea otters, narrative descriptions of the fisheries for these benthic invertebrates which occur within the range of the Southwest stock of sea otters are included in this report, along with summaries of catch and effort data.

The range of the Southwest stock of sea otters is defined by FWS as including the coastal areas of the Aleutian Islands, the north side of the Alaska Peninsula from False Pass to the Kvichak River, the south side of the Alaska Peninsula from False Pass to Cape Douglas, the Kodiak Archipelago, the Barren Islands and Kamishak Bay in Cook Inlet, and the Pribilof Islands.

The State of Alaska generally manages those waters which occur within 3 miles of shore. In some instances, usually where there was a management history that predated the Fishery Conservation and Management Act of 1976, the federal government has delegated management authority to the State. For some other "parallel" fisheries, management regulations are coordinated between state and federal waters so that the same seasons, gear restrictions, quotas and other regulations apply.

There are very few recorded instances of sea otter take in Alaskan fisheries, and entanglement risk is thought to be very low. Some gears, such as salmon gillnets, theoretically have the

potential to entangle sea otters, but are usually fished outside of sea otter habitat or in other ways such that the reported instances of sea otter entanglement is very low. No fishery records or observations suggest that fishing gear encounters contributed to the decline of sea otters.

Most commercial fisheries in the area of the Southwest stock of sea otters that take benthic invertebrates occur offshore, well outside the foraging range of sea otters. Exceptions to this include fisheries for Dungeness crabs, sea cucumbers, and sea urchins. There is a long history of competitive interactions between Dungeness crab fishermen and sea otters in other locations. Sea otters are usually able to forage far more efficiently and persist at lower crab densities than is feasible for commercial fishermen or allowed under fishing regulations. Alaskan crab fisheries are restricted by seasons, sex, and size limits, leaving the females and undersized males unharvested.

A very small fishery for green sea urchins exists along the west side of Kodiak Island, with a few landings recorded from Unalaska Island as well. While there is potential for overlap with sea otter diets, fishery quotas are thought to be low enough so as not to cause local depletion, and removals have occurred only in very limited areas.

Red sea cucumber fisheries occur around Kodiak Island, and to a lesser extent in several areas off of the Alaska Peninsula. The fisheries are regulated by area-specific guideline harvest levels which are thought to be conservative and not result in localized depletion. Sea cucumber fishers are present in the nearshore areas for a very limited number of days each year, so disturbance is not thought to be a problem. In addition, a significant proportion of the sea cucumber resource occurs below practical diving limits and is not harvested, although it is well within sea otter diving ranges.

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 Pacific cod fishery is restricted to fixed gear only. In addition, restrictions are placed 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, with 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 embedded 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 author hopes that the information provided here is useful, not only to FWS in their analysis of sea otter populations, but also to other individuals with interests in Alaska's fisheries.

2. INTRODUCTION

Sea otters have been declining in the Aleutian Islands and along the Alaska Peninsula for approximately the last decade. A complex network of fisheries stretches across Alaskan coastal areas, including the area where sea otters have declined. While fisheries have not been implicated as causal factors in the decline of sea otters, their decline increases the need to understand where fisheries and sea otters may overlap in time, space, and patterns of resource utilization.

2.1 Purpose and Scope of Report

The purpose of this report is to provide fisheries background information to the U.S. Fish and Wildlife Service (FWS) for consideration in their analysis of the potential listing of the Southwest stock of sea otters *Enhydra lutris* under the Endangered Species Act (ESA). As part of the process of evaluating the status of sea otters under the ESA, the FWS will be examining the potential for interactions of commercial fisheries and sea otters. This report addresses potential interactions in commercial fisheries managed by the State of Alaska, including those for which federal agencies delegate management authority to the State. Potential interactions between fisheries and sea otters include direct entanglement in fishing gear leading to direct mortality and/or serious injury, and competition for prey species. Fisheries with potential for entanglement will be considered separately from fisheries with potential for competition in this report. With a few exceptions, fisheries that have potential for competition with sea otters do not use gear that has potential for entanglement.

2.1.1 Entanglement

The National Marine Fisheries Service (NMFS) has determined that the set gillnet fishery for salmon, trawl fisheries for groundfish, and pot fisheries for Pacific cod, king crab, and Tanner crab have the potential to entangle sea otters. To evaluate the potential for entanglement in state-managed fisheries, an analysis of trends in fishing effort in state-managed fisheries that use set gillnets, trawls, and pots, and occur in the range of the Southwest stock of sea otters was conducted over the period 1970 to 2001. For purposes of this analysis, fishing effort is in most cases defined as landing-based data from the Alaska Department of Fish and Game (ADF&G) fish ticket database. The spatial resolution of landings is limited to ADF&G statistical area definitions as recorded on fish tickets. Release of fish ticket information is subject to confidentiality restrictions to protect the identity and location of catches of individual fishermen. For some areas and fisheries, the number of landings has been aggregated or averaged to meet the requirements for public release.

2.1.2 Competition for Prey

The FWS has determined that sea otters feed primarily on benthic invertebrates in shallow water (<100 m). Fisheries for benthic invertebrates in the range of the Southwest stock of sea otters include those for Dungeness crab, shrimps, razor and other clams, sea urchins, sea cucumbers, sea urchins, scallops, and octopus. To evaluate the potential for competitive interactions of

fisheries and sea otters, narrative descriptions of the fisheries for these benthic invertebrates in the Kodiak, Alaska Peninsula, Aleutian Islands, and Kamishak Bay Areas are included in this report, along with summaries of catch and effort data. These narratives include descriptions of the fishing gears, depth and spatial distribution of catch, history of the fisheries, and catch magnitude summaries.

2.1.3 Scoping Framework

Where the information is available, these fishery descriptions are intended to address the following questions:

- What fisheries occur near sea otter habitat (waters < 100 m)?
- What gear types are used?
- What is the spatial distribution of effort and/or catch in these fisheries?
- What are the trends in effort over the period 1970 to 2001?
- What time of year does the fishing effort occur?
- For fisheries with potential for competition, what has been the recent and historic pattern of removals?
- What are the status and trends of the fished stock?
- What are the stock assessment methods?
- What is the harvest policy for the fishery?
- What interactions might occur with sea otters?

This report attempts to answer the FWS request for information by addressing these questions for state-managed fisheries as best as possible, given available information and time constraints. This report summarizes queries to the State's electronic database of fish tickets (records of landings), compiles information from annual fishery reports, and reviews fishery information obtained from regional and area fishery managers. Fish ticket catch and effort data were compiled from 1970 to 2001 for the list of fisheries of interest by fishery, gear type, month, and individual statistical area. Detailed maps were made in a geographic information system using ArcInfo. Borrowing from published annual management reports and the expertise of regional fishery management staff, histories of each fishery were compiled, along with attributes of contemporary fisheries, and readily available information on interactions between the fisheries and sea otters. This project was a substantial effort that was not without its glitches and caveats. Nonetheless, we remain hopeful that this report is useful, not only to FWS for their analysis, but to others interested in Alaska marine fisheries.

2.1.4 Spatial Coverage

This analysis is limited to fisheries that occur within the range of the Southwest stock of sea otters (Figure 2.1). The range of the Southwest stock of sea otters is defined as coastal areas of the Aleutian Islands, the north side of the Alaska Peninsula from False Pass to the Kvichak River, the south side of the Alaska Peninsula from False Pass to Cape Douglas, the Kodiak Archipelago, the Barren Islands, Kamishak Bay in Cook Inlet, and the Pribilof Islands.

The State of Alaska management jurisdiction in these areas is divided among two management regions (Westward Region and Central Region) which are further subdivided into a number of management areas. Management area definitions vary somewhat among groundfish, shellfish, and salmon fishery regulations. Fishery information is usually compiled by individual management area. This report synthesizes fishery information from the numerous, sometimes overlapping, fishery management areas into a more comprehensive spatial overview of fisheries in the range of the Southwest stock of sea otters.

2.1.5 Linkage to Previous Publications

This report builds on a growing genre of state-managed fisheries overviews related to potential endangered species interactions in Alaska. Sections of this report borrow heavily from the author's participation in a previous fisheries overview of Steller sea lion issues (Kruse et al. 2000) and the more general Alaska fisheries management overview of Rigby et al. 1995. Annual management reports provided the backbone of the numerous individual fisheries sections; references to those reports are provided in each fishery section. A somewhat similar overview of federally-managed fisheries was recently compiled for analyzing Essential Fish Habitat for the North Pacific Fisheries Management Council (NPFMC 2002a).

2.2 Methods Used to Monitor and Describe Catch and Fishing Effort

The ADF&G 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 the quantity of fish of each species that was delivered and purchased by a processor from a particular fishing permit holder 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 area, 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. Therefore, 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 in the fish ticket database. For example, 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.

Fish tickets are believed to provide an excellent accounting of fishery landings, in part because of law enforcement efforts. The State of Alaska maintains a Division of Fish and Wildlife Protection within the Department of Public Safety. The division maintains seagoing vessels and an active law enforcement presence in Alaska that works cooperatively with federal enforcement agencies. Violators are rigorously prosecuted and hefty fines can result from serious infractions, including failure to report catches as required by statute and regulation.

Other ADF&G monitoring programs can provide different views of fisheries operations. Logbook programs record detailed catch and information for some fisheries. In some fisheries,

logbooks are required to be submitted along with fish tickets, usually under the authority of a special commissioner's permit. ADF&G also maintains dockside monitoring programs in some fisheries to describe the biological attributes of fishery removals such as age, weight, and length, and other attributes of the catch. Such information, coupled to fishery-independent stock assessment surveys, is used to estimate stock abundance in some fisheries. Also, the Commercial Operators Annual Report database provides a view of seafood processing including price data. Onboard observers in many fisheries collect more detailed information than provided on fish tickets about fishing effort, retained and bycatch species brought aboard, and fishing location.

This report will focus on the ADF&G fish ticket database as the primary source of information. The number of deliveries (landings) provides a crude index of the amount of fishing effort expended. However, the number of deliveries can be influenced by season length, opening style, holding capacity onboard the vessel, and other factors. For these reasons, care must be exercised when using fish ticket landings as a measure of fishing effort, particularly over a long time series, or when comparing fishing areas where vessel types or fishery opening styles vary. In addition, some fisheries have changed in nature, from being prosecuted predominantly by catcher vessels which had to make frequent deliveries, to catcher-processors which can remain at sea for much longer periods of time. For many shellfish fisheries, the number of pots hauled during the trip must also be submitted on the fish ticket. This provides a much better index of fishing effort and is used in this report where practical.

Alaska statutes (AS 16.05.815, Confidential Nature of Certain Reports and Records) preclude the release of information that would identify individual fishermen or the magnitude or location of their catch. This statute has been interpreted to allow release only of catch information aggregated to include 3 or more landings, vessels, or processors. In this report some catch data are averaged over years or statistical areas to comply with this requirement, or we simply present presence and absence of catch on maps to allow us to convey the most salient information about the fisheries.

It should be noted that the primary source of fishery data, the fish ticket database, provides estimates of landed catch (i.e., deliveries) not catch brought aboard (i.e., all fish and invertebrates captured at sea). So, whereas it is common practice to use the terms catch and landed catch interchangeably in fisheries circles, as we sometimes do in this report, it is important to keep in mind that ADF&G really monitors only landings. Also, the fish ticket database may contain some errors in coding that assign 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 typical error rates during data recording and entry. Thus, maps of landings by statistical area or bar charts of landings by gear type may occasionally contain some errors. The smallest spatial resolution of a landing is a state statistical area—i.e., there is no specific 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, set gillnet fisheries confine their fishing to a fraction of a statistical area, approximately one net length from shore. As a result, pinpoint accuracy is impossible with the existing data set.

While the initial scope of the analysis was to examine spatial patterns in fishing effort over the 1970 to 2001 period, for shellfish and groundfish fisheries the effort distribution analysis is

restricted to 1985–2001. Beginning in 1985, ADF&G revised its system of shellfish and groundfish statistical area boundaries to more closely conform to the ½ degree latitude by 1 degree of longitude statistical area reporting scheme used by the NMFS. As a result, it is not possible to compile effort distribution maps across the time period when this change was implemented. In most cases the 1985–2001 effort distribution was felt to be a sufficiently long time series to be representative of long-term distributions. Salmon statistical area definitions have not changed substantially since 1970.

Catch information was extracted from the ADF&G fish ticket databases, aggregated by statistical area, averaged over years, and joined with statistical area boundary definitions to create overlay maps in a geographic information system. For some fisheries, a single map over the range of the Southwest stock of sea otters was sufficient. However, for some fisheries more detailed maps of parts of the range are presented. Two strategies were used to convey the spatial distribution of fishing effort and catch. Often fishery catch and effort information is extremely lognormal. Most of the catch or effort occurs in a relatively small number of areas or by a small number of vessels. For fisheries with this pattern, catch or effort are represented as vertical bars overlaid on maps of statistical area definitions. This approach effectively describes the quantitative scale of the catches where most of the catch often occurs in a very few statistical areas. For some other fisheries where the catch scaling was not as disparate, shading of statistical areas is used to convey the spatial distribution of catch or effort.

2.3 Review of State of Alaska Regulatory Regime

The following review of the regulatory regime for fisheries off Alaska is synthesized from Rigby et al. (1995), and Kruse et al. (2000). 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 Fishery Conservation and Management Act of 1976 (FCMA), 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, 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 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). The 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 FCMA, which was enacted, in large part, because of unrestricted foreign catches off Alaska. Created under the FCMA, 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 Area crab FMP, and a statewide scallop FMP. Each of these defers 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 ESA, have had increasing implications on Alaska fisheries pertaining to the goal of increased protection of marine mammals and depressed salmon stocks of Oregon and Washington which migrate into Alaska waters.

Two treaties between Canada and the U.S. regulate fisheries for transboundary salmon and halibut *Hippoglossus stenolepis*, 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 in the North Pacific. The International Pacific Halibut Commission determines overall catch quotas, but within-nation catch allocations are implemented separately by Canada and in the U.S. The U.S. halibut allocations are determined by 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 ensure 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 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 Gulf of Alaska (GOA) regulatory area, scallops in the GOA and Bering Sea/Aleutian Islands (BS/AI) Area, and king and Tanner crabs in the BS/AI Area. 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 these 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 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 benthic 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 Pacific cod fisheries in Alaska. Moreover, the BOF has closed to bottom trawling most of the state waters in the central GOA and western GOA GOA, an action unparalleled in federal waters and territorial waters of other states in the U.S. (Figures 2.2, 2.3).
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.

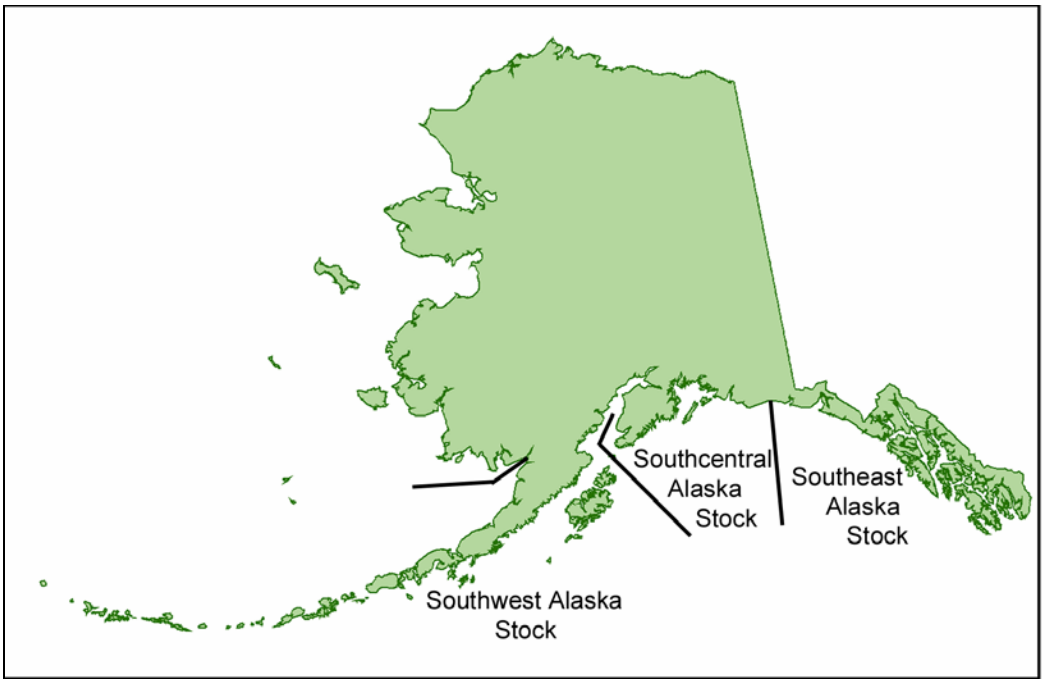


Figure 2.1 Distribution of sea otters in Alaska, showing extent of the Southwest stock.

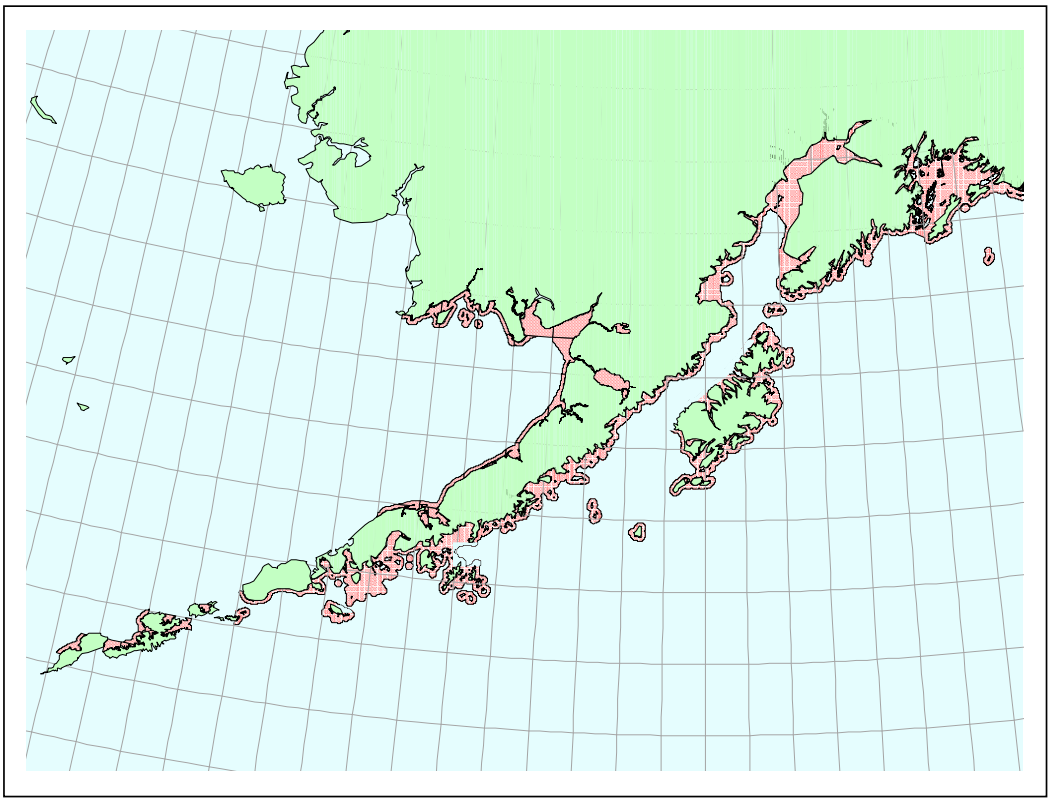


Figure 2.2 Year-round non-pelagic trawl closure areas (shaded area) in state waters of the central and western Gulf of Alaska and southeastern Bering Sea.

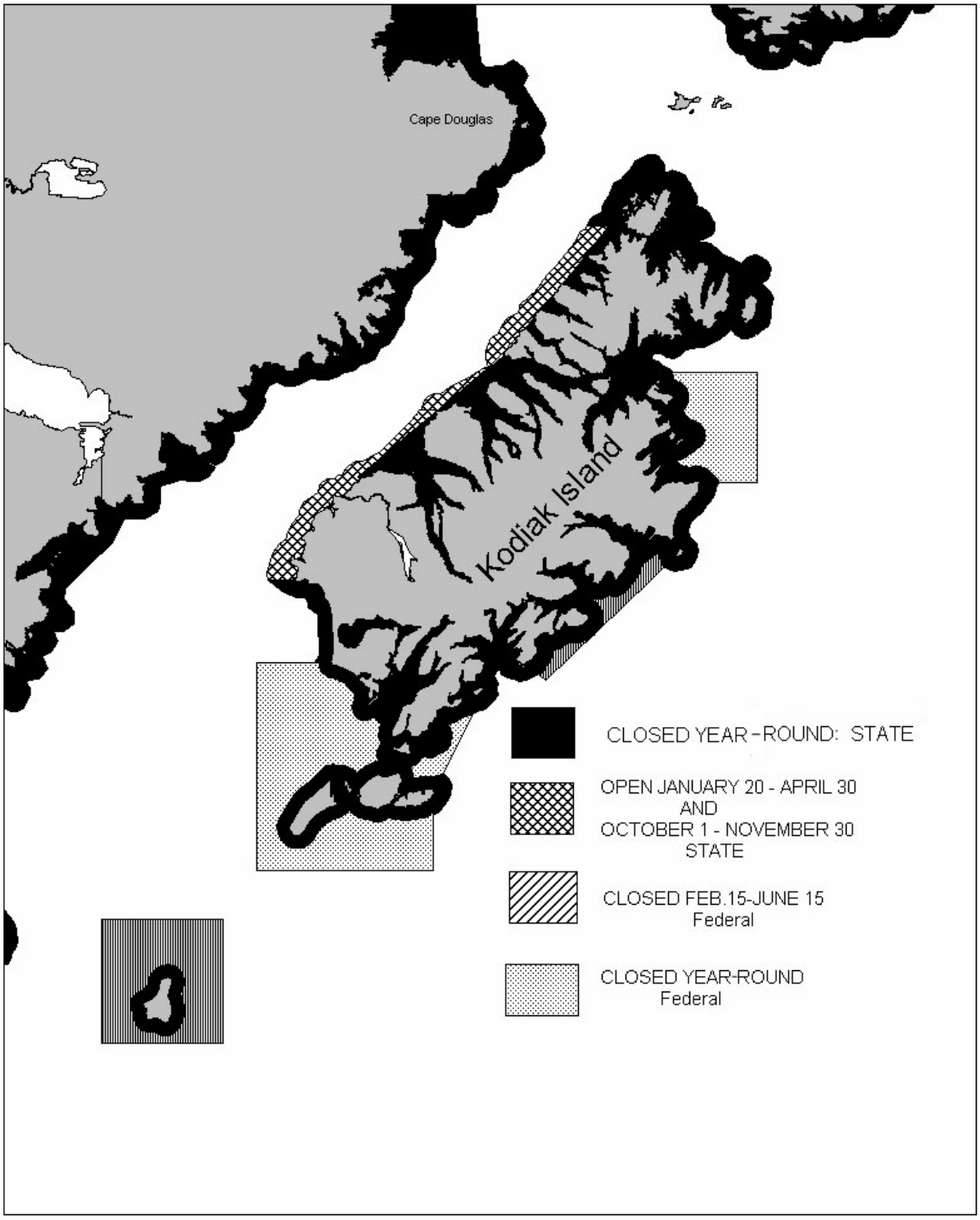


Figure 2.3 Details of time and area for trawl closures around Kodiak Island.

3. SEA OTTER BIOLOGY AND DESCRIPTION

This condensed review of some pertinent elements of sea otter biology is intended to provide information useful for scoping the potential interactions of fisheries and sea otters in Alaska. For more detailed reviews of sea otter biology see Riedman and Estes (1990), Kenyon (1969) or the most recent Alaska Marine Mammal Stock Assessments (U.S. Fish and Wildlife Service 2002).

3.1 Species Description

Sea otters are large members of the weasel family (Mustelidae) adapted for foraging in nearshore areas. Adult males range from 32–41 kg and females 18–27 kg, reaching lengths to 1.4 m. The hind feet are webbed and are specialized for swimming. The toes on the forefeet are short and stiff, enabling the animal to deftly manipulate food items. On land their gait is clumsy and they are seldom found more than a few yards from water.

Sea otters have very dense underfur of inch-long fibers with sparse guard hairs. Unlike pinnipeds, which rely on a heavy layer of blubber for insulation, sea otters depend on air trapped in their fur for maintaining body temperature, leaving them vulnerable to contamination by oil.

Sea otters evolved for a marine existence relatively recently, at the start of the Pleistocene. The only other marine otter, *Lutra felina,* inhabits the Chilean and Peruvian coasts and has declined to endangered levels.

3.2 Distribution, History, and Management Jurisdiction

Sea otters' range once extended from southern California north to the Aleutian Islands, west to the Kamchatka Peninsula, and south along the Asian coast to the northern islands of Japan. The chronology of the sea otter over the last three centuries includes a period of drastic decline during intensive harvests, followed by a remarkable recovery (Table 3.1). Extremely heavy exploitation for the fur trade began in the 18th century; by the end of the 19th century the species was nearly extirpated. It was notable that the many scientific observers of the 1899 Harriman expedition to Alaska recorded not a single sighting of sea otters. Following treaty protection in 1912 and a series of re-introductions from the few remaining remnant populations, sea otters have expanded into a substantial part of their former range.

Just after achieving statehood in 1960, the state of Alaska assumed management authority for sea otters. The management program conducted by the State included the successful reintroduction of sea otters to unoccupied habitat in Southeast Alaska, British Columbia, and Washington. The MMPA transferred management authority to the U.S. Fish and Wildlife Service in 1972.

3.3 Stock Delineation and Listing Status

Initially, all sea otters occurring in Alaska were treated as a single stock. Increasing evidence developed during the 1990s that there were multiple stocks of sea otters in Alaska, based on genetics, distributions, abundance trends, and comparative morphology (Cronin et al. 1996; Bodkin 1992, Bodkin et al. 1999; Gorbics and Bodkin 2001). Initial partitioning of the Alaska stock of sea otters into three components based on the scientific evidence available to that date was delayed by a 1998 request by the Alaska Sea Otter Commission for an MMPA proceeding on the record about the process of stock identification.

With concern developing for the decline of sea otters in the Aleutian Islands, FWS designated sea otters in the Aleutian Islands as a candidate species on August 22, 2000 (Table 3.1). Petitions were filed by the Center for Biological Diversity to request immediate listing of sea otters under the ESA in the fall of 2000 and for designation as "depleted" under the MMPA in the fall of 2001. The most recent sea otter stock assessments include partitioning sea otters into three stocks, with separate assessments for each stock.

3.4 Recent Trends in Abundance

Recovery of the Alaska sea otter population from the decimation of the fur industry has been dramatic. Perhaps as few as 2,000 total animals existed in 1911, but by the mid-1970s the Alaska population numbered between 110,000 and 160,000. Smaller populations exist in the Commander and Kurile islands, British Columbia, Washington, and California. However, in the last decade the number of sea otters in the Aleutian Islands has been declining. First noted by the 1992 surveys of Evans et al. (1997), the available surveys now indicate that the number of sea otters in the Aleutian Islands has declined by up to 70% between 1992 and 2000 (Figure 3.1). East of Cook Inlet, sea otter numbers are stable or increasing; the decline appears to be limited to the area west of Cook Inlet.

Estes et al. (1998) hypothesize that the decline of the western stock of sea otters is a result of increased predation by killer whales, based on observations of sea otter attacks and contrasts in sea otter population trends in areas accessible and inaccessible to killer whales. No other plausible explanations for the decline have yet been advanced.

3.5 Sea Otter Habitat and Foraging

Sea otters inhabit shallow waters of the Pacific coasts, usually within 1 to 2 km of shore. In areas with rocky substrates, sea otters generally occur within the outer limit of the kelp canopy, which corresponds approximately to the 18 m depth contour (Riedman and Estes 1990). However, in the Aleutian Islands, sea otters commonly forage at depths to 40 m (Estes 1980).

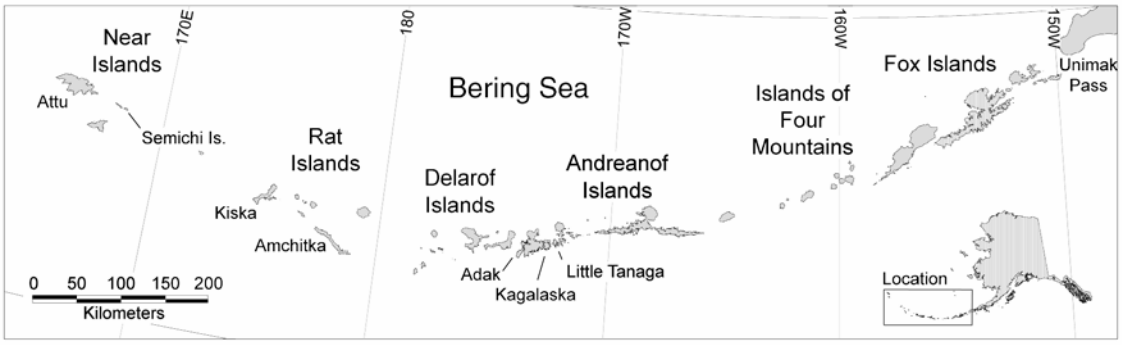
Although sea otters primarily forage on benthic invertebrates, Aleutian Island diet studies report fish as an important part of the diet, which may be the result of the reduced abundance of benthic invertebrates and abundant epibenthic fish (Riedman and Estes 1990). Fish are not usually part

of sea otter diets in newly established populations or in areas where sea otters are well below equilibrium densities (Estes et al. 1982). Estes (1990) speculates that the availability of fish may actually raise the equilibrium population density for sea otters.

The sea otter's role in structuring marine communities has long been used as a prime example of "top down" control of ecosystems (Estes and Palmisano 1974; Simenstad et al. 1978). By removing primary herbivores (usually sea urchins), sea otter foraging allows dense kelp canopies to proliferate which adds greatly to the spatial complexity of nearshore areas. In the absence of sea otter predation, herbivores greatly reduce the coverage of kelp forests and the complexity of the nearshore community declines. The possibility of killer whale control of sea otter populations (Estes et al. 1998) adds one higher layer to the top-down control of nearshore ecosystems.

While sea urchins *Strongylocentrus* sp. are certainly a key element of sea otter diets when available, sea otters are opportunistic generalists who will utilize just about any species they can readily capture and process. Their diet includes clams, crabs, shrimp, and fish, in addition to a wide array of other benthic invertebrates. The top ten sea otter prey items from an ecological study at Adak Island (Estes and Tinker 1996) comprise the focus species for the prey competition aspect of this report (Figure 3.2). The Adak Island study ranked sea otter prey items by the number of dives on which the prey item was directly observed through spotting scopes. Highest ranking prey items include sea urchins, various bivalves, crabs, fish, worms, and sea cucumbers. Worms are not considered in this report because they are not subject to any commercial fisheries in Alaska. Though not in the top ten prey items, this report will also consider fisheries for octopus because of their potential importance.

(a)



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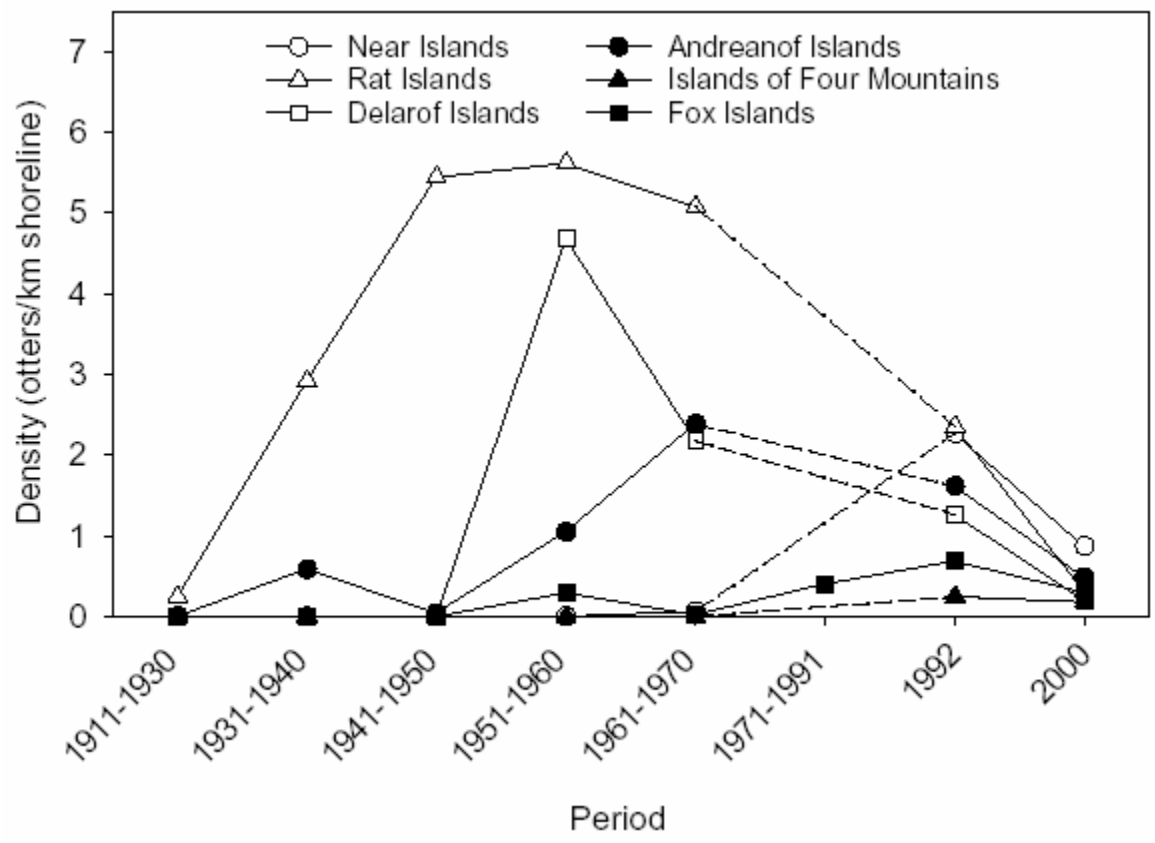

Figure 3.1 (a) Sea otter survey locations in six major island groups in the Aleutian Archipelago (b) Temporal changes in density of sea otters for the six major island groups in the Aleutian Archipelago, 1911–2000. Representative densities for each period were based on maximal counts by aircraft for each island divided by the length of shoreline surveyed for each group. Dashed lines indicate when no data were available (reproduced with permission, from Doroff et al. 2003).

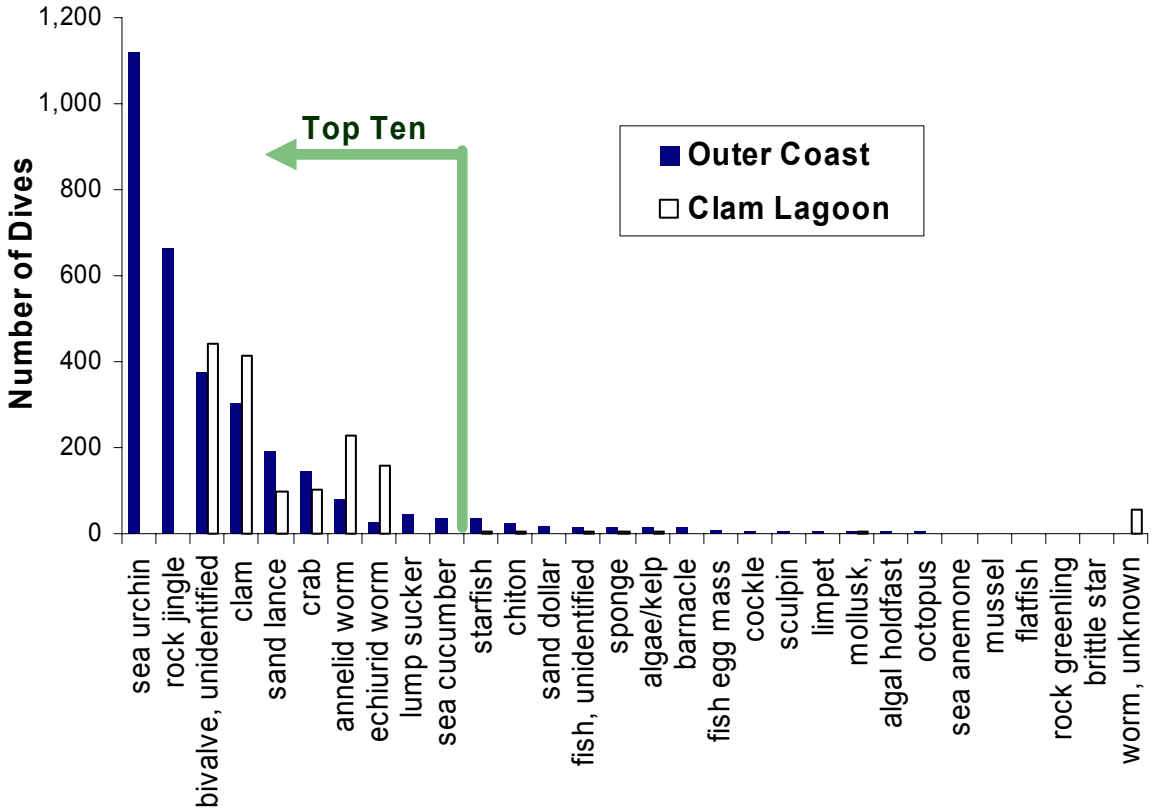

Figure 3.2 Sea otter prey items from a direct observation study at Adak Island, classified by the number of dives on which the prey item was observed. Fisheries for species in the top ten items, plus octopus, are included in this study. (Data from Estes and Tinker 1996, Appendix D).

Table 3.1 Key events in the chronology of the Southwest stock of sea otters in Alaska.

Date	Theme	Event
1742		Vitus Bering returns to Russia with sea otter pelts
1867		Seward's purchase of Alaska. Sea otters are greatly depleted, but Russian conservation measures are relaxed under U.S. jurisdiction.
1899		Harriman Expedition to Alaska voyages out as far as Unalaska Island. Scientists onboard report no sea otter sightings.
1911		Sea otters protected under Fur Seal Treaty. Sea otters nearly extinct.
1960		State of Alaska assumes sea otter management
1972	MMPA	FWS assumes management under MMPA
1980s		Sea otters expanding range and generally at record high levels
1990s		Sea otter genetic research. First declines noted.
1998		Estes et al. (1998) paper in *Science* articulates orca predation hypothesis for sea otter declines
1998		FWS proposes three sea otter stocks in Alaska.
Sep. 14, 1998	MMPA	Sea Otter Commission requests MMPA "proceeding on the record" regarding sea otter stock delineations
Aug. 22, 2000	ESA	Candidate listing for Aleutians
Oct. 25, 2000	ESA	Petition for listing sea otters under ESA by Center for Biological Diversity
Nov. 09, 2000	ESA	Federal Register Notice of Designation of sea otter as "Candidate Species" under ESA
Nov. 14, 2000	ESA	Notice of Intent to sue for immediate listing proposed rule, instead of candidate listing, filed by Center for Biological Diversity
Aug. 09, 2001	MMPA	Petition filed for listing as "depleted" under MMPA by Center for Biological Diversity
Oct. 30, 2001	ESA	CNOR (Candidate Notice of Review), includes sea otters. Candidate status continued warranted but further action precluded. Priority 3.
Nov. 02, 2001	MMPA	Federal Register notice of finding of "Not Warranted" on Center for Biological Diversity petition to list sea otter as "depleted" under MMPA
Feb. 14, 2002	MMPA	Revised draft stock assessment report identifies three stocks of sea otters and describes the decline of the Southwest stock
June 13, 2002	ESA	Candidate status expanded to the range of the southwest Alaska stock

4. POTENTIAL ENTANGLEMENT

Fisheries occurring in nearshore areas present varying levels of entanglement risk for sea otters. At present, the number of reported encounters is very small and erratic from year to year (Table 4.1). Logbook records from 1990 show 1 sea otter killed and 7 injuries in the Copper-Bering River drift gillnet fisheries near Prince William Sound (U.S. Fish and Wildlife Service 2002). In 1991 logbooks, 1 sea otter was reported killed in the Kodiak set gillnet fishery. Two sea otters were reported killed in the Aleutian Islands black cod pot fishery in 1992. An observer program conducted in the are near Prince William Sound from 1988 to 1990 observed no sea otter mortalities. In 1997, one sea otter mortality was self-reported in the Bering Sea/Aleutian Islands groundfish trawl fishery (U.S. Fish and Wildlife Service 2002).

Some potential exists for sea otters to be entangled in gillnets, trapped inside pot fishing gear, and entangled in buoy or groundlines used in longline and pot fisheries. Fisheries considered in this section may have some entanglement risk. Some of the fisheries considered in this entanglement section, such as red king crab fisheries, also target species that overlap sea otter prey fields.

Table 4.1 Known encounters of sea otters and fishing gear in the range of the Southwest stock.

Year	Source	Outcome	Fishery and Source
1975	Self report	1 mortality	Aleutian Islands king crab pot (Newby 1975)
1991	Logbook	1 mortality	Kodiak salmon setnet (U.S. Fish and Wildlife Service 2002)
1992	Observers	8 takes, 2 fatalities	Aleutians black cod pot (Anglis et al. 2001)
1997	Self report	1 mortality	Bering Sea/Aleutian Islands trawl (Anglis et al. 2001)

4.1 Red and Blue King Crab Pot Fisheries [1]

Red king crabs *Paralithodes camtschaticus* and blue king crabs *P. platypus* are distributed in Alaska from the southeast panhandle throughout the Aleutian Islands, and Bering Sea. Southwestern Bristol Bay and Kodiak Island have been historical centers of abundance for red king crab, with blue king crab being most abundant around St. Matthew and the Pribilof Islands. Red and blue king crabs can occur from the intertidal zone to more than 200 m. Adults move into shallower waters in the late winter and spring for mating and molting, followed by movements to feeding areas in deeper water, and may range up to 150 km in annual movements.

Aging techniques are not well developed for king crabs, but the maximum age is thought to be approximately 20 to 30 years, with sexual maturity occurring at 4 to 5 years. Adult females must molt in order to mate, but males often skip molting for a year or more.

4.1.1 Description of Fishery

King crabs are commercially fished using large 600 to 700 pound steel-framed pots covered with nylon-webbing (Figure 4.1.1). Each pot is baited, usually with chopped herring, lowered to the bottom and allowed to soak, typically for one to two days when fishing red or blue king crabs. Buoys are attached to the pots with heavy line and pots are retrieved and lifted onto the vessel with a hydraulic puller. The catch is sorted on deck and all females and undersize males are tossed overboard. The retained catch of large males is held in large recirculating seawater tanks for live delivery, or are processed and frozen onboard the small fleet of catcher-processor vessels. King crab vessels fishing the Bering Sea usually exceed 100 feet in length, although smaller vessels have participated in Gulf of Alaska fisheries.

Fishing regulations for king crab were initially grounded in the concept of season, sex, and size limit ("3S") harvest policies which allowed only the harvest of large males. However, this harvest policy has been criticized in recent years because of the potential handling mortality on female and sublegal crabs. In addition, research on the reproductive capabilities of male king crabs now indicates that large males are more important to the brood stock than small males (Paul and Paul 1990). In the few areas where king crab fishing is still allowed, quota and sometimes threshold-based harvest policies are now used, in addition to the 3S harvest policy.

Biodegradable escape mechanisms are required on crab pots so that if the pot is lost it will soon stop fishing, and pot limits are imposed on fishing vessels in an attempt to control fishing effort.

In most of Alaska, king crab may only be taken with pot gear. Pots must be no more than 10 feet long by 10 feet wide by 42 inches high with rigid tunnel eye openings that individually are no less than five inches (13 cm) in any one dimension, with tunnel eye opening perimeters that

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[1] Much of the management information in this section was excerpted from more detailed treatments in Ruccio and Worton (2001a,b), Bowers (2001), Bowers et al. (2001), Kruse et al. (2000) and Bechtol et al. (2002). The current fishery management contacts are Charles Trowbridge (Cook Inlet), Michael Ruccio (Kodiak Island and Alaska Peninsula), and Forrest Bowers (Bering Sea/Aleutian Islands).

individually are more than 36 inches (91.4 cm), or pots must be no more than 10 feet long by 10 feet wide by 42 inches high and taper inward from the base to a top consisting of one horizontal opening of any size. King crab pots may be stored submerged under certain conditions, if they are unbaited and the doors are secured fully opened. King crab can also be harvested with ring nets in Cook Inlet. In the Kodiak and Alaska Peninsula Areas, each king crab pot must have at least one-third of one vertical surface of the pot composed of not less than 9-inch stretched-mesh webbing.

In the Kodiak and Cook Inlet areas, regulations allow only male king crab 7 inches (178 mm) or more in carapace width (CW) to be retained. Carapace width is defined as the greatest straight-line distance across the carapace at a right angle to a line midway between the eyes to the midpoint of the posterior portion of the carapace and includes any projecting spines. In fishing areas of the Alaska Peninsula, Bering Sea, and Aleutian Islands, the size limit is 6.5 inches. Some areas have allowed more restrictive fishing seasons with size limits larger than 7 inches.

Threshold levels of abundance are required to be defined by the BOF regulations for fisheries with sufficient data. Harvest policies for individual areas must conform to the BOF's policy statement on king crab resource management. Stocks with abundances below their thresholds may not be fished. Guideline harvest levels and exploitation rates may be determined from estimates of exploitable biomass, estimates of recruitment, estimates of accepted biological catch, historical fishery performance data, estimates of reproductive potential, and market or other economic considerations

For Bristol Bay red king crab, fishery quotas are set annually based on NMFS trawl surveys and NMFS and ADF&G stock assessment analyses. A combination threshold and exploitation rate harvest policy is used. The maximum exploitation rate is set at 15% of the abundance of mature males, or no more than 50 percent of the legal-sized male red king crab abundance, whichever is less. Based on recent research of red king crab spawning behavior, an "effective spawning biomass" (ESB) is defined as the estimated biomass of mature female red king crab that the population of mature male red king crab could successfully mate with in a given year. A threshold of 8.4 million mature female crabs and 6,577 mt of ESB is established, below which fishing is not allowed. If the ESB is below 24,948 mt, the exploitation rate is reduced from 15% to 10%. After applying the exploitation rate, the guideline harvest level must be above 1,814 metric tons (mt) for the fishery to open.

Pot limits are in effect in most king crab fisheries to attempt to control fishing effort and allow fishery managers to constrain the rate of harvest so that GHLs are not exceeded. The pot limit requirements vary by vessel size, area, and GHL level, and range from 75 pot limits in Cook Inlet (may be reduced to 40-pot limit with GHLs less than 680 mt) to 250 pot limits in Bristol Bay when GHLs are high.

4.1.2 History of the Fishery

The red king crab fishery can be described as a brief pulse of extremely intensive fishing activity in the 1960s and 1970s in both Gulf of Alaska (Figure 4.1.2) and Bering Sea areas (Figure 4.1.3).

Red king crab stocks crashed in almost all areas in the early 1980s and only a small amount of fishing continues.

Before the period of intense fishing, the fishery was slow to develop, although king crabs had been harvested for subsistence and personal use for long periods. Small amounts of red king crab began to be landed in Cook Inlet and Kodiak in the 1930s, but catches were not officially recorded until 1950. Exploratory fishing increased in 1940 and by 1949 all major red king crab stocks in Alaskan waters were known (Otto 1990). During this early exploratory period, the harvest was for males only with a minimum CW of 5½ inches. In 1949, the size limit was increased to 6½ inches CW. In 1959, pots and ring nets were classified as the only legal gear and a pot limit of 30 pots per vessel was established for the Kodiak Area.

In 1963, the minimum legal size limit was increased to 7 inches CW based on Kodiak-area growth rate studies. These studies concluded that a 7 inch CW size limit would allow mature male king crab to breed at least one year before being recruited to the fishery.

Cook Inlet red king crabs have been harvested since the late 1930s, but available catch records begin with the 1960–61 season. During the 1960s, the king crab fishery expanded to the Kamishak and Barren Islands Districts. Harvests peaked in these areas at 2,495 mt in the 1962–1963 season. However, catch dropped significantly the following year after processing facilities in the Seldovia area were severely damaged by the 1964 earthquake. Catches ranged from 635 mt to 1,361 mt for the next decade before drastically declining in the early 1980s. The commercial fishery has remained closed due to low stock abundance following a harvest of only 85 mt in the 1983–84 season.

The Kodiak area was the first to develop a major red king crab fishery, with catches increasing dramatically in the early 1960s. Fishing seasons had been open year-round until 1965 when a new-shell crab closure went into effect from May 1 to June 30. The peak harvest of 42,833 mt occurred in 1965, with harvests declining steeply in the following years (Figure 4.1.2). Beginning in 1968, fishing seasons were gradually shortened. The pot limit was increased to 60 pots per vessel in 1970, and a catch quota system was established. The 1973 fishery lasted only 10 days. Harvests continued through the 1970s at levels of 5,000 to 10,000 mt, while effort increased dramatically (Figure 4.1.2). The fishery was closed in 1983 and has never reopened. Kruse et al. (1996) estimated that the exploitation rate on male crabs had reached as high as 80% in the terminal years of the fishery, although managers had intended to keep exploitation rates near 30%. Fishing in other Gulf of Alaska areas for red king crab followed a similar pattern, although the magnitude of catch in other areas was considerably less than in the Kodiak Area.

In the Bering Sea, commercial fishing for red king crabs began with Japanese harvests in the 1930s, with the Japanese fishery resuming after World War II. A Russian king crab fleet also operated in the eastern Bering Sea from 1959 through 1971. All foreign fishing for red king crabs was ended by 1974. Domestic fishers entered the eastern Bering Sea fishery with trawl gear in 1947, but domestic effort and catches declined in the 1950s and remained low until the late 1960s. Effort increased dramatically in the 1970s when pot fishing vessels transferred effort into the Bering Sea from the declining Kodiak fishery. The peak harvest in Bristol Bay occurred

in 1980 at 58,944 mt, with harvest dropping sharply afterwards (Figure 4.1.3). In an attempt to control fishing effort, in 1980 the BOF created "exclusive registration areas" so that vessels registering for and fishing in one area were prohibited from fishing in any other exclusive or super-exclusive king crab registration areas. The Bristol Bay king crab stock declined sharply in the early 1980s, and was closed in 1983. Since then, the stock has fluctuated around lower levels with total closures occurring again in 1994 and 1995. Fishing effort increased dramatically from 89 vessels in 1984 to over 300 vessels in 1991, with the number of pots being fished by the fleet also increasing. Almost 90,000 pots were registered for the 1991 fishery, compared to 22,000 pots registered in 1984. To attempt to control fishing effort, in 1993 vessels in excess of 125 feet were limited to 250 pots each and vessels under 125 feet were allowed a maximum of 200 pots. With this amount of effort, fishing seasons have been shortened to as little as 5 days, even with pot limits in effect.

Domestic fisheries for red king crabs in both the western Aleutians (Adak Area) and eastern Aleutians (Dutch Harbor Registration Area) began in 1961, with effort and harvest increasing rapidly in both areas. The Adak area reached a peak harvest of 9,525 mt 1964/65, while maximum production in the Dutch Harbor Area was reached in 1966/67 with a harvest of 14,969 mt. These fisheries crashed along with other red king crab fisheries in the early 1980s. Commercial fishing for red king crabs in the Dutch Harbor Area was closed after the 1982/83 season. The Adak fishery remained open until the 1995/96 season when only 18 mt were harvested.

The king crab fishery around the Pribilof Islands began in 1973, with vessels targeting blue king crabs. When red king crab abundance increased around the Pribilof Islands in 1993, the fishery targeted both species. Red and blue king crab harvests from the Pribilof Islands are pooled together for this report. The Pribilof Idlands fishery was closed from 1988 to 1992 and has remained closed since 1999.

Advances in technology greatly increased the efficiency of the crab fishing fleet, which originally started out primarily as converted wooden salmon seine vessels. Vessel size increased, allowing more and larger pots to be carried, and hydraulic launchers and pullers allowed efficient handling of the large pots. LORAN navigation and chart plotters allowed pot locations to be precisely tracked and large numbers of pots to be managed. Bright sodium deck lights became available in the 1970s, allowing fishing around the clock.

Harvests declined abruptly in all king crab fisheries in the early 1980s. Kruse et al. (1996) attributed the demise of Alaskan king crab stocks to overfishing, with a lesser role played by the 1977 regime shift in ocean conditions which may have affected recruitment and mortality levels. Zheng et al. (1997) found that periods of apparent high natural mortality coincided with the high harvest rates of the early 1980s.

4.1.3 Recent Catch, Effort, and Status

Red king crab populations in most areas occupied by the Southwest stock of sea otters are at extremely low levels, with the exception of Bristol Bay. The Bristol Bay red king crab fishery remains the only viable red king crab fishery in the area. Almost all other red king crab fisheries

have been closed for at least 15 years. Populations are thought to be so low that sport and subsistence harvests have also been restricted. Most of the fishing effort and catch since 1985 has occurred in southwestern Bristol Bay (Figure 4.1.4). Nearshore catch and effort is low in Bristol Bay. In the Aleutian Islands, catch is closer to shore because of the relatively narrow band of shallow areas (Figure 4.1.5), but only very small amounts have been harvested since 1985. Fisheries in the eastern Aleutian Islands are closed. Some red king crab catch is occurring in the western Aleutians, but mostly in conjunction with the deepwater golden king crab fishery which occurs further offshore and in deeper water than sea otters inhabit.

King crab harvests are concentrated in a very small number of statistical areas. The top 15 of the 93 statistical areas in the EBS reporting some catch account for 93% of the king crab harvest over the period 1985 to 2001. The remaining statistical areas averaged 30 mt or less from 1985–2001 and are shown as "trace" amounts in Figure 4.1.4. The top 10 of the 76 statistical areas in the Aleutian Islands with some catch account for 85% of the king crab harvest over the period 1985 to 2001. The remaining statistical areas averaged 3 mt or less and are shown as "trace" amounts in Figure 4.1.5.

The red king crab population of the Kamishak Bay and Barren Islands Districts of Cook Inlet remains severely depressed; the fishery has not been opened since the 1983–84 season. Trawl surveys have been conducted annually in the Kamishak and Barren Islands Districts since 1990 (Bechtol 2001). Red king crabs are not abundant and have a patchy distribution in trawl survey catches. Population abundance estimates are not expanded from the survey catches; the survey is treated as a relative index of king crab abundance. Catches of male crab in annual trawl surveys ranged from only 2 crabs in 1993 and 1999 to 140 in 2000, with a mean among survey years of 28.3 crab per survey. Although trawl survey catches in the last two years show some improvement relative to surveys in the early 1990s, interannual variability is high, likely due to the patchy distribution of king crab aggregations.

The Kodiak Island red king crab population is also at historically low levels, and fishing seasons for this species have remained closed since 1983. Recent trawl surveys estimated there were 347,833 mature red king crab females in the population, well below the 5.1 million threshold necessary for a fishery opening (Ruccio and Worton 2000a). Most of the red king crabs are located in the Southwest Section of Kodiak Island.

The Alaska Peninsula red king crab population also remains at very low but increasing levels, with a population estimated at 133,521 animals (Ruccio and Worton 2000b).

In the eastern Aleutian Islands, red king crab populations remain severely depressed. Recent bottom trawl surveys of the eastern Aleutian Islands have been capturing too few crabs to make population estimates. Since 1999, BOF regulations have closed the sport fishery for red king crab in the eastern Aleutian Islands, and reduced the subsistence bag limit from six to one crab per day.

The red king crab fishery in the western Aleutian Islands remains closed, although some retention of red king crabs is allowed in the deepwater golden king crab fishery, and some small

experimental research fisheries have been allowed on Petrel Bank to acquire more information about red king crab abundance and distribution there. Prior to reopening a full commercial fishery, ADF&G intends to develop a separate management plan for the western portion of the Aleutian Islands Management Area.

A systematic trawl survey of the Bering Sea provides the most robust population estimates of any of the king crab stocks. However, the trawl survey estimates still have substantial variability and are integrated into length-based stock assessment models to further refine the abundance estimates. The Bristol Bay red king crab stock declined somewhat between 2001 and 2002 but remains above the minimum stock size and mature female abundance thresholds. The ESB of the Bristol Bay red king crab stock for 2002 is estimated at 17,105 mt. Based on the ESB, a 10% exploitation rate is applied to this year's estimate of mature male crabs to derive the GHL for the 2002 season of 4,205 mt. Abundance and fishing effort appear to have stabilized at low levels in the Bristol Bay area.

4.1.4 Potential Fishery–Sea Otter Interactions

Red king crab fisheries present some potential for both competitive and entanglement interactions with sea otters. The risk of entanglement, although present, is probably quite low because king crab gear is usually set further offshore and in deeper water than sea otters typically forage. However, sea otter mortality has been recorded in red king crab fishing gear. A sea otter was reported drowned in a king crab pot set in 100m of water in the Aleutian Islands (Newby 1975, in Riedman and Estes 1990), which was notable at the time because it set a new record for sea otter diving depths. Most of the current fishing effort occurs in the fall in Bristol Bay, in areas further offshore than sea otters usually frequent. Recently, the fishery has been occurring during approximately a 5 day period, starting October 15.

Red king crab do not appear in the list of prey items noted by Riedman and Estes (1990) although there are informal reports that sea otters do consume red king crabs. Red king crab move into shallow water to mate and molt during the late winter and spring and are probably available to sea otters during this period. At other times of the year, red king crab move to deeper waters and are probably not available to sea otters.

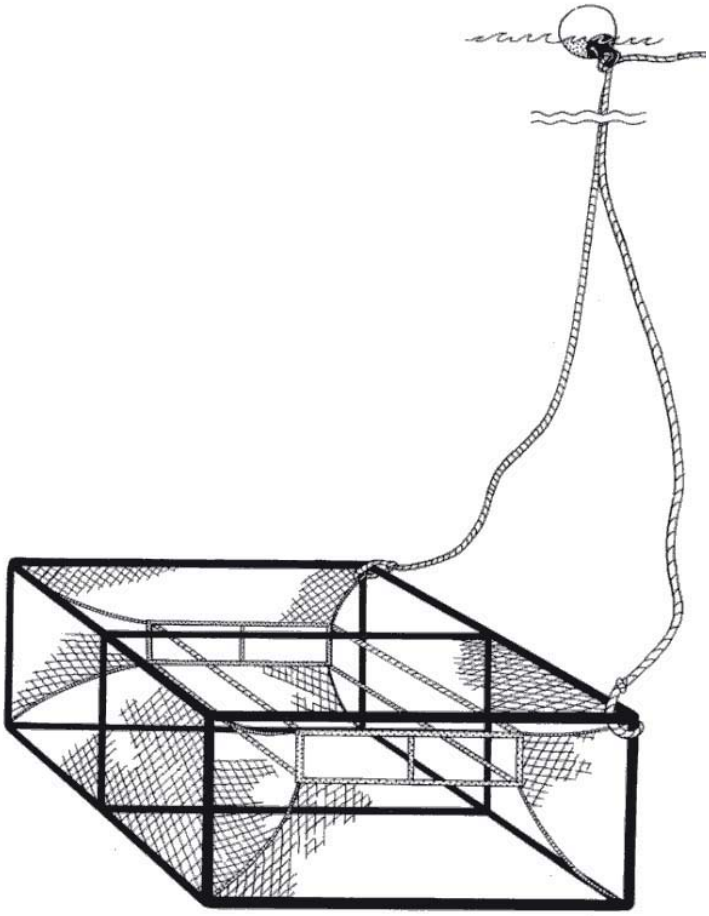

Figure 4.1.1 Typical rectangular king and tanner crab pot, showing tunnel openings. Rectangular pyramid-shaped pots are also sometimes used, commonly called "conical" pots. (Figure credit: Ashley Dean, Alaska Department of Fish and Game).

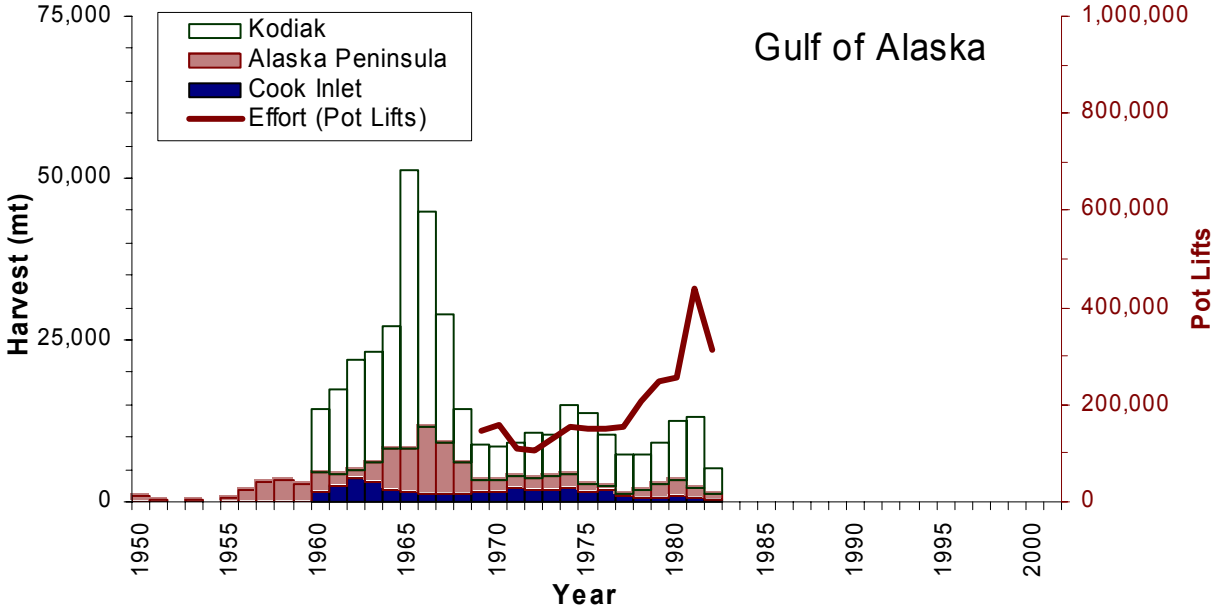

Figure 4.1.2 Harvest of red king crabs in the Gulf of Alaska from Cook Inlet to Unimak Pass, 1950–2001.

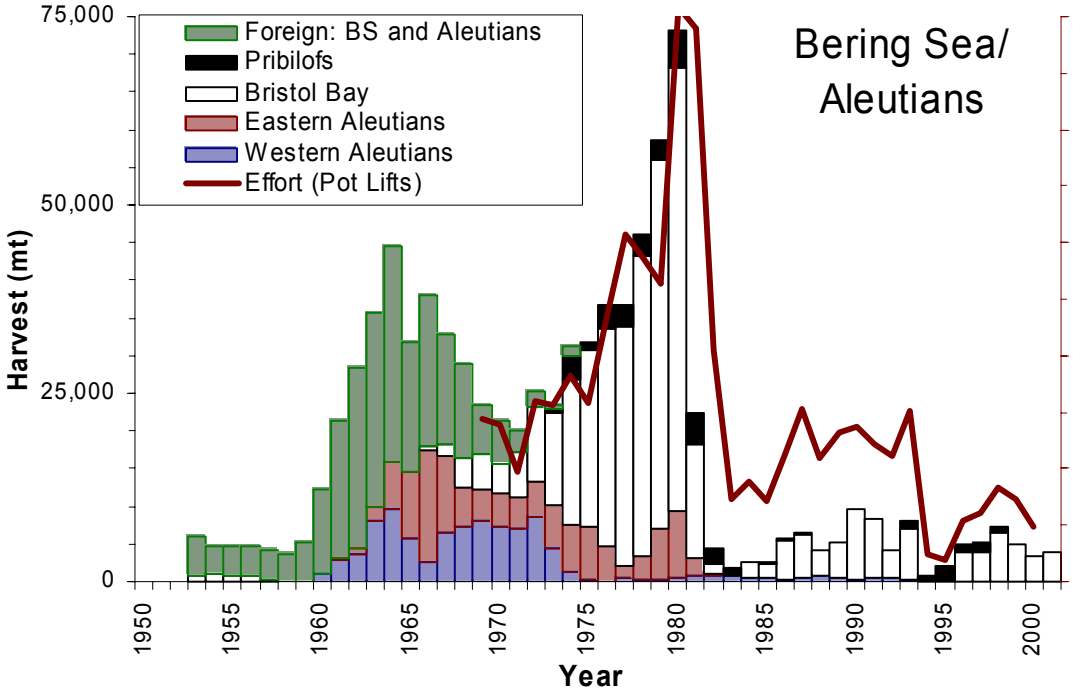

Figure 4.1.3 Harvest of red king crabs in the Bering Sea and Aleutian Islands, 1950–2001. Pribilof Islands and foreign harvests include both red and blue king crabs. Effort in pot lifts does not include the foreign fishery. Foreign harvest data from Otto (1990).

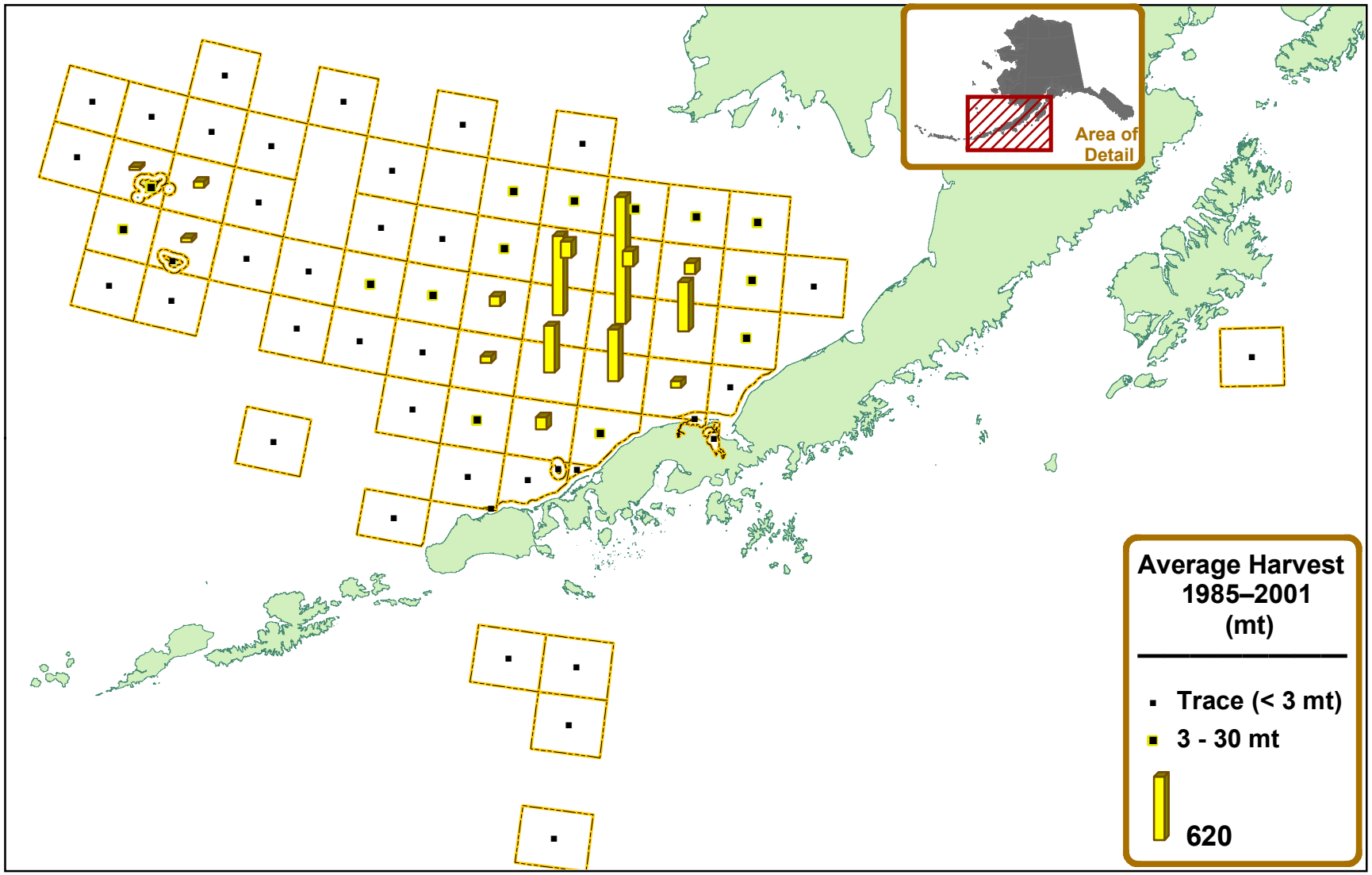

Figure 4.1.4 Spatial distribution of average red king crab harvests in the eastern Bering Sea, 1985–2001.

Figure 4.1.5 Spatial distribution of average red king crab harvests in the eastern Aleutian Islands, 1985–2001.

4.2 Tanner Crab Pot Fisheries[2]

Tanner crabs are distributed in the Pacific Ocean from Oregon to Alaska, in the Bering Sea, and adjacent to the Aleutian Islands, and inhabit depths from subtidal areas to 437 m. (Jadamec et al. 1999).

Tanner crabs are difficult to age, but the maximum age is thought to be about 14 years. The age of sexual maturity is approximately 5 to 6 years. Males of commercial size usually range from 7 to 11 years of age and vary in weight from 1 to 2 kg. Females molt to sexual maturity and mate in the softshell condition while grasped by the male. Older hardshelled females are also mated by adult males, but in the absence of a male they are capable of producing an egg clutch with sperm stored from a previous mating. Female Tanner crabs are estimated to pass through 12 instars before they terminally molt at the 13th instar in about 5 years. Male Tanner crabs are estimated to mature in about 6 years with the largest males passing through as many as 18 instars (Donaldson et al. 1981). Duration of instar stages, or the intermolt period, increases with crab age. Estimates of growth per molt, in percent carapace width, range from 15 to 32% and decrease as crab size increases.

4.2.1 Description of Fishery

Fisheries for Tanner crab have occurred from Southeast Alaska to north of Bristol Bay in the Bering Sea, and throughout the range of the Southwest stock of sea otters. Standard rectangular king crab pots (Figure 4.1.1) or conical pots are used to fish for Tanner crabs, and deployment of fishing gear is generally similar to that for king crab. Rectangular pots must have tunnel eye openings constrained to less than 5 inches (13 cm) in height to prevent the larger king crabs from entering the pot. This is usually accomplished by placing wooden slats in the tunnel eye of the king crab pots.

The minimum size limit for Tanner crab 5.5 inches (140 mm) CW, defined as the greatest straight-line distance across the carapace at a right angle to a line midway between the eyes to the midpoint of the posterior portion of the carapace and includes any projecting spines

BOF regulations require that a threshold level of abundance be defined for Tanner crab fisheries for which sufficient data are available. Harvest policies for individual areas must conform to the BOF policy statement on king and Tanner crab resource management. Stocks with abundances below their thresholds may not be fished. Guideline harvest levels and exploitation rates are determined from estimates of exploitable biomass, estimates of recruitment, estimates of accepted biological catch, historical fishery performance data, estimates of reproductive potential, and market or other economic considerations.

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[2] Most of the management information in this section was excerpted from more detailed treatments in Ruccio and Worton (2000a, b); Bowers (2001), Bowers et al. (2001); Kruse et al. (2000); and Bechtol et al. (2002). The current fishery management contacts are Charles Trowbridge (Cook Inlet), Michael Ruccio (Kodiak and Alaska Peninsula), and Forrest Bowers (Bering Sea and Aleutian Islands).

4.2.2 History of the Fishery

The domestic Tanner crab fishery began to develop in the late 1960s as king crab stocks declined and fishers began to look for alternative resources. The domestic fishery developed first in Kodiak in 1967 (Figure 4.2.1), then spread to other areas of the Gulf of Alaska and the Bering Sea (Figure 4.2.2). Fishing effort has been broadly distributed throughout the Gulf of Alaska and Bering Sea, with only low levels of effort in the Aleutian Islands (Figure 4.2.3). Kodiak Island and southwestern Bristol Bay have been the most intense centers of fishing activity.

The fishery was slow to develop in the 1960s because of low consumer acceptance of Tanner crab, competition on the U.S. market from imported Tanner crab meat, a black encrustment on the Tanner crab shells (black mat syndrome), and the lack of economical methods of extracting of meat from the shell. By the early 1970s solutions to processing and marketing Tanner crabs had been developed and the fishery expanded rapidly.

The Tanner crab fishery on the west side of lower Cook Inlet (Kamishak and Barren Islands Districts) began in 1968 and the catch peaked at 2,127 mt in 1973–74, with a maximum participation of 28 vessels. Because of the decline in abundance, the commercial fishery has been closed since 1992. In the Kamishak and Barren Islands Districts, fishing occurred in a 30 to 180 m depth range (Bechtol et al. 2002).

Around Kodiak Island, fishers began to target Tanner crabs in 1967 as the Kodiak Island king crab fishery began to decline. The fishery grew to a peak of 15,096 mt 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. Because of the persistent decline of Tanner crab stocks around the Kodiak Area, the commercial fishery was closed from the 1993–94 season until 2001. Two sections of the Kodiak District opened for a limited commercial Tanner crab fishery in 2001 and 2002 as the stock exhibited some improvement. Most of the Tanner crab harvest around Kodiak since 1985 has occurred on the east side of the island (Figure 4.2.4).

Tanner crab fisheries in the Alaska Peninsula Area were prosecuted in two districts: Chignik and the South Peninsula. The fishery in the Chignik district started in 1968. The harvest peaked in 1975–76 at 3,142 mt 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 with an effort from 48 vessels. 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.

In the Bering Sea, Tanner crabs were initially harvested as bycatch in 1969, with the directed fishery starting in 1974–75 with 28 vessels. The catch peaked in 1977–78 at 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. Landings began to increase from 1989 onwards with 109–296 vessels participating, 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 that time. There are two centers of fishing effort in the Bering Sea. Most of the catch since 1985 has occurred on the southwest part of the Bristol Bay shelf. A smaller concentration of catch and effort has occurred near the Pribilof Islands (Figure 4.2.5).

Tanner crab fisheries in the eastern Aleutian Islands have been relatively small, with a peak harvest of 1,134 mt during the 1977–78 season. The fishery began in Akutan and Unalaska Bays and subsequently expanded to include all areas of known Tanner crab distribution in the Eastern Aleutian District. Vessel participation was low in 1973–74, with only six vessels registered and reached a high of 31 in 1982. Commercial fishing for Tanner crabs has not been permitted in the Eastern Aleutian District since 1994 due to low stock abundance.

In the Western Aleutian District, Tanner crab harvest has been largely incidental to the directed red king crab fishery. Tanner crab harvests have ranged from a high of over 363 mt during the 1981–82 season to less than 4 mt in 1991–92. No commercial harvest of Tanner crabs has occurred in the Western Aleutian District since 1995–96. Tanner crab abundance in the Western Aleutian District is probably limited by available habitat. Most of the historical harvest occurred within a few bays in the vicinity of Adak and Atka Islands (Figure 4.2.6). Historic fisheries were managed using GHLs set from previous commercial catch and performance data.

4.2.3 Recent Catch, Effort, and Status

Tanner crab populations remain depressed throughout the range of the Southwest stock of sea otters and most fisheries are closed. The only fishery openings in recent years have been near Kodiak Island, with quotas of only a few hundred mt.

Cook Inlet Tanner crab populations remain depressed and the fishery has been closed since 1992. Estimated abundance of female Tanner crab in the Kamishak and Barren Islands Districts from recent surveys has ranged from 305,000 in 1998 to 5.1 million in 2001. Although the estimated abundance of mature female crab has increased from the historical low of 7,900 females, the contribution of 2.1% mature female crabs to total female abundance in the 2001 survey was the lowest on record.

Recent surveys have indicated increases in the number of mature male crabs in some sections of the Kodiak District. A substantial increase in the number of crabs below 80 mm has occurred throughout the district. The 2000 trawl survey in the Kodiak District showed the Northeast and Eastside Sections as being above the established thresholds for a second consecutive year. These two sections were opened to commercial fishing in January 2001, with GHLs of 90.7 mt for the Eastside Section and 136.1 mt for the Northeast Section, and individual vessel pot limits of 30. A total of 159 vessels registered for the fishery. The Southeast and the Westside Sections were close to the opening thresholds, but all other sections of the Kodiak District are currently far below the established thresholds for a commercial fishery opening.

The last commercial fishery for Tanner crab in the Chignik and South Alaska Peninsula Districts occurred in 1989 and Tanner crab abundance remained very low through the 1990s. The 2000 Tanner crab population estimates were at the highest level since the trawl survey series began in the late 1980s. The Alaska Peninsula population was above the threshold needed to open a commercial fishery, and a GHL of 170.1 mt was established for 2001. A large component of the recent survey estimates are male crabs smaller than 70 mm CW, suggesting that future recruitment to the legal population will be improving.

A 1999 trawl survey indicated that the biomass of Tanner crabs in the eastern Aleutian Islands was increasing, but still below threshold levels for a commercial fishery. The majority of the recruitment was observed in Akutan, Unalaska and Makushin Bays (Worton 2000). However, survey estimates from 2000 declined again and the fishery remains closed; the next survey is scheduled for the summer of 2003.

No stock assessment surveys are conducted for Tanner crabs in the Western Aleutian District, and no population estimates are available. Stock status is currently unknown. The Tanner crab fishery has not opened recently because there is no BOF-approved management plan, nor has sufficient population data been collected to develop a GHL.

In the Bering Sea, results from the NMFS eastern Bering Sea trawl survey indicate that Tanner crab abundance remains below threshold levels. The 2002 survey estimated the mature female biomass to be 6,260 mt, a slight decrease from the 2001 mature female biomass estimate. The entire Bering Sea District will remain closed to the harvest of Tanner crab for the 2002 season.

4.2.4 Potential Fishery–Sea Otter Interactions

Tanner crabs are listed as sea otter prey items in the Aleutian Islands by Riedman and Estes (1990). However, most of the fishing effort for Tanner crabs occurs further offshore than normal sea otter foraging range, with the possible exception of some areas on the east side of Kodiak Island, when those fisheries were open (Figure 4.2.4). Because Tanner crab pot tunnel openings must be constrained to less than 5 inches in height, it is unlikely that sea otters would enter Tanner crab pots.

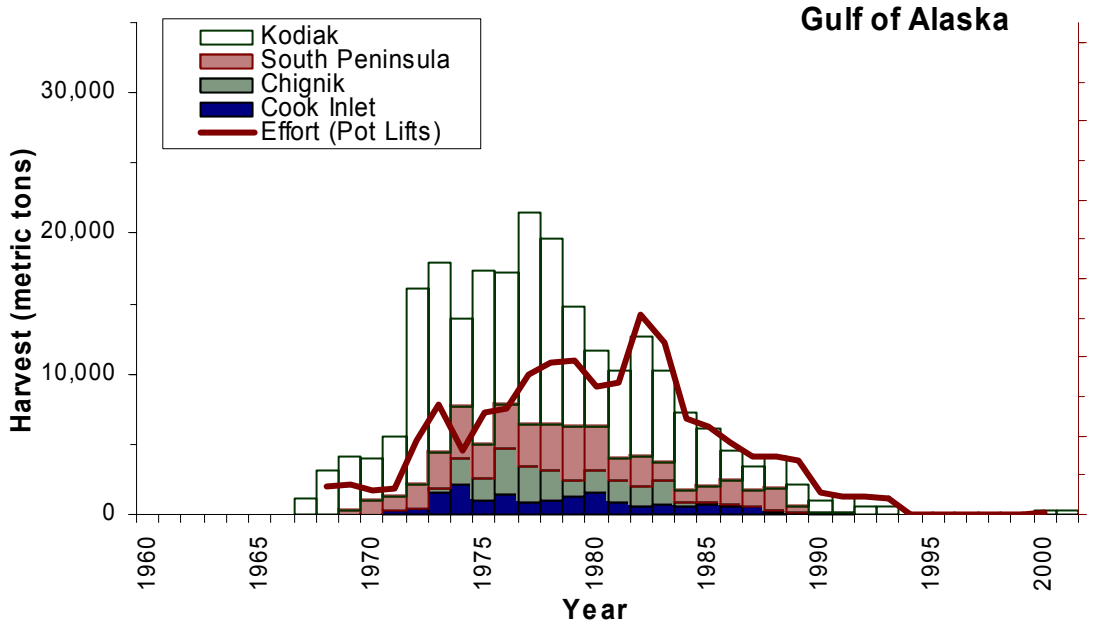

Figure 4.2.1 Harvest of Tanner crabs in the Gulf of Alaska from Cook Inlet to Unimak Pass, 1960–2001.

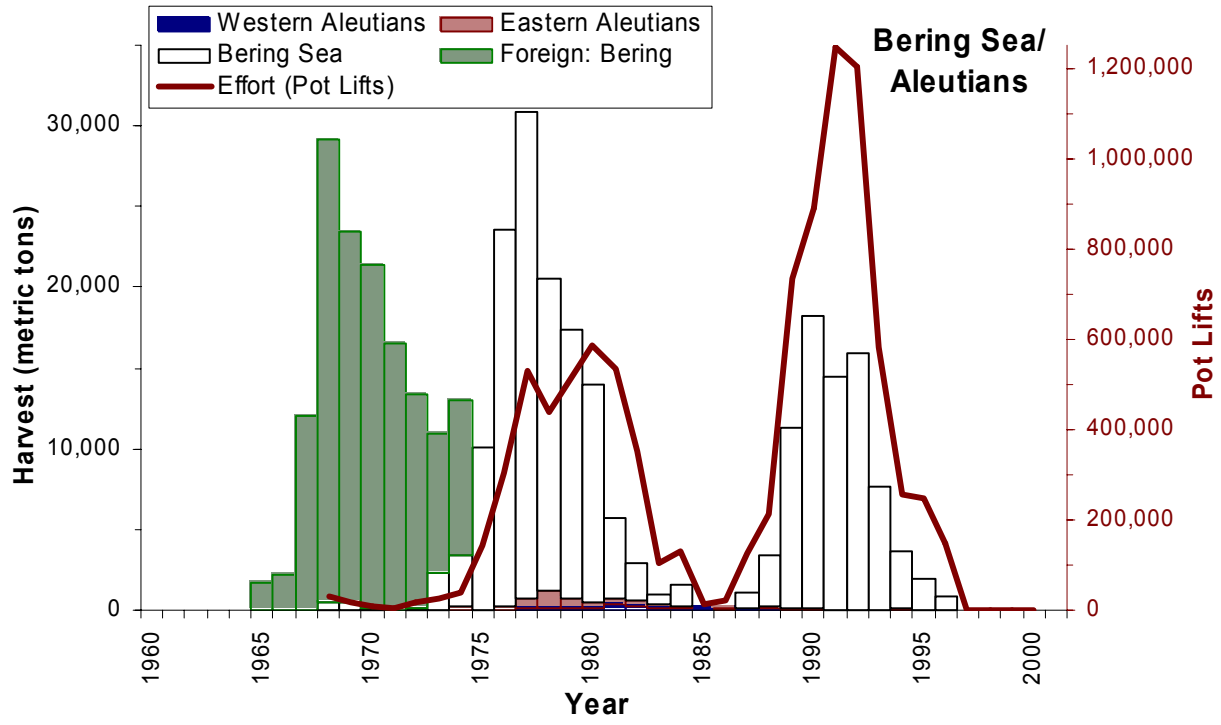

Figure 4.2.2 Harvest of Tanner crabs in the Bering Sea and Aleutian Islands, 1960–2001. Effort in pot lifts does not include the foreign fishery. Foreign harvest data from Otto (1990).

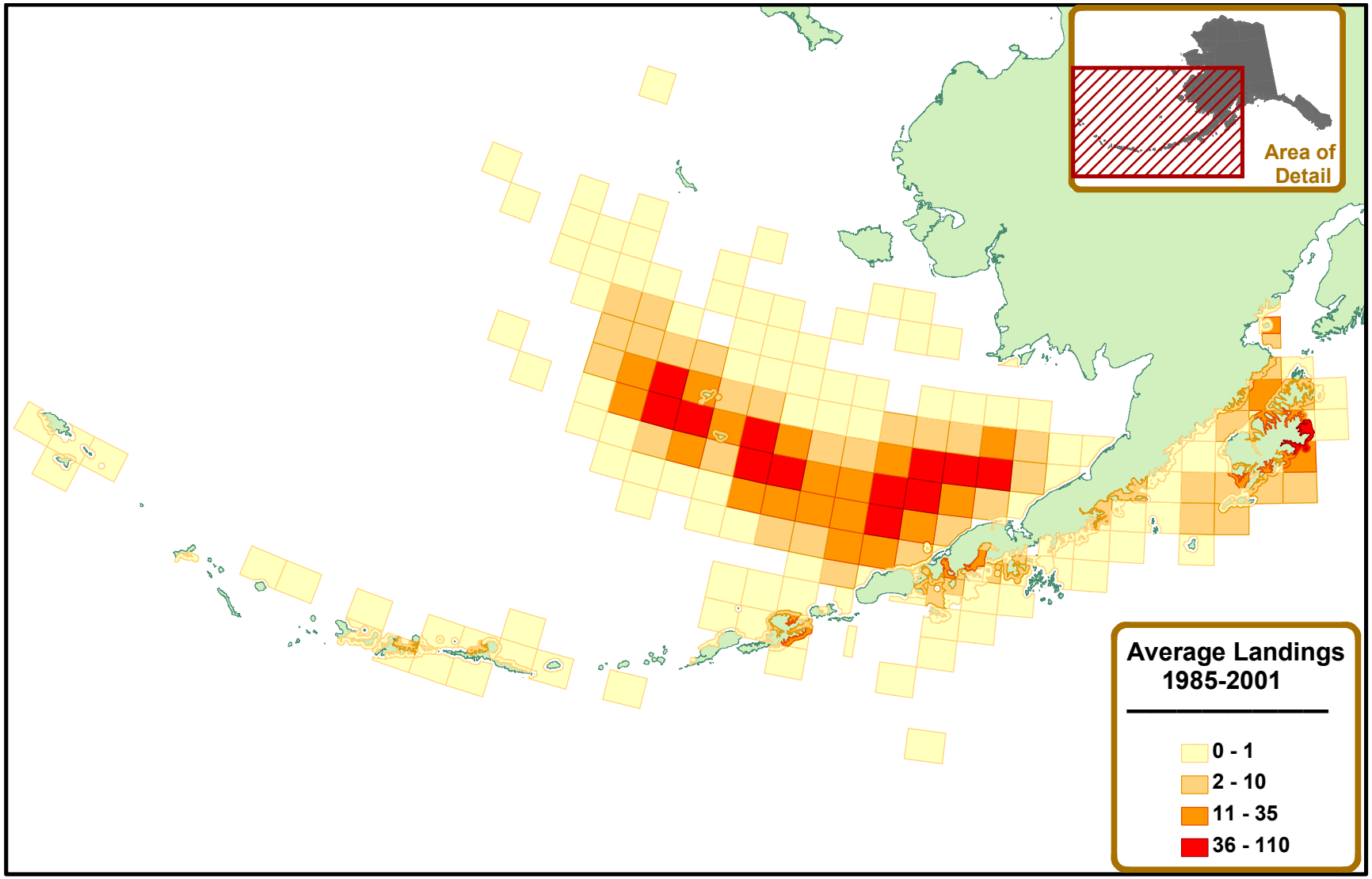

Figure 4.2.3 Spatial distribution of average Tanner crab landings, 1985–2001.

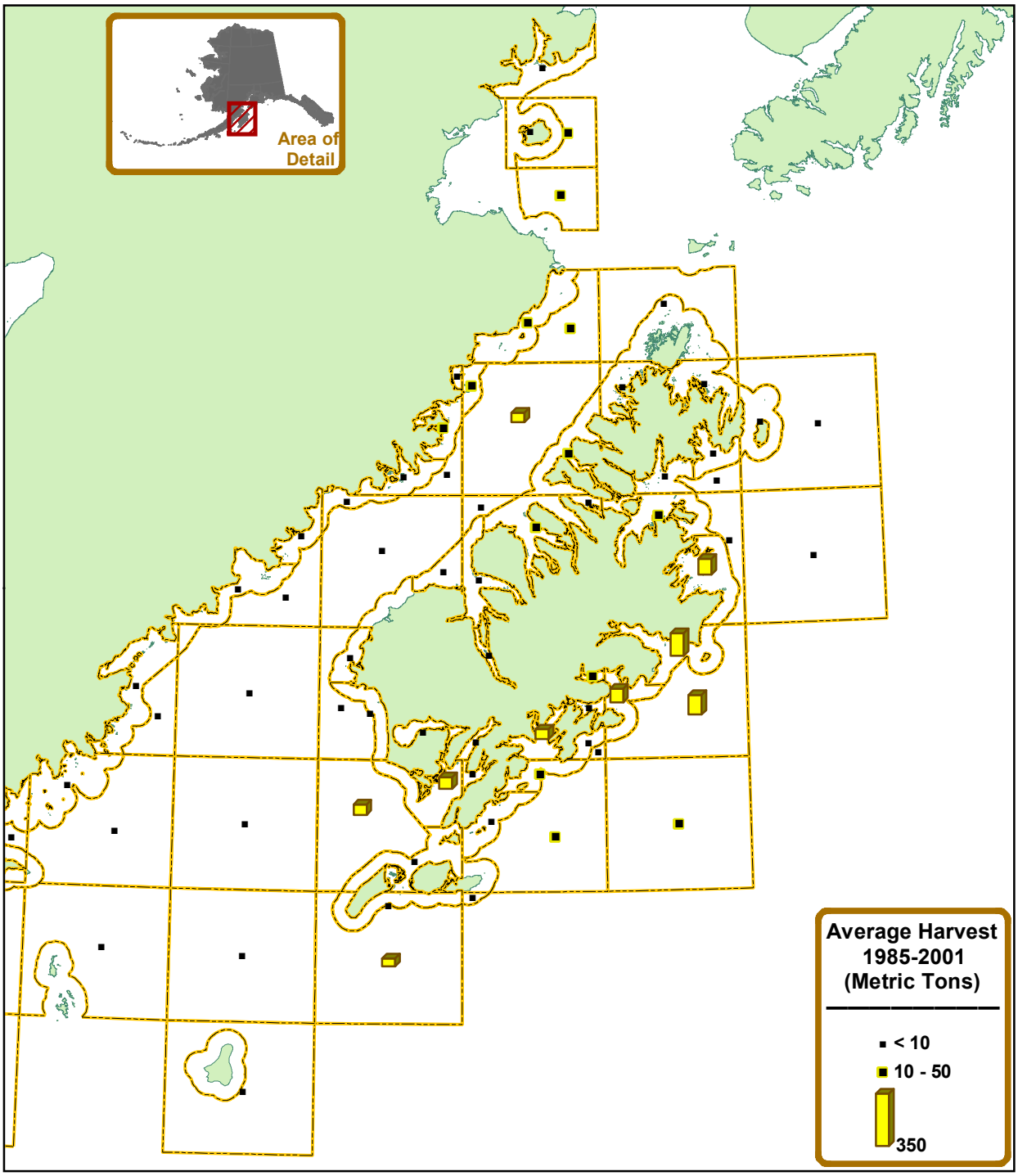

Figure 4.2.4 Spatial distribution of average Tanner crab harvest in the vicinity of Kodiak Island, 1985–2001.

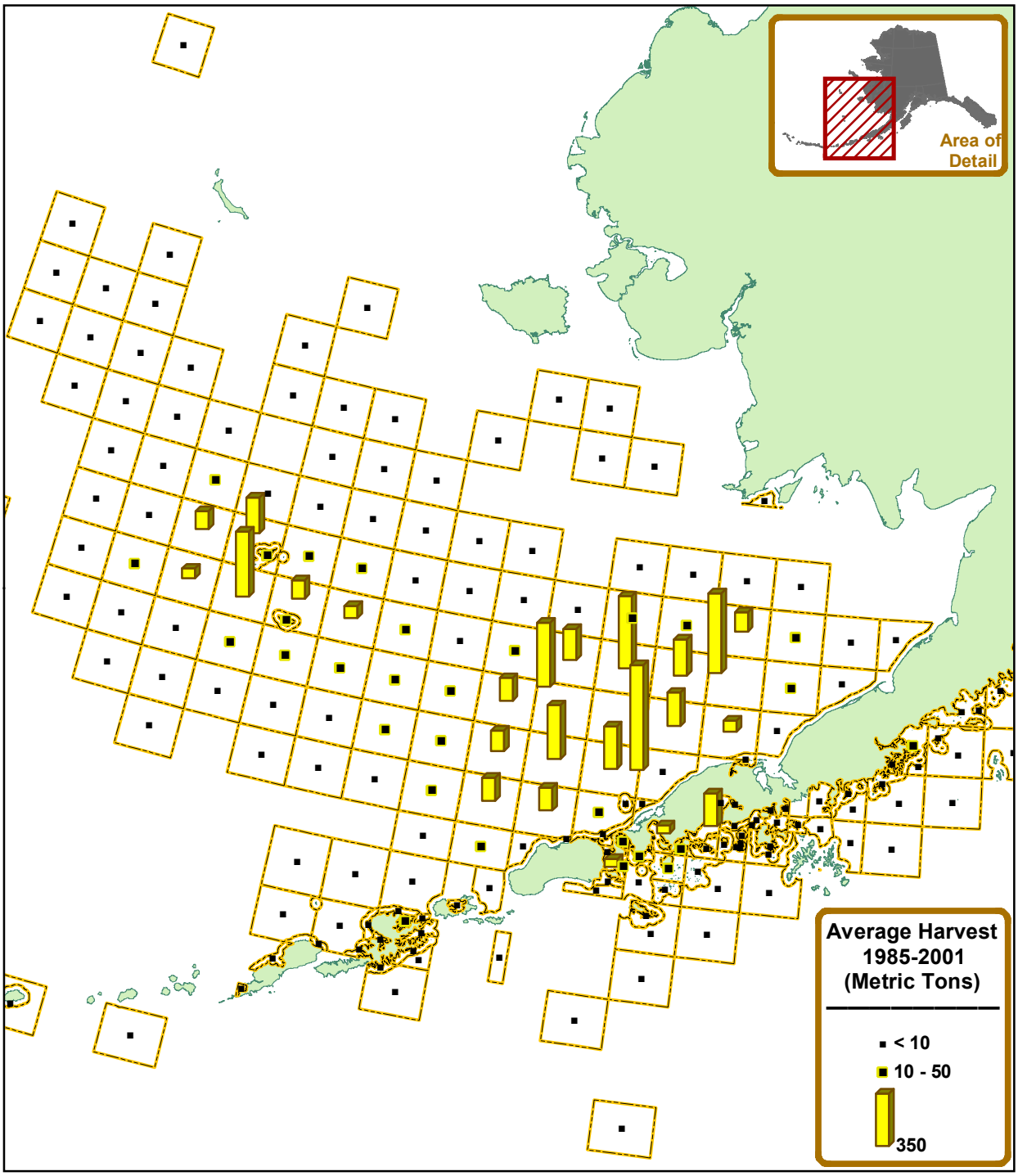

Figure 4.2.5 Spatial distribution of average Tanner crab harvest in the eastern Bering Sea, 1985–2001.

Figure 4.2.6 Spatial distribution of average Tanner crab harvest in the western Aleutian Islands, 1985–2001.

4.3 Deepwater and Offshore Crab Pot Fisheries [3]

Following the collapse of the red king crab and Tanner crab fisheries, fishers became interested in exploiting other crab species. Most of the alternatives occur in deeper water and were not preferred target species until the shallower water-dwelling red king crab were no longer available. Because they occur at great depths, these deepwater crab fisheries likely have very low potential for either competitive or entanglement interactions with sea otters. Only brief descriptions of these fisheries will be provided here.

4.3.1 Golden King Crab Fisheries

Golden (Brown) King crabs (*Lithodes aequispina*) primarily inhabit waters deeper than 200 m, with a depth distribution centered about 300 to 500 m (Blau et al. 1996). Golden king crabs were landed for many years in some fishing areas as bycatch from deepwater sets in red and blue king crab fisheries. Fisheries in the Aleutian Islands have accounted for most of the landings, although there is a small directed fishery near the Pribilof Islands. In the Aleutian Islands, the depths and steep bottom topography in the interisland passes inhabited by golden king crabs necessitates the use of longlined rather than single-pot gear. There are no other major king crab fisheries in Alaska where longlined pot gear is the only legal gear type. 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).

Golden king crabs are found in only a few deep canyons in the Bering Sea District and have never sustained large harvests when compared to other Bering Sea king crab fisheries. As with many other crab fisheries in the Bering Sea, the fishery for golden king crabs was pioneered by foreign fishing fleets. A domestic fishery developed during the 1982–83 season after the BOF directed ADF&G to open and close fishing for golden king crabs in the Pribilof District by emergency order. Subsequently, effort in the Pribilof District peaked during the 1983–84 season when 50 vessels harvested 388.5 mt of golden king crabs. Since the 1983/84 season, no more than seven vessels have registered for this fishery in a given year and harvest has not exceeded 159 mt annually. During the last 15 years in the Pribilof District fishery an average of three vessels have annually harvested an average of 67 mt.

4.3.2 Scarlet King Crab Fisheries

Scarlet king crabs (*Lithodes couesi*) are a deepwater species that lives beyond sea otter diving depths, typically deeper than 600 m. Harvest of scarlet king crabs has primarily occurred as bycatch in the grooved Tanner crab and golden king crab fisheries, with a limited amount of exploratory directed fishing under special commissioner's permits. Exploratory fishing does not indicate that a large biomass is present. Scarlet king crabs have only been landed since 1995, and the peak harvest has been 41 mt. Participation in the fishery has been very limited. No directed

[3] Most of the management information in this section is extracted from more detailed treatments in Ruccio and Worton (2000a,b), Bowers (2001), Bowers et al. (2001) and Kruse et al. (2000). The current fishery management contacts are, Michael Ruccio (Kodiak and Alaska Peninsula), and Forrest Bowers (Bering Sea and Aleutian Islands)

fishing for scarlet king crabs is anticipated prior to adoption of the Plan for the Development of New Fisheries in Alaska by the BOF.

4.3.3 Grooved Tanner Crab Fisheries

Grooved Tanner crabs (*Chionoecetes tanneri*) are another deepwater shellfish species that began to be exploited following the demise of the red king crab fisheries. Limited data have been collected regarding the abundance, distribution, and stock status of deep-water crab species in the Bering Sea and Aleutian Islands. The fisheries are small-scale and primarily exploratory in nature.

Grooved Tanner crabs have a southern boundary in the Pacific Ocean off the California-Mexico border. Their distribution extends northward into the North Pacific, primarily adjacent to the Aleutian Islands, and in the Bering Sea with a reported depth distribution of 53 to 1,900 m (Garth 1958).

The Alaska Peninsula was initially explored for commercial fishing for grooved Tanner crabs in 1994. This species is found along the continental shelf break at great depths, with commercial fishing usually occurring between 600 and 900 m. Vessels were initially required to use single line pot gear, but longlined pot gear is now allowed. A minimum legal size CW of 5.0 inches (127 mm) for grooved Tanner crabs was stipulated. Only a small handful of vessels have been registering or fishing for this species so catches often remain confidential.

Fishing for grooved Tanner crabs in the Eastern Aleutian District typically occurs between March and December. Peak harvest in the Eastern Aleutian District occurred in 1995 when seven vessels landed approximately 386 mt.

The first reported landings of grooved Tanner crabs from the Pribilof Islands area occurred in 1988 after the BOF established a special permit season. Fishing effort has been concentrated in a few statistical areas immediately to the south of Saint George Island. Catch rates indicate that in the area historically fished, the population was heavily exploited.

In 1997, the ADF&G established GHLs of 90 mt for grooved Tanner crabs in the Eastern Aleutian, Bering Sea, and Alaska Peninsula Districts where most historical harvests had occurred. Harvest levels in this fishery were derived using catch information from previous seasons and data collected by onboard observers. Smaller GHLs of 45 mt were established for the Kodiak and Western Aleutian Districts to allow for exploratory fishing.

Pots used for grooved tanner crab are required to have at least two escape rings of 4.5 inches (114 mm) minimum diameter. Observers are required on all vessels registered for the fishery to collect biological and fishery data.

4.3.4 Triangle Tanner Crab Fisheries

Triangle Tanner crabs (*Chionoecetes angulatus*) are another deepwater species inhabiting environments similar to grooved Tanner crab. Triangle Tanner crabs are harvested mostly as

incidental bycatch in the grooved Tanner crab fisheries and can only be retained under a special commissioner's permit.

Triangle Tanner crabs occur in the North Pacific from Oregon to Alaska, the Bering Sea, adjacent to the Aleutian Islands, and the Kamchatka Peninsula. They are reported from depths of 90 to 3,000 m (Garth 1958). Recent Aleutian Islands and Bering Sea fisheries for this species have averaged 878 and 948 m depths respectively (Jadamec et al. 1999).

Two vessels targeted triangle Tanner crabs in the Eastern Aleutian District during the 1995 and 1996 seasons, thus harvest information from those fisheries is confidential. Since 1996, no vessels have registered to harvest triangle Tanner crabs in the eastern Aleutian Islands.

In the Bering Sea, triangle Tanner crabs were harvested in 1995 and 1996 but the catch remains confidential because less than three vessels participated. No vessels registered to fish triangle Tanner crabs in the Bering Sea District in 1997, 1998, or in 1999, while a single vessel registered to harvest triangle Tanner crabs in the Bering Sea District in 2000.

A very small amount of triangle Tanner crabs were harvested along the Alaska Peninsula, beginning in 1994. As in the other areas, harvest occurred in conjunction with a grooved Tanner crab fishery.

Surveys of population abundance are not conducted for triangle Tanner crabs so the status of this stock is unknown. Because of the lack of information for this species, additional fishing for triangle Tanner crabs is limited to bycatch during the grooved Tanner crab fishery. Vessels registered to fish for grooved Tanner crabs are permitted to harvest triangle Tanner crabs at up to 50% of the weight of the target species as bycatch. This harvest level is consistent with the historic development of the fishery and allows retention of a deepwater species that is believed to have high bycatch mortality.

4.3.5 Korean Hair Crab Fisheries

The Bering Sea hair crab (*Erimacrus isenbeckii*) fishery occurs in an area well north of the Alaska Peninsula, in waters north of lat. 54°36' N, and west of long. 168° W. The fishery was pioneered by the Japanese fleet during the 1960s and first commercially exploited by the U. S. fleet in 1978. In the early years of the U. S. fishery, the hair crab season was opened by emergency order concurrent with the Bering Sea Tanner crab fishery; however, by 1980 a yearlong permit fishery had been established. Throughout the 1980's, harvest of hair crabs occurred primarily as bycatch in the Bering Sea Tanner crab fisheries. Interest in the fishery increased in the 1990s with all fishing occurring under special commissioner's permits that now require observers to be carried onboard vessels greater than 44 feet. Access to the fishery is now restricted. Licenses have been issued to 23 vessels for waters beyond 5 nautical miles of St. George and St. Paul Islands. Any vessel less than 58 ft. in length may fish within 5 nautical miles of St. George and St. Paul Islands.

Participation and harvest in the Bering Sea hair crab fishery has varied greatly over the history of the U.S. fishery. Effort and harvest reached a peak of 67 vessels and 1,089 mt in 1980 when the fishery was prosecuted as a bycatch fishery during the Tanner crab season. Between 1987 and 1990 effort was minimal due to low stock abundance. Since the moratorium, effort has remained at 21 or fewer vessels and in 1997 only 16 vessels made landings. In the 1990s, harvest reached a peak of 1,043 mt 1994. Since 1995, both effort and GHL have been declining.

Abundance information is derived from the NMFS Bering Sea trawl survey. Population trends observed during the last four years and weak performance of recent commercial fisheries, indicates that the Bering Sea hair crab population remains depressed. Small male abundance is currently at near record low levels and total abundance in the historically productive Pribilof Islands Area is very low. Given this information, the reopening of any portion of the Bering Sea to commercial fishing for hair crabs will be unlikely in the absence of significant recruitment.

4.3.6 Snow Crab

Snow crabs (*Chionoecetes opilio*) occur in the Bering Sea, and are fished offshore, north of the Alaska Peninsula, along the steeper contours at the edge of the continental shelf (Figure 4.3.1). There is only low potential for overlap of the snow crab fishery with sea otters, except perhaps for sea otters transplanted to the Pribilof Islands. The first commercial landings of snow crabs from the Bering Sea were recorded in 1977, incidental to the harvest of Tanner crabs. In 1981, with reductions in the Tanner crab harvest, snow crab harvest began to increase. The fishery is prosecuted during the winter, often at the southern limit of the ice edge, and ice conditions have occasionally disrupted the fishery. The NMFS summer trawl surveys of the eastern Bering Sea indicate the snow crab population is declining, though it remains above the threshold for commercial fishing.

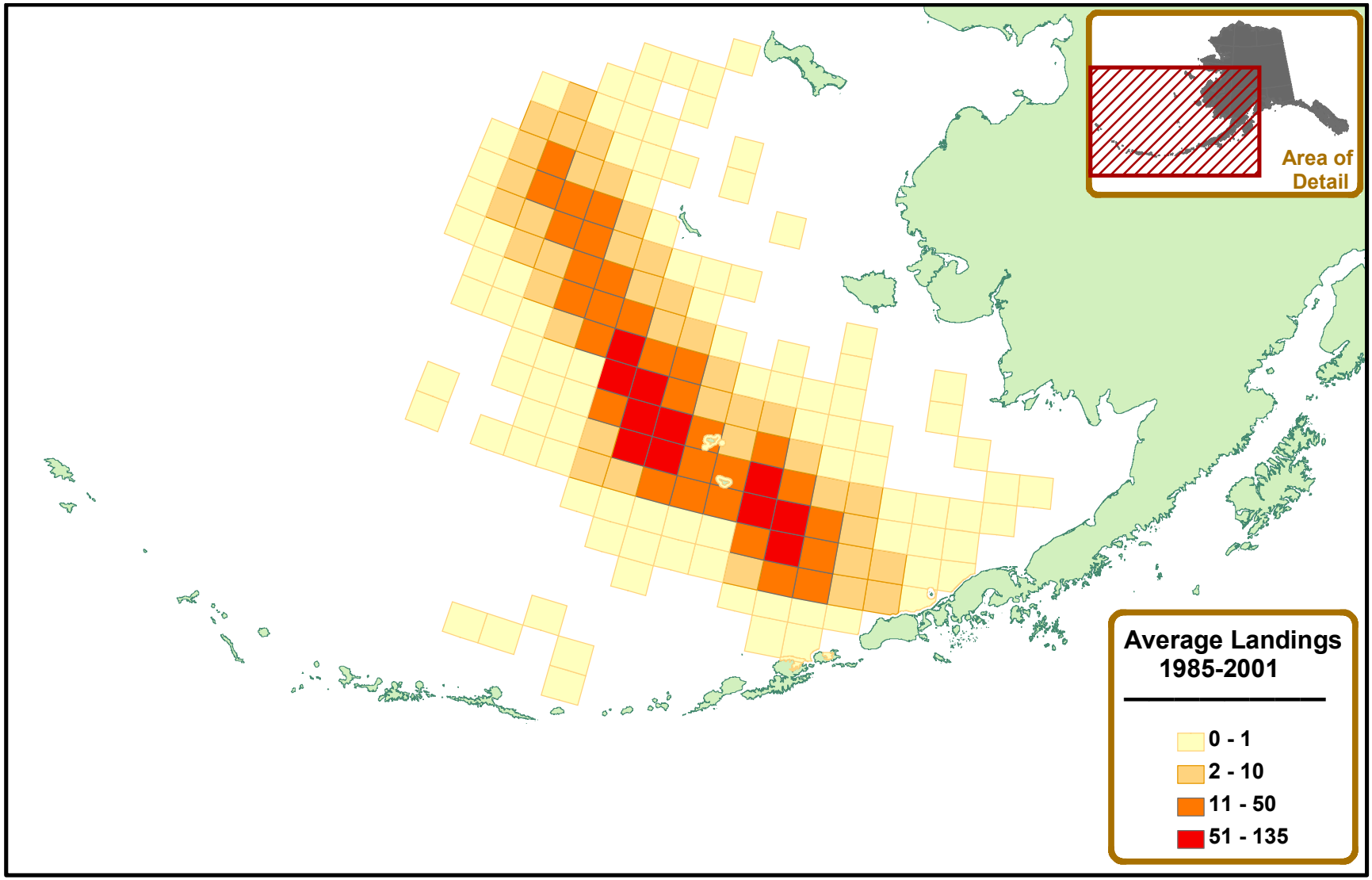

Figure 4.3.1 Distribution by statistical area of average number of landings in the snow crab fishery, 1985–2001.

4.4 Salmon Set Gillnet Fishery[4]

Set gillnets have been commercially fished for salmon in many areas occupied by the Southwest stock of sea otters for at least a century. Some techniques incorporated in contemporary set gillnet operations date back to millennia of subsistence utilization by indigenous cultures. Unlike most other fisheries in Alaska, set gillnet fisheries operate from specific sites, with the same location often being fished for generations within an extended family.

Set gillnets account for only a small fraction (15%) of the salmon harvest in the area of the Southwest stock of sea otters. Half of the salmon harvest in this area is taken by purse seine, with the remaining 35% taken by drift gillnet (Figure 4.4.1).

4.4.1 Description of Fishery

A salmon "setnet" is an anchored gillnet. Similar to a drift gillnet, nets are hung from the set line with corks on the top and a leadline on the bottom (Figure 4.4.2). The net does not sink; if water depth is sufficient, there is sufficient floatation in the corkline to float the leadline off of the bottom. Maximum gillnet size is limited by state regulations, which vary by region. Gillnets for the set gillnet fishery must be made of multifilament line.

Some setnets have a "lead" comprised of very large mesh seine webbing at the inshore end of the set gillnet to channel the fish toward the net during high tide periods. The inshore end of most set gillnets is anchored on the beach and the offshore end is secured to anchors and buoys. However, some setnets are not anchored to the shoreline, but held stationary with anchors on each end of the net. Set gillnets can be simply set in a straight line, or set to have a v-shaped hook at the end. Salmon become caught in the nets by their gills when they attempt to swim through the net. Fishermen may use small skiffs to tend the nets and pick the salmon, or the nets can be accessed by motor vehicles and picked at low tide in some shallow areas such as Bristol Bay. Running lines are sometimes used for setting out and retrieving the setnet, with a line manually dragged from the beach straight out to a pulley and screw anchor, and back to the beach. Setnet sites are often run as family operations, supported by fixed shore-based facilities. The State of Alaska Department of Natural Resources manages a permit system for shore fishery leases on the tidelands, which grants up to 10 years use for first priority access to the site. Many setnet sites are located in remote areas, accessibly only by boat or airplane.

Salmon management authority in the area of the Southwest stock of sea otters is delegated into two ADF&G "Regions" (Central and Westward) and five management areas: Lower Cook Inlet, Kodiak, Chignik, Alaska Peninsula (north and south), and Bristol Bay (Figure 4.4.3). Setnet fishing is not permitted in the Kamishak Bay District of lower Cook Inlet or in the Chignik Management Area. A large number of setnet sites occur throughout the Bristol Bay management area, which includes the north shore of Bristol Bay out to Cape Newenham. Because of the range

[4] Most of the management information in this section was excerpted from more detailed treatments in Weiland et al. (2002), Brennan (2001), and Shaul and Dinnocenzo (2002a,b). The current fishery management contacts are Kevin Brennan (Kodiak), Keith Weiland (Egegik/Ugashik), Steve Morstad (Naknek/Kvichak), and Arnie Shaul (Alaska Peninsula).

limits of the Southwest stock of sea otters, this report considers only those setnet fisheries in eastern Bristol Bay, those which occur near the Egegik, Ugashik, Naknek, and Kvichak Rivers.

Salmon management in Alaska is based on an optimal escapement harvest policy. Escapement goals are set for major salmon-producing systems based on stock-recruit analyses where available, or in some cases less formally based on historical production records supplemented by guidance and biological insight from fishery managers. Salmon runs escaping up rivers are enumerated using direct observation from towers or weirs, inriver sonar, or aerial overflights. Fishery managers strive to adjust offshore fishing catch such that the inriver enumeration achieves escapement goals. For fishery systems with simply-structured harvests occurring only in terminal fishing areas adjacent to river mouths or in small rivers, this task is relatively straightforward. However, some salmon runs are caught in interception fisheries located far from their river of origin. Typically these interception fisheries occur somewhat offshore, sometimes in the vicinity of ocean capes or passes. Limits are placed on the catch of interception fisheries to preserve the historical allocations of the harvest to inshore user groups and protect depleted salmon runs from overharvest. For example, the salmon fishery near False Pass is constrained by a long and controversial history of intercepting chum salmon *Oncorhynchus keta* bound for the distant Kuskokwim River.

4.4.2 History of the Fishery

Setnet fishing predates Alaska statehood, with many sites being fished by successive generations of family members. Like other gear types, salmon setnet landings were relatively low in the early 1970s, due to poor salmon runs, with less than 5,000 total landings recorded in the Kodiak, Chignik, Alaska Peninsula and eastern Bristol Bay areas (Figure 4.4.4). With the imposition of limited entry and improved salmon runs of the middle and late 1970s, effort increased to 20,000 to 30,000 landings per year. Eastern Bristol Bay contributes the largest number of setnet landings per year.

The salmon resources of the Kodiak Management Area have been used for subsistence for perhaps thousands of years, and have been exploited commercially for over 150 years (Roppel 1986). The first commercial fisheries were small salted salmon ventures by the occupying Russians in the early 1800s (Brennan 2001). Salmon streams were blocked and salmon captured as they became schooled behind these barriers. Sockeye salmon *O. nerka* returning to the Karluk River brought fishermen and processors to Kodiak Island soon after the territory was transferred from the Russians in 1867. Commercial sockeye salmon harvest records date back to 1882. Intense competition led to expansion of the fishery to other areas and species. By the early 1900s fisheries for coho salmon *O. kisutch*, pink *O. gorbuscha*, and chum salmon had developed.

Beach seines were the first gear type effectively used commercially in the Kodiak Area, with huge, heavily-manned seines of 450 fathoms in length in use in the Karluk area. The first fish trap was built in Kodiak in 1896. Until the late 1950s the Kodiak commercial salmon fishery was dominated by cannery-owned fish traps, with some independent fishers owning purse seine, beach seine, and set gillnet operations. When Alaska was granted statehood in 1959, fish traps were prohibited, and the Kodiak Area commercial salmon fishery was conducted by purse seine, set gillnet, and beach seine gear (in decreasing order of abundance). Since 1988 there has been a

decline in the gross exvessel value of the Kodiak Area salmon fisheries, and consequently in the number of permits actually fished.

Commercial salmon fisheries in the Alaska Peninsula Area date back to at least 1888 when canneries were reportedly constructed on the South Peninsula Area at Orzinski (Orzenoi) Bay and Thin Point Cove. However, the earliest catch records for the Alaska Peninsula Area originate in 1906. Early catches in the Alaska Peninsula were predominantly sockeye salmon with a few chinook and coho salmon. Both pink and chum salmon harvests exceeded 500,000 for the first time in 1916 (Shaul and Dinnocenzo 2002a).

The Aleutian Islands and Atka-Amlia Areas support runs primarily of pink salmon, with much smaller runs of sockeye and chum (Shaul and Dinnocenzo 2002b). The first recorded Aleutian Islands Area commercial salmon catches were in 1911. Setnet gear is legal only in the Atka-Amlia area, while purse seine gear may be fished in both areas. The BOF created an open-to-entry set gillnet salmon fishery around Atka and Amlia Islands in 1991, while salmon seine permit holders may still seine for salmon in the Atka-Amlia Islands Area (5 AAC 11.333). Markets often limit commercial salmon harvests in Aleutian and Atka-Amlia Islands Areas, with markets developing only if pink salmon prices and abundance warrant tenders moving into the area. With the decline in demand for pink salmon, there have been no commercial salmon harvests in the Atka-Amlia Area since 1994, and only one year (2000) where some harvest occurred near Unalaska Island. Relatively low amounts of fishing effort occur for subsistence in the area.

The rivers of the Bristol Bay area are home waters for the largest sockeye salmon runs in the world. Annual commercial catches (1981–2000) from Bristol Bay averaged 25.5 million sockeye, 24 thousand chinook, 870 thousand chum, 17 thousand coho, and 742 thousand pink salmon in 2001. Legal gear for the commercial salmon fishery includes both drift gillnet (1,883 permits) and setnet (1,010 permits). Drift gillnets are limited to 150 fathom nets, while setnets are limited to 50 fathom nets.

4.4.3 Recent Catch and Effort

A total of 205 statistical areas in the area of the Southwest stock of sea otters had recorded setnet landings between 1970 and 2001. However, 95% of the landings occurred in just 50 statistical areas. Most of the setnet effort in this area has been concentrated near the major river systems of eastern Bristol Bay (Figure 4.4.5), with some significant effort on the west side of Kodiak Island (Figure 4.4.6), and a much lower amount in the Alaska Peninsula (Figure 4.4.7). The 155 statistical areas accounting for the remaining 5% of the landings are shown as “trace” amounts in the effort distribution.

In the Kodiak Area in 2001, a total of 172 set gillnetters out of 190 possible permits participated in the Kodiak fishery. Seine fishers accounted for 89.6% of the total of 23,711,965 salmon harvested while set gillnet fishers accounted for 10.4% (Brennan 2001).

In the Alaska Peninsula Area in 2001, 64 of the 121 available seine permits fished, 137 of 161 available Area M drift gillnet permits were fished, and 99 of 115 available set gillnet Area M permits were fished (Shaul and Dinnocenzo 2002a). In addition to Area M permit holders, four Area T drift gillnet and one Area T set gillnet permit holders made at least one delivery during the year. The effort level of all gear types declined to the lowest since at least 1984, due to poor market conditions.

In the Bristol Bay Area, 837 set permits were fished in 2001, out of a total of 1,010 possible permits (Weiland et al. 2002).

4.4.4 Potential Interactions with Sea Otters

While there is potential for gillnets to entangle sea otters, the number of reported entanglements is very low. Gillnet panels present large potential wall-like barriers across nearshore areas, which sea otters must avoid. Unweighted gillnet-like tangle nets are sometimes used a method for live capturing sea otters. In part, the low number of reported entanglements in commercial setnet gear may result from the location of fishing effort. Set gillnet fishing normally does not occur in the rocky nearshore areas which are preferred sea otter habitat. The NMFS marine mammal observer program observed the Kodiak setnet fishery in the summer of 2002 and recorded four sea otter entanglements; two sea otters released themselves from the net and two required intervention, but were released without apparent injury (Amy Van Atten, National Marine Fisheries Service, Juneau, Alaska, personal communication). In 1990, one sea otter was reported killed and 7 were injured in the Copper-Bering River drift gillnet fisheries near Prince William Sound (U.S. Fish and Wildlife Service 2002). Of the 7 injuries, 4 resulted from gear contact and 3 from deterrent measures. In 1991 voluntarily-submitted logbooks, one sea otter was reported killed in the Kodiak set gillnet fishery. These are the only records of salmon setnet sea otter entanglements currently available.

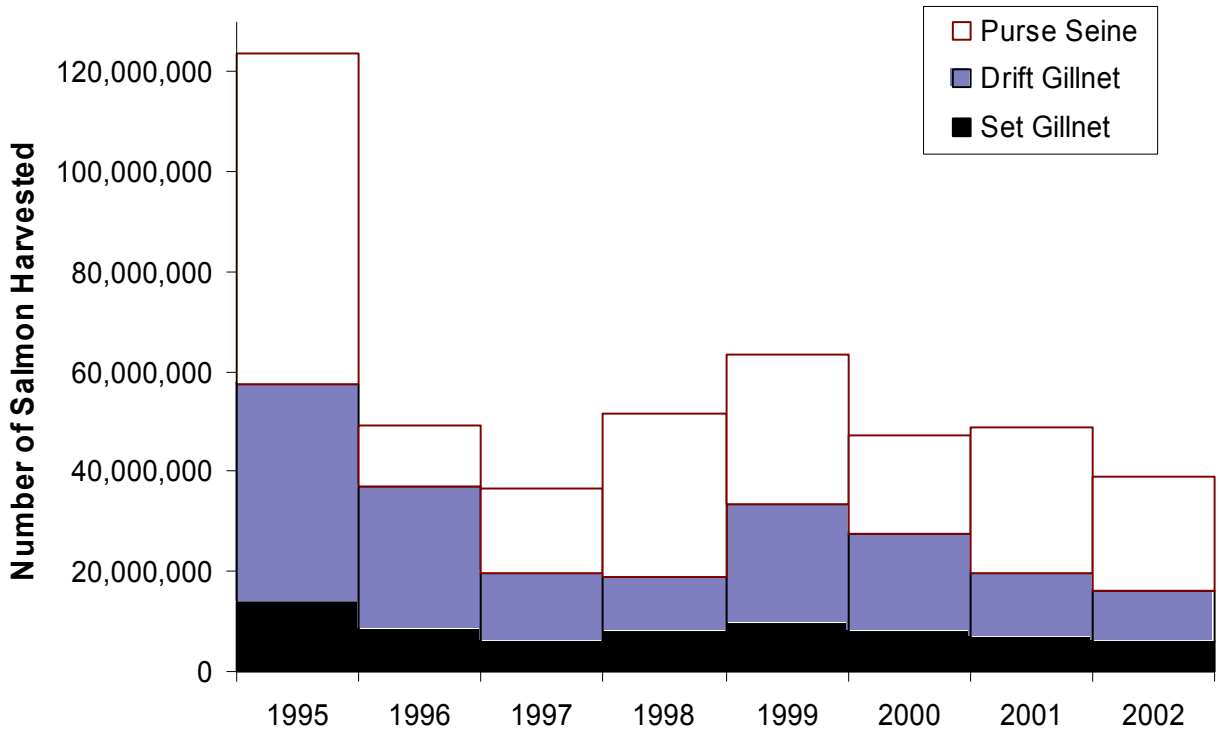

Figure 4.4.1 Salmon harvest by gear type from the Kodiak, Alaska Peninsula, and Bristol Bay Areas, 1995–2002.

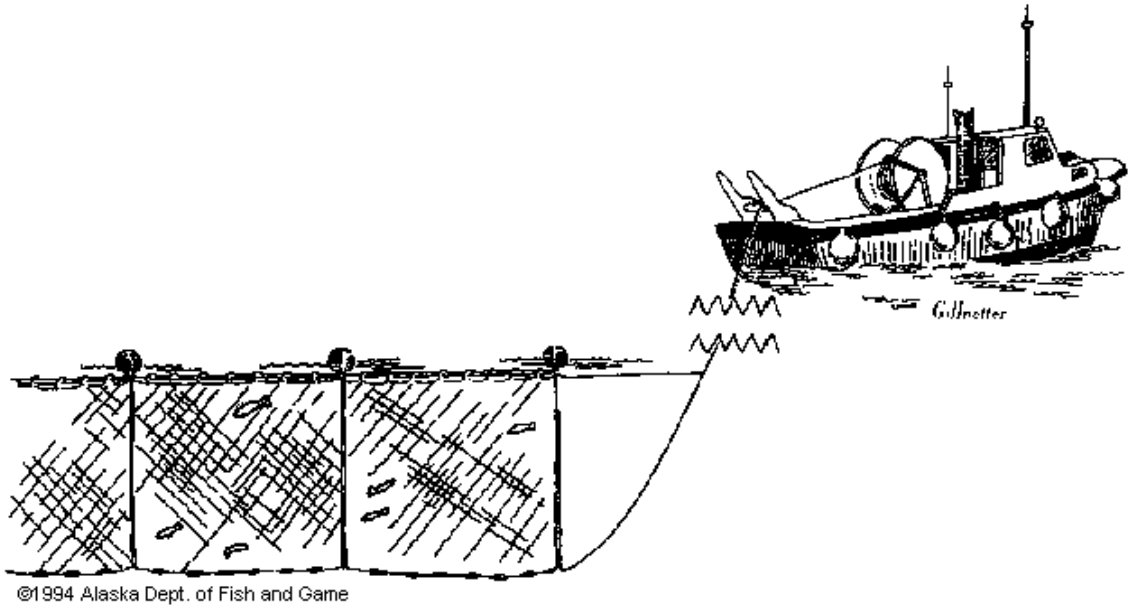

Figure 4.4.2 Typical arrangement for salmon gillnet gear. For set gillnets, smaller, shore-based boats are usually used, the net is hauled to and from the shore, and the net is anchored to the bottom and/or fixed to the shore.

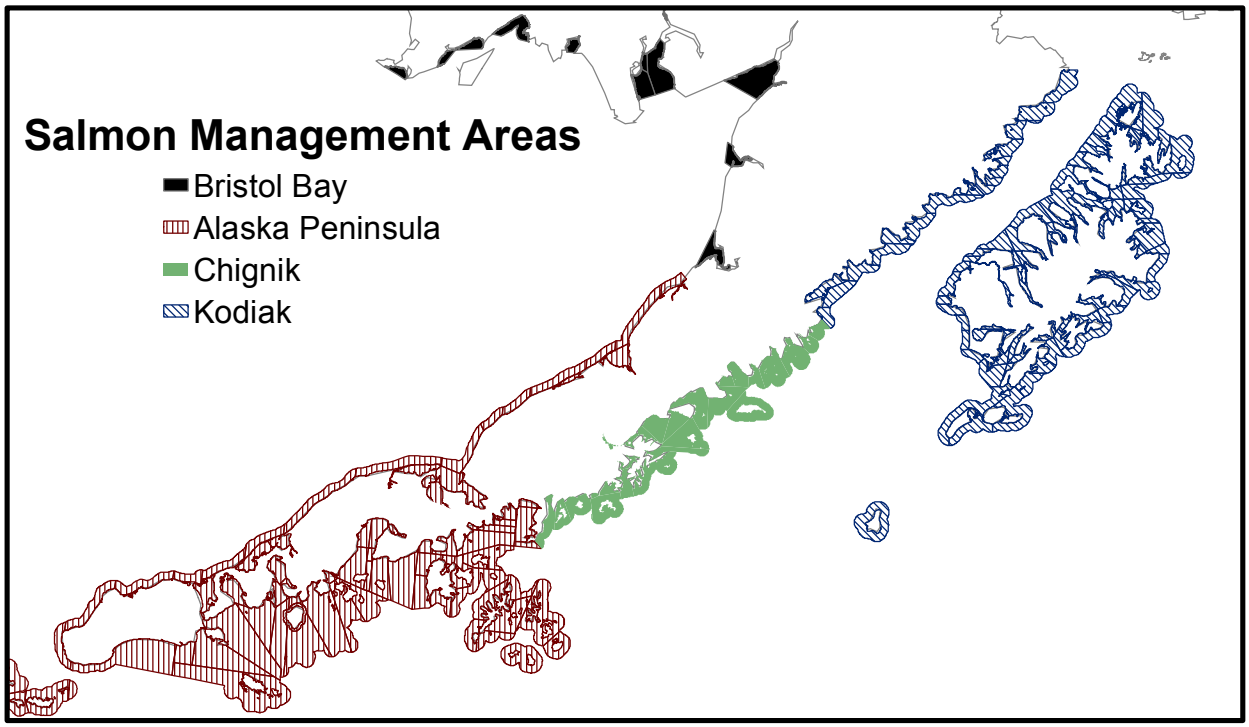

Figure 4.4.3 Management areas used for salmon fisheries in the area of the Southwest stock of sea otters. Setnet gear is not legal in the Chignik Area or in Kamishak Bay.

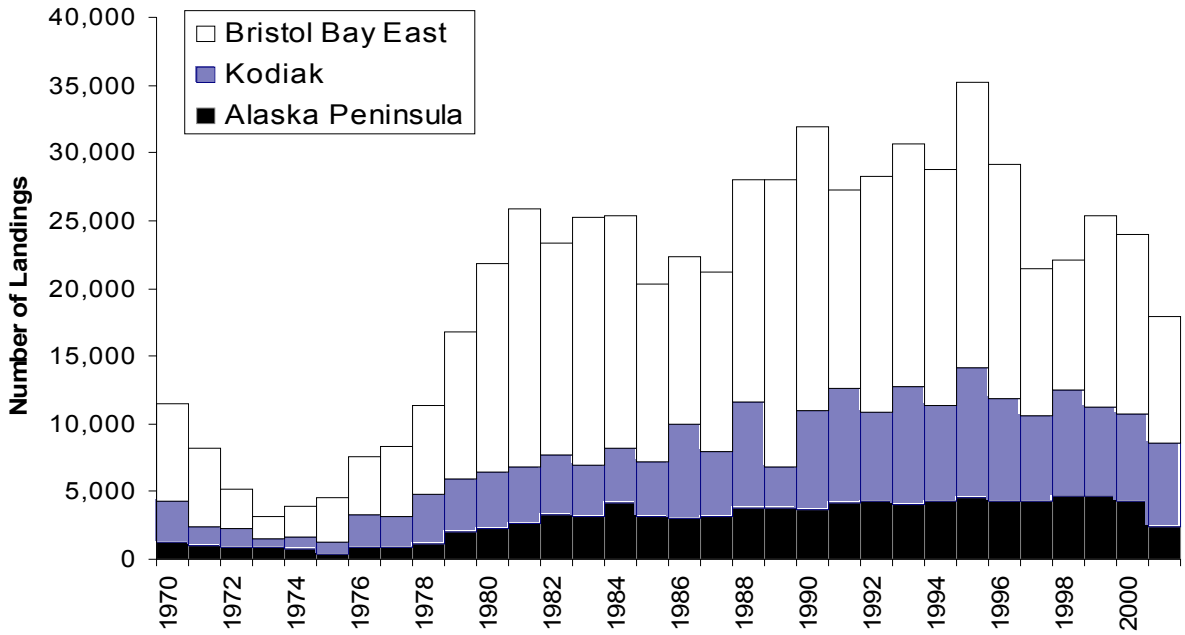

Figure 4.4.4 Number of salmon setnet landings in the area of the Southwest stock of sea otters.

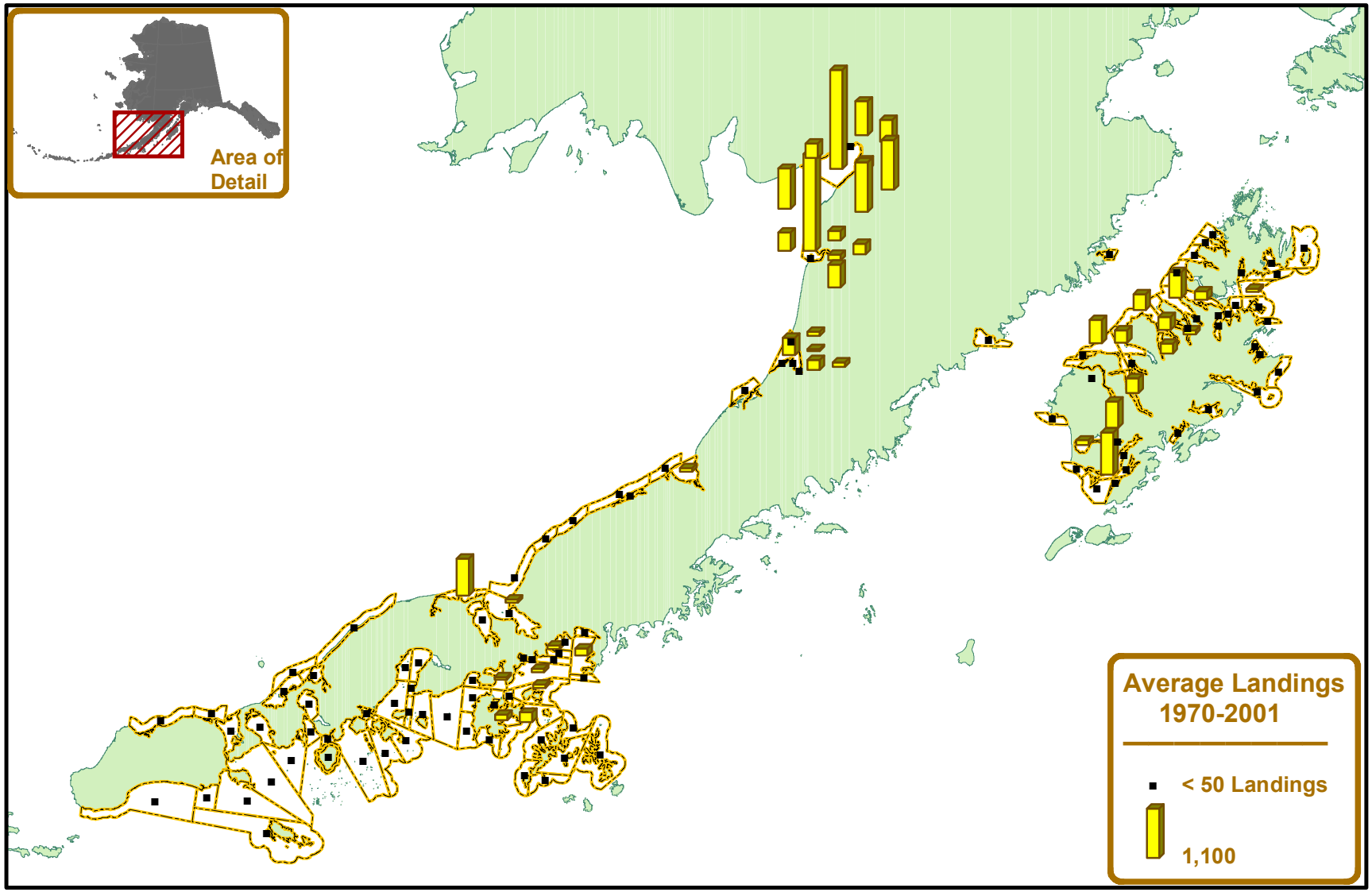

Figure 4.4.5 Distribution of the average number of salmon setnet landings, 1970–2001, throughout the range of the Southwest stock of sea otters.

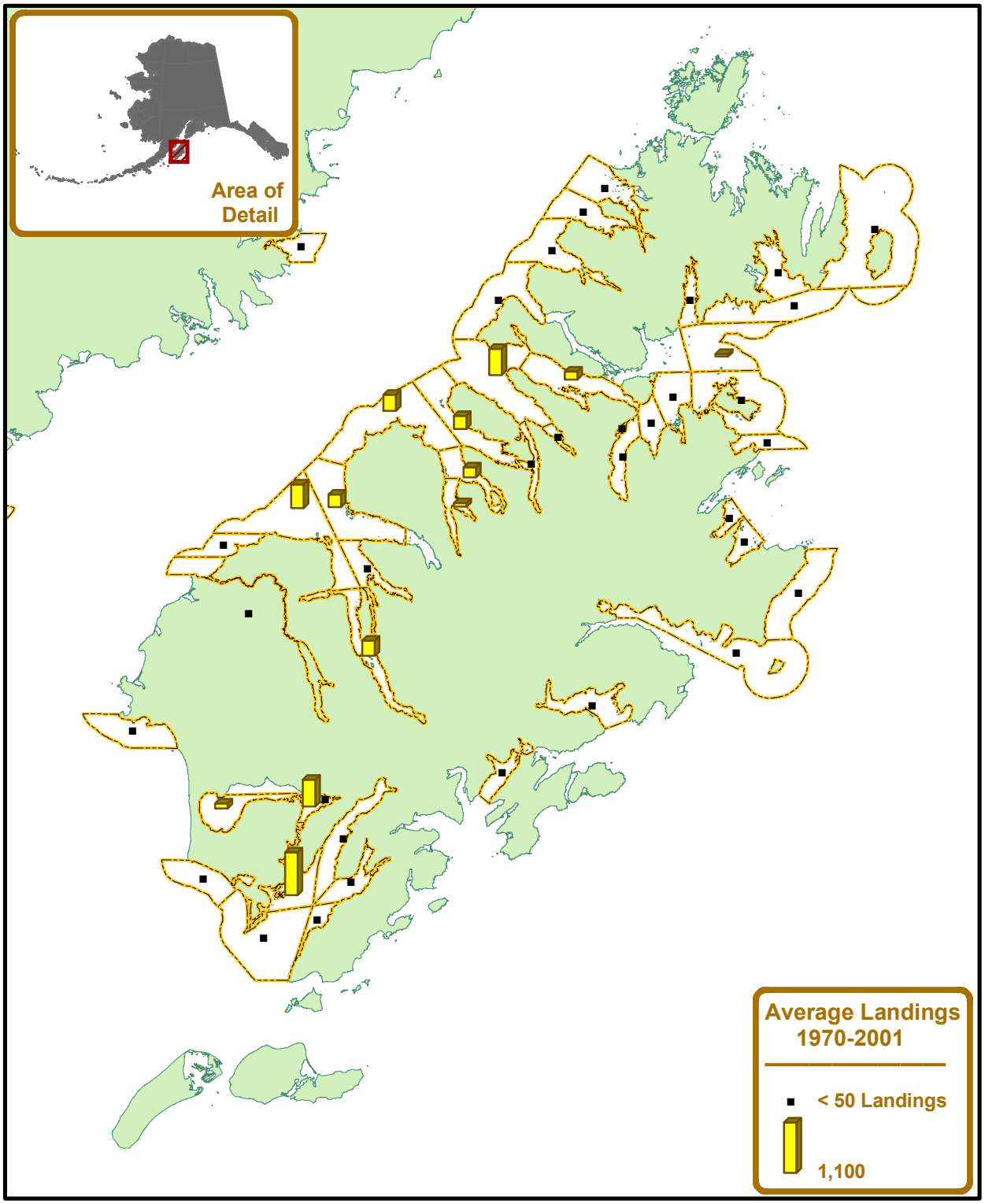

Figure 4.4.6 Distribution of the average number of salmon setnet landings, 1970–2001 in the Kodiak area.

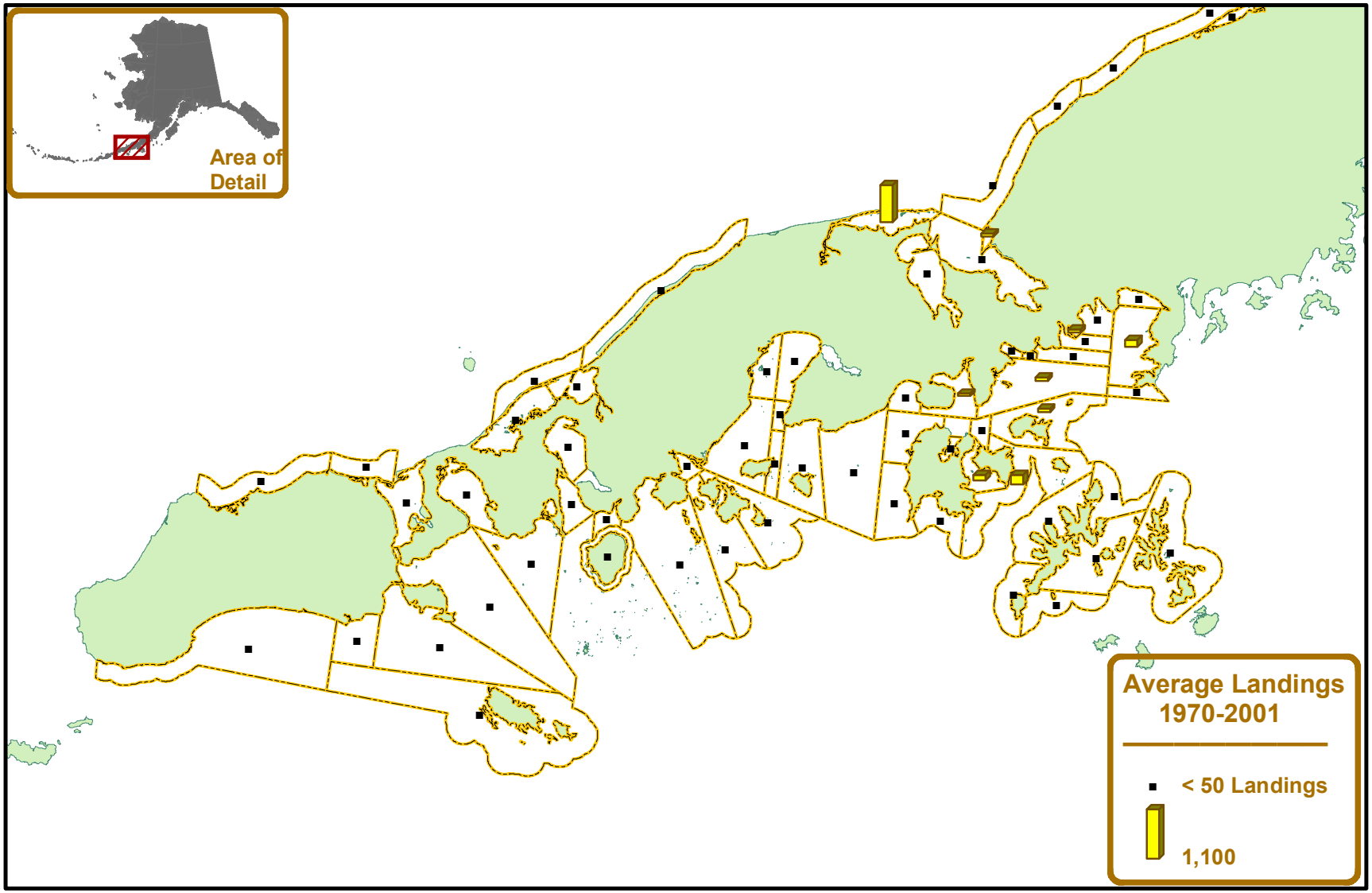

Figure 4.4.7 Distribution of the average number of salmon setnet landings, 1970–2001 along the western Alaska Peninsula.

4.5 Other Types of Gillnet Gear

4.5.1 Sunken Gillnets

Sunken gillnets are not legal fishing gear in Alaska. Salmon gillnets must have floating corklines. Sunken gillnets are used for catching dogfish sharks in the state of Washington and other locations. Sunken gillnets were legal fishing gear in some parts of Alaska until 1992, but only a minor amount of exploratory fishing occurred. There has been periodic recent interest in using sunken gillnets to catch Pacific cod, but the BOF has repeatedly and firmly refused to permit their operation because of bycatch concerns.

The BOF had initially adopted regulations permitting an experimental sunken gillnet fishery in Southeast Alaska in 1979. Provisions for sunken gillnet fisheries to occur under the terms of a commissioner's permit were established for the Cook Inlet Area in 1980, in the Westward Region in 1981, and for Prince William Sound (PWS) in 1985. Common permit stipulations of these fisheries included requirements for logbooks and periodic observer coverage. Cumulative data from Southeast Alaska showed sunken gillnets to be a nonselective gear type with high mortality of nontarget species. Bycatch included salmon, halibut and crab. In 1983 the BOF acted to prohibit sunken gillnets in Southeast Alaska. Seasons were specified in other areas at that time. In Kodiak, the season opened November 1 and closed April 15. In PWS, seasons opened September 15 to April 14. In PWS, only two vessels actually fished with this gear type. The Westward Region issued 17 sunken gillnet permits between 1981 and 1987. Little logbook data was submitted for these permits.

Renewed interest in the sunken gillnet fishery occurred in 1991. A department proposal to prohibit the use of sunken gillnets was submitted to the BOF in October 1991. The BOF requested the department to collect more information on the fishery and associated issues of bycatch. Data collected during 1991–1992 supported the findings in Southeast Alaska of high levels of bycatch species in the sunken gillnet fisheries. Bycatch species included halibut, king crab, Tanner crab, porpoise, salmon, Pacific herring and seabirds. Another issue associated with sunken gillnets is the ability of lost gillnets to persist and continue fishing. During the March 1992 meeting the BOF prohibited the use of sunken gillnets for groundfish. Proposals to once again allow the use of sunken gillnets were submitted to the BOF in 1999 and 2000 but were unanimously rejected because of the potential bycatch concerns.

4.5.2 Drift Gillnets

In the area of the Southwest stock of sea otters, drift gillnets (Figure 4.4.2) are legal gear for salmon fishing along the north shore of the Alaska Peninsula and in Bristol Bay. Off the mouths of the major river systems of Bristol Bay, drift gillnet fishing effort can be extremely intense for short periods of time. Drift gillnets are not legal gear in Kamishak Bay of lower Cook Inlet, in the Kodiak and Chignik Areas or along most of the south Alaska Peninsula (see Figure 4.4.3). However, drift gillnet fishing is allowed in the south Alaska Peninsula west of a line from Kenmore Head to the Hague Rocks to the easternmost tip of the Sanak Islands.

4.6 Groundfish Trawl Fisheries [5]

Most groundfish fisheries off the Alaskan coast are managed by NMFS under FMPs adopted by the NPFMC and approved by the U.S. Secretary of Commerce. Current FMPs reflect many amendments since their adoption. DiCosimo (1998) and Witherell and Pautzke (1997) prepared concise summaries of these FMPs. The status of groundfish stocks and federally-managed fisheries in the Gulf of Alaska and Bering Sea/Aleutian Islands areas are summarized annually in stock assessment and fishery evaluation reports, such as NPFMC (2002b). A description of these federally-managed fisheries is beyond the scope of this report.

Whereas fisheries occurring 3–200 nmi offshore fall under federal authority, the State of Alaska has management authority for fishery resources within state territorial (0–3 nmi) waters by virtue of the Submerged Lands Act (1953), further recognized by the MSFCMA. For most groundfish fisheries, ADF&G issues emergency orders for state waters that duplicate all NMFS groundfish fishery management actions. These emergency orders 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 GHLs 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.

4.6.1 Description of Fishery

Groundfish fishing gear includes bottom and pelagic trawls, longlines, pots, and hook and line jigging. This section focuses on the bottom trawl gear, where one sea otter mortality has been recorded. Bottom trawls (Figure 4.6.1) are towed by two warps unreeled from relatively large vessels. Otter board "doors" are attached to the warps so as to stretch the net opening horizontally, typically from 30 to 60 m. Vertical openings of bottom trawls typically range from 4 m to 10 m. Heavy roller, chafing, and other types of gear are strung along the footropes stretched across the bottom opening of the net, which is usually in contact with the bottom. Warps and door bridles usually have a "herding" effect, so that fish from a wider area than just the net opening are captured. Mesh near the mouth of the net is usually relatively large, leading to finer mesh in the "cod end" bag at the rear of the net. Towing speed while trawling is typically 2.4 to 4 knots, with tow durations of 1 to 4 hours.

Most trawling for groundfish occurs outside of typical sea otter habitat. Because otter (bottom) trawl gear is closely associated with the bottom, trawlers generally avoid rocky areas. In addition, most groundfish trawling occurs in deeper water than sea otters normally forage and occurs in federally-managed offshore fisheries, rather than state-managed fisheries.

While trawl gear is technically legal to fish for a number of groundfish fisheries, the BOF has now closed all but an extremely small area to on-bottom trawling (Figure 4.6.2). There has been a growing patchwork of time and area closures to nonpelagic trawl gear around Kodiak Island,

[5] Most of the management information in this section was excerpted from more detailed treatments in Kruse et al. 2000. The current fishery management contacts are Wayne Donaldson (Westward Region), and William Bechtol (Central Region).

along the Alaska Peninsula and throughout western Alaska. Generally, the bays have been closed year round. Most of the current trawl closures were adopted in 1986. Modifications occurred in 1993 when the BOF created a controlled observed fishery in Marmot Bay and South Sitkalidak Strait. Crab bycatch limits were established and vessels were required to report to ADF&G daily. Additional changes occurred in 1994 and 1995 when the BOF opened state waters near Castle Rock and Sanak Island.

Nonpelagic trawl use was considered again during 1999 with public proposals to close all state waters in the Kodiak and Chignik Areas. The BOF adopted those proposals with the exception of a strip along the westside of Kodiak Island. That area was left open seasonally from January 20 to April 30. Additional closure areas added in the 1999 BOF action included state waters along the Alaska Peninsula from Cape Kumlik to Cape Douglas, Marmot Bay and South Sitkalidak on Kodiak Island, and areas off Sitkinak and Ugak Islands (Figure 2.3). Off-bottom or "pelagic" trawls are used only for walleye pollock *Theragra chalcogramma*, which in the area of the Southwest stock of sea otters are used almost entirely offshore in federally-managed fisheries. In addition to state regulations, federal regulations have closed much of the nearshore area to trawl fishing to protect the endangered Steller sea lions.

4.6.2 History of the Fishery

Commercial fishing for groundfish in Alaska began with hook and line fisheries for Pacific cod in the 1860s. Following World War II, Japanese and Russian fleets began exploring the Bering Sea, and eventually the Gulf of Alaska for groundfish resources. A period of intense fishing, including cases of severe overfishing, followed until the passage of the Fisheries Conservation and Management Act of 1976, which extended U.S. fishing jurisdiction out to 200 miles. While most of the foreign fishing effort occurred offshore, inshore areas where impacted by fish stocks with cross-shelf movements over their life history, and by illegal fishing close to shore.

The period of foreign trawling began with an exploratory fishing expedition by Japan in the Bering Sea in 1930. Japan fished for walleye pollock 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 Bering Sea in 1958, contributed to the decline. By the early 1960s Japanese trawlers began targeting walleye 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 Bering Sea during the late 1960s and early 1970s, Bering Sea foreign fisheries reached a record 2.2 million mt of walleye pollock, flatfish, rockfish, Pacific cod, and other groundfish in 1972. Subsequently, total groundfish harvests dropped sharply in the Bering Sea and Aleutian Islands.

The Japanese fleets moved into the GOA in 1960 followed by the Russian trawl fleet in 1962. Their primary target was Pacific ocean perch *Sebastes alutus*. Catches of this and other red rockfish species peaked at 350,000 mt in 1965. As Pacific ocean perch stocks declined from overfishing, flatfish, Pacific cod, walleye 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 at that time included Poland, 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.

Following the 1976 passage of the Fishery Conservation and Management Act, groundfish fisheries began a transition to Americanization typified by foreign-U.S. joint ventures. The joint venture fishery peaked at 1.3 million mt in 1987, which was also the last year of any foreign directed catches. By 1991, only U.S. vessels participated in the groundfish fisheries off Alaska.

4.6.3 Recent Catch, Effort, and Status

Since 1985, bottom trawl landings from state waters have averaged 986 annually (Figure 4.6.3). The number of landings was on an increasing trend from 1985 through 1996, but has declined sharply in recent years because of increasing restrictions placed on trawlers operating in state waters because of concerns over Steller sea lion impacts, bycatch of other species, and competition with other gear types.

Most trawling reported from state waters typically targets Pacific cod (Figure 4.6.4). Flatfish landings from state waters had been averaging about 1,200 mt annually through the 1990s, but declined in recent years with the increasing trawl closure areas. Walleye pollock comprise the other large category of landings from state waters.

Over the period 1985 to 2001 in the central Gulf of Alaska, nearshore trawl effort was concentrated around Kodiak Island and in the general vicinity of the Shumagin Islands (Figure 4.6.5). Very little fishing effort occurred in the Aleutian Islands (Figure 4.6.6).

Trawl effort depicted in Figures 4.6.5 and 4.6.6 describes the spatial distribution of effort, averaged over 1985 to 2001. Currently, trawl effort is confined to the far more restrictive areas depicted in Figure 4.6.2.

4.6.4 Potential Fishery–Sea Otter Interactions

Because most of the groundfish trawl effort occurs well offshore, the risk of sea otter entanglement is likely very low. The only record of a trawl-related sea otter mortality occurred in 1997, with a self-report from the Bering Sea/Aleutians groundfish trawl fishery (U.S. Fish and Wildlife Service 2002). Before sea otter abundance declined, there were reports of sea otters occurring further offshore, north of the Alaska Peninsula, which would place them in closer proximity to the working area of groundfish trawl gear. It is possible that during such periods of high abundance sea otter/trawl gear encounters might be more likely, but with the current known range of sea otter distribution, there appears to be little overlap. Trawlers generally avoid the nearshore rocky areas that sea otters prefer because of the high potential for damage to their fishing gear.

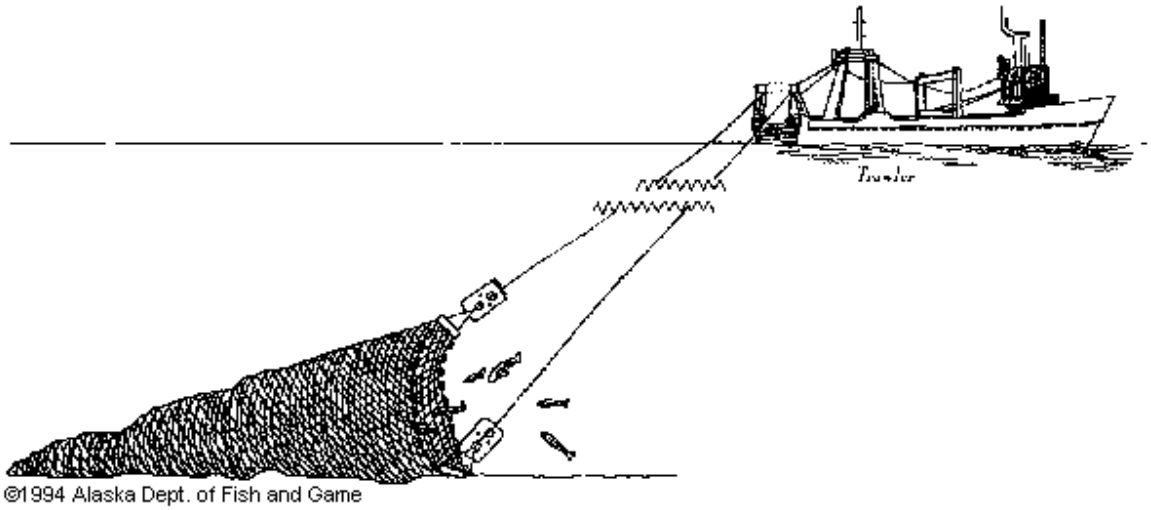

Figure 4.6.1 Typical arrangement for bottom trawl gear, showing otter board "doors" used to stretch the net opening horizontally. Robust ground contacting gear is usually stretched between the doors on the lower side of the net opening.

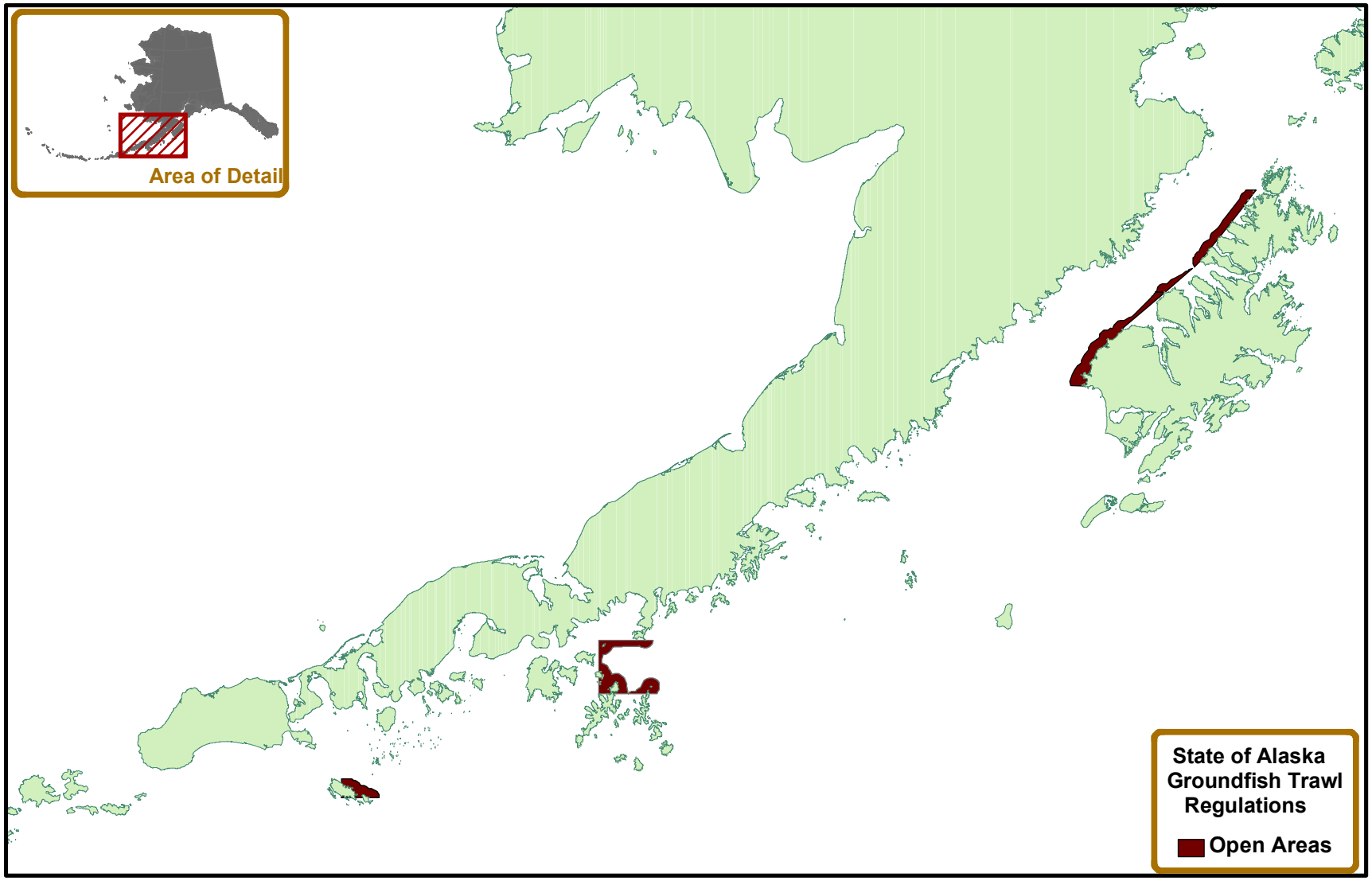

Figure 4.6.2 Areas open to limited trawling under State of Alaska regulations.

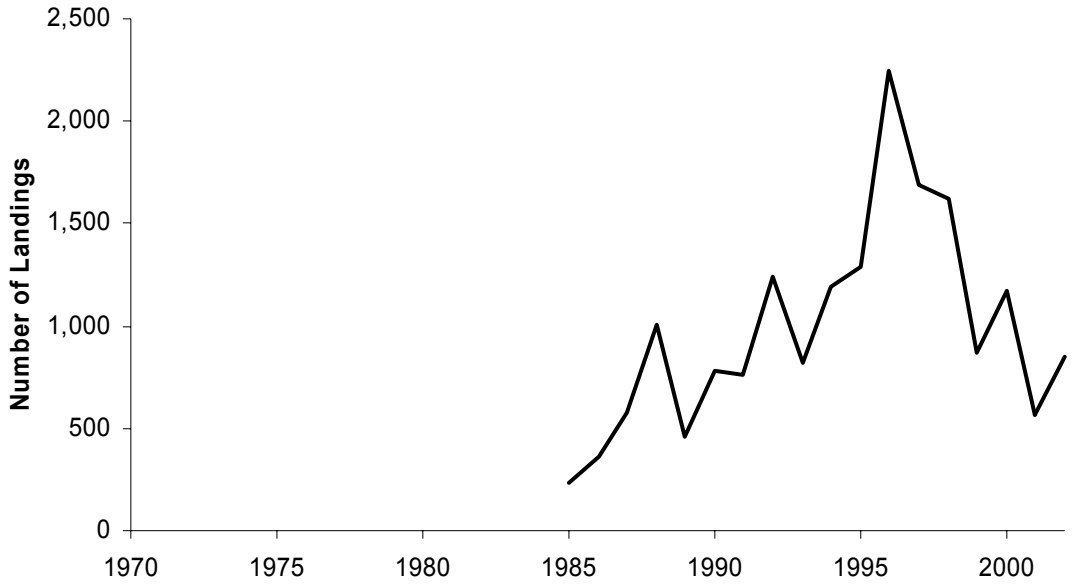

Figure 4.6.3 Number of landings in state waters (0–3 miles offshore) in Alaskan groundfish bottom trawl fisheries, 1985 – 2002. For years before 1985, the fish ticket database does not contain a code differentiating landings from state waters from landings from outside federal waters.

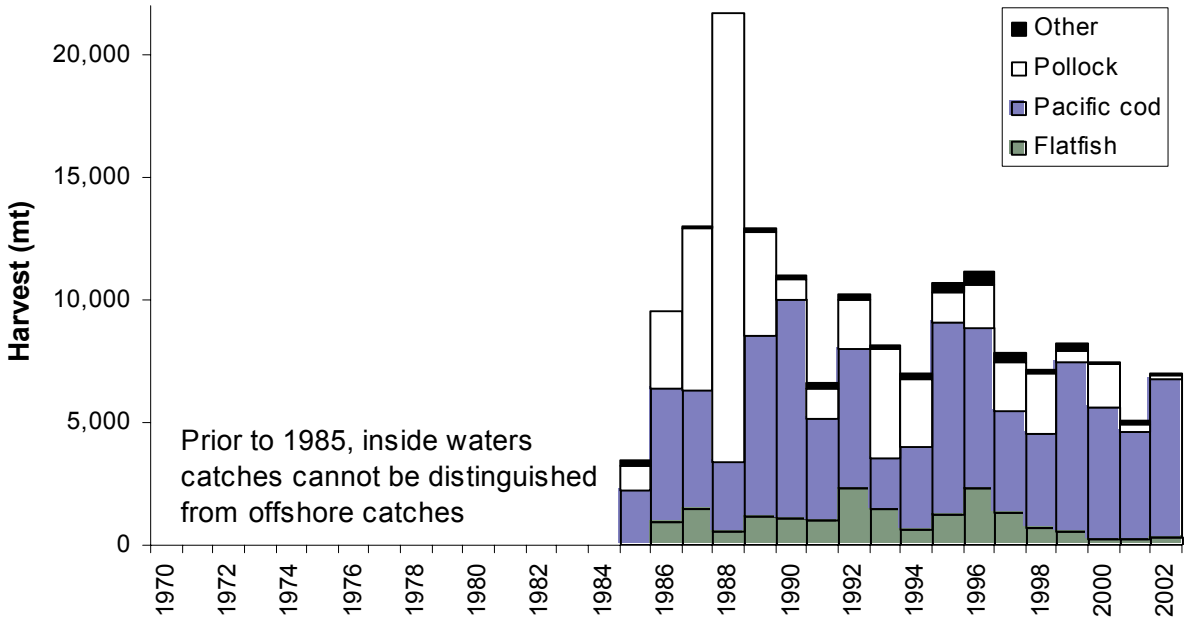

Figure 4.6.4 Harvest by species in state waters (0–3 miles offshore) in Alaskan groundfish bottom trawl fisheries, 1985–2002. For years before 1985, the fish ticket database does not contain a code differentiating state waters landings from those from outside federal waters.

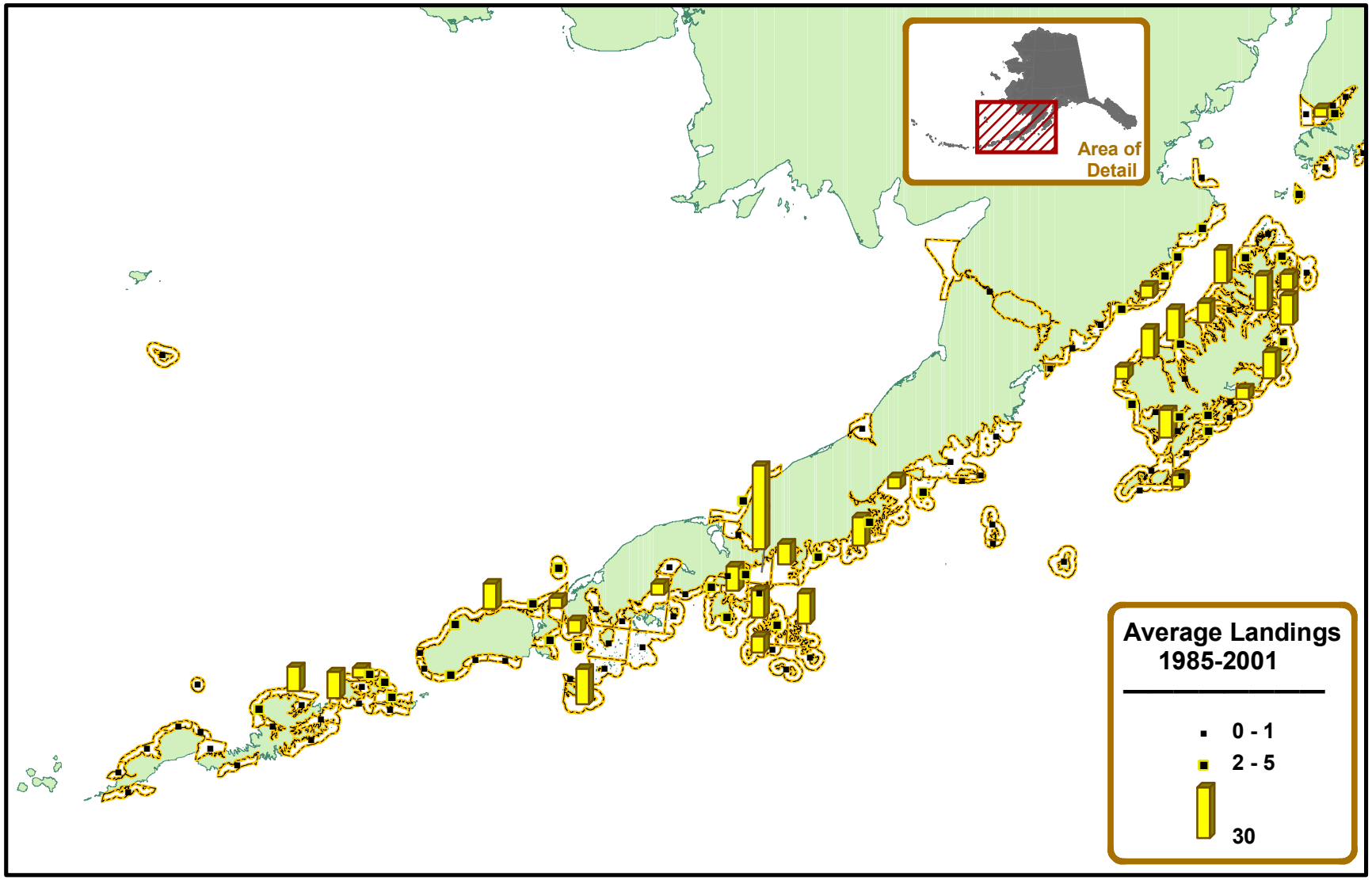

Figure 4.6.5 Distribution of average groundfish bottom trawl landings in state waters in the central Gulf of Alaska, 1985–2001.

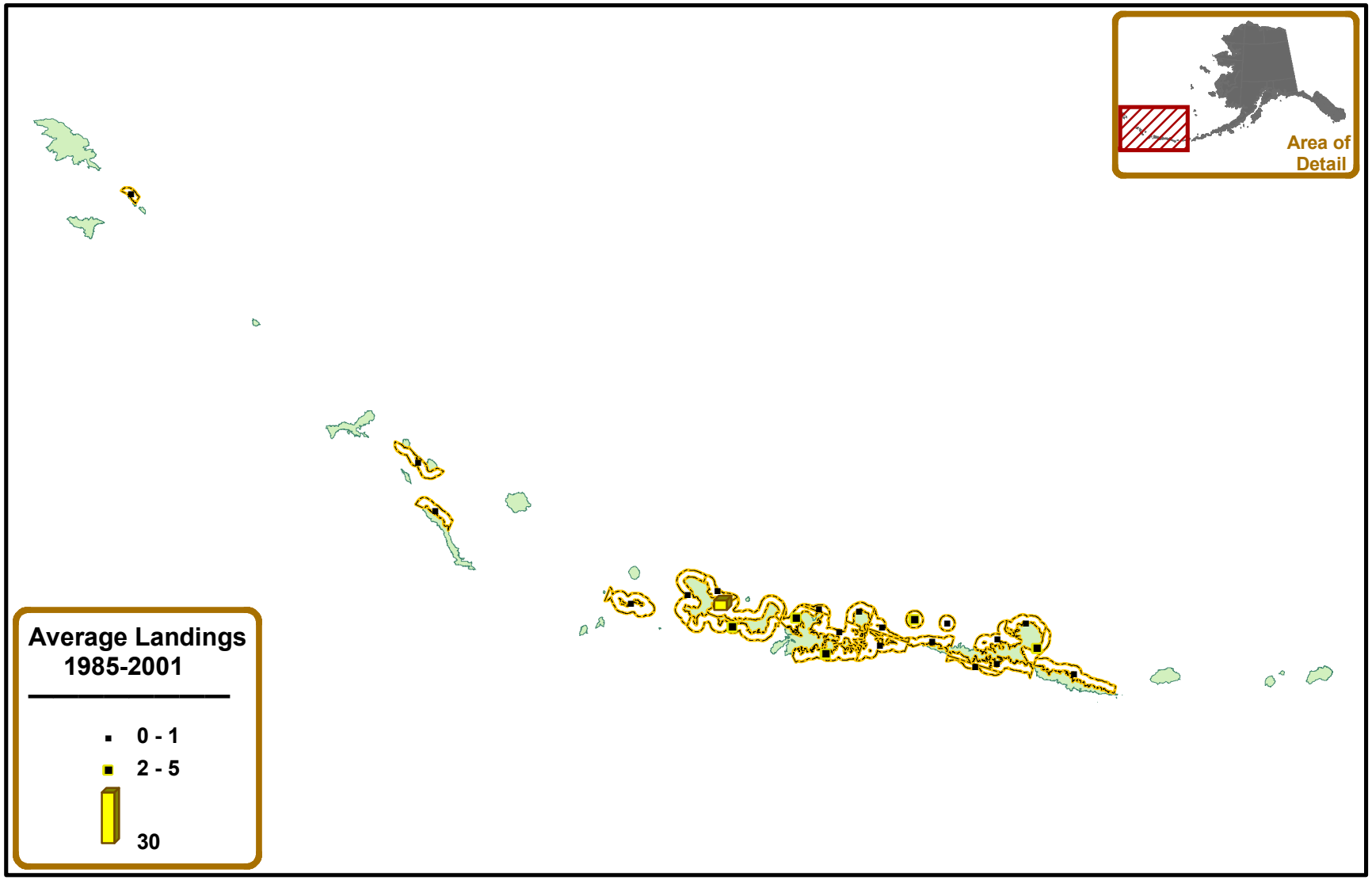

Figure 4.6.6 Distribution of average groundfish bottom trawl landings in state of waters of the Aleutian Islands, 1985–2001.

4.7 Pacific Cod Pot Fisheries [6]

Pacific cod are fished in Alaskan inside waters under a joint management scheme with the federally-managed fishery. Fishermen may fish in state waters in the "parallel" fishery which occurs during open seasons established for federal waters. After the federal season closes, the state-managed fishery opens. Up to 25% of the allowable harvest is taken in state waters.

The distribution of Pacific cod encompasses the entire Gulf of Alaska and Bering Sea/Aleutians areas, with a distribution ranging from about lat. 34° N to 63° N. on both sides of the Pacific Ocean. Pacific cod are managed as a single stock throughout the entire Gulf of Alaska and Bering Sea area because tagging and genetic studies performed to date have not demonstrated separation among stocks. However, harvest quotas are apportioned out between the Bering Sea and Gulf of Alaska. The species is primarily demersal, found at depths of 15–550 m. Although found at depths to 500 m, Pacific cod tend to concentrate on the outer continental shelf at depths from 100–200 m. They move to the shallower waters where spawning occurs from January through April. Most of the fishing effort is concentrated at this time. Pacific cod are opportunistic feeders targeting mostly polychaetes, amphipods, shrimp, and fish. Halibut, sharks, seabirds, and marine mammals such as fur seals *Callorhinus ursinus* prey on Pacific cod. Pacific cod enter the fishery about age 7 and may live 19 years or more.

4.7.1 Description of Fishery

The Pacific cod pot fishery uses modified 2 m by 2 m steel-framed crab pots (Figure 4.1.1), covered with tarred nylon mesh netting of 9 cm stretched mesh. Pots are fished individually on single buoy lines. Each pot has two tunnel openings on opposite sides, with plastic "finger" funnels to retain the catch. Regulations require rigid tunnel eye openings constrained to no more than 9 in wide and 9 in high to exclude halibut from entering the pot.

In 1996, the BOF adopted Pacific cod FMPs for state waters fisheries in Prince William Sound, Cook Inlet, Chignik, Kodiak, and the South Alaska Peninsula, consistent with their recently adopted policy on "Guiding Principles for Groundfish Fishery Regulations". All five Pacific cod 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% pot and 50% jig 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 Pacific cod are assumed to be one stock in the GOA, state GHLs are set as a percentage of the federal Allowable Biological Catch (ABC). Up to 25% of the Central Gulf of Alaska ABC is allocated among the Chignik (up to 8.75%), Kodiak (up to 12.5%) and Cook Inlet

[6] Most of the management information in this section was excerpted from more detailed treatments in Jackson and Ruccio (2001), and Kruse et al. (2000). The current state fishery management contacts are William Bechtol (Cook Inlet), Michael Ruccio (Kodiak), and Forrest Bowers (Bering Sea/Aleutians).

(up to 3.75%) Areas. The state GHL for the South Alaska Peninsula fishery is set at 25% of the western Gulf of Alaska ABC.

4.7.2 History of the Fishery

The Pacific cod fishery was the first U.S. commercial fishery in Alaska waters, predating commercial salmon fisheries by fifteen years, although sealers and whalers were harvesting off Alaska much earlier. The Pacific cod fishery began as a distant-water dory fishery, using motherships carrying stacks of rowing dories, much in the style of east-coast Grand Banks fishermen. Later, because of the extreme long distances to the fishing grounds, shore-based Pacific cod processing plants appeared. During 1916, the peak year of the shore-based fishery, over 800 people were employed in salt cod processing in the remote fishing villages of the Shumagin Islands. The nearshore areas, in what are now termed state waters, near the processing plants were intensively fished for many years.

There was little or no fishing effort for Pacific cod in state waters from 1950 until well after the passage of the FCMA. From 1985 the fishery began growing steadily, reaching a peak harvest of 20,137 mt in 1999 (Figure 4.1.1). Catch has declined in recent years because of restrictions placed on fishing to protect Steller sea lions. The specific state-managed Pacific cod fishery was first implemented in 1997.

4.7.3 Recent Catch, Effort, and Status

In 2000, 347 vessels harvested 11,587 mt in the state-managed Pacific cod fishery. The largest catches came from Sanak Island, one of the principal locations of the historic dory-era fishery. Catches declined from previous years in the Chignik Area, which took only 26% of the GHL in 2000. In part, this was attributed to the designation of Chignik as a “superexclusive” area starting in 2000, meaning that vessels fishing Chignik could not have fished elsewhere, and vessels fishing elsewhere could not fish in the Chignik Area. The state managed fisheries opened in early March, following the closure of the federally managed offshore and “parallel” inshore fisheries. Most of the catch in state waters occurs during the state-managed portion of the fishery (Figure 4.1.2). Effort in state waters tends to taper off in June as fishers and vessels become engaged in salmon fishing, regardless of whether the entire GHL is taken or not.

4.7.4 Potential Fishery–Sea Otter Interactions

Although Pacific cod move up into shallower spawning grounds during the time of the spring cod fisheries, these fishing and spawning grounds are situated well outside kelp beds and further offshore than typical sea otter habitat. Fishing occurs during a few months in the spring; any disturbance from fishing vessels or potential for capture occurs over a relatively short period of time. There are no known records of sea otters entering Pacific cod pots, although there is one record of sea otters entering a similar king crab pot (Newby 1975).

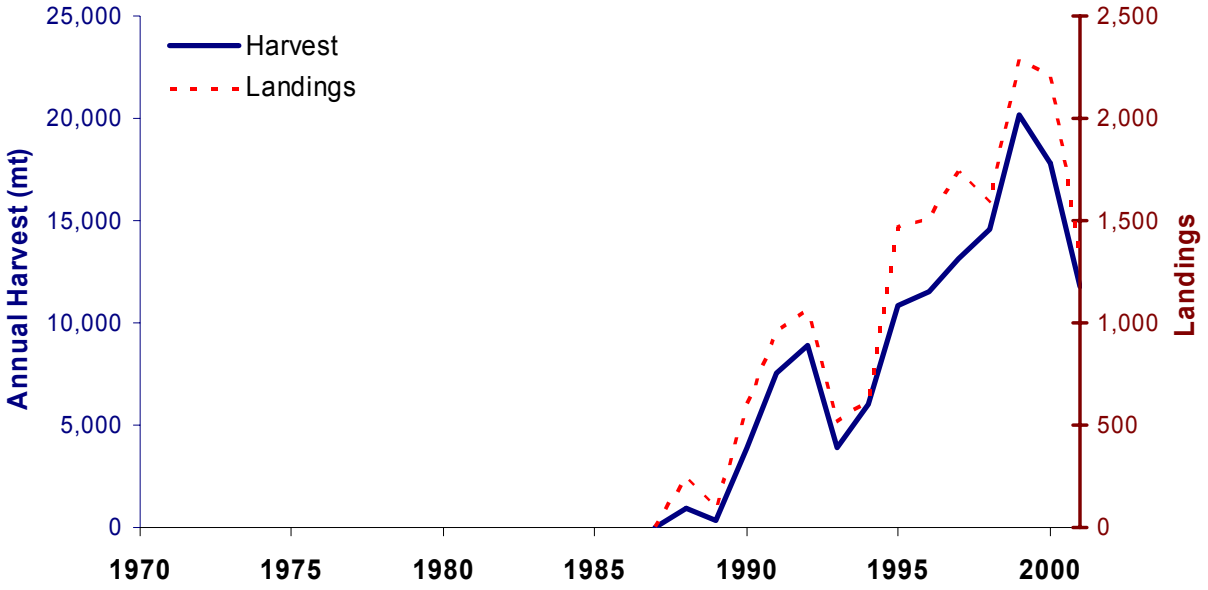

Figure 4.7.1 Harvest and landings in the Pacific cod pot fishery in State of Alaska-managed waters, 1970–2001

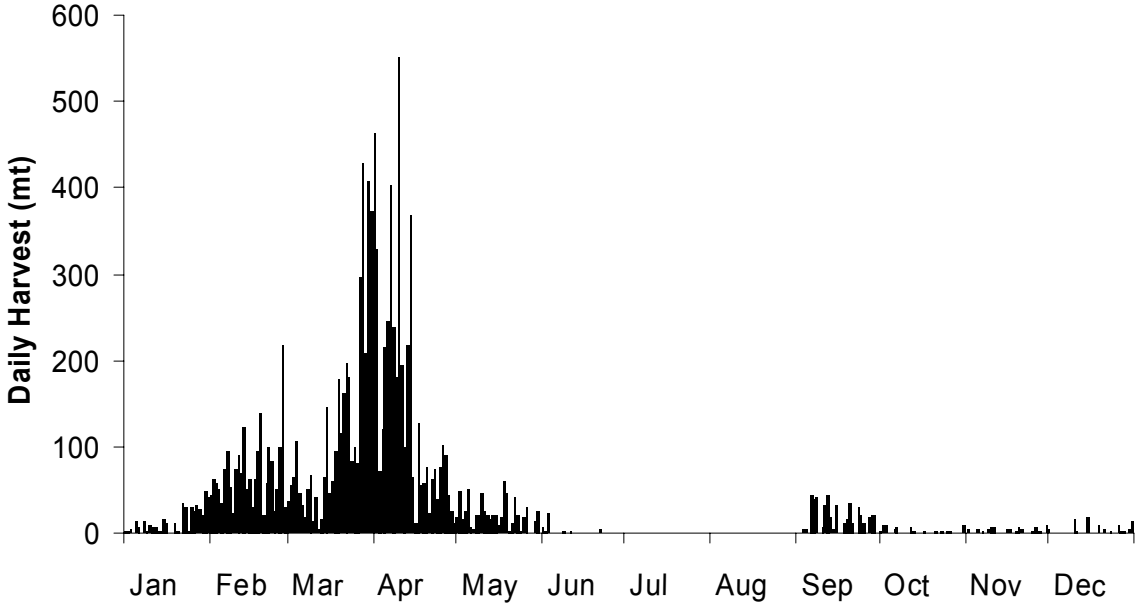

Figure 4.7.2 Temporal distribution of the 2001 Pacific cod harvest in state waters in the area of the Southwest stock of sea otters. The "parallel" fishery under regulations coincident with federal waters fisheries extended from January 1 to early March, followed by the state waters-only fishery.

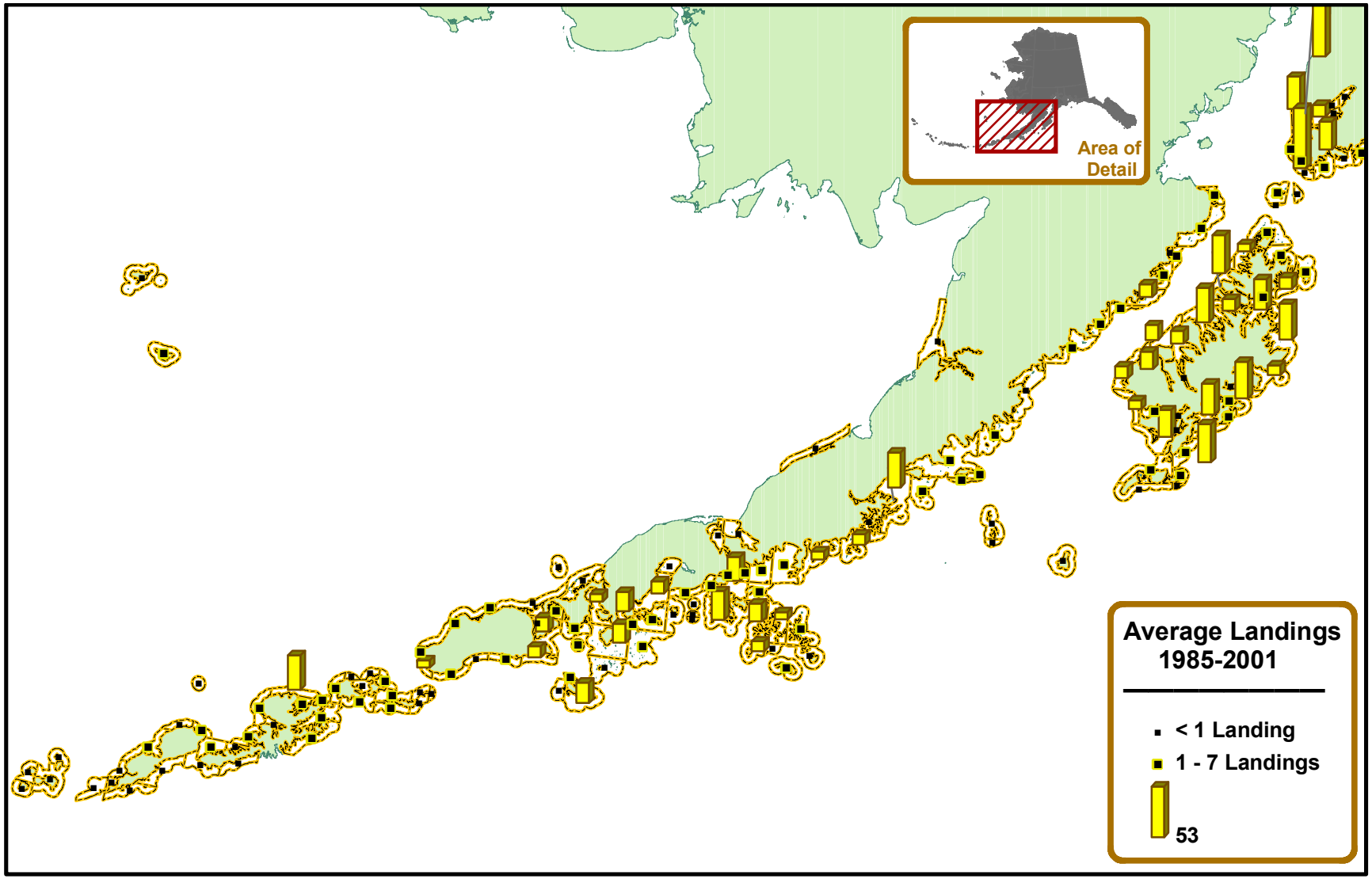

Figure 4.7.3 Spatial distribution of average Pacific cod pot landings in state waters, 1985–2001.

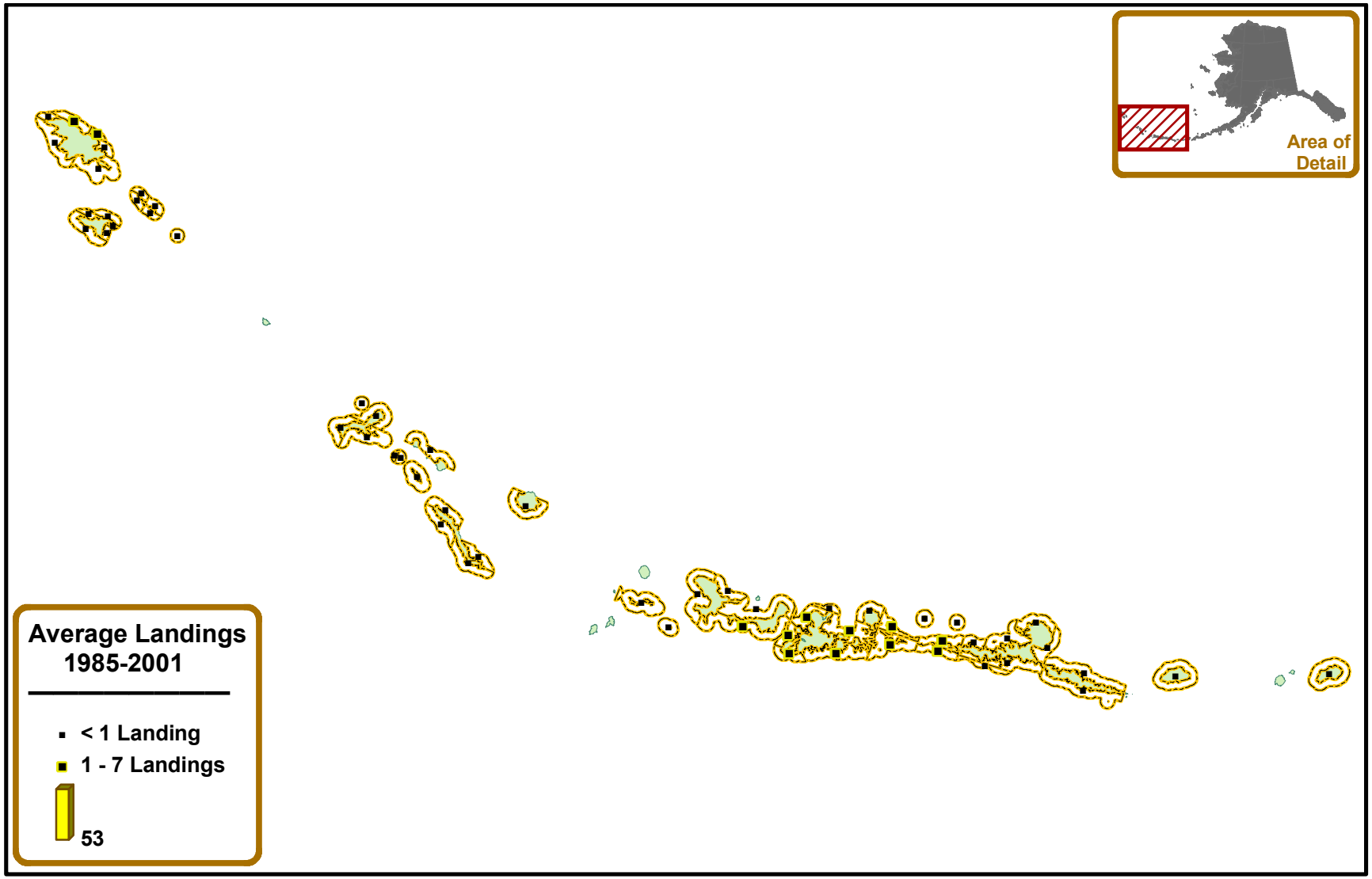

Figure 4.7.4 Spatial distribution of average Pacific cod landings in State of Alaska waters of the Aleutian Islands, 1985–2001.

4.8 Black Rockfish[7]

Black rockfish, *Sebastes melanops*, were formerly part of the pelagic shelf rockfish group, managed under federal jurisdiction, that included dusky, yellowtail, and widow rockfish. Because of conservation concerns, the State of Alaska took action in the 1990s to more explicitly control the harvest of certain species within this group. The majority of the biomass of black rockfish occurs in state waters.

4.8.1 Description of Fishery

Fishermen primarily use jig gear to target black rockfish but some bycatch occurs in longline and trawl fisheries. Production was originally concentrated in areas easily accessible to the city of Kodiak, but has since expanded to other parts of Kodiak Island and the mainland off of the south side of the Alaska Peninsula.

4.8.2 History of the Fishery

Black rockfish were of low market interest and generally not harvested in the Kodiak area until 1990. The catch jumped to 381 mt in 1991 as operators fished on previously unexploited populations. Fishery performance fell sharply in the following years presumably due to low abundance of fish. Lower value for fish and alternative fisheries may have been additional factors that limited production after 1991. There was also concern that localized depletion could occur very easily on this long-lived, low-fecundity fish. Harvests during the 1992–1997 period averaged 109 mt from the Kodiak Area. Stocks along the Alaska Peninsula were initially targeted in 1995. The highest catch was in 1996 with over 157 mt combined from the Chignik and the South Alaska Peninsula Areas.

Prior to 1997, the black rockfish fisheries were managed by NMFS, with black rockfish lumped into the larger pelagic shelf rockfish species group. Gulfwide, dusky rockfish is the most abundant species in the group and predominated in the NMFS survey catches. An annual ABC largely supported by dusky rockfish biomass estimates was assigned to the entire group. This management scheme placed few restrictions on the take of individual species within that group. ADF&G was concerned with the harvest of black rockfish in several inshore areas during that period and state waters were closed by emergency order in some cases. Adjacent federal waters, however, did not close. Although the majority of the black rockfish resource is in state waters, enforcement of closures became a problem. Landings continued with federal statistical areas reported on fish tickets.

An FMP amendment was implemented in 1998 that separated black rockfish from the pelagic shelf group, with the state asserting jurisdiction over fisheries within state waters. Harvest levels were set low enough to accommodate potential black rockfish bycatch in other fisheries. GHLs

[7] Management information in this section was excerpted from more detailed treatment in Jackson and Ruccio (2001). The current state fishery management contact is Michael Ruccio (Kodiak).

were assigned to areas within the region with the goal of distributing the effort throughout the region.

4.8.3 Recent Catch, Effort, and Status

The 2000 Kodiak Area fishery opened with the federal groundfish seasons on January 1, 2000, with a GHL of 83 mt, which was further divided into fishing sections to distribute the catch. Most of the harvest occurred in April. Most of the fishing sections reached GHLs and were closed between April 18 and May 12, however, the Mainland Section remained open until September 12. Following the closure of sections to directed black rockfish fishing, operators were allowed to retain black rockfish taken incidentally in other species, up to 5% of the weight of the target species catchally in other fisheries. For the 2000 season, 95 vessels made 287 landings from the Kodiak Area totaling 116 mt. Much of the Kodiak Area harvest was taken as bycatch in Pacific cod fisheries, both state and federally managed. Approximately 6 mt were taken incidentally to Pacific cod jig operations. The trawl fleet landed about 2 mt and longliners landed about 0.5 mt.

In the Chignik and the South Alaska Peninsula Areas, black rockfish fishing began in May and continued through the summer. All of the 2000 black rockfish harvest in these areas was taken with jig gear. A total of 42 mt was taken by 12 vessels at Chignik, with an additional 42 mt taken by 27 vessels along the south Alaska Peninsula.

4.8.4 Fishery-Sea Otter Interactions

Because most of the black rockfish catch is taken with jig gear, there is extremely low potential for gear interactions with sea otters. There are no known records of sea otter take on hook and line gear from Alaska. Black rockfish vessels do generally fish in the inshore areas. However, the potential for vessel interference with sea otters is likely very low, given the low participation in the fishery and the lack of documented hook and line interactions.

5. POTENTIAL COMPETITION FOR PREY

Very little is published about whether fisheries and sea otters do actually compete for food resources in a way that is limiting for sea otters. This section describes fisheries for which at least some degree of diet overlap is thought to exist, based on the ten most frequent species appearing in sea otter diets (Figure 3.2) in a study at Adak Island (Estes and Tinker 1996), with the addition of octopus.

5.1 Dungeness Crabs [8]

Dungeness crabs (*Cancer magister)* are widely distributed in bays, estuaries, and along the nearshore coast of Alaska from Dixon Entrance out into the Aleutian Islands. Dungeness crab abundance is lower in the islands of the Aleutian Chain, which are separated by deep passes with swift currents and are closely bordered by steep depth contours. Dungeness crabs primarily inhabit bays, estuaries, and other shallow water habitats that are more common east of the Aleutian Islands.

Dungeness crabs are broadly distributed subtidally and prefer a sandy or muddy bottom. They are tolerant of salinity changes and can be found in brackish estuarine environments. Mating occurs from spring through the fall. The male crabs are polygamous, a factor utilized in developing the male-only harvest strategy. Male crabs mate only with female crabs that have just molted. Fertilization is delayed until eggs are fully developed and the female extrudes them under her abdomen where they are carried until hatching. After hatching, the young crabs are planktonic, with larval development taking from 4 months to as long as a year in Alaska. Six successive stages (5 zoea and 1 megalopa) occur before the crabs molt into the first juvenile stage. Sexual maturity may be reached at three years, and the estimated maximum life span is between 8 and 13 years. Dungeness crabs forage along the sea floor for organisms that live partly or completely buried in the sand, including shrimp, mussels, small crabs, clams, and worms.

Depth distribution studies currently underway in Southeast Alaska have identified nearly complete overlap between Dungeness crab occurrence and sea otter diving depths. Almost all Dungeness crab appearing in Southeast Alaska ADF&G king/Tanner crab survey data occurred in depths less than 50 m. (Shirley et al. 1996, Tom Shirley, University of Alaska Fairbanks, Juneau, personal communication). While Dungeness crabs are sometimes found in deeper depths than sea otters typically dive, these deeper waters are not usually found sufficiently close to shallower optimal Dungeness crab habitat to offer effective refuge from sea otter predation. Even if Dungeness crabs attempt to use deeper depths as refugia, they are still vulnerable to otter predation when moving up or down the gradual slopes to the shallower waters occupied during parts of their life history.

[8] Most of the management information in this section is condensed from more detailed treatments in Ruccio and Worton (2000a,b), Bowers (2001), Bowers et al. (2001) and Kruse et al. (2000). The current fishery management contacts are Michael Ruccio (Kodiak and Alaska Peninsula), and Forrest Bowers (Bering Sea and Aleutian Islands).

5.1.1 Description of Fishery

Dungeness crabs are usually captured in circular pots baited with herring, squid, or clams (Figure 5.1.1). The pots are about 40 inches in diameter and 14 inches high, constructed of 3/4-inch round, steel frames wrapped in rubber tubing then covered with stainless steel wire mesh woven in 2-inch squares. Two 4⅜" diameter escape rings are required to be built in each pot to allow undersize crabs to leave the pot. The number of pots that can be set by a vessel and the fishing season varies by management area in Alaska. Dungeness crab pots are individually tethered to floating marker buoys.

Dungeness crab fisheries in Alaska use a "3-S" management strategy, setting seasons, size limits, and sex of harvest in lieu of harvest quotas (Table 5.1.1). This harvest policy is predicated on the assumption that the fishing gear is does not cause significant injury so that crabs may be identified, measured, and sexed, with non-legal crabs returned unharmed to the ocean. The minimum size limit throughout Alaska is 6.5 in (165 mm) CW. This minimum legal size is set one molt increment above the size at maturity. Seasons vary according to management area.

Routine stock assessments are not conducted for Dungeness crabs because of the difficulty of surveying the numerous bays and inshore areas comprising Dungeness crab habitat. Fishery managers track catch per unit effort and size of crabs harvested by the commercial fleet as an index of Dungeness crab stock status.

Prior to 1977, the Kodiak Dungeness crab fishery was open year-round. Closures were first implemented by the BOF from January 1 to April 15 when fishermen were unable to operate effectively due to winter storms. This season change was aimed at reducing the amount of gear fishing with extremely long soak times. Some gear had been left out fishing all winter. The June 15 opening date was set for the south end of Kodiak Island to avoid high incidences of female red king crab bycatch in Dungeness gear (Figure 5.1.2).

5.1.2 History of the Fishery

References to commercial Dungeness crab fishing appear in the Alaska Fishery and Fur Seal Industry Reports as far back as 1916, with the first mention of commercially canning occurring at Seldovia in Cook Inlet in 1920. Today, Dungeness crab is processed by shorebased processors, catcher processors, and floating processors. The crabs are sold whole or in sections as a fresh or frozen product.

Harvest of Dungeness crabs has fluctuated widely since 1970, a combination of fluctuating abundance and changing market interest (Figure 5.1.3). Most of the harvest has occurred in the area around Kodiak Island, with small amounts out on the Alaska Peninsula. No commercial fishing for Dungeness crabs has occurred on the lower west side of Cook Inlet in the area of Kamishak Bay.

Around Kodiak Island, Dungeness crabs were first harvested commercially in 1962, with harvests escalating rapidly to the maximum recorded catch of 3,098 mt 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. Harvest declined through the 1970s as both stock levels and market value for Dungeness crabs decreased (Jackson 1997). Minor increases in recruitment led to slight increase in harvest from the Kodiak District during the late 1970s.

During the early 1980s, declines in abundance of other commercially harvested Alaskan shellfish occurred and created a void in markets that still demanded crab. This led to an increase in both effort and harvest of Dungeness crabs in the Kodiak District. A harvest of 2,540 mt occurred in the 1981–82 Kodiak fishery. Effort peaked in 1985 when 125 vessels participated in the Kodiak District Dungeness fishery. Many of the postrecruit crabs were removed from the district, resulting in lower yields through the middle of the 1980s (Jackson 1997). In 1987, stocks experienced increasing recruitment that provided the bulk of the harvest through 1990. The Kodiak District fishery has been prosecuted primarily on new-shell, recruit male Dungeness crabs from 165–193 mm CW. The fishery has experienced years of lower harvests corresponding to fluctuations in recruitment. Decreased fishery production has also been a product of reduced effort. Participation decreased from 64 vessels in 1990 to only 11 in 2000.

Another significant factor limiting interest and effort in the Kodiak District Dungeness crab fishery during the 1990s was a lower market value resulting from the toxin causing paralytic shellfish poisoning being documented in the viscera of Dungeness crabs. The Alaska Department of Environmental Conservation (DEC) placed restrictions on the sale of live and whole cooked crabs beginning in 1992. Prices paid for Kodiak Dungeness crabs dropped from $1.37 per pound in 1991 to $0.86 per pound in 1992 after the DEC restrictions took effect. Prices have fluctuated widely and reached a high of $2.05 in 1997. Kodiak fishermen have received lower than average exvessel value when compared to other areas in Alaska or the West Coast of the lower 48 states in most years.

Dungeness crab harvests along the south 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 rose to 545 mt. This harvest attracted 132 vessels to the fishery and local fishermen became concerned about an excessive influx of effort. In subsequent years the BOF designated the south Alaska Peninsula Dungeness crab fishery as “superexclusive”, meaning that vessels that fished Dungeness crab in other management areas could not also fish the Alaska Peninsula. The numbers of vessels operated during 1990s were low, varying from less than 3 to 24.

Fishing effort for the North Peninsula Dungeness crab fishery has been sporadic, with few vessels participating. Most effort has occurred north of Unimak Island. In 1995 six vessels made 19 deliveries for a harvest of 61 mt. Catch information from 1996 to 1998 is confidential, as less than three vessels participated in those years. The average annual harvest in the three-year period from 1996–1998 was approximately 22 mt. No vessels registered to fish for Dungeness crabs in the North Peninsula District in 1999. One vessel, for which landings are confidential, participated in the 2000 fishery.

In the Aleutian District, the Dungeness crab fishery has occurred primarily as a small-vessel, summer fishery in the vicinity of Unalaska Island. Some larger-vessel effort has occurred in other locales within the district, but fishing in these areas has been sporadic throughout the history of the fishery. Interest and activity in this fishery has been erratic from year to year, with the first reliable reports of harvest made in 1970. Since 1974, deliveries have ranged from 0 in several years, to a peak of over 40 mt in 1984–85. Four boats fished that year, with over 80% of their catch coming from Unalaska Bay and Makushin Bay. In addition to commercial harvest, Dungeness crabs have also been taken in subsistence and sport fisheries in the vicinity of Unalaska Island. No estimate of current Dungeness crab harvest by sport or subsistence users is available, but it is believed to be small.

5.1.3 Recent Catch, Effort, and Status

Since 1985, most Dungeness crab catch has occurred near the southern end of Kodiak Island, with lesser amounts harvested from the east side (Figure 5.1.5). By comparison, only relatively small and trace amounts are harvested along the Alaska Peninsula or in the Aleutian Islands (Figure 5.1.6). In the past five years, most of the harvest has occurred, in July, August, and September (Figure 5.1.4).

The 2001 fishery opened on May 1 in all areas except the Kodiak District's south end, which opened on June 15. Twenty-one vessels harvested 94 tons from 57 landings. The 2001 harvest and effort was the second lowest in the history of the fishery. Only vessels less than 90 feet overall length participated in the 2001 fishery. The majority of the Kodiak District harvest during 2001 came from the southeast section. This represents a shift back to the historic production area as the eastside section had produced the largest harvests during the previous two years. An average of 2.4 legal crabs per pot was landed for the 2001 fishery, which was very similar to the catch per unit effort (CPUE) from the 2000 season. It remained almost constant over the course of the commercial fishery. The CPUE has historically been highest in the late summer months.

In the Aleutian District the 1999–2000 Aleutian District Dungeness crab fishery opened by regulation on May 1, 1999, and closed by regulation January 1, 2000. Two vessels registered for the fishery but made no landings.

Dungeness crabs harvested in the Kodiak District had a mean CW of 175 mm in 2001. This was slightly larger than the 173 mm CW for the 1998–2000 seasons. The percentage of post-recruit crabs taken in the commercial harvest decreased from 33% in 2000 to 12% in 2001. This may be an indication of increased recruitment to legal-size crabs or fewer postrecruit crab. The CPUE remained relatively constant over the last two years and is similar to CPUE seen in some earlier seasons. There is no stock assessment for Dungeness crab in the Kodiak District. However, annual fishing performance suggests that stock size has decreased in the past few seasons.

The status of this species in the Aleutian Islands and Alaska Peninsula is not known, but the resource is believed to be limited in the Aleutian Islands due to the lack of suitable habitat.

5.1.4 Fishery-Sea Otter Interactions

Commercial fisheries and sea otters occur throughout the range of Dungeness crabs. Dungeness crabs appear in sea otter diets from California through the Aleutian Islands (Riedman and Estes 1990) and have been reported to be a very significant part of sea otter diets in Prince William Sound (Garshelis et al. 1986). Dungeness crab predation by sea otters has been a contentious issue with commercial fishermen in many Pacific coastal areas. While sea otters may impact commercially harvestable crabs, it is much less likely that commercial fishing under "3-S" management will impact sea otter prey resources. Commercial fisheries retain only the largest male crabs, leaving the entire female and sublegal male population untouched, except for handling mortality. However, for king crabs, large males are reproductively more successful than smaller males and may be essential for good reproductive success (Zheng et al. 1995). The effect of removing largest males in the breeding population for Dungeness crabs is not known, but could possibly affect reproductive success.

There are no reported instances of sea otter entanglements with Dungeness crab pot gear (Shari Coleman, Alaska Department of Fish and Game, Kodiak, personal communication).

Table 5.1.1 Season-sex-size limit harvest policies for Dungeness crabs in the area of the Southwest sea otter stock.

	Season	Sex	Size Limit
Kodiak District, South End	June 15–December 31	Males Only	6.5 in CW
Kodiak District, All Other	May 1–December 31	Males Only	6.5 in CW
N. Alaska Peninsula District	May 1–October 18	Males Only	6.5 in CW
S. Alaska Peninsula District	May 1–December 31	Males Only	6.5 in CW
Aleutian District	May 1–December 31	Males Only	6.5 in CW

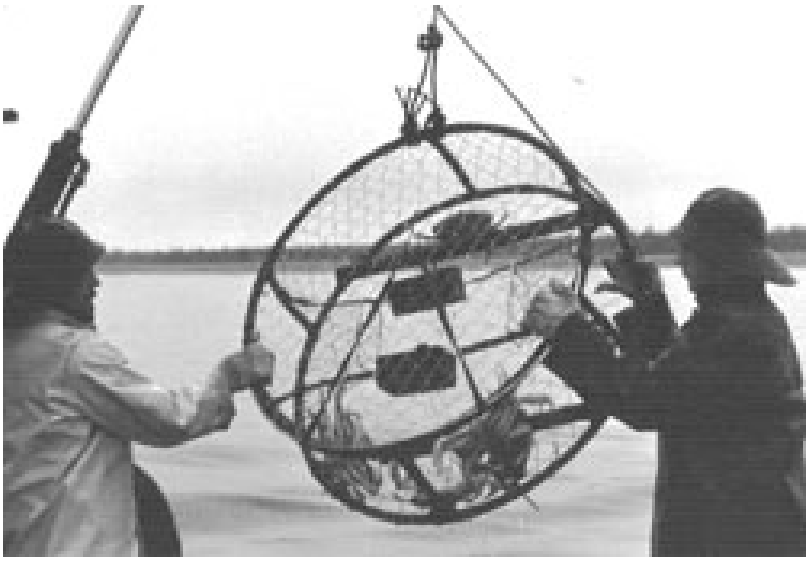

Figure 5.1.1 Typical Dungeness crab pot, showing entrance tunnels, bait pots and escape ring on lower edge of pot.

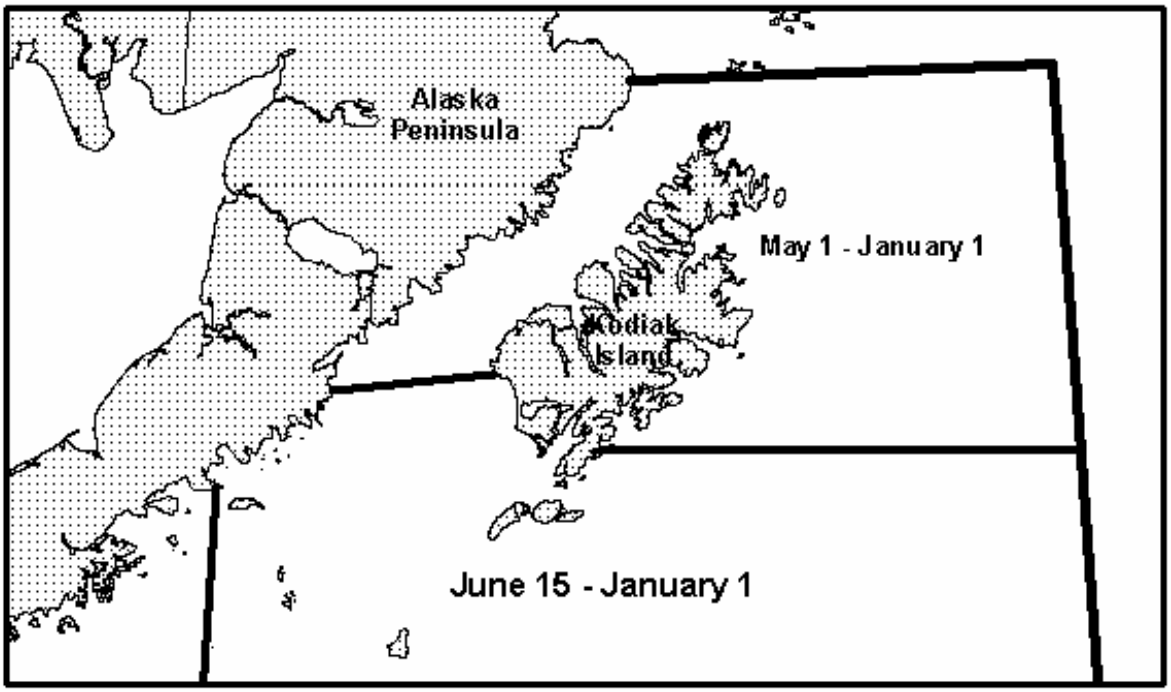

Figure 5.1.2 Dungeness crab seasons around Kodiak Island.

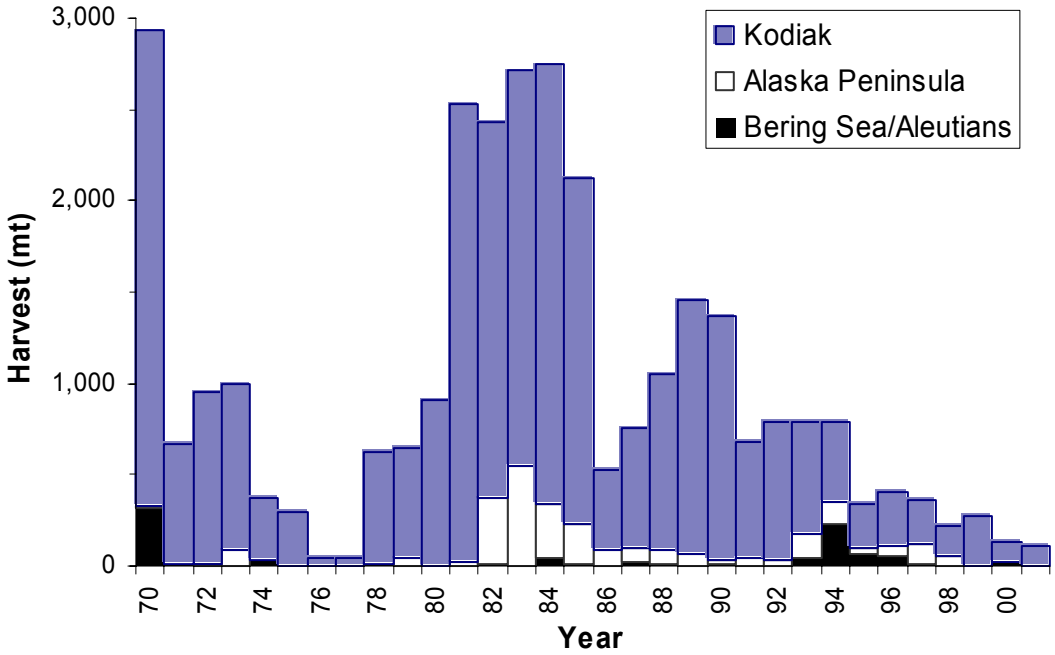

Figure 5.1.3 Harvests of Dungeness crabs in Alaska in the area corresponding to the Southwest stock of sea otters, 1970–2001.

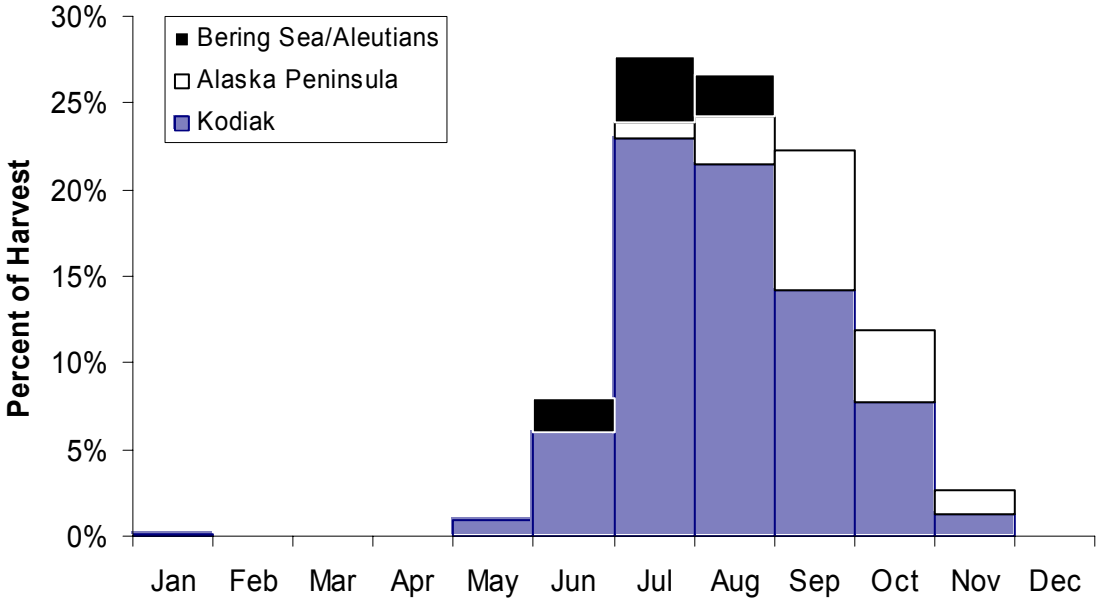

Figure 5.1.4 Temporal distribution of Dungeness crab harvest in the areas corresponding to the Southwest stock of sea otters, 1997–2001.

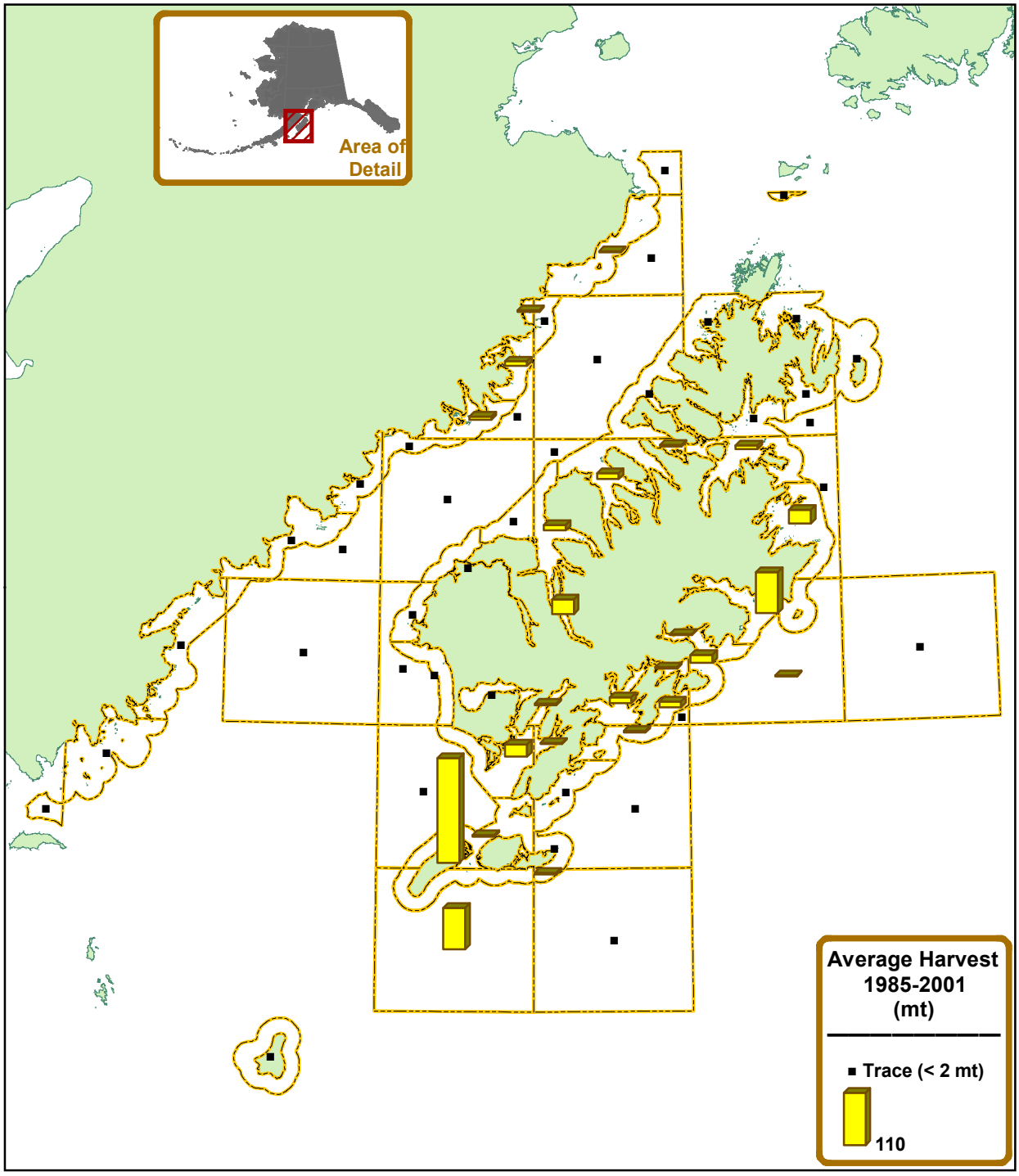

Figure 5.1.5 Spatial distribution of average Dungeness crab harvest around Kodiak Island, 1985–2001.

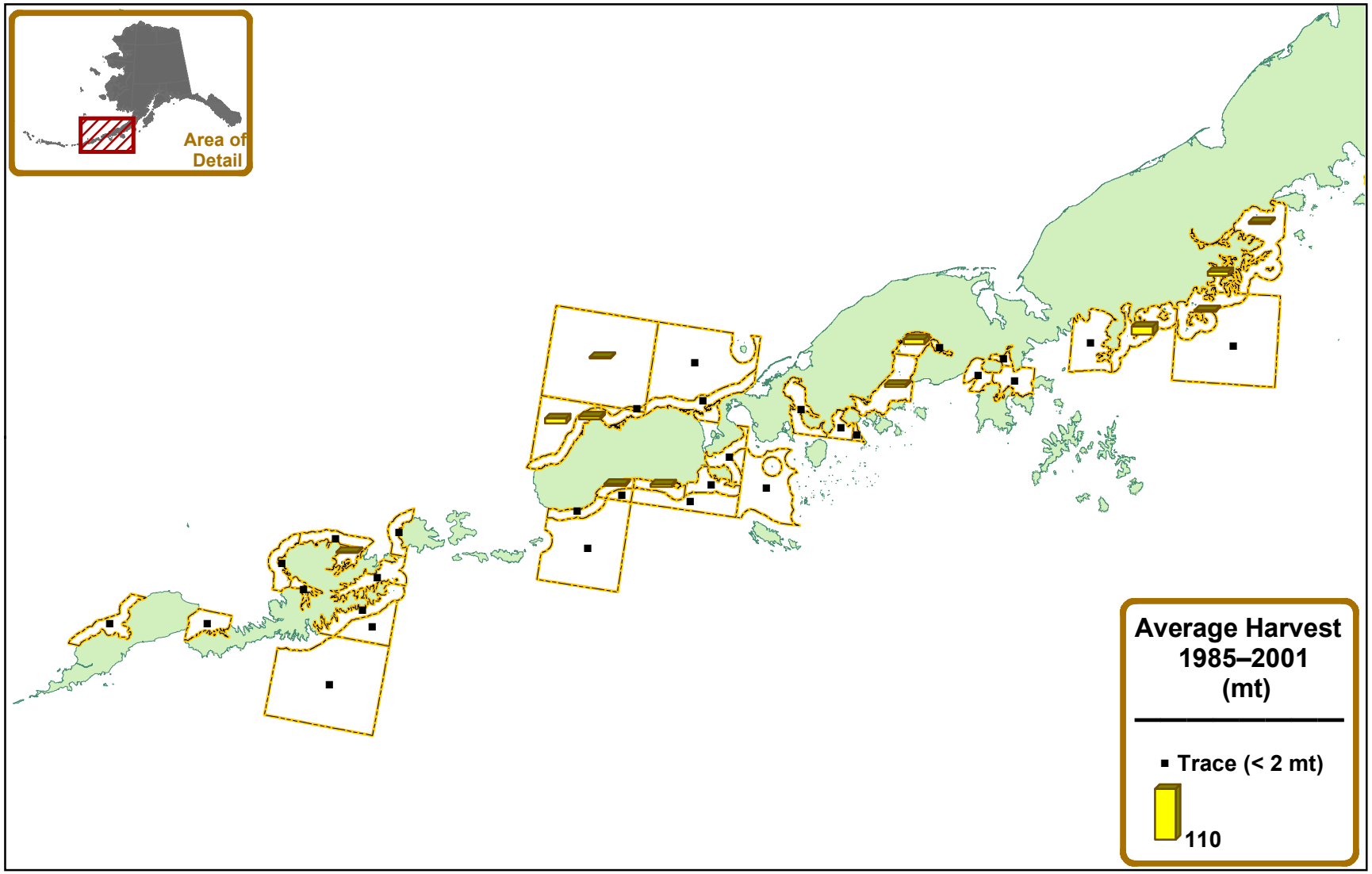

Figure 5.1.6 Spatial distribution of average Dungeness crab harvest along the western Alaska Peninsula, 1985–2001.

5.2 Shrimp Fisheries [9]

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*. Northern and sidestriped shrimp now comprised almost all the landings from the areas west of long. 144° W.

5.2.1 Description of Fishery

The shrimp fishery in the area of the Southwest stock of sea otters has been prosecuted primarily with trawls, along with a very small amount of pot effort. In recent years the Bering Sea has contributed most of the harvest because of the decline of shrimp stocks in almost all other areas.

5.2.2 History of the Fishery

Shrimp resources in Alaskan waters have been exploited since 1915, but catch records are available only for the last five decades. In almost all areas, the early exploratory fishing led to rapid escalation of effort, overharvest, and closure. High effort levels coinciding with the oceanic regime shift of 1976–77 combined to reduce shrimp stocks to very low levels.

In lower Cook Inlet, a trawl fishery for northern shrimp in Cook Inlet's 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 et al. 2000).

In the Kodiak Management Area, trawl and pot gear have been used to harvest shrimp, but pot gear has been used in only a few areas, with only limited harvest. The Kodiak Management Area trawl shrimp fishery began in 1958 with the harvest consisting primarily of northern shrimp. Other species landed included sidestriped, coonstriped, spot, and humpy shrimp. The 1964 earthquake and tidal wave destroyed most of the Kodiak fishing infrastructure, including that supporting shrimp fishery. The fishery soon rebounded, and the trawl harvest peaked at 37,265 mt in 1971, with effort peaking at 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.

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 in 1977–78. Catches started to decline thereafter in both areas with the decline in stock abundance. The fishery in the South Peninsula area has been 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.

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[9] Most of the management information in this section is condensed from more detailed treatments in Ruccio and Worton (2000a, b), Bowers (2001), Bowers et al. (2001) and Kruse et al. (2000). The current fishery management contacts are Michael Ruccio (Kodiak and Alaska Peninsula), and Forrest Bowers (Bering Sea and Aleutian Islands).

Shrimp fishing in the Aleutian Islands and Bering Sea started in the 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 the Bering Sea, catch peaked at 3,085 mt in 1977–78. A precipitous decline in shrimp catches after 1978 resulted in reducing in the season duration. There was no shrimp harvest between 1983 and 1992. Following a small harvest in 1992, there was no further harvest until 1999.

Overall trends in total shrimp catch in the central and western GOA reveal a prominent rise and fall (Figure 5.2.1). 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.

5.2.3 Recent Catch, Effort, and Status

Current shrimp populations remain well below long-term historic averages in most of the Kodiak Area. Localized areas showed increases in shrimp densities during a survey conducted in 2001; however, most commercial trawl shrimp fisheries remain closed. Most of the nearshore areas where shrimp abundance has increased and where the historic trawl fishery once occurred are now within the areas closed to non-pelagic trawl gear by the BOF (Figures 2.2 and 2.3). An offshore Kodiak area, the General Section, remains open to exploratory shrimp trawling. One vessel registered for the shrimp trawl fishery in the General Section in 2000–01. The data associated with the effort of that vessel remain confidential. However, the combined data from the years 1998–2001 results in 16 landings by four unique vessels with a total harvest of 11 mt. A very small amount of shrimp fishing with pot gear also occurs in the Kodiak Management Area. However most of the pot gear shrimp catch is retained for personal use and not sold as commercial catch.

No vessels have registered for the North Peninsula District pot or trawl shrimp fishery since 1994. Currently, shrimp fishing is not permitted in this district due to a lack of data concerning the shrimp stocks.

In the Bering Sea-Aleutians Area, shrimp harvests resumed in 1999, the first commercial harvest of shrimp since 1992. Only two vessels registered for the fishery; therefore, catch information is confidential. Initial catches were composed primarily of northern shrimp. As the 1999 fishery progressed, sidestripe shrimp became the dominant species in the catch. The fishery was then closed because ADF&G did not possess adequate information regarding the abundance and distribution of these species and it was not possible to prosecute the fishery in accordance with BOF regulation 5 AAC 39.210 “Management Plan for High Impact Emerging Fisheries”. The fishery was not reopened in 2000 fishery because there was still insufficient information on shrimp stock abundance and distribution. The last extensive commercial activity occurred in the 1970s and stock assessment surveys conducted by ADF&G and NMFS do not specifically target shrimp or cover much of the important shrimp habitat areas. Consequently, ADF&G does not possess adequate information to develop a management plan or conduct a commercial fishery. Fishers have expressed interest in collaborating with ADF&G on a stock assessment survey, but funding constraints have limited such endeavors.

5.2.4 Potential Fishery–Sea Otter Interactions

Very little fishing for shrimp presently occurs in the area of the Southwest stock of sea otters. It is highly unlikely that trawl effort for shrimp would increase in the near future, even if shrimp populations were to rebound. Most of the areas traditionally trawled for shrimp are within areas closed to non-pelagic trawl gear by the BOF (Figures 2.2 and 2.3) or fall within the extensive closure areas for Steller sea lions. The potential for shrimp fisheries competing with sea otters appears to be very low.

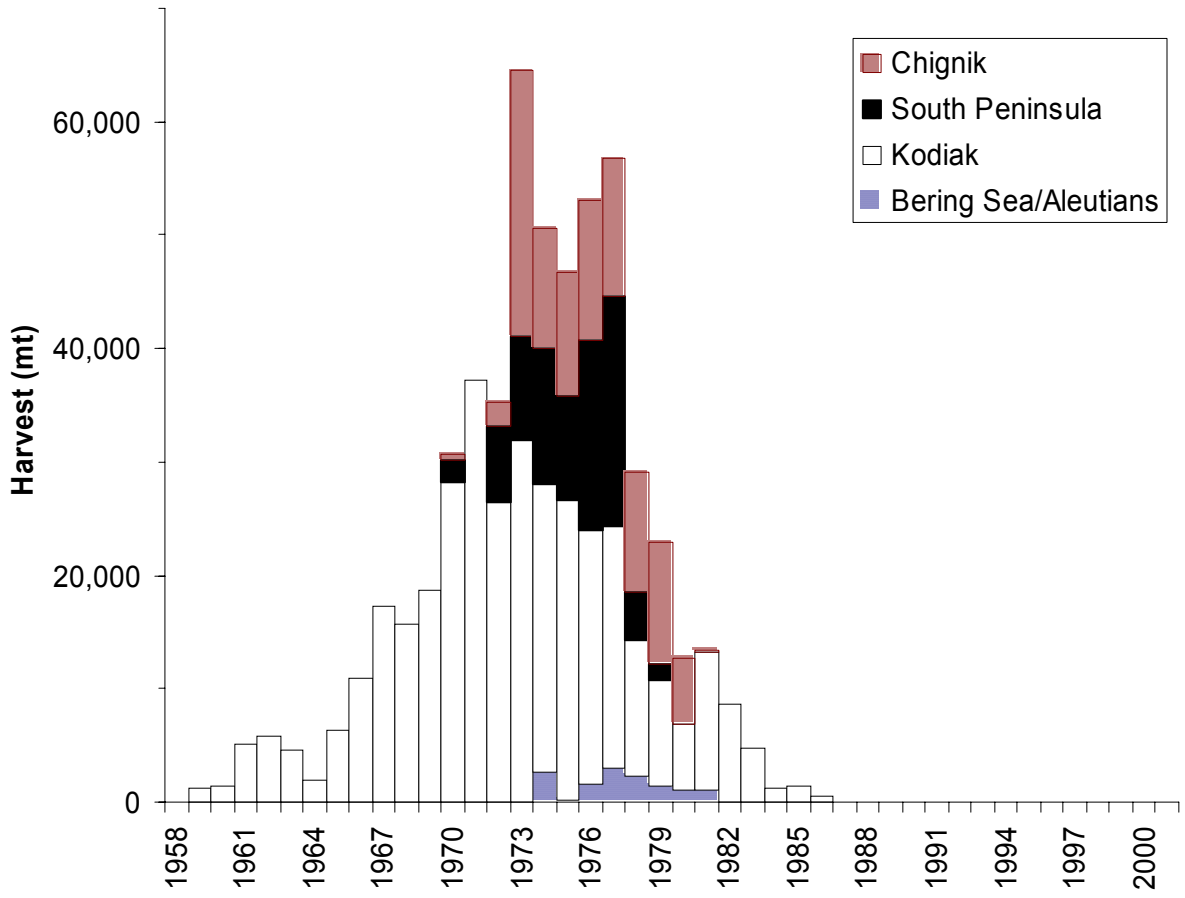

Figure 5.2.1 Harvest of all species of shrimp in the area of the Southwest stock of sea otters, 1958–2001.

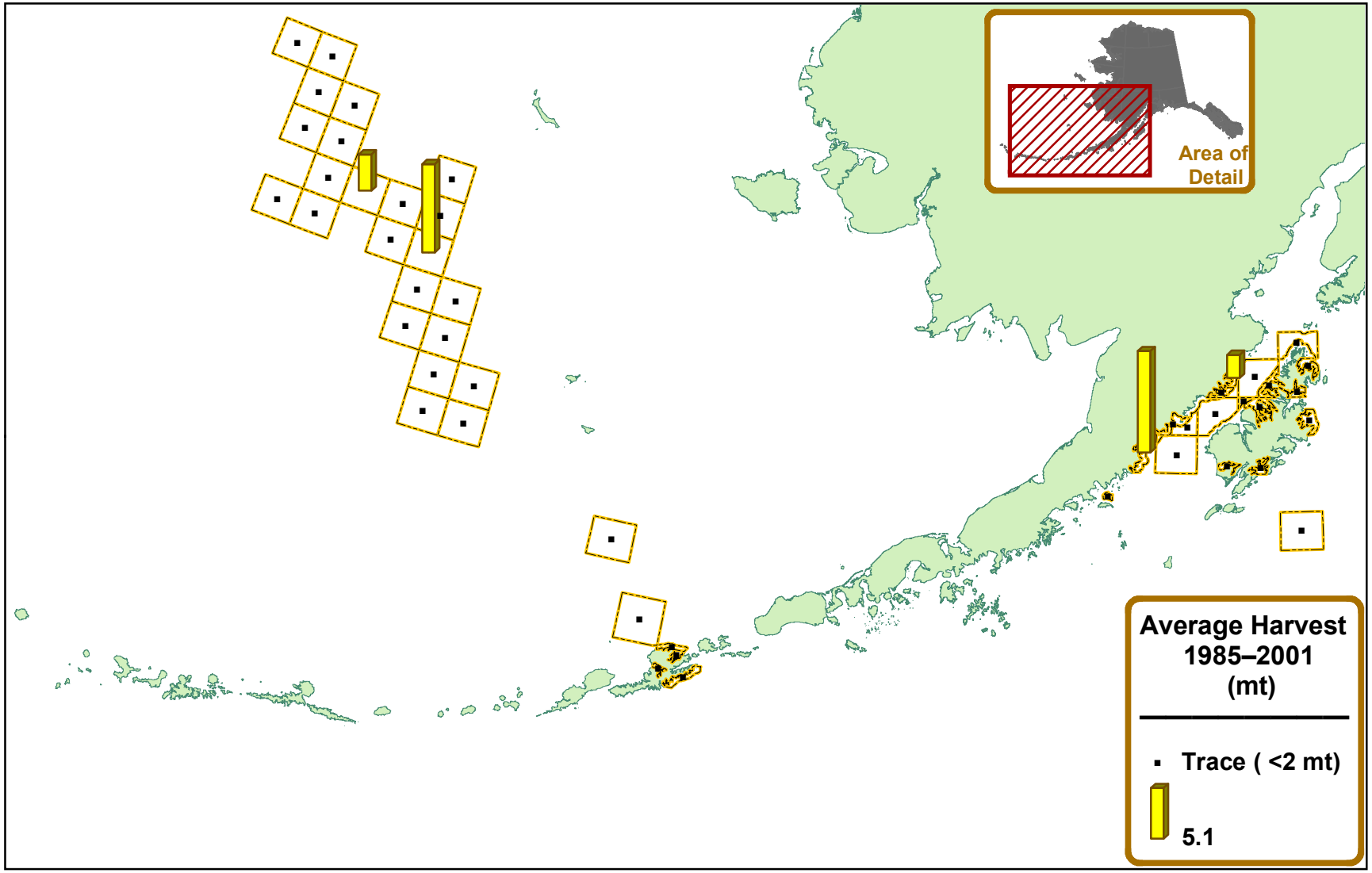

Figure 5.2.2 Spatial distribution of average shrimp harvest, for the years 1985–2001.

5.3 Green Sea Urchins [10]

Green sea urchins *Strongylocentrotus droebachiensis* are broadly distributed in rocky coastal areas of Alaska from Dixon Entrance through the Aleutian Islands. Their preferred habitat is a rocky substrate, especially ledges and crevices located near or in beds of brown algae in areas of moderate to swift currents or wave action. Their depth ranges from extreme low tide to over 100 m subtidal depth with the most concentrated abundances found just below the upper limit of low tidal range. Sea urchins graze on attached marine plants and drifting kelp fragments and their grazing often limits kelp distribution. Sea urchin larvae are planktivorous. Juveniles settle near kelp beds, often associated with aggregations of adults and seeking shelter under adult spines until mature.

The only substantial green sea urchin fishery has occurred on the southeast side of Kodiak Island. Limited exploratory fishing has occurred around Dutch Harbor. Green sea urchin experimental fisheries are also open on the Alaska Peninsula in the Aleutian and Pribilof Islands, but there have been no landings recorded.

5.3.1 Description of Fishery

Sea urchins are harvested for their roe and are taken by diving. Action by the BOF in March of 1997 authorized the use of 4-foot rakes for taking urchins, but the BOF reaffirmed its opposition to the use of pots in the urchin fishery. Pot gear could result in unacceptable handling mortality of unmarketable green sea urchins. Enforcement concerns had also been raised for pot gear. The prime green sea urchin season coincided with the historical Tanner crab fishery and it was feared that under the guise of green sea urchin pot fishing, fishermen could prospect for Tanner crab. There are currently no size limits for green sea urchins in regulation. However, buyers will only purchase green sea urchins two inches or greater in diameter at present.

Commercial fishermen participate in the green sea urchin fishery under the terms of a miscellaneous shellfish permit as authorized in BOF regulations (5 AAC 38.062). The commercial fishing regulations set the season from October 1 to January 31. While marketable roe may be available at other times of the year, the potential is high for increased sorting and handling mortality of unmarketable green sea urchins. Special exploratory permits have been issued for in the eastern Aleutian Islands during the summer and early fall to check the quality of the roe, but divers have found little marketable product during these periods.

In 2000, ADF&G worked to develop conservative GHLs for the green sea urchin fisheries based on historic harvest information (Table 5.3.1). The management sections utilized for Tanner crab and sea cucumber management were adopted for green sea urchin management. Management sections that lacked historic harvest data were assigned a 5,000 pound GHL. A GHL of 10,000 pounds (4.6 mt) was established for management sections with previous exploration for which

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[10] Most of the management information in this section is extracted from more detailed treatments in Ruccio and Worton (2000a, b), Bowers (2001), Bowers et al. (2001) and Kruse et al. (2000). The current fishery management contacts are Michael Ruccio (Kodiak and Alaska Peninsula), and Forrest Bowers (Bering Sea and Aleutian Islands).

some harvest data was available. For future management, ADF&G will work closely with fishery participants to collect baseline biological data from the green urchin fishery and may adjust these established GHLs based on that data.

Green sea urchins are an important subsistence species for Native Alaskans and several other ethnic groups found in Kodiak. The subsistence harvest is spatially distributed around Kodiak Island. The current subsistence harvest tracking system pools sea urchin harvests with other species in an "other" category, so specific subsistence farvest estimates for sea urchins are not available. However, the subsistence sea urchin removals are thought to be very small (Mike Ruccio, Alaska Department of Fish and Game, Kodiak, personal communication).

5.3.2 History of the fishery

Green sea urchins were not harvested commercially in the Westward Region until 1980 when a small amount was taken in the Kodiak area to test marketability. There was little further interest in green sea urchins in Kodiak until 1985 when a small harvest occurred. In 1986, the harvest increased with more divers participating. Peak harvest occurred in 1988 at 86 mt (Figure 5.3.1). Green sea urchins are usually shipped live to Japan for processing.

Red sea urchins *Strongylocentrotus franciscanus,* which are widely harvested in Southeast Alaska and along the west coast of Canada and the Lower 48 states, are found in extremely small quantities in the Kodiak Area. Their abundance is insufficient to support a commercial fishery.

5.3.3 Recent catch, effort, and status

Green sea urchins have been taken primarily from the south and east sides of Kodiak Island (Figure 5.3.3). Small exploratory harvests have taken place along the Alaska Peninsula.

Two divers registered to harvest green sea urchins in the Kodiak Area during 2001–02. Only one diver made landings and acted as the only processor, shipping live product to Japan for sale. All harvest information is confidential because fewer than three divers or processors participated in the fishery. As has been typical in recent years, although the sea urchin and sea cucumber seasons both open concurrently on October 1, interest in harvesting sea urchins occurred only after the Kodiak Island waters closed to sea cucumber harvesting. Most harvest has occurred in November, with smaller amounts harvested in December and January (Figure 5.3.2).

No stock assessment analysis is currently conducted on green sea urchin populations in the Westward Region. The sole fishery participant this year worked extensively with ADF&G to ensure that deliveries were available for biological sampling before processing or shipping. In addition to determining the spawning condition, roe content, diameter measurements, and physical structures (e.g. rotules, components of Aristotle's lantern) were collected for a recently developed aging technique. Given the low effort levels in the fishery, CPUE data from logbooks varies widely and does not lend itself to inferences on stock status. Fishery information indicates the biomass is small compared to other areas on the Pacific Coast and when compared to an estimated annual worldwide sea urchin harvest of over 45,000 mt (Lourie and Sanders 2000).

5.3.4 Potential Fishery–Sea Otter Interactions

The interplay of sea otters and sea urchins is well known to structure nearshore communities in the Pacific Northwest (Simenstad et al. 1978; Estes and Palmisano 1974), and green sea urchins appear in sea otter diets throughout Alaska (Riedman and Estes 1990). The extremely small spatial scale of the sea urchin fisheries are not likely to play a role in the system-wide declines of sea otters. Sea urchin fisheries have been short in duration, thus divers are only present in nearshore areas for limited amounts of time. It is unlikely that the presence of divers for such short periods of time would significantly disturb sea otter foraging patterns. The established GHLs for the commercial harvest are thought to be conservative and not cause excessive local depletion of green sea urchins. Subsistence harvests are very low and not likely to deplete sea urchin populations or affect sea otter foraging.

Table 5.3.1 Green sea urchin guideline harvest levels (GHL) for 2001 in the area of the Southwest stock of sea otters.

Location	**Sea Urchin GHL (Pounds)**
Northeast Section	5,000
Eastside Section	40,000
Southeast Section	30,000
Southwest Section	20,000
Westside Section	30,000
North Mainland Section	5,000
South Mainland Section	5,000
Semidi Island Section	5,000
Kodiak District Total	140,000
Chignik District	25,000
Alaska Peninsula District	5,000
Aleutian Islands District	5,000
Bering Sea (excluding St. George Island)	5,000

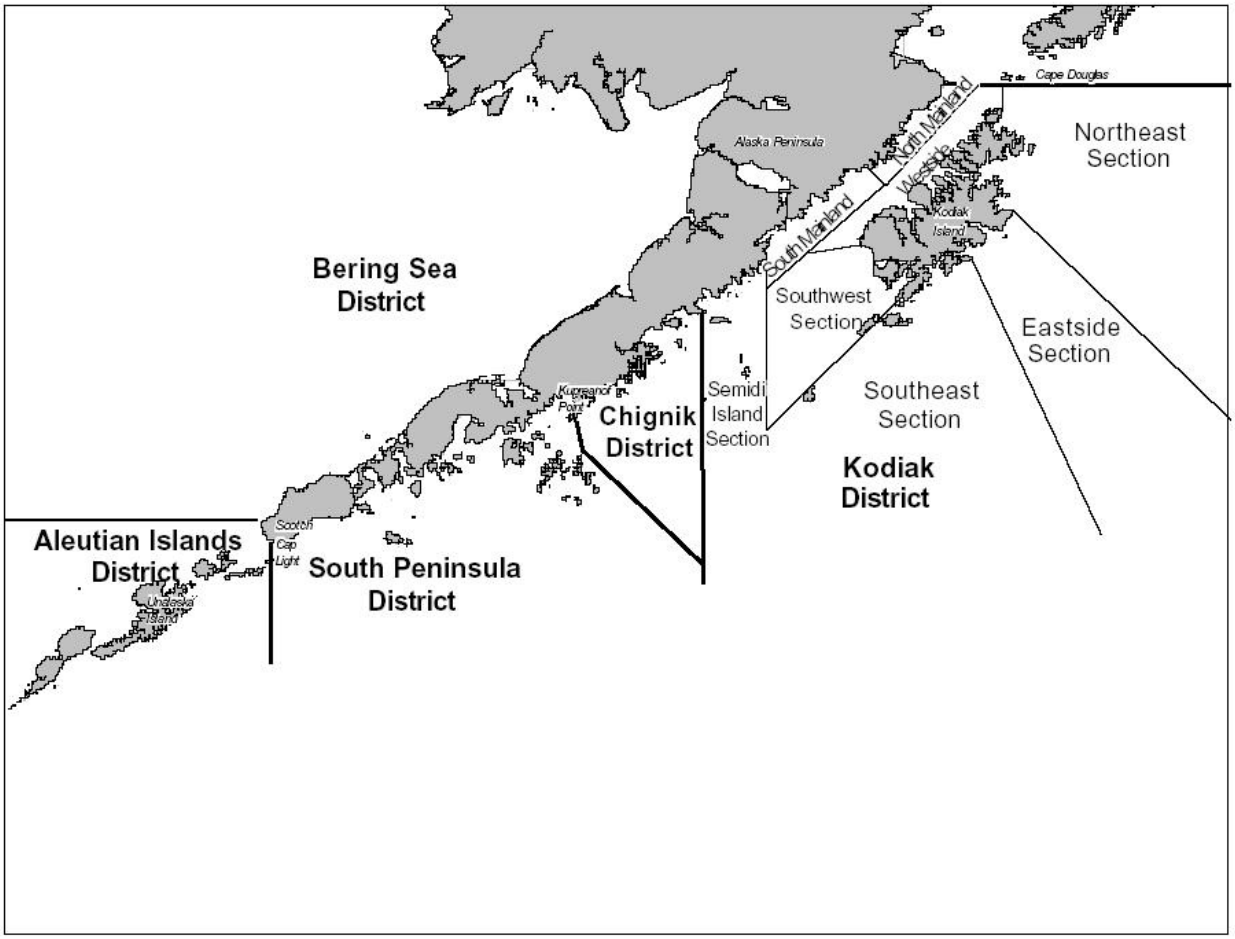

Figure 5.3.1 Sea cucumber and sea urchin management areas for 2002–2003.

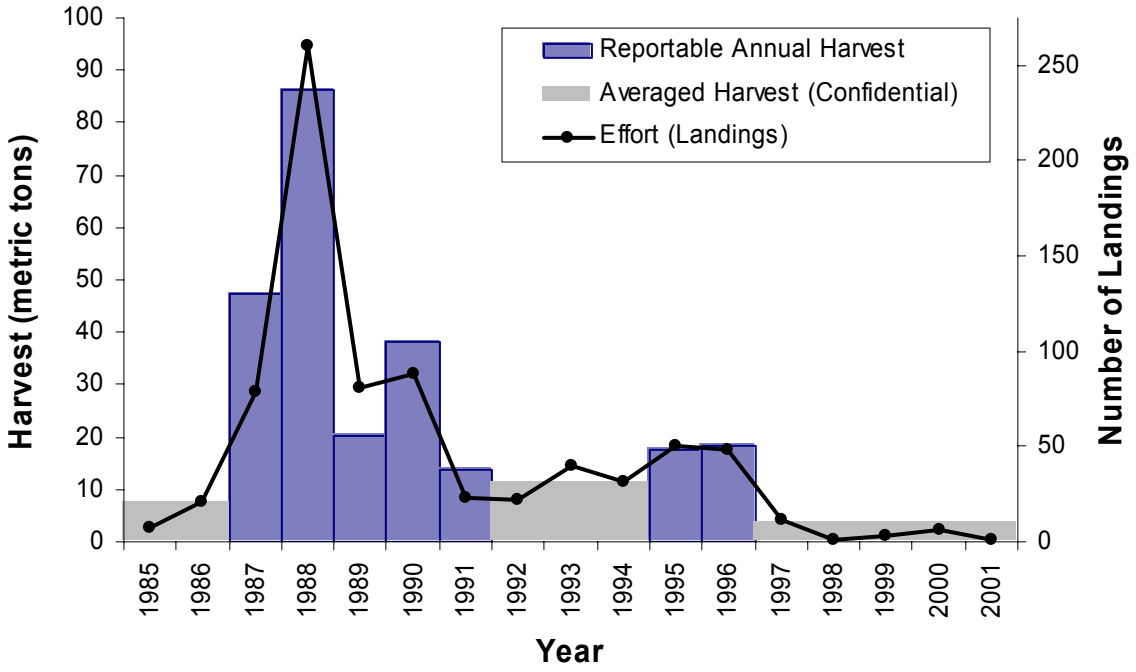

Figure 5.3.2 Harvests of green sea urchins in Alaska in the area corresponding to the Southwest stock of sea otters, 1985–2001. Harvest for 1992–1994 and 1997–2001 are averaged because less than three permits or processors participated in those years.

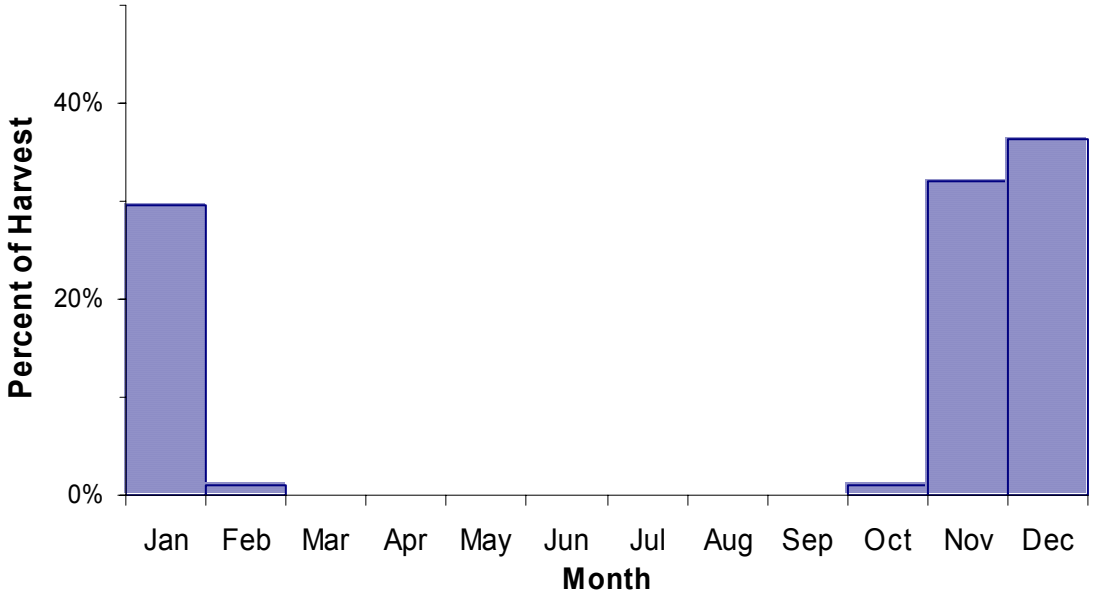

Figure 5.3.3 Temporal distribution of green sea urchin harvest in the area corresponding to the Southwest stock of sea otters, 1996–2001.

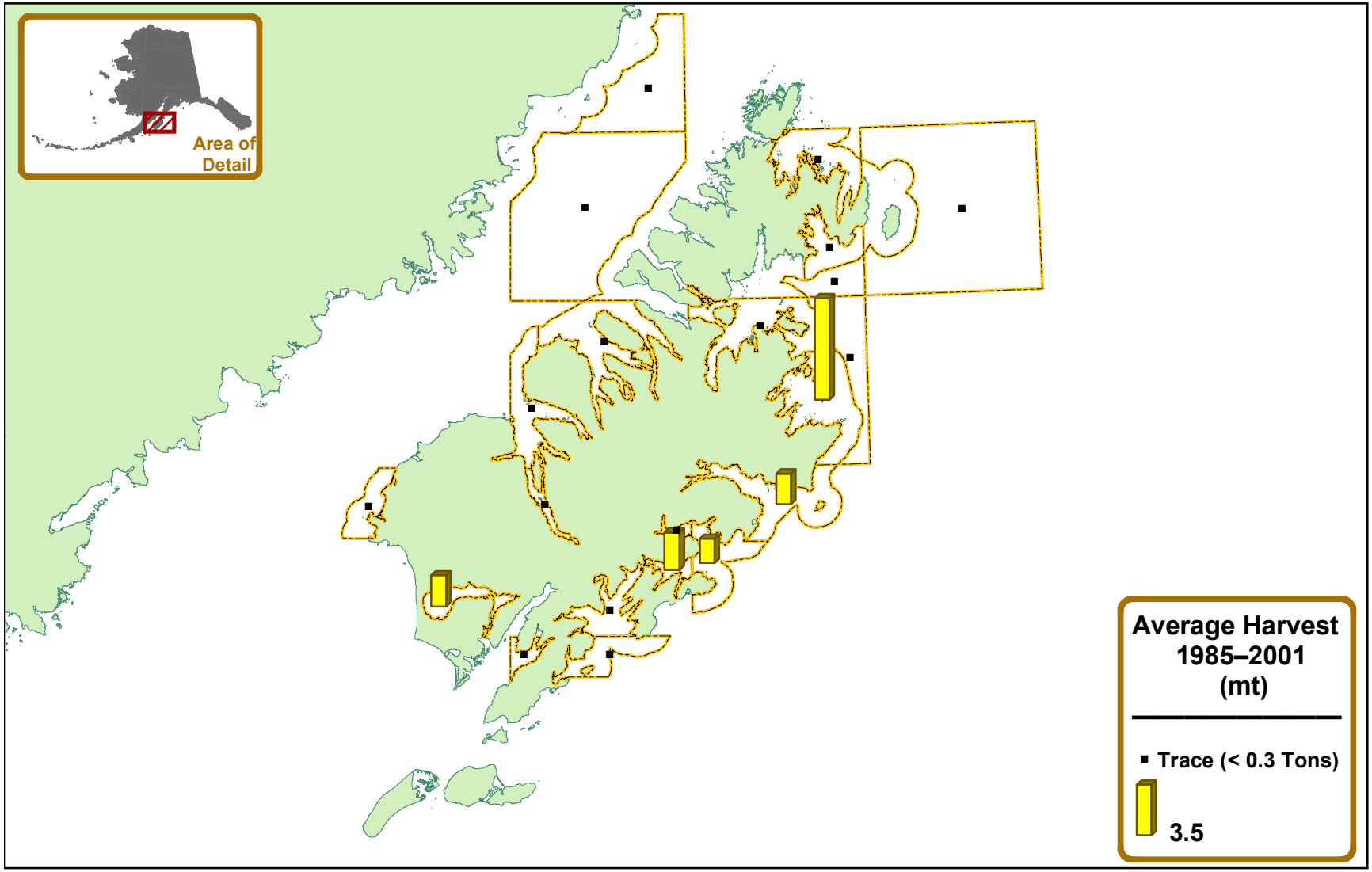

Figure 5.3.4 Spatial distribution of average green sea urchin harvest, 1985–2001.

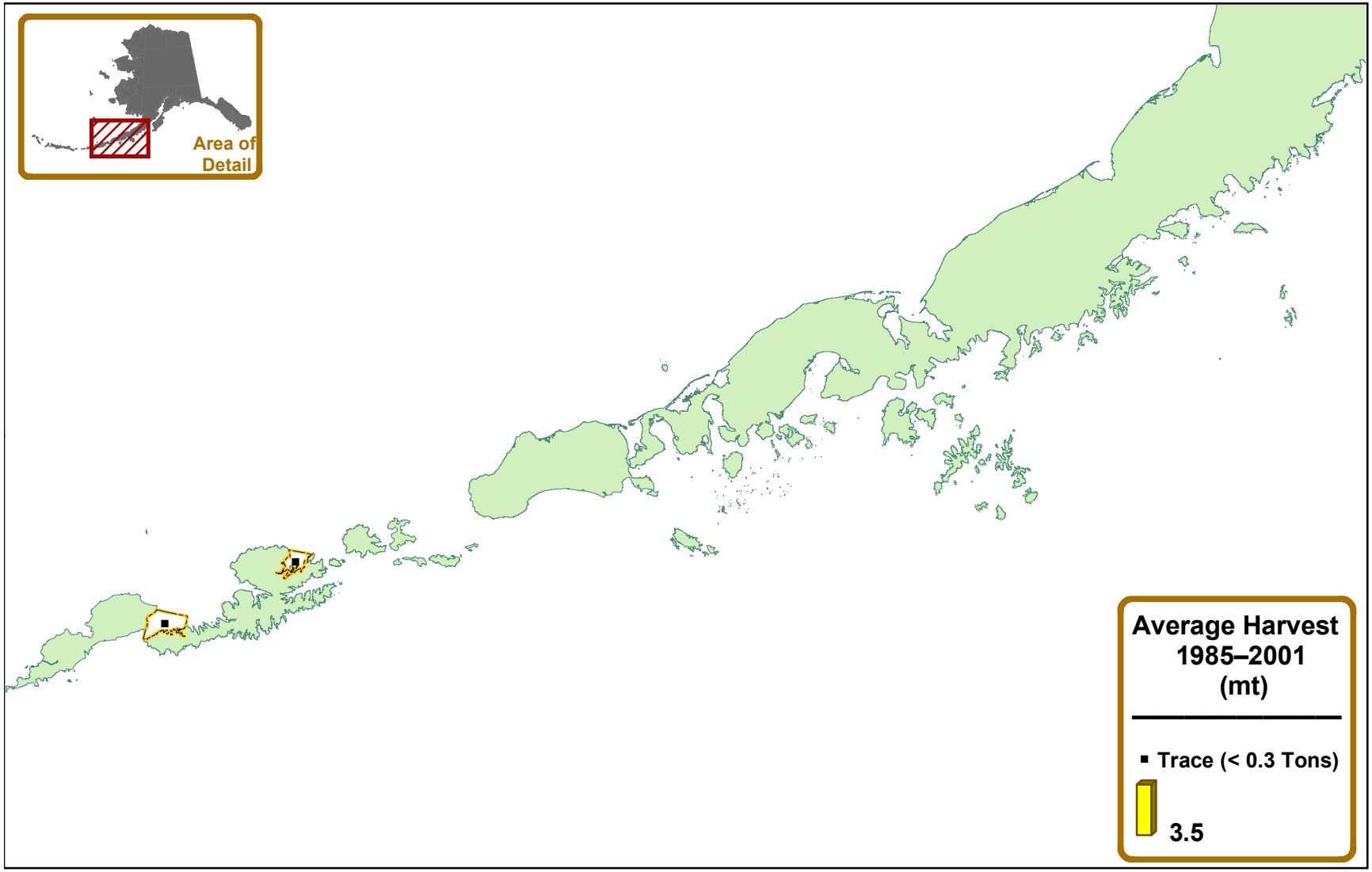

Figure 5.3.5. Spatial distribution of average green sea urchin harvest, 1985–2001.

5.4 Red Sea Cucumbers [11]

The red sea cucumber *Parastichopus californicus* is a benthic detritus feeder found from the Aleutian Islands to Baja California. It occurs on all types of bottom, from muddy sand to bedrock, ranging from the low intertidal to 300 m depths and prefers areas protected from strong wave action. In Southeast Alaska, a study using submersibles found highest sea cucumber densities in two depth bands: less than 60 m and 100 to 150 m (Zhou and Shirley 1996). Sea cucumbers have limited mobility but can travel up to about 4 m per day (DFO 1999). They feed by picking up organic detritus with their tentacles as they move over the sea floor.

The red sea cucumber is a broadcast spawner with a pelagic larval stage that ranges from two to four months. Sea cucumbers cannot be aged, so birth, death, and other vital rates are not known. The animals undergo an annual fluctuation in body mass, skin thickness, and muscle weight during their yearly cycle of resorbing and regenerating their internal organs.

5.4.1 Description of Fishery

Red sea cucumbers are harvested by hand picking from the sea floor by divers. Because of practical limitations on diving depths, the deeper portion of the population is not harvested.

The fishing season is open from October 1 through April 30, with three-day weekly fishing periods (Ruccio and Worton 2000a). Diving logs must be submitted with each fish ticket landing to help fishery managers track fishing performance. The GHLs (Table 5.4.1) set for each of several management areas (Figure 5.3.1) are based on historic production and fisheries performance.

5.4.2 History of the Fishery

Red sea cucumbers were first experimentally harvested in the Westward Region in 1991, with larger scale commercial harvests beginning in the spring of 1993. The fishery was allowed to develop under the terms of a permit authorized by 5 AAC 38.062 of the ADF&G Commercial Shellfish Regulations. Diving was specified as the only legal gear and dive logs were required to be submitted with fish tickets. Harvests were monitored to determine abundance and distribution. As the harvest reached levels where ADF&G felt there was a potential for overfishing, the various fishing areas were closed. The 1993 harvest of 256 mt was taken by 50 dive permit holders.

In February of 1994, ADF&G announced several management measures intended to prevent overharvest of the red sea cucumber resource. A seasonal closure from May 1 through September 30 was established to protect the spawning aggregates of red sea cucumbers. In

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[11] Most of the management information in this section is extracted from more detailed treatments in Ruccio and Worton (2000a, b), Bowers (2001), Bowers et al. (2001), Kruse et al. (2000), and DFO (1999). The current fishery management contacts are Michael Ruccio (Kodiak and Alaska Peninsula), and Forrest Bowers (Bering Sea and Aleutian Islands)

addition, GHLs were established for the Kodiak and Chignik Districts. A total of 90.7 mt was announced for Kodiak and the Chignik GHL was set at 22.7 mt. Management areas based on the Tanner crab fishing sections were utilized in Kodiak in an attempt to spread the effort and harvest around the island and prevent localized depletions (Figure 5.3.1). A GHL was set for each of the individual areas based on historic production and fisheries performance. Registration permit provisions included a weekly fishing period of 5 days and daily dive logs submitted by the divers with their fish tickets.

Following the May 1 to September 30 closure, ADF&G reopened the Westward Region to red sea cucumber fishing. The GHLs for the Kodiak and Chignik Districts combined totaled 102.1 mt with 3 day weekly fishing periods. The shortened fishing periods were set to allow ADF&G a better opportunity to assess inseason fishery performance. The GHLs were quickly reached in the sections surrounding Kodiak Island, but the Mainland and Chignik Sections received little effort and remained open for the duration of the established season.

The 1995–1996 sea cucumber fishing season opened on October 1, 1995. Evaluation of another year of fishery performance resulted in a decreased GHL. The combined GHL for the Kodiak and Chignik Districts was set at 72.6 mt. Effort concentrated on the Eastside, Southeast, Southwest, and Westside Sections of Kodiak. Although outlying areas along the Alaska Peninsula have historically remained open for the duration of the regulatory season, divers were reluctant to cross Shelikof Strait in the face of stormy weather and the expectation of marginal returns. Since the 1996–97 season, the fishery has followed a similar pattern of approximately five fishing periods of varying length occurring before the areas around Kodiak Island obtained their respective GHLs and were closed for the season.

5.4.3 Recent Catch, Effort, and Status

Fishing for red sea cucumbers has been occurring primarily in the fall (Figure 5.4.2). The 2001 season opened on October 1, 2001 with a combined GHL for the Kodiak and Chignik Areas of 63.5 mt. The Kodiak Area was further subdivided into sections with individual GHLs. Management strategy was the same as previous years with a 3-day weekly periods, and dive logs required with each fish ticket. For the 2001 fishery, ADF&G requested latitude and longitude information for each dive and requested that each dive be recorded on a separate line within the logbook. All harvest occurred in the Kodiak Island Sections. No harvest was reported from the mainland sections or Semidi Islands Section.

There are no population estimates for red sea cucumbers in the Westward Region. Following the establishment of conservative GHLs in 1995, catch rates estimated from diver logbook data in the commercial fishery have remained stable in recent years, as has total catch and landings (Figure 5.4.3). Actual biomass levels, especially at depths unavailable to divers, are unknown. Near shore initiative research funding has been procured and may be utilized for some preliminary dive and video assessment of red sea cucumber populations around Kodiak Island.

Over the period 1997–2001, most of the sea cucumber harvest has been removed from the southeast side of Kodiak Island near Sitkalidak Island (Figure 5.4.4), with small amounts removed from the remainder of Kodiak Island and near Chignik.

5.4.4 Potential Fishery–Sea Otter Interactions

Sea cucumber fisheries have been short in duration, thus divers are only present in nearshore areas for limited amounts of time. It is unlikely that the presence of divers for such short periods of time would significantly disturb sea otter foraging patterns. The current GHLs are thought to be conservative and not result in excessive local depletions. In addition, a significant proportion of the sea cucumber resource occurs below practical diving limits and is not harvested, although it is well within sea otter diving ranges.

Table 5.4.1 Red sea cucumber guideline harvest levels (GHL) for 2001 in the area of the Southwest stock of sea otters.

Location	**Sea Urchin GHL (Pounds)**
Northeast Section	5,000
Eastside Section	40,000
Southeast Section	30,000
Southwest Section	20,000
Westside Section	30,000
North Mainland Section	5,000
South Mainland Section	5,000
Semidi Island Section	5,000
Kodiak District Total	140,000
Chignik	25,000
Alaska Peninsula	5,000
Aleutian Islands	5,000
Bering Sea Area (excluding St. George Island)	5,000

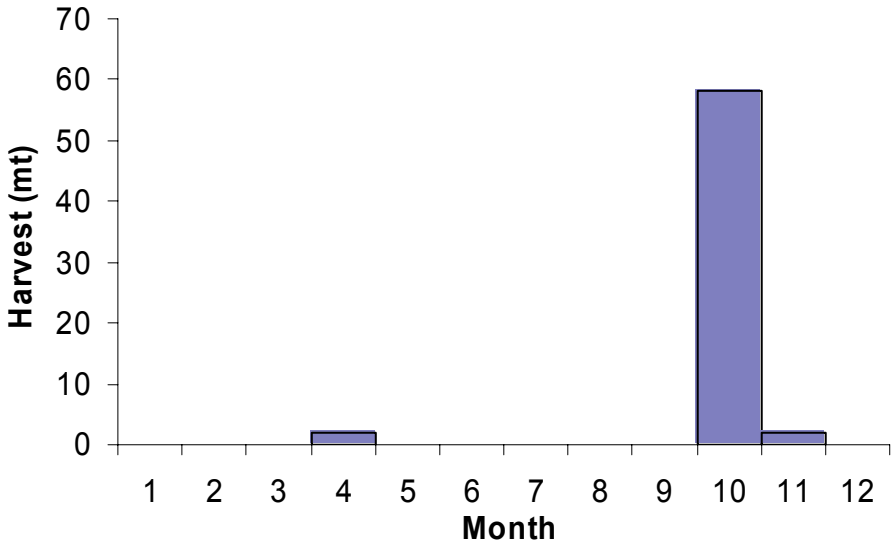

Figure 5.4.1 Temporal Distribution of red sea cucumber harvest in the area corresponding to the Southwest stock of sea otters, 1970–2001.

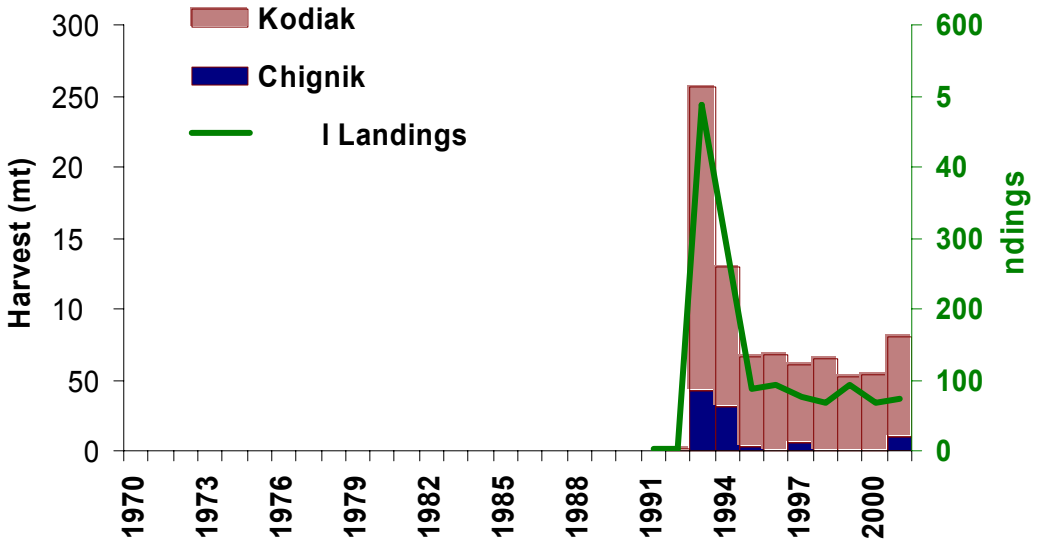

Figure 5.4.2 Harvests of sea cucumbers in Alaska in the area corresponding to the Southwest stock of sea otters, 1970–2001.

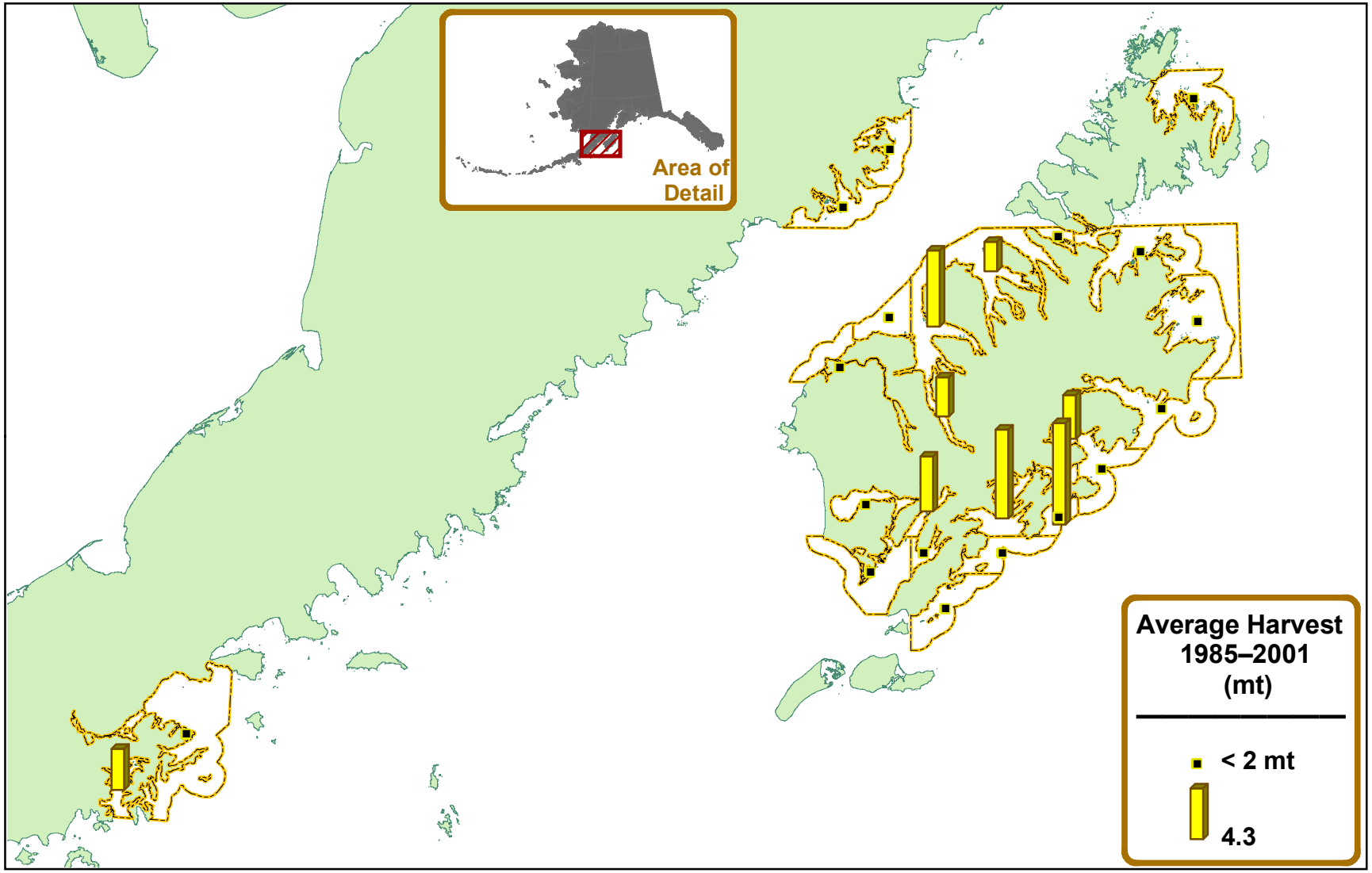

Figure 5.4.3 Spatial distribution of average sea cucumber harvest, 1997–2001.

5.5 Weathervane Scallops [12]

Seven species of scallops are known to occur in Alaska (Table 1). The primary commercially fished species, the weathervane scallop *Patinopecten caurinus*, occurs offshore aggregated in elongated beds that lie parallel to Alaska's coastline from Southeast Alaska to the Aleutian Islands. Weathervane scallop beds occur on mud, silt, sand, gravel, and to a lesser extent, rocky bottoms at depths of 60–220m.

Weathervane scallops are dioecious, with males distinguished by their white colored testes and females by bright red/orange ovaries. Spawning occurs once annually between mid May and early July. Spermatozoa and eggs are released directly into the water where fertilization occurs. Fertilized eggs settle to the bottom where they hatch into larvae within several days (BLM 1980). For the next two to three weeks, the young scallop larvae gain shell weight as they drift with prevailing currents in the upper water column. The scallops then settle to the bottom and attach to the substrate with byssal threads. While attached, the foot of the scallop develops. Scallops may move about the substrate using their foot or remain attached with the byssal threads. Within four to eight weeks, the nearly transparent juveniles develop the ability to swim and after a few months, the shell becomes pigmented. At this life stage, young scallops resemble the adult form but are less than one-half inch across the shell. Food is obtained by filtering microscopic plankton from the water. Hennick (1970) suggested that weathervane scallops become sexually mature at age three or older. Studies conducted in Oregon showed that weathervane scallops less than 70 mm in shell height contained gonads without gametes (Starr and McRae 1983).

Scallops are the only bivalves in Alaska capable of swimming. Propulsion is accomplished by rapid ejection of water from the interior of the shell in a jet-like action. Older, heavier scallops are less adept at swimming than juveniles. The oldest weathervane scallop found in Alaska was caught near Kodiak Island, measured 10 inches across the shell, and was estimated to be 28 years old (Hennick 1970).

5.5.1 Description of Fishery

This fishery is prosecuted using a standard “New Bedford style” scallop dredge. On average, a 15-foot dredge weighs approximately 1.2 mt and a 6-foot dredge weighs about 0.4 mt. The frame design provides a rigid, fixed dredge opening. Attached to and directly behind the rigid frame, is a steel ring bag consisting of 4-inch (inside diameter) rings connected with steel links. A sweep chain footrope is attached to the bottom of the mesh bag. The top of the bag consists of 6-inch stretched mesh polypropylene netting. The mesh netting helps hold the bag open while it is towed along the ocean floor. A club stick attached at the end of the bag helps maintain the shape of the bag and provides for an attachment point to dump the dredge contents on the deck. Steel dredge “shoes” are welded onto both lower corners of the rigid frame. The dredge shoes bear most of the weight and act as “sled runners” permitting the dredge to move easily along the

[12] Most of the management information in this section is extracted from more detailed treatments in Barnhart (2000a, b) and Kruse et al. (2000). The current fishery management contacts are Jeffrey Barnhart (Kodiak and Alaska Peninsula), and Forrest Bowers (Bering Sea and Aleutian Islands).

substrate. Each dredge is attached to the boat by a single steel wire cable operated from a deck winch. Vessels fishing inside the Cook Inlet Registration Area are limited to operating a single dredge not more than 6 feet in width. Vessels fishing in the remainder of the state are limited to operating no more than 2 scallop dredges at one time and the scallop dredges may not be more than 15 feet wide. Vessels used in the weathervane scallop fishery range in size from 60 feet to 124 feet in length, with a maximum of 1,200 horsepower.

Scallop fishing operations involve the following steps: (a) dredge deployment, (b) tow dredge for about 60 minutes on the bottom at an average speed of 4.7 knots, (c) retrieve dredge, (d) empty dredge contents on deck, (e) sort retained scallops from the catch while discarding bycatch overboard, (f) move baskets of retained scallops from the deck to the shucking house, (g) prepare gear for the next set, and (h) shuck, wash, grade, package, and freeze scallop meats. The scallop meat is the adductor muscle that is shucked from the retained scallops by the crew using a specialized hand-held scallop knife.

From the inception of the fishery in 1967 through mid May 1993, the Westward Region scallop fishery was passively managed, employing minimal management measures. Closed waters and seasons were initially established to protect crab and crab habitat. Scallop management was not based on scallop stock abundance or biology. As catches declined in one bed, vessels moved to better grounds. While this may have been generally acceptable for a sporadic, low intensity fishery, increased participation led to boom and bust cycles experienced from 1967–1992 (Figure 5.5.1). Details of specific management actions over the history of the fishery are given in Barnhart (2000a).

However, by 1993 weathervane scallop fishery management changed in response to the increased effort. The fishery was declared to be a high impact and emerging fishery on May 21, 1993 by the Commissioner of the ADF&G and was closed until a conservative management plan could be developed by the department. The resulting interim Alaska Scallop Fishery Management Plan approved by the ADF&G Commissioner in June 1993 and later adopted by the BOF included: 1) a requirement for 100% onboard observer coverage, 2) regulations that limit efficiency and slow the pace of fishery, 3) regulations that reduce the capture rate of small scallops, and 4) crab bycatch limits. Regulations prohibited the use of mechanical shucking machines and chafing gear, restricted the number and size of dredges, required a minimum ring size, and limited the number of crew members. At the BOF meeting in March 1997, the statewide regulatory season was established as July 1 through February 15, excluding the Cook Inlet Registration Area. Although the season dates were established to protect molting and mating crab they have the added benefit of not disturbing scallops prior to and during their spawning period.

Other regulatory actions also changed the character of the fishery. The fishery was closed from February 1995 to August 1996 in response to an unregulated vessel operating in the EEZ**.** Effective July 1, 1997 the NPFMC adopted a federal FMP for the scallop fishery off Alaska. The FMP applied to waters of the EEZ and included a moratorium on the entry of new vessels into the fishery. In 1998, Amendment Three to the FMP delegated authority to the state of Alaska to manage all aspects of the scallop fishery, except limited access, in federal waters (Barnhart 2000b).

Participation in the Alaska scallop fishery remains limited in the EEZ by a federal Scallop License Limitation Program that became effective on January 16, 2001. Vessels in state waters are limited by an Alaska legislative moratorium. The regulatory fishing season is from July 1 through February 15 or until closed by emergency order. Most fishing occurs in late summer to early fall (Figure 5.5.2). Scallop GHLs and crab bycatch limits for upcoming seasons are usually announced by late spring. All vessels are required to carry onboard observers who collect detailed information on CPUE, area and depth fished, location, scallop meat weight recovery, and catch composition. Data are also collected on crab and halibut bycatch, retained scallop catch, and discarded scallop catch. Observers report scallop harvest, number of tows, area fished, and crab bycatch to ADF&G at least three times each week during the season. These data are incorporated into inseason management decisions.

5.5.2 History of the Fishery

Alaskan weathervane scallop populations were first evaluated for commercial potential in the early 1950s by both government and private sector research (Kaiser 1986). However, it was not until the late 1960s as catches declined in the U.S. and Canadian scallop fisheries on Georges Bank, that interest in a fishery off Alaska began to take shape (Orensanz 1986). Initial commercial fishing effort took place in 1967 when fishermen on two vessels harvested weathervane scallops from fishing grounds off the eastside of Kodiak Island. By the following year, 19 vessels consisting of New England type scallop vessels, converted Alaskan crab boats, salmon seiners, halibut longliners, and shrimp trawlers entered the fishery (Kaiser 1986).

The fishery developed from 1967 through 1973 through several developmental phases of rise and fall as virgin scallop beds were identified and harvested (Shirley and Kruse 1995). This was followed by a period of declining scallop harvests from 1974 to the end of the decade. A smaller, more stable fishery followed through the 1980s.

By 1993 the fishery again expanded with an influx of scallop boats from the east coast of the United States. The fishery changed in the 1990s 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 the product onboard the vessel. The average number of deliveries per year between 1990 and 1994 was 133. By 1996, all the scallop catcher-boats participating in the statewide fishery were converted to catcher-processors, which freeze product on board (Barnhart 2000b). Freezing product on board allowed longer trips without concerns about product spoilage.

The majority of the scallop vessel owners formed a cooperative just prior to the 2000–01 regulatory season. Within the cooperative, vessel owners allocate themselves shares of the projected harvest based on their previous fishing history. The formation of the cooperative slowed the harvest rate and extended the fishing effort over a longer time period. Some qualified vessels did not participate and owners arranged for their shares to be caught by other vessels. This program is not endorsed or managed by ADF&G or any federal agency.

5.5.3 Recent Catch, Effort, and Status

Over the last five years, scallop harvest has come principally from upper Shelikof Strait, the east side of Kodiak Island, and the Bering Sea (Figure 5.5.3). Large areas of the central and western Gulf of Alaska and Bering Sea are now closed to scallop fishing as a conservation measure (Figure 5.5.4).

In lower Cook Inlet, 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 shucked scallop meats harvested from waters along the east coast of Kodiak Island. The harvest peaked at 643 mt with seven vessels in 1970 and the effort peaked at 15 vessels in 1981. Catches declined to zero in 1977 and 1978. Since 1980, landings have fluctuated between 21 mt and 313 mt. As early as 1969, large areas around Kodiak Island were closed to scallop fishing to protect king and Tanner crab populations.

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 Mitrofania 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.

In the Bering Sea, significant commercial harvests have occurred since 1993, with harvests peaking at 229 mt in 1994–95. The principal fishing area is near the outer edge of the continental shelf, north of Unimak Island. Large areas of the Bering Sea including the Pribilof Islands area, the red king crab savings area, and all waters east of long. 162º W. are closed to scallop fishing. (Figure 5.5.4)

The first harvest of weathervane scallops from the Dutch Harbor Registration Area took place in 1982 when 5 vessels landed 28 mt of scallop meats. The average annual catch from 1985 through 1992 was 113 mt of scallop meats. Closed waters were established to protect crab nursery areas. As a result of the closed areas, scallop catches declined significantly. The average annual catch between 1993 and 2001 was 6 mt of shucked scallop meats.

The Adak Registration Area includes the Aleutian Islands west of long.171º W. Weathervanes were first harvested in 1979 and then again in 1992 and 1995. During those years few fishermen participated in any given year, so catch and effort information is confidential. The Petrol Bank in the vicinity of Amchitka Island has been closed to scallop fishing since 1991 due to concerns about king crab bycatch in the *Chlamys spp.* scallop fishery (Figure 5.5.4).

5.5.4 Potential for Fishery-Sea Otter Interactions

Weathervane scallops have not been documented in the diet of sea otters. The giant rock-scallop *Crassadoma gigantea* and some scallops of the genus *Chlamys* occur infrequently in the diet of sea otters in southwestern and southcentral Alaska (Riedman and Estes 1990; Johnson 1987).

Most weathervane scallops are found deeper and further offshore than sea otters usually dive, at depths of 60–220m, with the majority of the fishing effort occurring between 70 and 110 m (Barnhart and Rosenkranz 2000). The average depth fished in the 1996–2001 observer information was 97 m, with a minimum depth of 29 m. There is no evidence that significant quantities of scallops occur in waters less than 30 m west of Cape Fairweather (Jeff Barnhart, Alaska Department of Fish and Game, Kodiak, personal communication).

Although scallops occur infrequently in the diet of sea otters, it is highly unlikely that scallop fisheries and sea otters compete for food because scallop fisheries occur in deeper, offshore waters where the relatively dense aggregations of weathervane scallops occur. There are no reported instances of entanglements of sea otters with scallop dredges and such encounters seem extremely unlikely.

Table 5.5.1 Scallop species known to occur in Alaskan waters.

Commercial Species

- Weathervane scallop *Patinopecten caurinus*
- Reddish scallop *Chlamys rubida*
- Spiny scallop *Chlamys hastata*

Non-commercial Species

- Giant rock-scallop *Crassadoma gigantea,* formerly *Hinnites giganteus*
- Bering scallop *Chlamys behringiana*
- Vancouver scallop *Delectopecten vancouverenis*
- Alaska glass scallop *Parvamussium alaskensis*

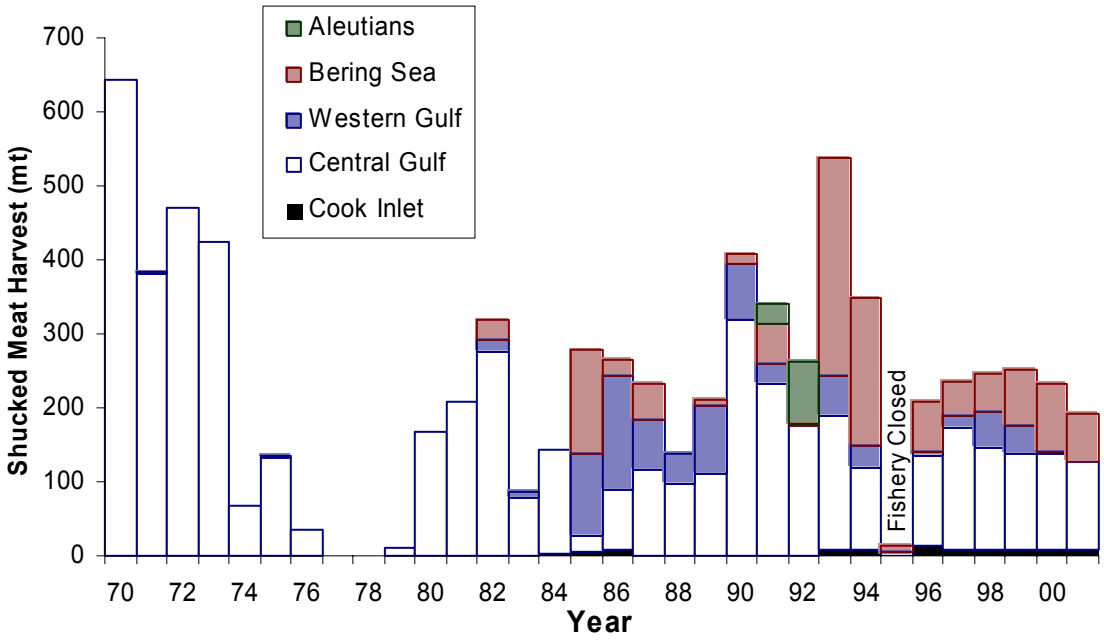

Figure 5.5.1 Harvests of weathervane scallops in Alaska in the area corresponding to the Southwest stock of sea otters, 1970–2001.

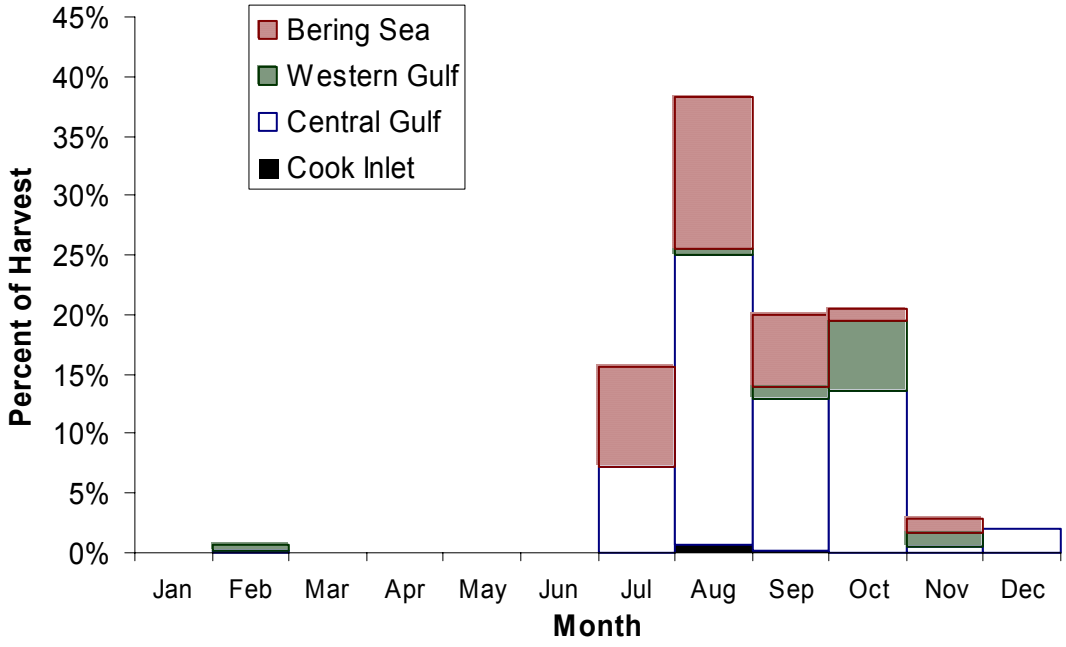

Figure 5.5.2 Temporal Distribution of scallop harvest in the area corresponding to the Southwest stock of sea otters, 1970–2001.

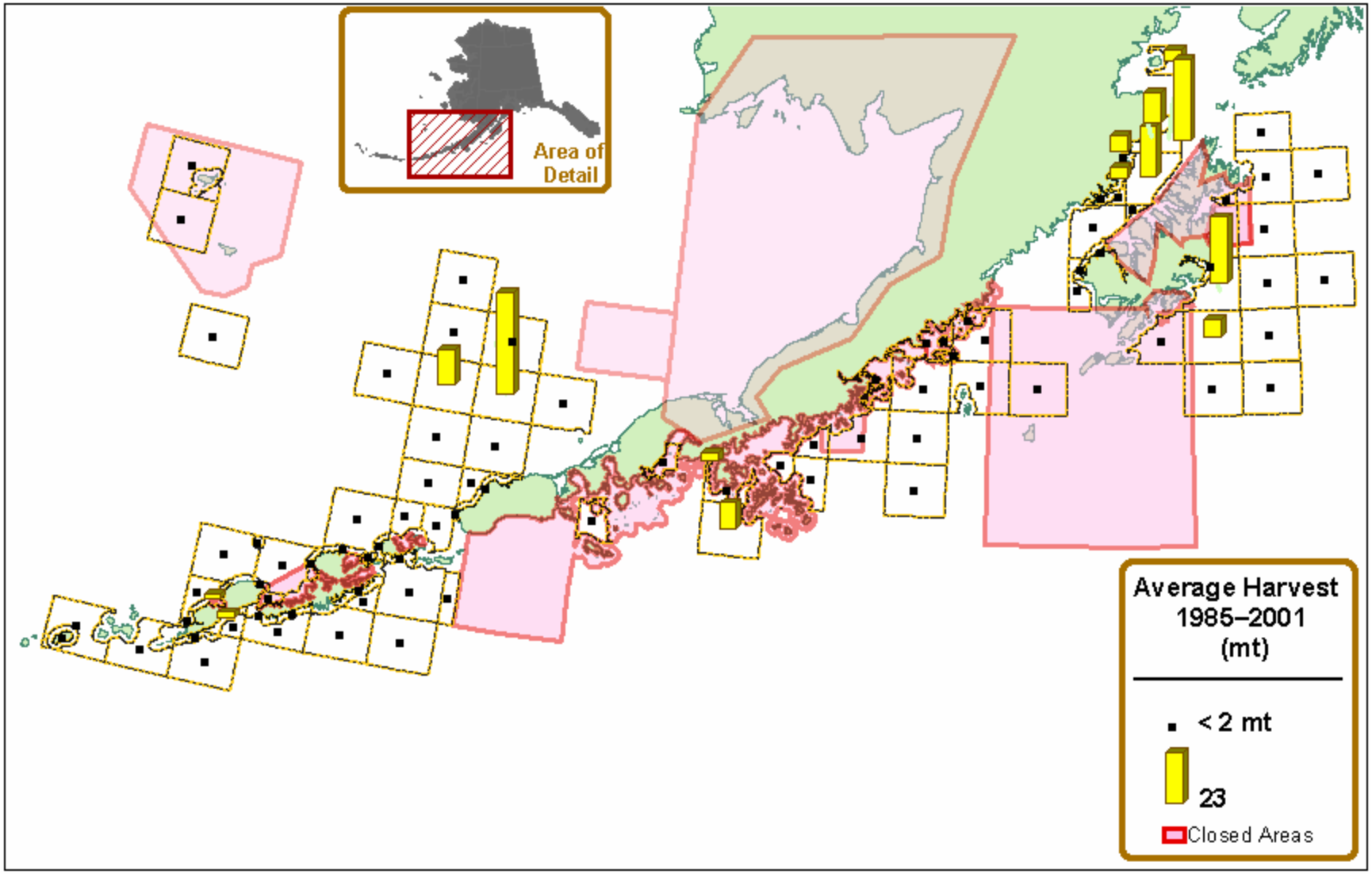

Figure 5.5.3 Spatial distribution of average scallop harvest, 1997–2001, showing areas closed to scallop fishing. The aggregate average catch from areas indicated "Trace Amount" totaled 8.3 mt.

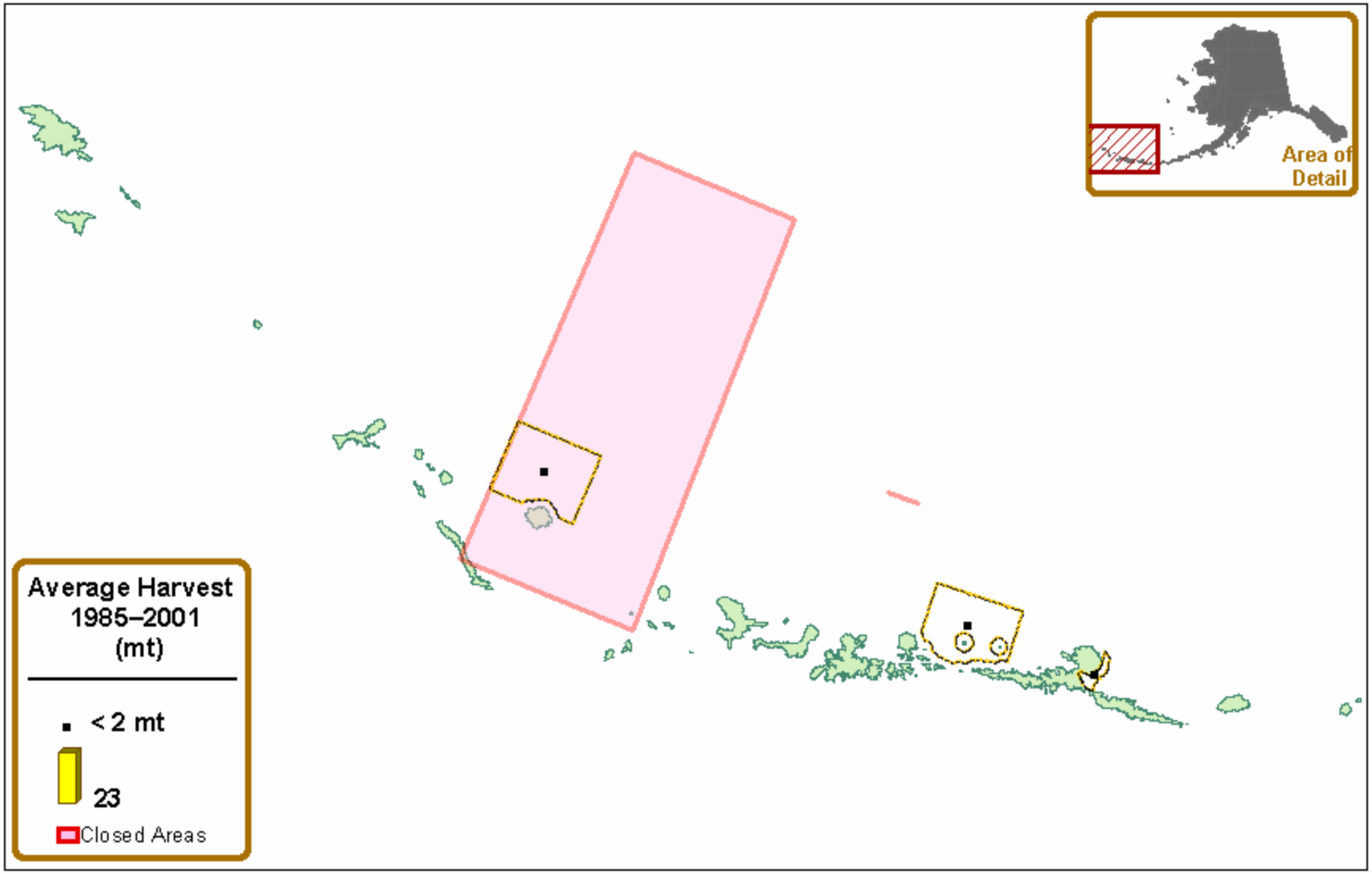

Figure 5.5.4 Spatial distribution of average scallop harvest in the central and western Aleutian Islands, 1997–2001, showing areas closed to scallop fishing. The aggregate average catch from areas indicated "Trace Amount" totaled 8.3 mt.

5.6 Octopus [13]

The giant Pacific octopus *Octopus dofleini* (hereafter referred to as octopus) exists throughout Alaskan waters. Octopus has long been sought after as bait in the Pacific halibut longline fisheries and is also being used extensively in the Pacific cod pot fisheries as bait. Periodic episodes of favorable market conditions have also resulted in large amounts of octopus sold to processors. Octopus is considered a groundfish species by NMFS and a miscellaneous shellfish species under ADF&G management classifications.

5.6.1 Description of Fishery

Most recorded catches have been incidental to other commercial fishing activities with the majority being taken in pot and less frequently by bottom trawl gear. Octopus are taken throughout the Gulf of Alaska, Bering Sea, and Aleutian Islands.

5.6.2 History of the Fishery

Before 1985, no distinction was made between state and federal waters regarding octopus harvest. In the period from 1977 to 1984, the highest recorded harvest was 9 mt taken from the Kodiak Area in 1980. A substantial amount of octopus taken during this early period was captured incidentally in Tanner crab pots. Much of the octopus harvested was used as bait or kept for personal consumption and was not reported on fishtickets. Therefore, harvests were likely higher than indicated.

The octopus fishery experienced a dramatic increase in the 1990s (Figure 5.6.1). The decline of many crab stocks in the Gulf of Alaska resulted in reduced harvest opportunity or fishery closures for many of the crab fisheries that had been prosecuted from late fall to early spring with pot gear. To fill the void, many pot gear fishermen turned to Pacific cod in those months. The ADF&G worked with industry to ensure that all octopus harvest, particularly harvests that were not sold but retained as bait, was documented on fish tickets; ADF&G also began requiring vessels to specify, at the time of registration for groundfish fisheries, their intent to retain octopus as bycatch.

5.6.3 Recent Catch, Effort, and Status

In the Kodiak Area in 2001, twenty-eight vessels made 258 landings for a total harvest of 45 mt from state waters. Many of the fish tickets submitted indicated that octopus were being retained for use as bait. The ADF&G changed how octopus fisheries were managed in 2001. Historically, vessels registering for groundfish or shellfish fisheries were allowed to register for octopus fishing in addition to the target species registration. This practice allowed fishermen to retain up to 100% of the octopus taken as bycatch in other target fisheries. Instead of allowing this arrangement to continue, ADF&G mandated that vessels could not be validly registered for both

[13] Most of the management information in this section was excerpted from more detailed treatments in Ruccio and Worton (2000 a, b), and Bowers et al. (2001). The current fishery management contacts are Michael Ruccio (Kodiak and Alaska Peninsula), and Forest Bowers (Bering Sea and Aleutian Islands).

octopus and another fishery at the same time. Therefore, vessels actually targeting groundfish or shellfish could only retain 20% of their octopus bycatch. To retain higher amounts of octopus, vessels would be required to register specifically for octopus, maintain a logbook that had to be submitted with fishtickets, potentially have restrictions placed on areas for gear operation, or carry an observer. Fisherman were asked to designate or report if they would be using baited or habitat gear for traps. Vessels registered for octopus were not allowed to sell any bycatch of other species.

In the Alaska Peninsula Area, the 2000 harvest of octopus totaled 3.1 mt from both state and federal waters. No vessels registered for directed harvest of octopus in the Alaska Peninsula Area in 2000. All harvest occurred as bycatch during groundfish fishing, primarily from vessels targeting Pacific cod using pot gear. Eighteen vessels harvested 0.7 mt from 17 landings in state waters. A total of 2.4 mt were harvested from federal waters by 19 vessels making 19 landings. All of the harvest was used as bait, retained for personal use, or had no price recorded by the processing facility issuing the fishticket. It is probable that the intense, short seasons for Pacific cod in both the federal and state fishery resulted in the low harvest of octopus.

In the Bering Sea, the last directed fishery for octopus occurred in 1995. Less than three vessels made landings; therefore, the harvest information is confidential. Since 1995, all reported harvests in the Bering Sea have been incidental bycatch. Octopus bycatch may be retained by any vessel registered for groundfish in the Westward Region using a miscellaneous finfish permit at up to 20% of the weight of the target species. During the 1999 season, only 0.2 mt were landed as bycatch in groundfish fisheries in state and federal waters in the Bering Sea. During the 2000 season, 114 vessels registered for octopus bycatch in the Bering Sea area. Fifty of these vessels made 128 landings with 7.4 mt of octopus reported as bycatch. Another 10.7 mt was discarded at sea. Seventy six percent of the landed octopus was retained for bait, and with the remainder used for fishmeal. During the 2000 season, 64% of the octopus bycatch was landed in pot gear. Currently, directed fishing for octopus is not permitted in the Bering Sea District.

Directed fishing for octopus is also not allowed in the Aleutian Islands District. Bycatch may be retained while fishing for finfish up to 20% of the weight of the target species. In 2000, out of the 114 registered for bycatch, 31 vessels made 91 landings of octopus totaling 9.6 mt from the Aleutian Islands. At-sea discards totaled 21.9 mt. The majority of retained octopus were utilized for bait (95%), while the rest was sold to processors for fishmeal production (5%). Vessels targeting Pacific cod or other groundfish species using pot gear made almost 100% of the 2000 landings in the Aleutians District.

No assessments are performed specifically for octopus. Octopus do occur occasionally in assessment surveys performed for other species. However, because of their preferred habitat, these capture rates are not likely indicative of octopus abundance.

5.6.4 Potential Fishery–Sea Otter Interactions

Octopus harvests are at relatively low levels throughout the Gulf of Alaska and Bering Sea and occur almost entirely incidentally to other fisheries which do not fish in primary octopus habitat. It is unlikely that these removals are depressing octopus populations. However, because there is

almost no assessment information about octopus, there is very little known about octopus population status.

Because the octopus harvest occurs incidental other fisheries such as Pacific cod pot and trawl, the entanglement risks for sea otters associated with octopus harvests are treated in the sections on the respective target fisheries.

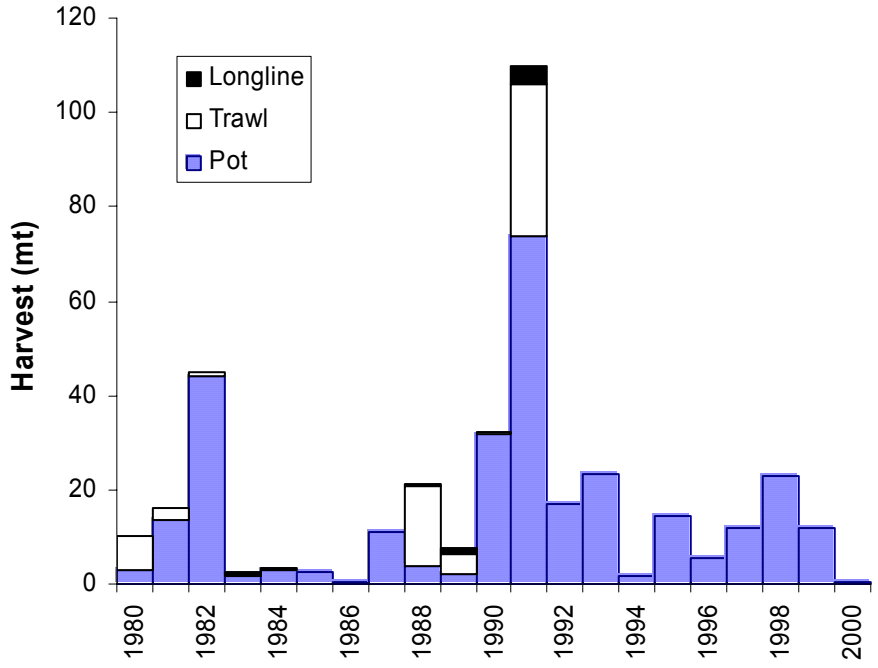

Figure 5.6.1 Landings of octopus from Alaskan waters, 1980–2000.

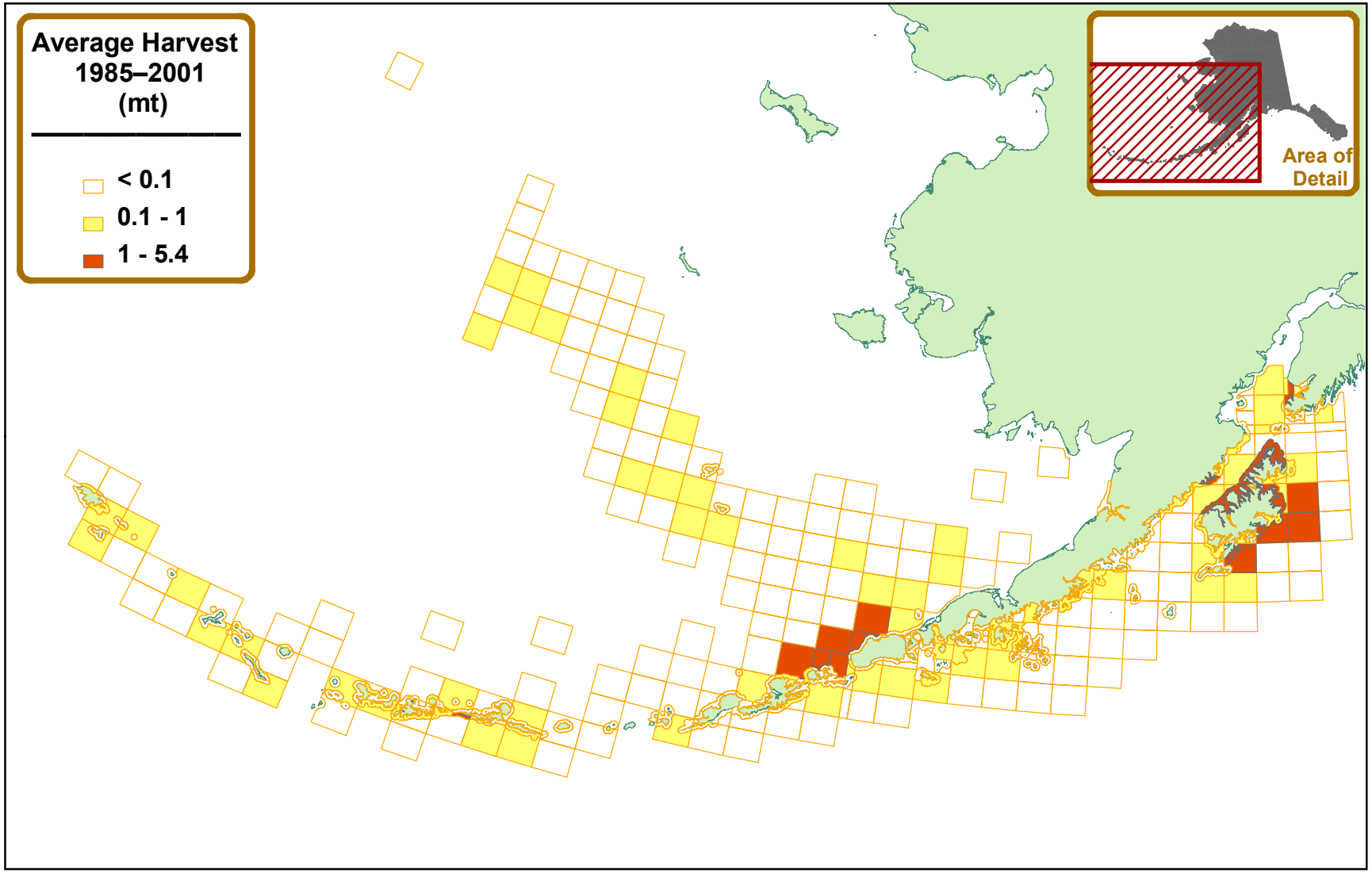

Figure 5.6.2 Spatial distribution of average reported octopus harvest in shellfish and groundfish fisheries, 1985–2001.

5.7 Pacific Razor and Other Clams

Several bivalve species in southwest Alaska have a history of human utilization. At present, there are no commercial fisheries for bivalves, primarily because of paralytic shellfish poisoning concerns and habitat use restrictions. There are also some very low levels of personal use and subsistence removals.

5.7.1 Razor Clams, Kodiak Management Area

The Alaska razor *Siliqua alta* and Pacific razor *Siliqua patula* clams have been harvested in the Kodiak Area from the early 1920s through 1986. Though many Kodiak Island beaches were explored with some success, the principal commercial harvest occurred about 70 miles northwest of Kodiak in the Kukak Bay, Hallo Bay, Big River, and Swikshak Beach regions of the Alaska Peninsula. Digging continued on a somewhat regular basis until the early 1960s when a combination of increasing federal and state clam processing regulations, poor market conditions, and the 1964 earthquake precipitated a decline in harvests. Commercial harvesting of clams for human consumption was re-established and the subsequent fisheries were strictly hand digging for use as bait in the Dungeness crab fishery. The certification program conducted by the Alaska Department of Environmental Conservation ended in July 1980. Currently, there are no clam beaches in the Kodiak Area commercially certified as safe for human consumption.

Many of the principal harvest areas along the Alaska Peninsula are adjacent to the Katmai National Monument, which includes all the land above mean high water from Cape Douglas to Cape Kubugakli. Commercial activity within the monument is restricted by the current policy of the U.S. Park Service that dictates a ban on camping in the monument in support of a business enterprise. In 1986, the BOF adopted a regulation prohibiting hydraulic mechanical dredges from harvesting clams in the Kodiak Area east of Kilokak Rocks.

The potential for a Alaska and Pacific razor clam harvest in the Kodiak Area has been established by historic catch records and studies conducted by ADF&G. These studies, however, were conducted in the mid-1970s and are of little benefit in judging stock status at this time. There were no landings of razor clams from the Kodiak Area during 2001. Recent information from sport harvesters indicates that a change has occurred in the substrate structure of the beaches of Kukak Bay and Swikshak Beach. These reports indicate that beaches have eroded considerably resulting in a loss of productive habitat.

5.7.2 Other Clam Fisheries

Seven mt of razor clams were removed from the north shore of Kamishak Bay by commercial operators between 1982 and 1986. Specific harvests for each year are confidential. A very small (< 500 lbs) harvest of cockles was also reported from the north shore of Kamishak Bay in 1983. In the Kodiak Area, a small amount (less than 0.5 mt) of butter clams and blue mussels were also reported harvested in 1981 and 1989, with specific amounts and years confidential. No other clam fisheries have been reported from the area of the Southwest stock of sea otters.

5.7.3 Potential for Fishery-Sea Otter Interactions

Razor clams appear in the diet of sea otters in some areas (Riedman and Estes 1980). However, there appears to be very low potential for future commercial fisheries for any type of clams in the area of the Southwest Alaska stock of northern sea otters, because of lack of sufficient market interest, concerns about paralytic shellfish poisoning, and habitat protection measures already in place.

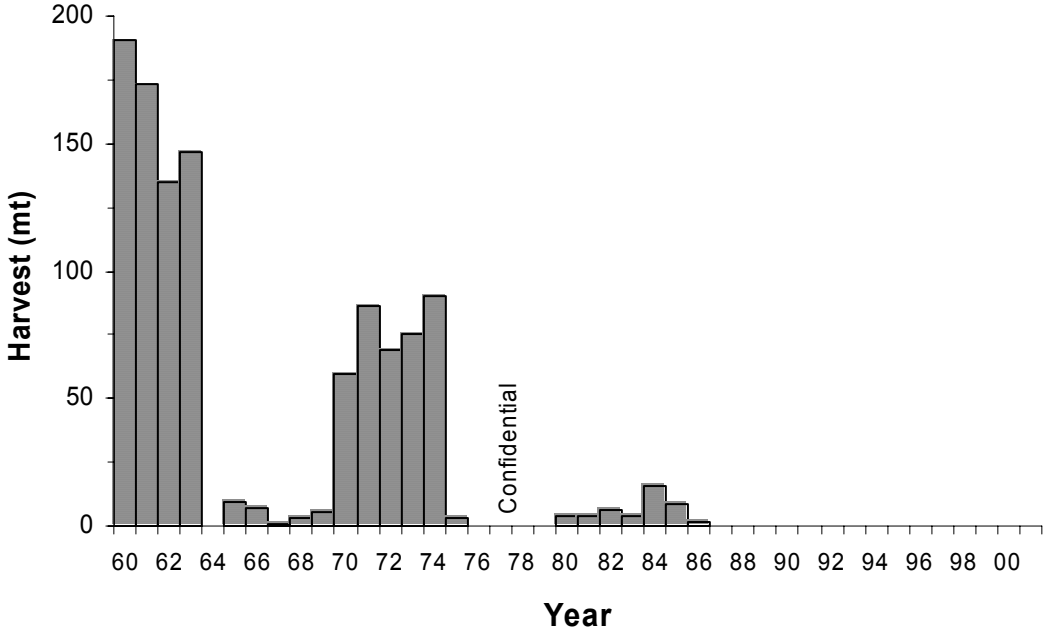

Figure 5.7.1 Harvests of razor clams in area corresponding to the Southwest stock of sea otters, 1960–2001.

6. EPILOGUE

As indicated in the Introduction, the purpose of this report was to respond to a FWS request for background information about state-managed marine fisheries where there may be potential for interaction with the Southwest stock of sea otters. Should further research be required on any of these fishery-sea otter interactions, this report should serve as a starting point for subsequent, more indepth analyses of the attributes of specific fisheries

There are very few recorded instances of sea otter take in Alaskan fisheries, and entanglement risk is thought to be very low. Some gears, such as salmon gillnets, theoretically have the potential to entangle sea otters, but are usually fished outside of sea otter habitat or in other ways such that the reported instances of sea otter entanglement has been very low. Fishery records and observations do not suggest that fishing gear encounters have contributed to the decline of sea otters in southwest Alaska.

Most commercial fisheries in the area of the Southwest stock of sea otters that take benthic invertebrates occur offshore, well outside the foraging range of sea otters. Exceptions to this include fisheries for Dungeness crabs, sea cucumbers, and sea urchins. There is a long history of competitive interactions between Dungeness crab fishermen and sea otters in other locations. Sea otters are usually able to forage far more efficiently and persist at lower crab densities than are economical for commercial fishermen to harvest or where fishing would be allowed under fishing regulations. Alaskan crab fisheries are restricted by seasons, sex, and size limits, leaving the females and undersized males unharvested.

A very small fishery for green sea urchins exists along the west side of Kodiak Island, with a few landings recorded from Unalaska Island as well. While there is overlap with sea otter diets, fishery quotas are thought to be low enough so as not to cause local depletion, and removals have occurred only in very limited areas.

Red sea cucumber fisheries occur around Kodiak Island, and to a lesser extent in several areas off of the Alaska Peninsula. The fisheries are regulated by area-specific quotas which are thought to be conservative and not result in localized depletion. Sea cucumber fishers are present in the nearshore areas for a very limited number of days each year, so disturbance of sea otter foraging is thought to be minimal. In addition, a significant proportion of the sea cucumber resource occurs below practical diving limits and is not harvested, although it is well within sea otter diving ranges.

It has been the intention of the BOF to manage fisheries conservatively, and in accord with Alaska's constitutionally-mandated sustained yield principles. 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 Pacific cod fishery is restricted to fixed gear. Further restrictions are placed on the 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, with 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 embedded in a number of policies that guide the BOF 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 author hopes that the information provided here is useful, not only to FWS in their analysis sea otter populations, but also to other individuals with interests in Alaska's fisheries.

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