Special Publication No. 05-09

Commercial Fisheries of Alaska

by

Doug Woodby,

Dave Carlile,

Shareef Siddeek,

Fritz Funk,

John H. Clark,

and

Lee Hulbert

June 2005

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

SPECIAL PUBLICATION NO. 05-09

COMMERCIAL FISHERIES OF ALASKA

By

Doug Woodby,
Dave Carlile,
Shareef Siddeek,
Fritz Funk,
John H. Clark,
and Lee Hulbert
Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau

June 2005

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

The Division of Sport Fish Special Publications series was established in 1991 for the publication of techniques and procedures manuals, informational pamphlets, special subject reports to decision-making bodies, symposia and workshop proceedings, application software documentation, in-house lectures, and other documents that do not fit in another publication series of the Division of Sport Fish. Since 2004, the Division of Commercial Fisheries has also used the same Special Publication series. Special Publications are intended for fishery and other technical professionals. Special Publications are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm. This publication has undergone editorial and peer review.

Doug Woodby,
Alaska Department of Fish and Game, Division of Commercial Fisheries
1255 W. 8th St. P.O. Box 25526, Juneau Alaska, 99802-5526, USA

Dave Carlile
Alaska Department of Fish and Game, Division of Commercial Fisheries
1255 W. 8th St. P.O. Box 25526, Juneau Alaska, 99802-5526, USA

Shareef Siddeek
Alaska Department of Fish and Game, Division of Commercial Fisheries
1255 W. 8th St. P.O. Box 25526, Juneau Alaska, 99802-5526, USA

Fritz Funk
Alaska Department of Fish and Game, Division of Commercial Fisheries
1255 W. 8th St. P.O. Box 25526, Juneau Alaska, 99802-5526, USA

John H. Clark
Alaska Department of Fish and Game, Division of Commercial Fisheries
1255 W. 8th St. P.O. Box 25526, Juneau Alaska, 99802-5526, USA

Lee Hulbert
Alaska Department of Fish and Game, Division of Commercial Fisheries
1255 W. 8th St. P.O. Box 25526, Juneau Alaska, 99802-5526, USA

This document should be cited as:
Woodby, D., D. Carlile, S. Siddeek, F. Funk, J. H. Clark, and L. Hulbert. 2005. Commercial Fisheries of Alaska. Alaska Department of Fish and Game, Special Publication No. 05-09, Anchorage.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

Figure **Page**

ABSTRACT

Commercial fisheries of Alaska fall under a mix of state and federal management jurisdictions. In general, the state has management authority for all salmon, herring, and shellfish fisheries, whereas the federal government has management authority for the majority of groundfish fisheries, excepting those within 3 nautical miles of shore and a few others. The first major commercial fisheries targeted salmon and herring in the late 1800s when much of the product was salted for storing and shipment. Today, commercial salmon and herring fisheries occur along most of Alaska's coastline north to the southern Chukchi Sea, with annual harvests averaging 750 million lb and 80 million lb of salmon and herring, respectively, in the 5-year period 1998–2002. Commercial shellfish fisheries target a diverse assemblage, including 7 crab species, 5 shrimp species, scallops, at least 3 clam species, and several "miscellaneous" invertebrates, including sea urchins and sea cucumbers. Crab harvests have fluctuated widely during their history. Peak years have seen as much as 400 million lb harvested, with a recent 5-year average of 137 million lb. Commercial shrimp harvests reached peak levels of over 120 million lb in the 1970s and declined following a climate induced regime shift to average harvests of slightly over 2.2 million pounds in the 5-year period 1998–2002. Groundfish fisheries for a variety of species dominate the harvest poundage, with nearly 4.2 billion lb harvested on average in the 5-year period 1998–2002. The majority of that total, about 2.9 billion lb, was walleye pollock (*Theragra chalcogramma*), 555 million lb were Pacific cod (*Gadus macrocephalus*), and 483 million lb were various flatfish.

Key Words: salmon, herring, shellfish, groundfish, Gulf of Alaska, Bering Sea, Aleutian Islands

FOREWORD

This document is intended to serve as a summary of Alaska's commercial fisheries for the general public. The fishery descriptions borrow extensively from previous publications of the Alaska Department of Fish and Game, including summary documents by Rigby et al. (1995) and by Kruse et al. (2000), both of which focused on state-managed commercial fisheries in marine waters. In an attempt to be more fully informative of all the commercial fisheries in Alaskan waters, this document integrates descriptions of federally-managed fisheries, notably many groundfish fisheries, and seeks to clarify the jurisdictional roles of the state and federal governments in fishery management. The Pacific halibut fishery, managed by the International Pacific Halibut Commission, is not addressed here.

INTRODUCTION

The vast fishery resources of Alaska are of tremendous importance to the economies of the state and the nation. In 2003, commercial fishermen landed over 5 billion lb of fish and shellfish worth over $1 billion. These resources are self-renewing if properly managed, and it is the mission of both state and federal fishery management agencies to maximize the production of seafood and economic benefits for generations to come. The purpose of this document is to provide summary descriptions of the major commercial fisheries of Alaska and how these resources are managed to insure sustained yield. For each of the major fisheries, a brief history is followed by a summary of how the fishery is managed, a description of the fishing gear used, amounts of recent harvests, and a summary of conservation and related issues. Throughout this document, an attempt is made to clarify the roles of state and federal managers when this varies between fisheries.

Recent 5 year average harvests are given for the period 1998 to 2002; more recent data are available on the Alaska Department of Fish and Game website. Unless otherwise noted, catch values are for the landed (retained) catch, equivalent to the harvest.

STATE AND FEDERAL MANAGEMENT REGIMES

The State of Alaska took management control of its fishery resources from the federal government soon after statehood in 1959. In fact, control of its salmon fisheries was a primary incentive of the statehood movement. Enactment of the Magnuson Fishery Conservation and Management Act (MFCMA) of 1976 asserted federal authority over the Exclusive Economic Zone (EEZ) from 3 to 200 miles offshore of the U.S. coasts, with the waters inshore of 3 miles under state jurisdiction. The Alaska Department of Fish and Game (ADF&G) is the primary state fisheries management agency and the National Marine Fisheries Service (NMFS) is the primary federal fisheries management agency. In general, with the exception of some groundfish fisheries in the eastern Gulf of Alaska and Prince William Sound, NMFS is primarily responsible for management of all groundfish fisheries off Alaska and ADF&G is primarily responsible for management of fisheries for salmon, herring, crabs, and other invertebrates. 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, allocating resources among users, 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). CFEC has the authority to establish moratoria or limited entry systems for state-managed fisheries.

Several federal laws substantially direct the regulation of some of Alaska's fisheries and actions of NMFS. Foremost is the MFCMA, which was enacted, in large part, because of unrestricted foreign harvests off Alaska. Created under the MFCMA, the North Pacific Fishery Management Council (NPFMC), an 11-person committee, 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; a Bering Sea/Aleutian Islands area crab FMP; and a 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, and in fact, ADF&G has inseason management authority for several of those as well.

Implementation of two other federal laws, the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA), has been used to increasingly restrict Alaska fisheries for the protection of pinnipeds (seals and sea lions), sea birds (e.g., short-tailed albatross) and depressed salmon stocks of Oregon and Washington that migrate into Alaska waters. Two treaties between Canada and the U.S. regulate fisheries for transboundary salmon and halibut and influence management of other Alaska fisheries that impact these stocks. As a revision of the International Fisheries Convention, the International Pacific Halibut Commission (IPHC) was created in 1953

to jointly regulate harvest and to conduct research on halibut (*Hippoglossus stenolepis*) in the North Pacific. The IPHC determines catch quotas, but within-nation catch allocations are implemented separately by each nation. In the U.S. the allocations are done through the NPFMC. The 1985 Pacific Salmon Treaty has established an international management regime designed to rebuild some salmon stocks, limit harvests in specific fisheries, and define equitable allocations between U.S. and Canadian fishermen. The treaty has been very controversial, and renegotiation of treaty annexes is a continuing process.

SALMON FISHERIES

The salmon returning to Alaskan streams and rearing in Alaskan waters are the basis for one of Alaska's most important industries and underpin a traditional subsistence lifestyle in rural portions of the State. From 1998–2002, the average harvest of salmon sold by commercial fishermen in Alaska was almost 167 million fish (about 750 million pounds). The value of the commercial harvest varies both with the size of the runs and with foreign currency exchange rates. Average annual value of the 1998–2002 harvest was in excess of $260 million (Table 1). Because of the magnitude of commercial fisheries for salmon, state biologists collect extensive information and statistics for management decisions. Alaska also has very important sport and subsistence fisheries for salmon. Many Alaskans depend heavily on subsistence-caught salmon for food and cultural purposes. Fishery management plans give top priority to the subsistence use of fish resources.

Table 1.–Recent 5-year average harvests, value, and permits fished for selected Alaska commercial salmon fisheries. Averages are for the period 1998–2002.

Fishery	Harvest (fish)	Harvest (lb)	Value[a]	Permits
Southeast & Yakutat	72,052,177	315,357,810	$76,410,018	1,913
Prince William Sound	39,569,777	159,065,417	$44,920,066	694
Cook Inlet	4,240,511	21,288,695	$13,001,875	1,052
Kodiak	20,728,977	83,820,140	$25,844,123	357
Chignik	2,788,447	16,222,507	$11,493,042	82
Alaska Pen. and Aleutians	9,816,129	45,055,559	$19,954,582	342
Bristol Bay	16,887,715	100,972,174	$64,988,392	2,511
Kuskokwim	394,342	3,052,759	$947,096	572
Yukon River [b]	62,801	886,262	$2,159,909	617
Norton Sound	183,110	594,933	$155,752	59
Kotzebue	114,920	970,335	$546,511	48
Statewide	166,838,906	747,286,592	$260,421,366	6,334

[a] Exvessel value of landed catch.
[b] No Yukon fishery in 2001.

History

Commercial salmon fishing in Alaska began in the 1880s (Figure 1). Initial commercial harvests were primarily salted. Canning became predominant at the turn of the century. After Alaska was purchased by the United States in 1867, the U.S. federal government had jurisdiction over these fisheries until statehood. The White Act, passed in 1924, required a closure of each fishery after the halfway point of the runs. At that time, much of the catch was taken in large fish traps. Federal management was weak, poorly funded, and ineffectively enforced. After World War II and at the request of the salmon processing industry, W. F. Thompson of the University of Washington began investigations of salmon and the salmon management program in Alaska. After Alaska became a state in 1959, ADF& G implemented an escapement goal-based fisheries management system using principles laid out by W. F. Thompson and his students. This science-based management system remains in place today with refinements.

Management

Local fisheries managers are given authority to open and close fisheries to achieve two goals: the overriding goal is conservation to ensure an adequate escapement of spawning stocks, and the secondary goal is an allocation of fish to various user groups based upon management plans

developed by the Alaska Board of Fisheries. The Alaska Board of Fisheries develops management plans in open, public meetings after considering public testimony and advice from various scientists, advisors, fishermen, and user interest groups.

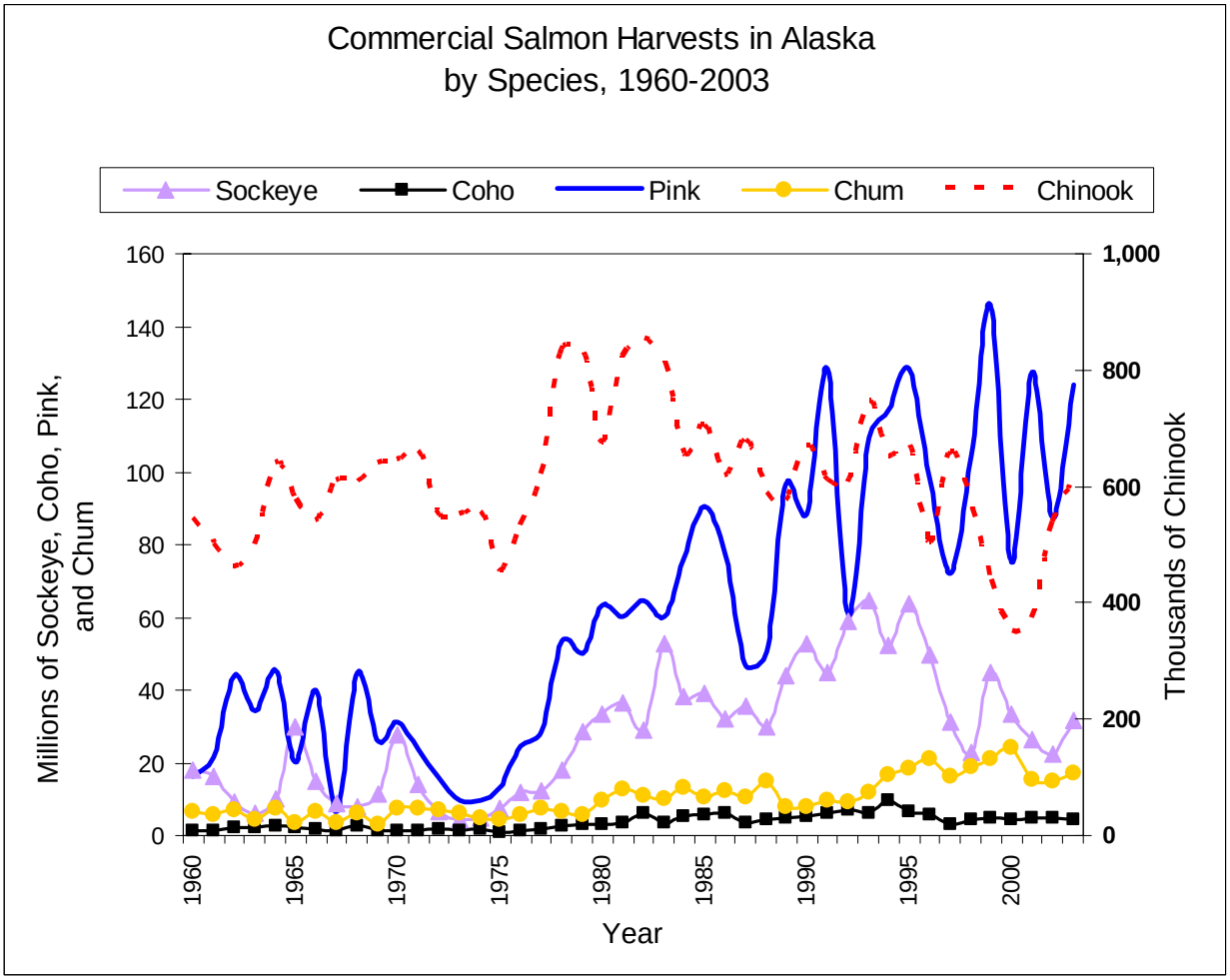

Figure 1.–Commercial harvest of salmon in Alaska, by species, from 1960–2003. Sockeye, coho, pink, and chum catches are scaled by the left axis; Chinook catches are scaled by the right axis.

Gear

By far, most salmon in Alaska are caught in commercial troll, gillnet, and purse seine fisheries in which participation is restricted by a limited entry system. Troll gear works by dragging baited hooks through the water. Gillnet gear works by entangling the fish as they attempt to swim through the net. Gillnets are deployed in two ways: from a vessel that is drifting and from an anchored system out from a beach. Purse seines work by encircling schools of fish with nets that are drawn up to create giant "purses" that hold the school until the fish can be brought aboard. Other kinds of gear used in Alaska's smaller fisheries include fishwheels, which scoop fish up as the wheel is turned by river currents.

Species and Recent Harvests

Five Pacific salmon species spawn and have directed fisheries in Alaska: *Oncorhynchus nerka* commonly known as sockeye or red salmon; *O. gorbuscha* commonly known as pink salmon; *O.*

keta known as chum or dog salmon; *O. tshawytscha* commonly called king or Chinook salmon; and *O. kisutch* commonly known as coho or silver salmon. Two other Pacific salmon species spawn exclusively in Asian systems and are not caught in Alaskan waters.

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

Pink salmon are the most numerous of the salmon species in the Alaska commercial catch and the most abundant salmon in the Pacific Ocean. Annual statewide commercial harvests have been around 100 million pink salmon since about 1990 (Figure 1). Pink salmon are characterized by the smallest size as mature adults, the least dependence on fresh water as their fry migrate to salt water directly after emergence from the gravel, and a fixed two-year life cycle that results in genetically distinct odd- and even-year runs. The adult diet consists of fish, squid, euphausiids, amphipods and other prey. In Alaska, pink salmon are harvested primarily by commercial purse seine fleets. Much of the pink salmon harvest is canned.

Chum salmon are the third most numerous salmon species in the Alaska commercial catch and the second most abundant salmon in the Pacific Ocean. Annual statewide commercial harvests of chum salmon have been around 20 million fish since the early 1990s. Adults are the second largest in size next to Chinook salmon. As with pink salmon, chum fry after emergence move directly out of fresh water; however, they may make more use of estuarine environments in the spring. Chum salmon spend between one and five years in the marine environment and have the widest distribution across the Pacific Rim of any salmon. In Alaska, chum salmon are harvested primarily by gillnet and purse seine fleets. This species is also important in subsistence fisheries in Western Alaska.

Sockeye salmon are the second most numerous in the Alaska commercial catch and the third most abundant salmon in the Pacific Ocean. Annual statewide commercial harvests of sockeye salmon have ranged from about 20 to 60 million fish over the past 35 years. This species of salmon is the most adapted to lake rearing in the juvenile stages. However, in some river systems, sockeye salmon spawn and rear in streams and do not utilize lakes. The majority of sockeye salmon rear from one to three years in lakes prior to outmigration, and spend from one to four years in the marine environment before returning to fresh water to spawn. In Alaska, most sockeye salmon are harvested by gillnets, or in some cases, in seine gear in limited entry fisheries. The Bristol Bay sockeye run is one of Alaska's most important commercial fisheries (Figure 2). This run is harvested as the returning adult salmon migrate past the Alaska Peninsula in June and then as they pass the large gillnet fisheries in Bristol Bay. The Copper River adjacent to Prince William Sound has the earliest run of sockeye salmon in the world. The fishing industry watches the Copper River fishery and its sockeye salmon run as a bellwether for prices in the coming season.

Figure 2.–Locations of major commercial salmon fisheries in Alaska.

Coho salmon are the fourth most numerous in the Alaska commercial catch and the fourth most abundant salmon in the Pacific Ocean. Recent annual statewide commercial harvests have been near 5 million fish. Coho salmon are generally the latest spawners in Alaska, with runs well into the fall or even early winter. Like pink salmon, coho salmon normally spend one winter in the ocean and return to spawn the following fall. Unlike pink salmon, coho can remain in the riparian environment to rear for an additional year prior to outmigration. In the more southerly latitudes of its range, coho salmon mainly spend only one year in fresh water and one year in the ocean. With increases in latitude, an increasing percentage of coho spend a second year in fresh water prior to migration to the marine environment. Juvenile coho salmon in the nearshore environment initially feed on marine invertebrates, but the diet changes mainly to fish and some marine invertebrates as they grow. As piscivores, coho salmon feed on herring, smelt, sandlance, chum and pink salmon fry, and many other fish species. In Alaska, coho salmon are important in sport and personal use fisheries, as well as in the commercial troll and net fisheries. Because of their late run timing, many coho salmon runs in Alaska may be lightly exploited or even unexploited. Because of poor weather during the coho salmon spawning period, little information exists about run size and timing in many areas of the state.

Chinook salmon are the least abundant of the five salmon species found on both sides of the Pacific Ocean and the least numerous in the Alaska commercial harvest. Recent annual statewide

commercial harvests have been around one-half million fish. Chinook salmon reach the greatest size of any salmon species and for this reason are called king salmon. Chinook salmon typically have relatively small spawning populations. The largest river systems tend to have the largest populations of Chinook salmon. Chinook salmon can migrate to the marine environment the spring after they hatch or can spend up to two years in the riparian environment prior to outmigration. The timing of outmigration can vary between and within systems, although this generally occurs during the spring. Chinook salmon can spend five or more years in the ocean prior to returning to freshwater to spawn. In the estuarine environment, Chinook salmon are largely opportunistic feeders. In Alaska, Chinook salmon are important in sport and personal use fisheries, as well as commercial troll and net fisheries. A Southeast Alaska troll fishery operates on mixed stocks of migrating Chinook salmon throughout the year, providing consumers with fresh Chinook salmon during the winter.

Conservation and Other Issues

In much of their southerly range in North America, wild salmon populations have declined from historic levels. Historic fisheries management practices in the past century, and in some cases poor hatchery practices, along with water-use conflicts, development, dams, agriculture, and logging have created an environment adverse to salmon survival. In Alaska, with few exceptions, our runs are in excellent shape, supporting sustainable, record harvest levels over the past 20 years. The ocean environment was extremely favorable in the 1980s and early 1990s. Good fisheries management and a pristine environment have allowed Alaska's salmon populations to make the most of favorable ocean conditions and to allow users the opportunity to achieve record level harvests.

The continued health of the salmon fishing industry in Alaska depends to some extent on external forces. Alaska is one of the last places in the world with large wild salmon populations. But even with continued scientifically based escapement goal and abundance based fishery management regimes, and with continued pristine freshwater environments for salmon reproduction and freshwater rearing, the adult run sizes will be dependent to some extent on oceanographic phenomena that are impossible to control. Also, the price of salmon and hence the economic health of the fishing industry is driven to some extent by the worldwide supply of farmed salmon originating outside of Alaska. And recently, increased escapes of farmed Atlantic salmon from British Columbia pose a threat in terms of diseases, competition, and possibly genetic mixing with our wild stock fisheries. Even so, Alaska's economy, culture, and even identity will continue to be shaped by salmon because of the importance, size and history of its salmon fisheries.

HERRING FISHERIES

Commercially exploitable quantities of Pacific herring (*Clupea pallasi*) occur in Alaska from its southern boundary at Dixon Entrance (55° N) to Norton Sound (64° N) (Figure 3). Herring spawn in nearshore areas and deposit their adhesive eggs on intertidal and subtidal vegetation. Spawning begins as early as late March in southern Southeast Alaska and continues through mid July in the northern Bering Sea. Gulf of Alaska herring are genetically distinct from Bering Sea herring (Grant and Utter 1984) and are smaller and non-migratory, generally moving less than 100 miles among spawning, feeding, and wintering grounds. Bering Sea herring are much larger and longer lived. Most travel to offshore central Bering Sea wintering grounds, with some herring migrating over 1,000 miles annually (Funk 1990). Herring are planktivores and provide a key link in pelagic and nearshore food chains between primary production and upper-level piscivores.

History

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

Alaska's commercial herring industry began in 1878 when 30,000 pounds were caught and prepared for human consumption. The early European settlers in the Pacific Northwest and Alaska caught herring and preserved them with salt in wooden barrels, as they had done with herring from the North Sea. Salted and pickled herring production for food peaked after World War I, when about 28 million lb (12,700 mt) were harvested annually (Figure 4).

Reduction fisheries which "reduce" herring to meal and oil began initially in Southeast Alaska, where a plant at Killisnoo in Chatham Strait was producing 30,000 gallons of herring oil annually by 1882. During the 1920s herring became increasingly valued for oil and meal. Herring reduction plants sprang up along the Gulf of Alaska from Craig to Kodiak near locations where concentrations of herring could be found. Harvests during the 1920s and 1930s, as high as 250 million lb (113,400 mt) per year, were probably too high and may have caused the stocks and fisheries to decline. During the 1950s, lower-cost Peruvian anchoveta reduction fisheries severely impacted the oil and meal markets. Alaskan herring reduction fisheries quickly declined, and the last Alaska herring reduction plant closed in 1966.

A Japanese and Russian trawl fishery for herring began in the Bering Sea in the late 1950s, reaching a peak harvest of 320 million lb (146,000 mt) in 1970. These high harvests were likely not sustainable and the foreign fishery declined until it was finally phased out following the passage of the Magnuson Fishery Conservation and Management Act in 1976.

Substantial catches of herring for sac roe began in the 1970s as market demand increased in Japan, where local herring harvests had declined dramatically. Presently, herring are harvested primarily for sac roe, still destined for Japanese markets.

The commercial catch of herring for bait in Alaska began around 1900 and remained relatively stable, typically 4–6 million lb (1,800–2,700 mt) per year, in spite of very large fluctuations in the herring catch for the reduction, foreign, and sac roe fisheries. The development of extensive crab fisheries in the 1970s greatly increased the demand for herring bait.

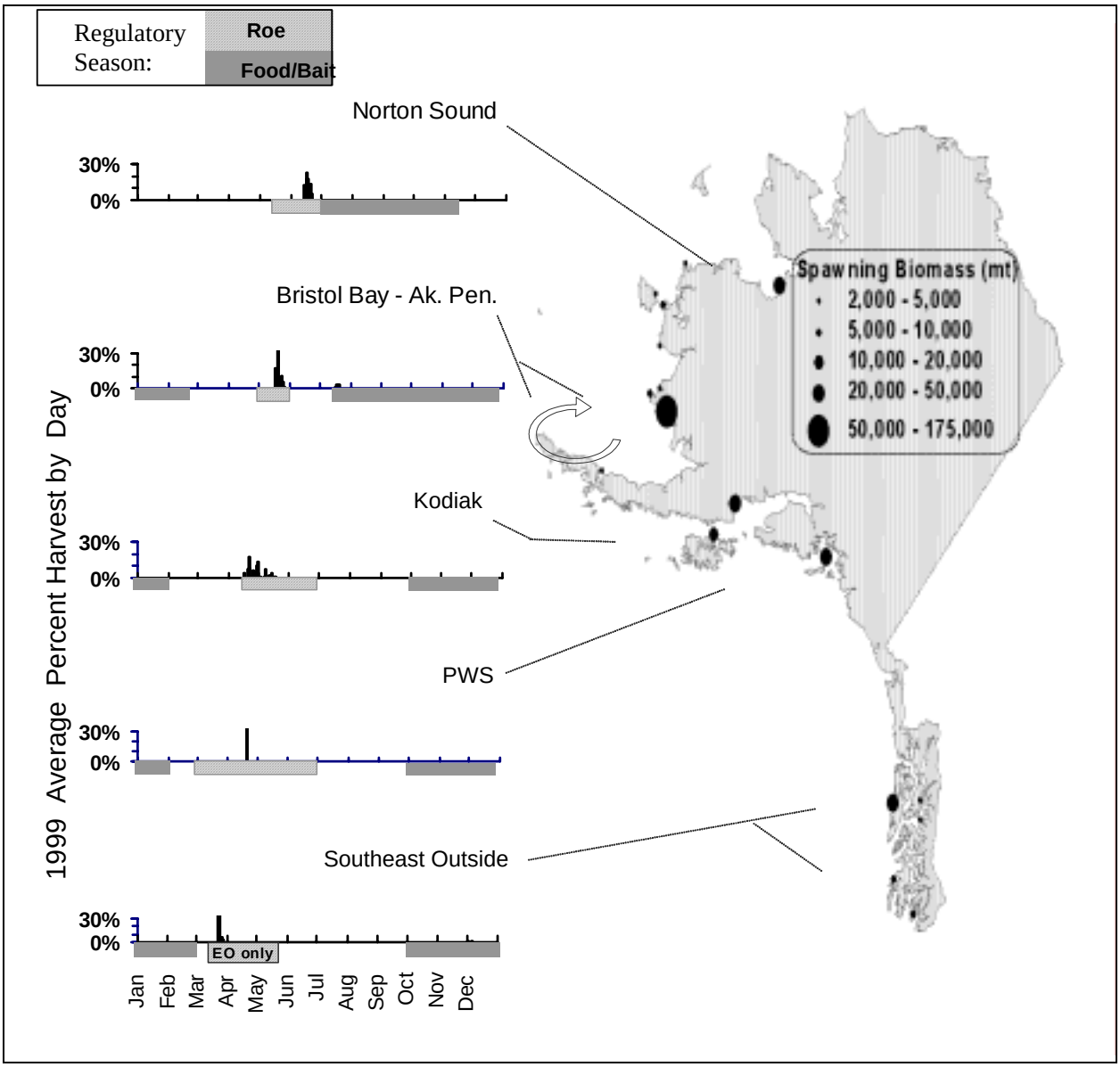

Figure 3.–Location and relative size of Alaska herring spawning populations, and timing of 1999 fisheries on spawning herring, illustrating the south to north gradient in spawning run timing, and the counterclockwise migration of Togiak-spawning herring around the eastern Bering Sea.

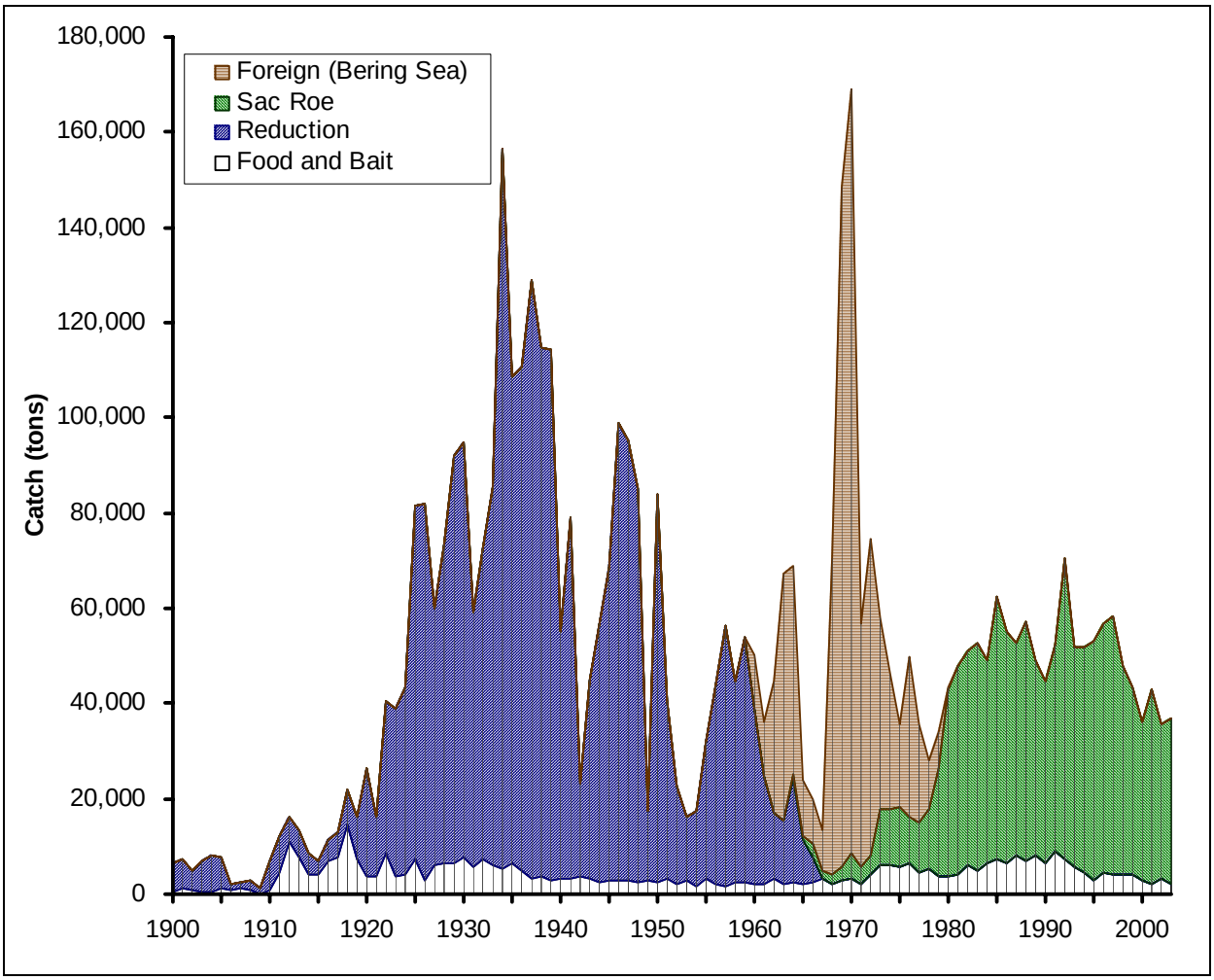

Figure 4.–Historical commercial herring harvests in Alaska from 1900–2003.

Management

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

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

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

For sac roe fisheries, openings are timed to occur when herring have produced the maximum amount of roe. The duration of openings is also set to achieve harvest quotas as closely as possible. Entry into most herring fisheries in Alaska has been limited under the authority of CFEC.

Gear

Purse seines and gillnets are the primary gears used to catch whole herring. Purse seine gear is used almost exclusively in herring food/bait fisheries, while both purse seines and gillnets are used in sac roe fisheries. Trawl gear is no longer legal for fishing herring in Alaska with three exceptions. Trawl gear is legal, but very rarely used, for fishing food/bait herring in Prince William Sound. The type of trawl used in Prince William Sound has been a pair trawl, similar to a purse seine net, towed between two purse seine vessels. At Kodiak, trawl gear has typically been used to catch a small amount of herring for food/bait.

Almost all herring sac roe purse seine fishermen and many gillnetters employ spotter aircraft to locate schools of herring and direct their fishing efforts. Spotter aircraft are able to locate schools of herring very quickly, so that herring fisheries have become extremely efficient. With spotter aircraft support, entire allowable harvests of thousands of tons of herring have been captured in fishery openings as short as 15 minutes.

In Gulf of Alaska areas, herring bait fisheries usually occur during the fall and winter, using purse seine gear. When used for bait on hook and line gear, fall- and winter-caught herring are retained longer on the hooks than those caught in spring and summer. Herring fat content is high during the summer, and summer-caught herring do not preserve as well. However, high oil content is desirable for some methods of preserving herring for food. Production of herring food products has been minimal in recent years.

In addition to fisheries for whole herring, a number of “spawn-on-kelp” fisheries harvest herring eggs after they are deposited on kelp fronds. Pound spawn-on-kelp fisheries harvest kelp fronds deliberately placed in the water to collect herring spawn. Wild spawn-on-kelp fisheries harvest naturally-occurring kelp fronds on which herring have spawned. A “closed-pound” fishery involves releasing captured sexually mature herring into a net impoundment in which kelp is suspended. The herring are released from the pound after they spawn on the kelp, and the suspended kelp with eggs is then harvested and sold. An “open-pound” fishery involves

suspending kelp from a floating frame structure in an area where naturally-occurring herring are expected to spawn.

Herring pound spawn-on-kelp fisheries are allowed by regulation at Craig-Klawock, Ernest Sound, Tenakee Inlet, and Hoonah Sound in Southeast Alaska, in Prince William Sound, and in Norton Sound. Naturally occurring herring spawn on kelp (sometimes called "wild" spawn on kelp) is also allowed by regulation to be harvested by SCUBA divers in Prince William Sound and to be hand picked at low tide in the intertidal zone in the Togiak district of Bristol Bay.

Recent Harvests and Status

Herring harvests in Southeast Alaska, Kodiak, Bristol Bay, the Kuskokwim delta and Norton Sound have been reasonably stable since the development of sac roe fisheries in the late 1970s (Figure 5). Herring in Prince William Sound and Cook Inlet have been at low levels since the early 1990s. The connection between reduced herring abundance and the Exxon Valdez oil spill in Prince William Sound is not clear, although disease outbreaks (Marty et al. 1999) have played a role.

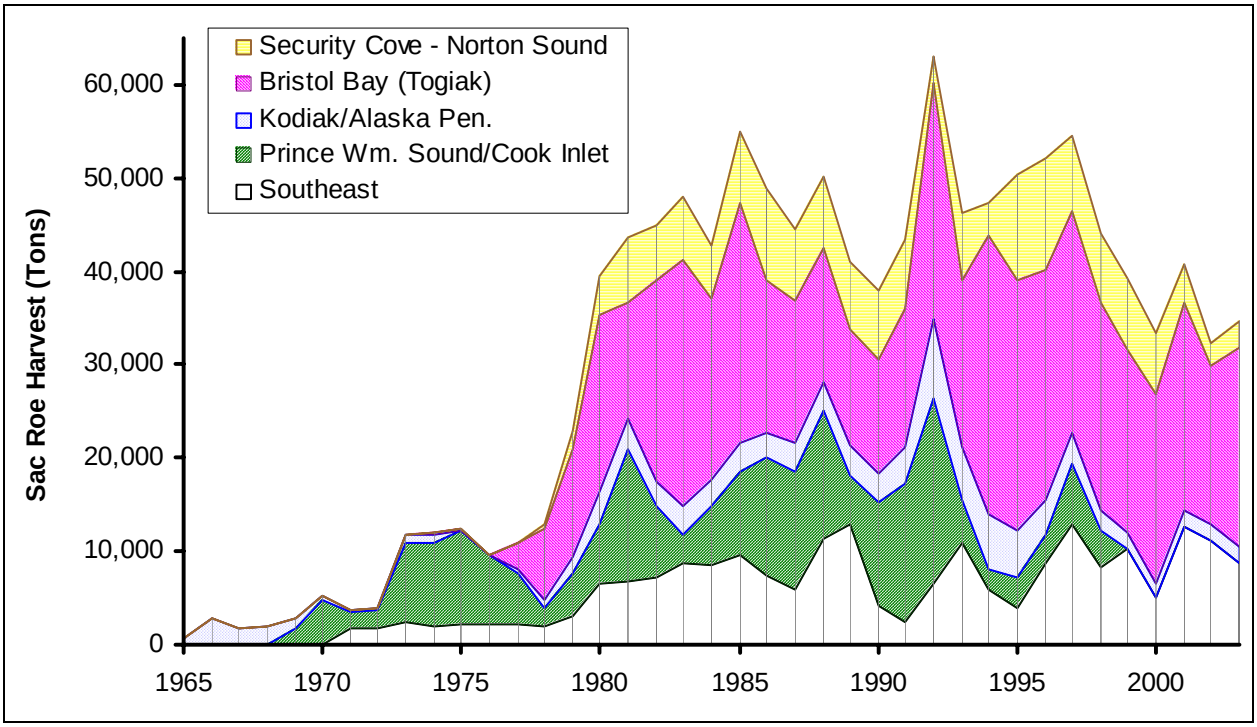

Figure 5.–Commercial harvest of herring for sac roe, 1965–2003, by area.

In more recent years, herring roe markets have begun to deteriorate as the consumption of herring roe declines in Japan. Processors are becoming reluctant to purchase all of the available herring. This usually happens in the northernmost and last sac roe fishery of the year, Norton Sound. Persistent ice floes and the opening of the year's first salmon fisheries also tend to diminish processors' interest in Norton Sound herring. Statewide herring harvests in the sac roe and food and bait fisheries have averaged approximately 83 million lb (37,000 mt) in the recent 5 years, with a value of approximately $13 million (Table 2, Figure 4). In addition, commercial fisheries for herring eggs on kelp harvest about 360 thousand lb (159 mt) of product annually (1998–2002).

With the deteriorating markets and lower prices, participation in herring fisheries has also been declining. From 1983 through 1997 herring were landed on an average of over 2,200 CFEC permits annually. The five year average from 1998 to 2002 was 959 permits (Table 2). By 2003 the number of permits on which landings were made had declined to 715.

Table 2.–Recent 5-year average harvest, value, permits, and fishery status for Alaska commercial herring fisheries. Averages are for the period 1998–2002. Total does not include eggs on kelp, bycatch, or other uses.

Fishery	Harvest (lb)	Value	Permits	Status
Sac Roe	75,312,470	$12,034,734	864	Stable
Food and Bait	7,435,925	$1,203,790	95	Stable
Total	82,748,395	$13,238,525	959	---

Southeast Alaska. Southeast Alaska commercial herring fisheries occur during the winter when herring are harvested for use as bait and also during the spring when herring are harvested for their roe. The roe harvest includes the traditional sac roe fisheries (set gillnet and purse seine) and, in recent years, spawn-on-kelp pound fisheries. Sac roe fishing effort is distributed among six fishing areas in Southeast Alaska: two exclusive purse seine (Sitka Sound and Lynn Canal) and three exclusive gillnet areas (Revillagigedo Channel, Seymour Canal and Hobart Bay/Port Houghton). A new fishery in West Behm Canal was set to start in the spring of 2004, with harvests alternating annually between set gillnet and purse seine gear, but the available stock size was too low to open the fishery. Spawn-on-kelp pound fisheries are conducted by regulation at Craig-Klawock, Ernest Sound, Hoonah Sound and Tenakee Inlet, and utilize open or closed pounds.

From 1998 to 2002, Southeast Alaska herring sac roe harvests averaged approximately 19 million lb annually. Bait fisheries contributed approximately 2 million lb annually, and spawn-on-kelp fisheries harvested an average of 248 thousand lb of spawn on kelp. Herring stocks in Southeast Alaska are generally healthy, with the exception of Lynn Canal, where the herring fishery has not been open since 1982 due to low herring abundance. In addition fishing has not been allowed in state waters of Revillagigedo Channel since 1998, in part due to shifts of herring spawning locations into the Annette Island Reserve, which is outside state management authority.

Prince William Sound. Prince William Sound herring fisheries have been closed since 1998 due to low stock abundance. Abundance was high through the 1980s and into the early 1990s, but dropped sharply in association with a virus outbreak in 1993. Fisheries were closed in 1994, 1995 and 1996. Abundance levels rebounded somewhat and were sufficiently above the threshold biomass of 44 million lb (19,958 mt) to allow fishery harvests in 1997 and 1998. High levels of the viral hemorrhagic septicemia virus (VHS) were detected in the 1998 spawning population. In 1999, a very limited pound fishery occurred, but was cut short and all other fisheries cancelled when it became clear that the stock had suffered a major reduction in biomass and poor recruitment. The interaction of the diseases VHS and the fungus-like organism *Ichthyophonus hoferi* with fish condition are thought to be major contributors to the decreased survival rate in Prince William Sound during the 1990s, perhaps in combination with lingering effects of the Exxon Valdez oil spill of 1989. Herring abundance levels remain low and stable in Prince William Sound. The wide variability in catches through the 20th century suggests that herring abundance may have fluctuated widely in the past.

Cook Inlet. The primary contemporary herring fishery in Cook Inlet has occurred in Kamishak Bay. However, in recent years this fishery has been below threshold and did not open from 1998 through 2003. This fishery had an average catch of about 5.2 million lb (2,400 mt) from the mid 1980s through 1997. Another period of low abundance and fishery closures occurred during the period 1980 through 1984. During the last viable fishery in 1997, catch was fairly typically concentrated in the western end of Kamishak Bay. In Kamishak Bay, herring are taken during the spring sac roe fishery by purse seines. Very small and sporadic herring fisheries have also occurred further north in Cook Inlet using gillnet gear. Early in the development of the sac roe fisheries there were some substantial harvests in the southern, eastern, and outer districts of Cook Inlet, but no sac roe catch has occurred in those areas in recent years. Preceding the roe fishery, there was a small herring reduction plant in Kachemak Bay on the eastern side of Cook Inlet.

Kodiak. Substantial commercial herring catch has occurred in the vicinity of Kodiak Island since 1920. During the reduction-fishery era, catches fluctuated widely due to likely over-exploitation and changing market conditions. Catches have been much more stable but lower during the more recent roe-fishery period.

The Kodiak fishery sac roe harvest is taken by both gillnet and purse seine gear. Historically about 75% of the catch was taken by seine gear. Starting in 2000, allocations to the gears were fixed by regulation. The sac roe fishery opens by regulation on April 15, and most of the catch is usually taken during the first 2 weeks of the season. Historically, commercial sac roe herring harvests have occurred in 63 sections in the bays around Afognak Island, Kodiak Island, and along the Alaska Peninsula within the Kodiak Management Area. However, most of the catch in recent years has been taken from the western side of Afognak and Kodiak Islands, in the Afognak and Uganik Districts.

Strong recruitment allowed higher catches on the order of 8.8 million lb (4,000 mt) annually during the early 1990s. With the senescence of these strong year classes, the catch has declined, but has remained relatively stable, averaging 3.4 million lb from 1999–2002.

A small food/bait fishery usually occurs in northern Shelikof Strait, but has been closed in recent years because the fishery also harvests some herring from the Kamishak Bay spawning population in Cook Inlet, which has been below threshold since 1998.

Alaska Peninsula. Alaska Peninsula herring catches are dominated by bait harvests in the vicinity of Unalaska Island (Dutch Harbor), where the Togiak–spawning herring reside during the summer feeding period. An early food and reduction fishery was established at Dutch Harbor from 1929–1939. The Dutch Harbor fishery resumed in 1982, primarily as a bait fishery. Because the primary stock harvested at Dutch Harbor spawns at Togiak, the overall exploitation rate is set at 7% of the allowable Togiak harvest. In addition, the Dutch Harbor fishery is closed if any of the eastern Bering Sea stocks, which are thought to potentially contribute to the fishery, are below threshold. In recent years the Dutch Harbor harvest has been stable, averaging 4.2 million lb from 1998–2002.

Elsewhere along the Alaska Peninsula, herring catch has been generally low and sporadic. On occasion, a significant sac roe harvest occurs at Port Moller along the North Peninsula, when in-season aerial surveys document sufficient quantities of herring, and if processing capacity is available. The last substantial herring sac roe harvest along the Alaska Peninsula occurred in 1996.

Bristol Bay. The largest aggregation of herring in Alaska spawns along the northern shore of Bristol Bay, near the village of Togiak. A large purse seine and gillnet fishery harvests the spawning herring in a sac roe fishery. A spawn-on-kelp harvest is also taken, primarily by local residents, usually in Togiak Bay. Following spawning, the Togiak herring migrate clockwise around Bristol Bay (Funk 1990), and are taken in the food/bait fishery off of Dutch Harbor in July. These herring then migrate along the shelf edge to spend the fall and winter in the general vicinity of the Pribilof Islands. A large foreign trawl fishery harvested these herring in the central BS area from the late 1950s through 1980. The Togiak sac roe fishery began in 1977, and has supported a fairly stable catch, averaging 40. 6 million lb from 1998–2002.

Yukon/Kuskokwim Coast. Fishing effort occurs in six commercial gillnet sac roe districts (Security Cove, Goodnews Bay, Cape Avinof, Nelson Island, Nunivak Island and Cape Romanzof) along the coastline encompassing the Kuskokwim and Yukon River deltas. In addition, a significant subsistence herring fishery occurs at Nelson Island. Harvests in these areas have been declining in recent years, in part due to lack of processing capacity. Harvests averaged 6.0 million lb from 1998 through 2002.

Norton Sound. Although herring biomass in the Norton Sound area has been relatively stable in recent times, catches have declined because of deteriorating market conditions and declining interest from processors in accepting catch. Harvests from 1998 to 2002 averaged 5.2 million lb, whereas quotas averaged around 10 million lb over this period. Participation in the fishery has also declined from the peak of 564 fishers in 1987 to only 32 fishers in 2003.

Conservation and Other Issues

With the degradation of herring roe markets, herring processors have been increasingly concerned about product quality. During the 1990s, fishermen, ADF&G, and the processing industry renewed efforts to increase roe percentages and reduce the length of time herring are held before processing. Roe percentages have improved in some areas. Managers also are attempting to better match the rate of harvesting with the rate of processing, so that herring can be more quickly frozen to prevent product deterioration.

Herring are sometimes taken as bycatch in Bering Sea trawl fisheries, principally those targeting pollock (*Theragra chalcogramma*). Before full observer coverage in the late 1980s, this bycatch may have been as high as 16 to 20 million lb (7,300 to 9,100 mt) (Funk et al. 1990). Federal regulations preclude the retention of herring in these trawl fisheries, and because survival of trawl-caught herring is very low, the entire trawl bycatch of herring is wasted. In the early 1990s the NPFMC adopted regulations which have successfully limited this bycatch to 1% of the biomass of Bering Sea herring. Bycatch of herring in all other fisheries is very low.

Because herring eggs are deposited on intertidal and subtidal vegetation, herring are particularly vulnerable to oil spills that occur near the time of spawning, such as the *Exxon Valdez* oil spill of 1989. Although immediate mortality of herring following the *Exxon Valdez* oil spill was thought to be low, a population crash that became apparent in 1993 may be linked to the earlier spill (Marty et al. 1999).

Most herring spawning habitat in Alaska is undeveloped and has not been degraded by human activities. However, there are occasional concerns about the impact of herring roe fishing vessels on herring spawning activities. Discharges from large pulp mills in Southeast Alaska have been

linked to herring mortality on a number of occasions. The longer-term effects of pulp mill effluents or log dumps on herring populations are unknown.

Because herring are an important food source for other species, commercial utilization of herring has always been controversial. In Southeast Alaska, halibut and salmon fishermen began objecting to herring fisheries early in the 20th century. Their objections continue to be heard by the BOF and have been one of the principle reasons for the conservative herring harvest policies adopted by the BOF. The controversy over the decline of Steller sea lion (*Eumetopias jubatus*) populations in the central and western Gulf of Alaska has highlighted an apparent diet shift away from herring to pollock over the last few decades. While the role of these diet shifts, as well as the role of commercial fisheries in altering herring, pollock, and marine mammal population levels remains unclear, the endangered species listing of the Steller sea lion has renewed interest in potential conflicting utilizations.

SHELLFISH FISHERIES

CRAB FISHERIES

The Bering Sea, Aleutian Islands, and Gulf of Alaska together produce approximately one-third or more of total U.S. crab catches on average. Ten species of crabs are caught in Alaskan crab fisheries, and seven of these have commercial importance: red king crab, *Paralithodes camtschaticus*; blue king crab, *P. platypus*; golden king crab, *Lithodes aequispinus*; Tanner crab, *Chionoecetes bairdi*; snow crab, *C. opilio*; hair crab, *Erimacrus isenbeckii*; and Dungeness crab, *Cancer magister*. The three minor species, scarlet king crab, *L. couesi*; grooved Tanner crab, *C. tanneri*; and Triangle Tanner crab, *C. angulatus*, are landed mostly as incidental catch in other crab fisheries. Besides commercial fisheries, subsistence and sport fisheries occur in many areas, but their contributions to total harvest remain small.

History

The history of crab fisheries extends back to 1930, but substantial commercial efforts were not undertaken until the 1950s when the king crab fisheries were developed in the Bering Sea. The history of harvests for the various crab species shows a wide range of fluctuations (Figure 6) and most of the stocks are currently in depressed conditions. A number of explanations for these conditions have been given: overharvest, decline in recruitment due to adverse climatic conditions, unintentional bycatch of broodstock in other fisheries, and others. Despite a variety of restrictions and regulations in the past two decades, most of the depressed stocks have failed to recover. Consequently, a number of precautionary management measures have been taken by the federal and state agencies to conserve these stocks.

Crab Stock Distribution

Red king crabs are distributed throughout the Bering Sea, Aleutian Islands, and Gulf of Alaska, with historical fishing centers in Bristol Bay, Norton Sound, Petrel Bank, the Pribilof Islands, Kodiak Island, and northern Southeast Alaska (Figure 7). In contrast, blue king crabs are found as discrete small populations around St. Matthew Island, the Pribilof Islands, St. Lawrence Island, Nunivak Island, and in isolated cold water areas in the Gulf of Alaska. The two king crab species are found in greater abundance at depths less than 180 m. Golden (brown) king crabs primarily inhabit waters along continental slopes of the Aleutian Islands, Bering Sea, and Gulf of Alaska at depths greater than 180 m. Fisheries in the Aleutian Islands have accounted for most of the golden king crab landings. Scarlet king crabs are a deepwater species living in waters deeper than 600m. They are caught primarily as bycatch in the grooved Tanner crab and golden king crab fisheries.

Hair crabs are mostly found near the Pribilof Islands. Tanner crabs are distributed in the eastern Bering Sea, Aleutian Islands, and the Gulf of Alaska with major concentrations restricted to less than 300 m. Snow crabs occur in the northern and central Bering Sea on the continental shelf with major concentrations restricted to less than 300 m. Grooved Tanner crabs and Triangle Tanner crabs are other deepwater species found at depths greater than 200m in the Bering Sea and Aleutian Islands. Dungeness crabs are found in estuaries and open ocean areas from Dixon Entrance to Unalaska Island. They occur from the intertidal zone to depths greater than 300 m. Prince William Sound, Cook Inlet, Kodiak, Alaska Peninsula, eastern Aleutian Islands, and Southeast Alaska are historical centers for Dungeness crab fisheries.

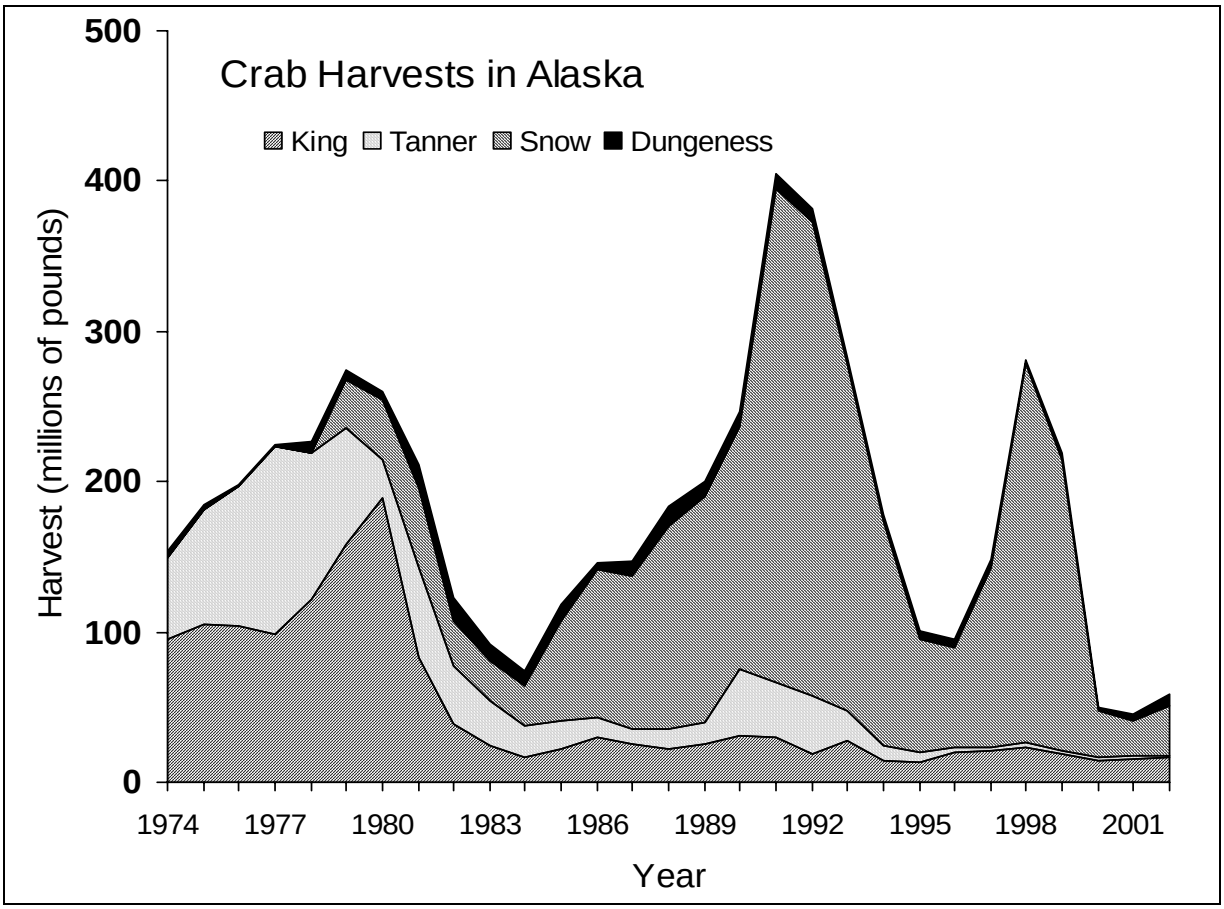

Figure 6.–Commercial harvests of king, Tanner, snow, and Dungeness crabs in Alaska during 1974–2002.

Management

The U.S. federal government through the North Pacific Fishery Management Council (NPFMC) and the State of Alaska jointly manage the Bering Sea and Aleutian Islands crab stocks, whereas the State of Alaska solely manages the Gulf of Alaska crab stocks. Harvest strategies vary among areas and species, but all crab fisheries have minimum size limits, male-only restrictions, and specific fishing seasons (i.e., size, sex, and season, or "3-S" management). Minimum size limits have been enforced to provide at least one opportunity for males to mate with females. Single-sex harvest has been in effect to protect mature females for reproduction and specific fishing seasons are set to avoid harvesting crab during mating and molting (soft-shell) periods. A number of king and Tanner crab fisheries are managed with a guideline harvest level (GHL) determined either from available abundance estimates and appropriate target harvest rates or from historical average catches. The fishery performance within a season is monitored, and if the fishery is expected to exceed the GHL before the declared closure date, then the season is closed by an ADF&G Commissioner's emergency order. Incidental mortality of crabs in other fisheries (trawl, pot, and dredge) is reduced by enforcing maximum allowable crab bycatch thresholds. Additional management measures include pot limits, permits, onboard observers, registration areas, reporting requirements, vessel tank inspections, legal gear specifications, and provisions for gear placement, removal, and storage.

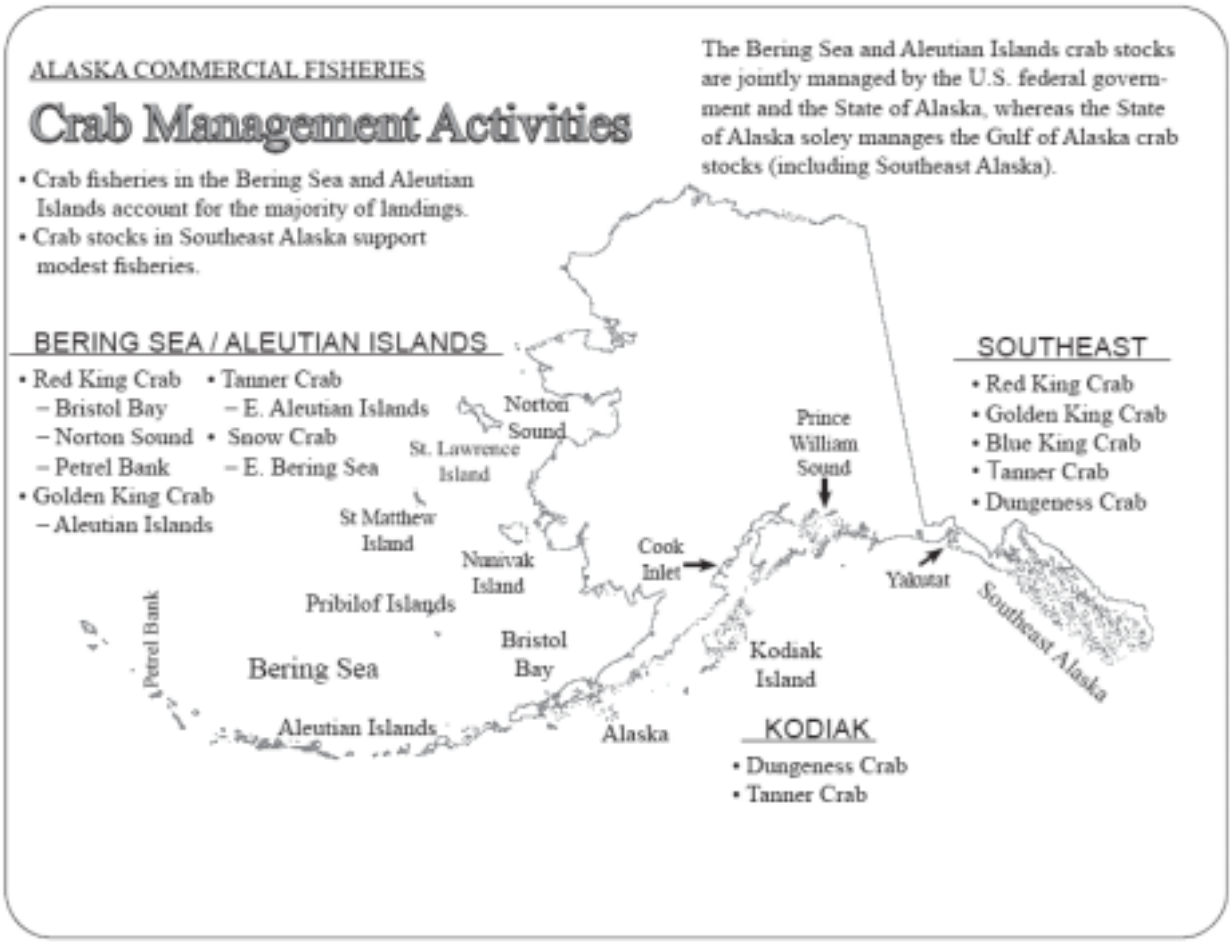

Figure 7.–Locations of major crab fisheries in Alaska.

Six Bering Sea crab stocks are managed by the NPFMC according to fishery management plans with thresholds for overfishing (an excessive annual rate of removal) and overfished (a minimum biomass level). These stocks are Bristol Bay red king crab, Bering Sea Tanner crab, Bering Sea snow crab, St. Matthew Island blue king crab, and Pribilof Islands red and blue king crabs. If the stock declines below the 'overfished' biomass level, then the stock is declared overfished, and management actions in the form of reducing fishing mortality or rebuilding plans must be implemented.

In addition to federal management regulations, the ADF&G has developed harvest strategies for king and Tanner crab stocks in selected fisheries of the Bering Sea and Gulf of Alaska. The harvest strategies aim to maintain sufficient spawning biomass for stock productivity by controlling the removal of mature males. Minimum stock size levels (mainly of mature portion) and minimum GHLs (for a few stocks) are estimated for assessing stock viability and for assuring manageability under continued fishing.

Gear

Both pots and ring nets are used in commercial crab fisheries. Pots and ring nets can be used in commercial Tanner crab fisheries and pots, ring nets, and diving gear can be used in commercial Dungeness crab fisheries. Only pots are allowed in commercial king crab fisheries. In all cases,

crab pots account for the vast majority of the catch. Pot design and regulations differ by species, but all pot gear must have a biodegradable seam, panel or device that renders the pot incapable of retaining fish or shellfish for more than six months when it is lost while fishing. King crab pots are steel-framed and rectangular covered with nylon webbing of varying mesh sizes at different locations (top, bottom, sides, tunnel, door). Common sizes range from 2.0 m by 2.0 m to 2.4 m by 2.4 m, with heights varying from 0.7 m to 1.0 m.

Tanner and snow crab pots are modifications of king crab pots intended to retain smaller Tanner and snow crabs. 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. A pyramid-shaped pot with a single tunnel at the top of the pot is also used in some areas (e.g., Southeast Alaska) specifically in Tanner crab fisheries. Dungeness crab pots are round and range from 1.0 to 1.5 m in diameter and about 0.4 to 0.5 m high. King crab pots have two tunnels on the sides of the pot with one tunnel opening for crab entry and the other with a secured door for emptying the pot contents. Dungeness crab pots have two escape rings to allow undersize crabs to leave the pot.

Pots are baited with chopped herring, other fish (such as cod or salmon), squid, or clams. Pots are lowered on a single buoyed line to the bottom and allowed to soak typically for one to two days when fishing for red king crabs, blue king crabs, or Dungeness crabs. Hydraulic pullers are used to launch and retrieve pots. In the Aleutian Islands, the depths and steep bottom topography in the inter-island passes inhabited by golden king crabs necessitates the use of longlined rather than single-pot gear. Longlined pots are set using a ramp over the stern of the vessel.

Once the pot is hauled, the catch is sorted on deck and all females and undersize males are released overboard. On catcher vessels, the retained catch of large males is usually held in large recirculating seawater tanks for live delivery. For the small fleet of catcher–processor vessels, retained crabs are processed and frozen onboard. King crab vessels fishing the Bering Sea usually exceed 100 feet in length. Smaller vessels are typical in Gulf of Alaska fisheries.

Red and blue king crabs are caught at depths less than 200 m, Tanner and snow crabs between 100 m and 200 m, golden king crabs and other deepwater crabs at depths 200 m to 1000 m and Dungeness crabs mostly at depths less than 20 m.

Processing and Marketing

U.S. domestic production of king, Tanner, and snow crabs comes entirely from Alaska, but only a relatively small amount of commercially harvested crabs is moved to consumers in Alaska. Commercially harvested crabs in the Bering Sea and Aleutian Islands are sold alive to catcher–processor vessels, floating processor vessels, or shore-based processors. In Prince William Sound, Kodiak, and Southeast Alaska, processing is mostly done in shoreside facilities. King, Tanner, and snow crabs are cleaned and either cooked and brined or left raw. The final product forms include crab clusters, claws, and meat. The product is frozen, packed in bulk and shipped for reprocessing in Seattle or the Far East. The products for retail market are also shipped to reprocessors for packaging, labeling, cold storage, and marketing. A very small amount of king crab is shipped live to Far East markets. Hair crabs are cooked whole. Dungeness crabs are processed by shore-based processors, catcher processors, and floating processors. Cooked and processed Dungeness crabs are sold whole or in sections as a fresh or frozen product. Dungeness crabs are also sold alive.

Recent Harvests and Status

The crab stocks discussed here are fully exploited and a number of them are in depressed condition. During the 1998–2002 period, an average annual total of 137 million lb (62,000 t) of crabs worth an exvessel value of $191 million was landed. Fisheries in the Bering Sea and Aleutian Islands accounted for the majority of the landings. The average annual harvests during the 1998–2002 seasons were: 22 million lb (9,980 t) of king crabs worth $83 million, 108 million lb (49,000 t) of snow crabs worth $95 million, 3 million lb (1,360 t) of Tanner crabs worth $6 million, and 5 million lb (2,270 t) of Dungeness crabs worth $7 million (Table 3).

Table 3.–Recent 5-year average harvest, value, permits, and status for Alaska commercial crab fisheries. Averages are for the period 1998–2002.

Stocks	Harvest (lb)	Value	Permits	2003 Status[a]	Remarks
King Crab					
Bristol Bay red	10,650,000	$50,900,000	261	I,S	
Pribilof red	540,000	$1,270,000	58	U	99–02 closed
Norton Sound red	190,000	$460,000	30	M,Dc	
Aleutian Islands red	370,000	$2,150,000	19	L	98–00 closed
Southeast red	270,000	$1,440,000	76	L,Dc	98–00 closed
St. Matthew blue	2,970,000	$5,940,000	137	Dp,C	99–02 closed
Pribilof blue	520,000	$1,200,000	57	Dp,C	99–02 closed
Southeast blue	3,000	$14,000	12	L,Dc	
Aleutian Islands golden	5,800,000	$17,520,000	27	M,S	
Southeast golden	460,000	$1,660,000	37	L,S	
Total	21,773,000	$82,554,000	714		
Tanner and snow crab					
Eastern Bering Sea snow	107,510,000	$95,200,000	249	L,Dc	
Eastern Bering Sea Tanner			-	Dp,C	closed
Kodiak Tanner	690,000	$1,550,000	261	L,S	98–00 closed
Southeast/Yakutat Tanner	1,770,000	$3,970,000	175	M,Dc	Yakutat 01–02 closed
Aleutians/Peninsula Tanner	260,000	$380,000	62	Dp,C	01 open
Total	110,230,000	$101,100,000	747		
Dungeness Crab					
Southeast	3,980,000	5,910,000	222	M,Cy	
Yakutat	90,000	150,000	20	Dp,C	00–02 closed
Kodiak	440,000	680,000	21	L,Cy	
Total	4,510,000	6,740,000	263		
Hair crab					
Bering Sea	260,000	720,000	11	Dp,C	01–02 closed
Grand Total	136,773,000	$191,114,000	1,735		

[a] Status abbreviations: C = closed, Cy = cyclic, Dc = declining, Dp = depressed, H -= high, I = increased, L = low, M = medium, S = stable, U = unknown.

The Bristol Bay red king crab stock has shown an increasing trend in abundance since the late 1990s. Fishing effort in this fishery has remained high with an average number of permits at 261 during 1998–2002 (Table 3).

Norton Sound red king crabs provide small summer and winter fisheries with an average fishing effort of 30 permits during 1998–2002 (Table 3). The 2002 survey found a decrease in legal male crab abundance from that estimated in 1999 due to weak recruitment over the previous three years. Recruitment is anticipated to be stronger over the next three years.

Considering its small stock size, the fishing effort in the Pribilof Islands red king crab fishery remained high with the number of permits at 58 in 1998. The fishery has been closed since 1999 due to the low precision of annual abundance estimates and the overlapping distribution with the closed fishery for blue king crabs for which there are bycatch concerns.

The St. Matthew Island stock is the larger of the two blue king crab stocks with 137 permits fished in 1998. There were 57 permits fished in the Pribilof Islands blue king crab fishery. Both stocks are depressed and have been closed since 1999. The NPFMC has developed rebuilding harvest strategies for both stocks. Causes of stock declines are not well understood, but a sudden drop in abundance was attributed to high natural mortality of the St. Matthew Island stock in 1999. The 2003 stock abundance estimates suggest a slight improvement of the St. Matthew Island female and prerecruit male abundances, but the Pribilof Islands stock remains weak.

The Bering Sea Tanner crab fishery was closed due to low stock abundance and poor fishery performance in 1997 and the fishery has remained closed under a rebuilding harvest strategy. The 2003 stock abundance increased over the minimum acceptable biomass level for the first time since the fishery closure.

The Bering Sea snow crab stock is depressed and has been managed under a stock rebuilding plan with a low GHL in recent years. Fishing effort remained high with an average of 249 permits from 1998–2002 (Table 3). Abundances of legal and prerecruit males continue to decline and these trends are likely to persist for some years.

The Bering Sea Hair crab stock has been declining for several years and recruitment trends are unclear due to poor representation of small crabs in the surveys. The fishery is small with average effort of 11 permits in the 1998–2000 period. The fishery has been closed since 2001.

Aleutian Islands and Gulf of Alaska king and Tanner crab stocks are small and most are depressed. The red king crab fisheries in Kodiak, the Alaska Peninsula, Cook Inlet, and Prince William Sound areas are closed due to low abundance. Aleutian Islands (Adak and Dutch Harbor) golden king crab populations support fisheries with harvest levels averaging nearly 6 million pounds. The average participation during 1998–2002 was 27 permits (Table 3). The 2002 pot survey in the eastern Aleutian Islands indicated a drop in legal male crab abundance while prerecruit male and female abundance remained roughly stable at their 1997 levels. The western Aleutian Islands (Petrel Bank area) red king crab fishery was started recently with a small GHL in 2002 and 2003 after high densities of legal crabs were encountered in a pot survey. The Tanner crab fisheries in the Aleutian Islands, Cook Inlet, Prince William Sound, and Yakutat areas are closed due to low stock abundances. The Alaska Peninsula Tanner crab stock showed some improvement and a fishery occurred with a small GHL in 2001 but has been closed since then. Parts of the Kodiak District opened for a limited commercial Tanner crab fishery beginning in 2001 after a prolonged closure as the stock exhibited some improvement. Tanner crabs in Southeast Alaska support a modest fishery with an average fishing effort of 175 permits during 1998–2002 (Table 3). The harvest has been declining in recent years. The Southeast Alaska red king crab stock trend and fishery are very similar to that of the region’s Tanner crab. Golden

king crabs in Southeast Alaska have recently outstripped red king crabs in landings, and blue king crabs are harvested largely as incidental catches in the region's red king crab fishery.

Even though fisheries for Dungeness crab have occurred throughout the Alaskan coast in the past, stocks in the Prince William Sound, Copper River delta, and Kachemak Bay areas have collapsed. Sport and personal use fisheries exist in these areas at low levels. Suspected causes for stock collapse include overfishing, sea otter predation, and adverse climatic changes. The Dungeness crab fishery in Yakutat also collapsed in 2000 and the fishery has been closed since 2001. In contrast, Dungeness crab stocks in Southeast Alaska and the Kodiak area continue to support mainly small boat fisheries with harvests fluctuating due to recruitment variability.

Conservation and Other Issues

A number of measures have been taken to limit bycatch in other fisheries. These include a prohibited species catch limit in groundfish trawl fisheries, which are set annually as a function of Bristol Bay red king crab effective spawning biomass, and a year-round closure for non-pelagic trawling in the red king crab savings area in the Bering Sea. The NPFMC has also closed an area surrounding the Pribilof Islands to trawl fishing to protect blue king crabs. In the Gulf of Alaska, nearshore crab habitat from Kodiak Island to Unalaska Island has been closed to bottom trawling and scallop dredging to protect king and Tanner crabs.

With the decline in abundances in Alaskan crab stocks, the price per pound has systematically increased. The average per pound exvessel prices during 1998–2002 for some major crab stocks are: Bristol Bay red king crab $4.95, Southeast Alaska blue king crab $3.58, Aleutian Island golden king crab $3.00, Bering Sea hair crab $2.76, Bering Sea snow crab $1.27, Southeast Alaska Tanner crab $3.14, and Southeast Alaska Dungeness crab $1.55.

Crab product quality has occasionally been affected by Paralytic Shellfish Poisoning (PSP) and Bitter Crab Syndrome. The PSP in Dungeness crabs and Bitter Crab Syndrome in Tanner crabs have prompted some fishery curtailments and closures in some areas in Southeast Alaska and Kodiak. However, the incidences were few and affecting only a small proportion of the population at any time.

SHRIMP FISHERIES

Shrimp are an important component of Alaskan marine ecosystems. They once supported large and historically important commercial fisheries in the late 1950s through the early 1980s, particularly in the central and western Gulf of Alaska. Recent commercial harvests are much smaller in volume and are predominantly from Southeast Alaska.

Northern (formerly "pink") shrimp (*Pandalus borealis*) are the primary species by weight, and these are targeted with bottom trawls and beam trawls. Most of the catch of northern shrimp is shelled by mechanical peelers and then frozen. Recent exvessel prices for northern shrimp have averaged 17 cents per pound. Spot shrimp (*P. platyceros*) are the largest and most valued of the Alaskan shrimp and are marketed as live, fresh, or frozen product. These are targeted with pots in generally steep and rough bottom terrain, with exvessel values averaging around $2.50 per pound. Other shrimp harvested include sidestripe shrimp (*Pandalopsis dispar*) with trawls, coonstripe shrimp (*P. hypsonotus*) targeted with pots, and humpy shrimp (*Pandalus goniurus*), mostly caught incidentally in trawls. All of these species are pandalid shrimp, which are protandric hermaphrodites, meaning they first mature and spawn as males, transition to females, and then spawn as large females for the remainder of their lives.

History

A beam trawl fishery for northern shrimp began in the Petersburg area in 1915 (Figure 8). This fishery peaked at 7.6 million pounds in 1958, and continues to this day in central Southeast Alaska with relatively stable harvests capped at 1.75 million pounds per year with permits capped at 41.

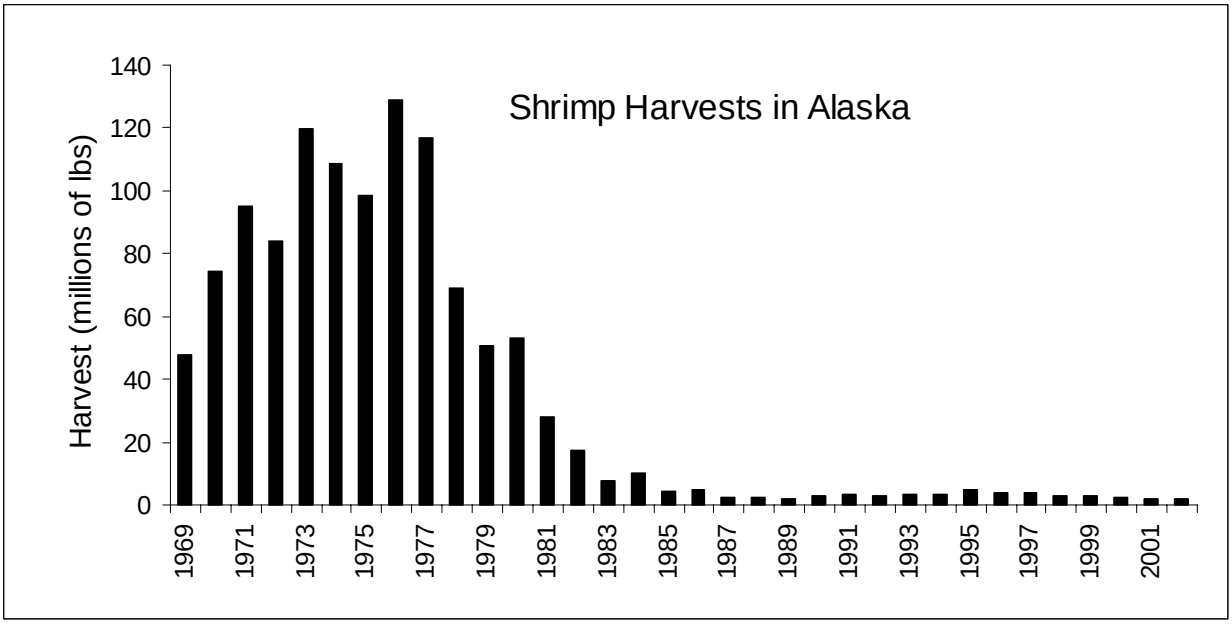

Figure 8.–Commercial harvests of shrimp in Alaska from 1969–2002.

The state's largest shrimp fishery targeted northern shrimp with otter trawls in the Kodiak area beginning in 1958, extending west to the Alaska Peninsula in the Chignik and South Peninsula districts in 1968 (Jackson and Ruccio 2003). Catches, mainly with trawl gear, averaged 115 million pounds annually at the peak from 1973 to 1977.

The shrimp populations in the western and central Gulf crashed in the late 1970s and early 1980s. In retrospect, the crash is attributed in part to a climate regime shift beginning in 1977 (Anderson and Piatt 1999) when waters warmed dramatically. The crash was associated with large increases in groundfish populations, including walleye pollock, Pacific cod, and flatfish. Declines in shrimp population abundance in both fished and unfished areas suggest that fishing played a limited role in the shrimp population collapse; however, fishing effort was very high in many areas before the collapse. Commercial shrimp fishing ceased in the South Peninsula district after 1979, and in the Chignik district after 1981 (Jackson and Ruccio 2003). Catches in the Kodiak district have averaged less than 10,000 pounds per year from 1986 to 2002, with no more than 4 vessels participating. Most of the formerly productive trawl fishing areas in the central and western Gulf of Alaska are closed to trawling pending stock recovery. This includes all of Cook Inlet and many areas around Kodiak Island and the south side of the Alaska Peninsula. A small scale trawl fishery is conducted in the northwest corner of Prince William Sound. Recent small mesh trawl surveys conducted jointly by NMFS and ADF&G suggest that shrimp populations may be recovering in some areas near Kodiak Island.

Prior to the shrimp crash in the late 1970s and early 1980s, northern shrimp accounted for over 85% of the total catches (Figure 9). Beginning in 1987, following the crash when identification of catch to species became routine, the percentage of the catch attributable to northern shrimp has averaged 64%, with 18% spot shrimp, 8% sidestripe shrimp, 8% humpy shrimp, and 2% coonstripe shrimp.

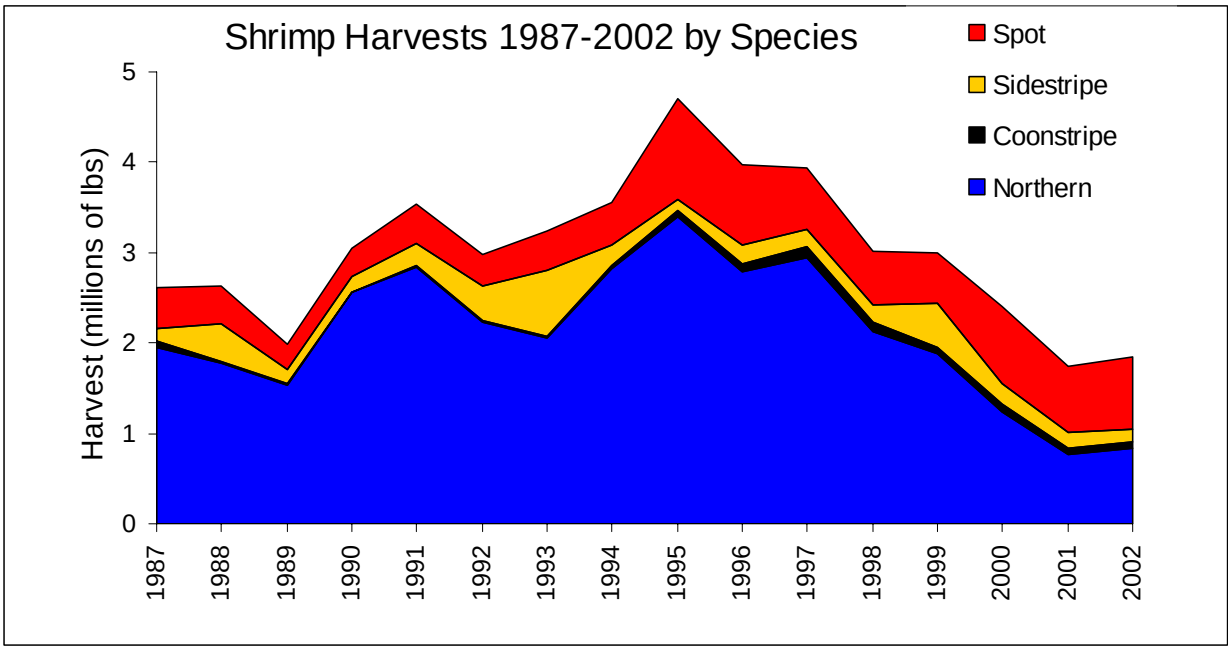

Figure 9.–Commercial harvests of shrimp by species in Alaska from 1987–2002.

Pot fisheries targeting spot shrimp have historically occurred in protected embayments, largely in Southeast Alaska and to a lesser extent in Prince William Sound. The pot fisheries in Southeast Alaska grew rapidly in the 1990s and are now capped at about 800,000 lb. with most of the harvest being taken in southern and central Southeast. Pot fishing in Prince William Sound has been closed since the early 1990s due to low stock abundance. A pot fishery for coonstripe shrimp in Cook Inlet is now closed due to low stock abundance.

Management

Shrimp fisheries are managed by the State of Alaska from zero to 200 nautical miles offshore (Figure 10). Management strategies vary between regions based on the availability of stock assessment information. The historically productive fishing grounds of Kodiak, Chignik and South Peninsula districts have been closed since 1984, and are not scheduled to open until surveys demonstrate that abundance has reached "minimum acceptable biomass index" criteria established in the *Westward Region Shrimp Fishery Management Plan*. Some sections in those areas that are outside of the historically productive grounds are open seasonally each year to trawl gear to allow a small fishery to continue during rebuilding periods (Jackson and Ruccio 2003). Shrimp fishing with pots is open year round in most of the Westward region, with the exception of 6 sections in the Kodiak and Chignik districts.

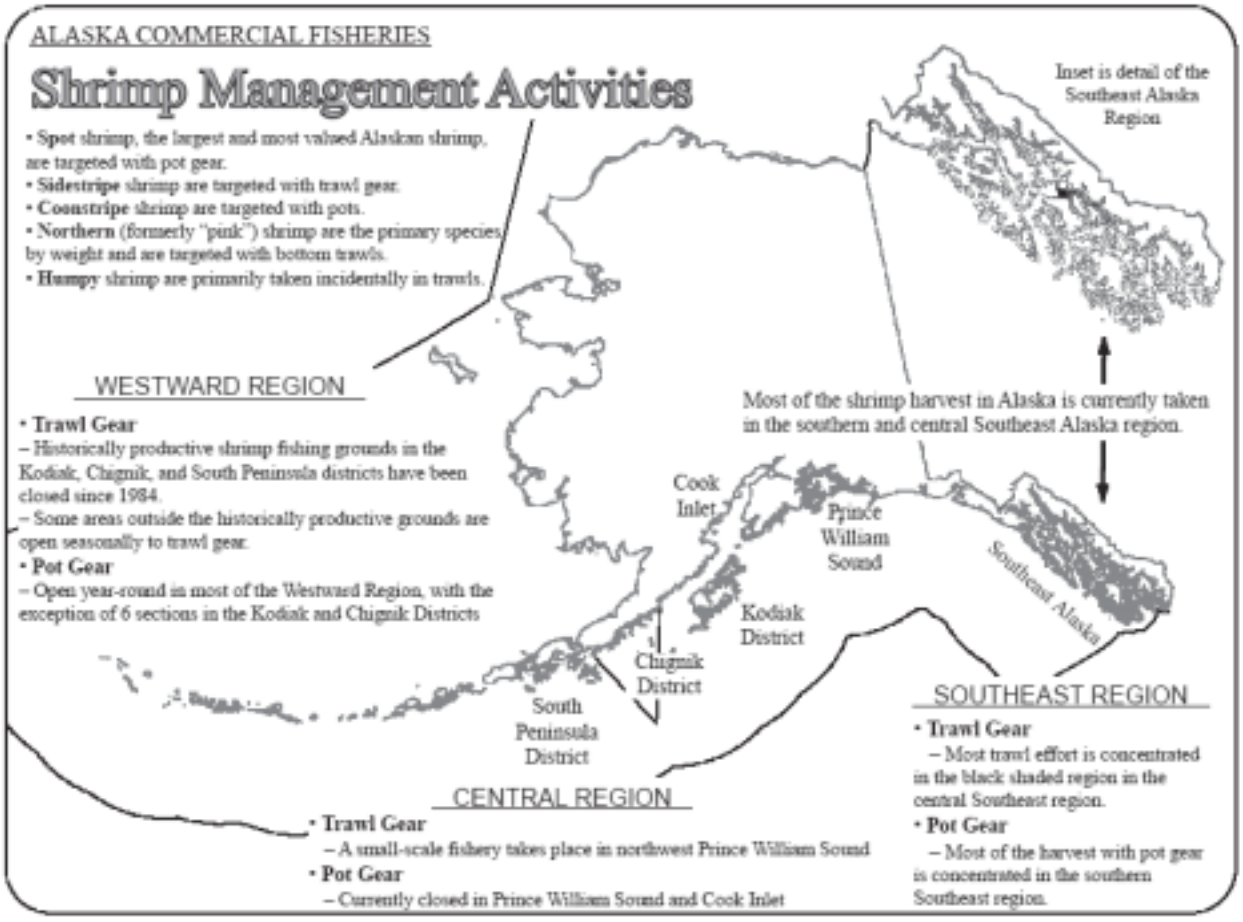

Figure 10.–Locations of major shrimp fisheries in Alaska.

Commercial shrimp harvests in Southeast Alaska are managed to stay within guideline harvest ranges. The upper ends of the guideline harvest ranges are established largely by examination of historic catch records, with annual harvest levels adjusted based on available information on stock status, including commercial catch rates, as well as age and size structure of the landed catch. Pot surveys of spot shrimp are conducted in the major harvest areas of Southeast Alaska to gauge the relative strength of local populations.

Shrimp fishing seasons are set to avoid the biologically sensitive egg hatch period, and are generally closed for at least two months between mid-February and mid-June, depending on the area.

Gear

Otter and beam trawls are used to target northern, humpy, and sidestripe shrimp, whereas pots are used to target spot and coonstripe shrimp. Otter trawls were the predominant bottom trawl used in the historic Kodiak and Alaska Peninsula area shrimp fisheries. Otter trawls use a double bridle and “otter boards” to deploy and maintain the net opening. They are most effective on smooth and level bottom, but can be outfitted with roller gear (wheels) to allow fishing on rougher substrates where the net might become snagged. The design and greater size of otter trawls relative to beam trawls allow larger catches.

In comparison, the beam trawl is a relatively simple gear type in appearance and function. A strong wooden or metal beam acts as a head rope, and metal "shoes" connected directly to each end of the beam act as the breast of the trawl. Thus, two important net dimensions are controlled by rigid members: 1) the width of the mouth is determined by the length of the beam; and 2) the opening height of the net is determined by the height of the metal "shoes." Vessel length limits beam length. Most beam trawls are deployed with a single bridle and fish best on flat substrates. However, they can effectively fish some gradual side slopes and irregular bottoms. Beam trawls are the only shrimp trawl allowed in Southeast Alaska where otter trawls were prohibited in 1997 by the Board of Fisheries. Beam trawls were also used in the Kodiak area in bays and nearshore beginning in 1971, with peak participation of 16 beam trawl vessels in the 1974/75 season.

Shrimp pots are typically cone shaped, covered with webbing having three tunnel openings and a pucker string on the bottom, which is opened to empty the pot and during bating. These pots are often fished in strings.

Recent Harvests and Status

Statewide catches averaged 2.2 million pounds valued at $3.6 million for the five year period 1998–2002 (Table 4). Given that much of the historic fishing grounds in the central and western Gulf of Alaska are closed to shrimp trawling, that Cook Inlet is closed to all shrimp harvests, and that Prince William Sound is closed to commercial shrimp pot fishing, the bulk of recent harvests have come from Southeast Alaska. Pot fisheries for spot and coonstripe shrimp and beam trawl fisheries for northern and sidestripe shrimp in Southeast Alaska are largely stable.

Table 4.–Recent 5-year average harvest, value, permits, and status for Alaska commercial shrimp fisheries by species. Averages are for the period 1998–2002.

Species	Harvests (lb)	Value	Permits	2003 Status[a]
Northern (pink) shrimp	1,344,685	$284,137	41 trawl, 28 pot	L,I
Sidestripe shrimp	123,313	$185,437	16 trawl, 55 pot	M,S
Spot shrimp	705,586	$3,003,459	23 trawl, 78 pot	H,S
Coonstripe shrimp	70,023	$166,039	4 trawl, 41 pot	U
Total	2,243,607	$3,639,072		

[a] Status abbreviations: C = closed, Cy = cyclic, Dc = declining, Dp = depressed, H -= high, I = increased, L = low, M = medium, S = stable, U = unknown.

Conservation and Other Issues

The impact of oceanographic and climate regime changes on shrimp populations is apparently profound. Regime changes are not readily predictable in timing or in their effect on constituent species and their relative abundances. Given the history of Alaska's shrimp fisheries and the depleted status of shrimp stocks in the central and western Gulf of Alaska, the management of shrimp fisheries will remain conservative and precautionary.

SCALLOP FISHERY

Weathervane scallops, *Patinopecten caurinus* are the only scallop species targeted by commercial harvesters in Alaska at this time. Weathervanes are the largest scallops in the world and are prized for their large muscle (the adductor muscle) that pulls the two shell halves (the "valves") together. Small commercial harvests of smaller species *(Chlamys* spp.) have been taken in prior years, and rock scallops (*Crassadoma gigantea*) are harvested by divers for personal use, largely in Southeast Alaska.

Commercial fishing for weathervane scallops occurs in the Gulf of Alaska, Bering Sea, and Aleutian Islands (Figure 11) where they occur in distinct "beds," usually on sand, silt, and clay substrates (Turk 2000) on the continental shelf at depths of 120 to 750 ft (37 to 229 m). Highest catch rates are at depths of 240 to 360 ft (73 to 110 m) (Barnhart and Rosenkranz 2000). These beds are typically elongated and oriented in the direction of the prevailing currents. The major commercial scallop beds are in the vicinity of Yakutat, Kayak Island at the southeast end of Prince William Sound, Kamishak Bay in lower Cook Inlet, Kodiak Island (east side), Shelikof Strait, the south side of the Alaska Peninsula, Umnak Island in the eastern Aleutian Islands, and north of Unimak Island in the Bering Sea.

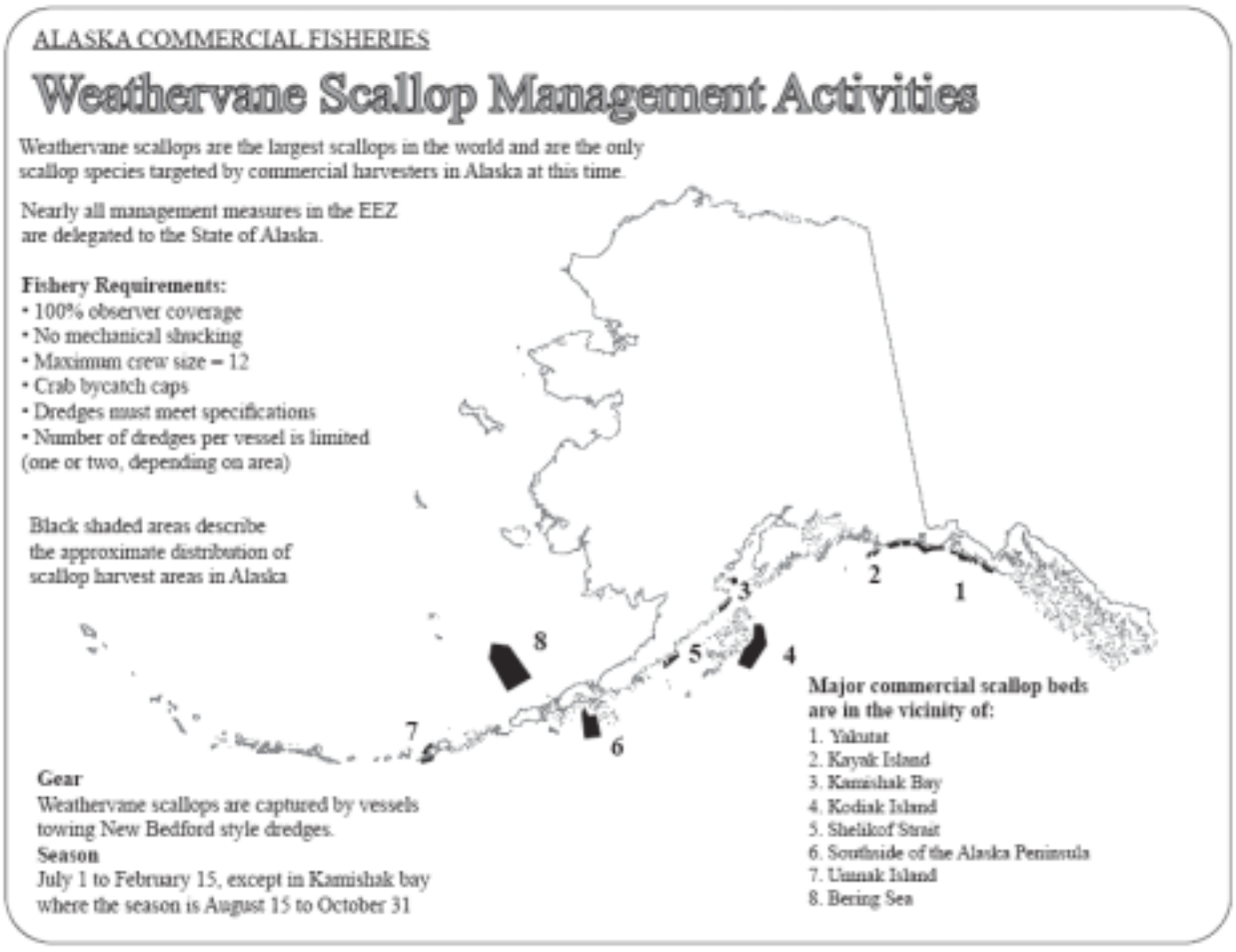

Figure 11.–Locations of commercial scallop beds in Alaska.

Harvesters target these beds with heavy dredges, typically making repeated tows until catch rates fall off, at which time they move to another bed where catch rates are expected to be higher. Scallops are shucked at sea and sold as frozen meats largely to domestic markets.

History

The commercial scallop fishery began in Alaska in the Kodiak area in 1967 and the Yakutat area in 1968. The fishery expanded to the Alaska Peninsula in 1975, Southeast Alaska in 1980, Cook Inlet in 1983, the Bering Sea in 1987, and Prince William Sound in 1992. The early 1990s saw an influx of scallop boats from the U.S. east coast (Shirley and Kruse 1995). The scallop fishery changed during this period from a short trip fishery to a long trip fishery with fewer deliveries as the vessels converted from icing to freezing of shucked product. By 1996, all vessels were converted to catcher–processors capable of producing frozen products at sea (Barnhart 2000).

The catch history illustrates a progression of large catches from virgin scallop beds in the early years with subsequent influx of effort in the early 1990s (Figure 12) which triggered the imposition of the state's "High Impact Emerging Fishery" regulations in 1993. Those regulations effectively closed the fishery, allowing time for the state to develop a fishery management plan (FMP) to prevent overharvest. Today, the scallop fishery is fully exploited.

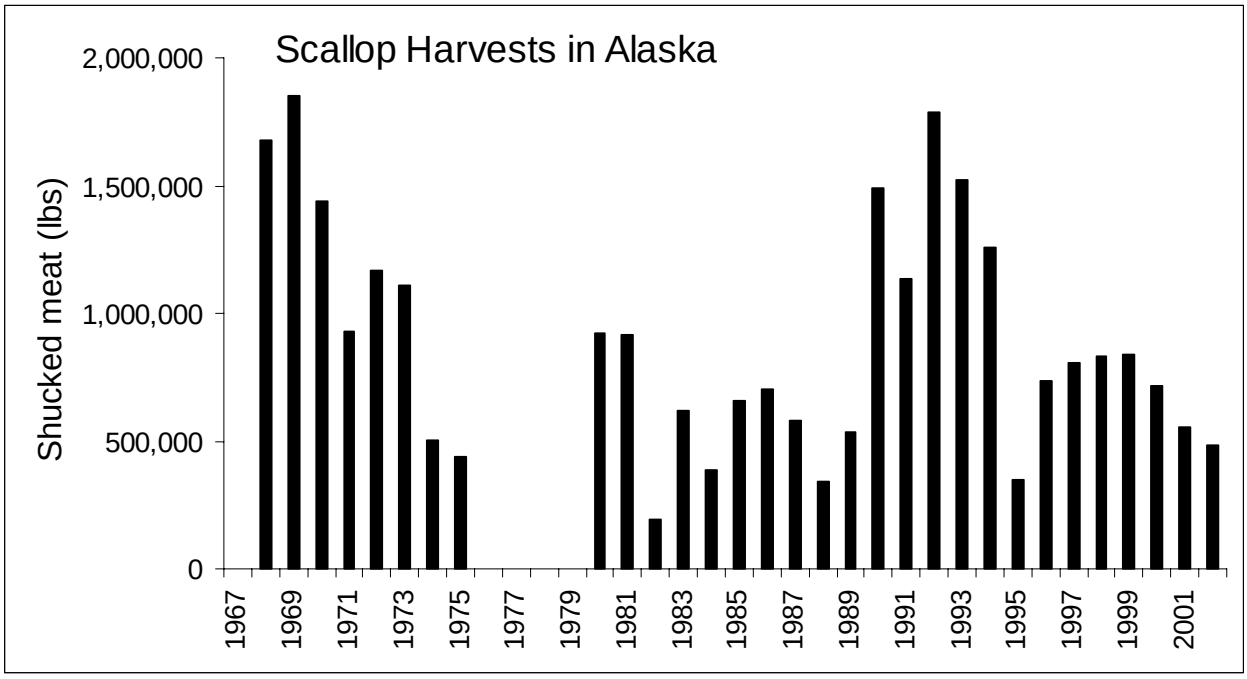

Figure 12.–Commercial harvests of weathervane scallops in Alaska. Weights are for shucked meats, which are approximately 10% of the whole scallop weight.

Management

The state fishery management plan invoked in 1993 imposed a sweeping suite of new regulations to meet the state's constitutional mandate for sustainability. The plan required 100% observer coverage, a ban on automatic shucking machines on scallop vessels, a maximum crew size of 12, crab bycatch caps, dredge gear specifications, limitation on number of dredges per vessel (a maximum of one or two depending on area), and establishment of scallop guideline harvest ranges (GHRs). That plan was followed by a federal fishery management plan (FMP) in 1995

and subsequent amendments that essentially frameworked the existing state plan under a cooperative state–federal management regime. Under this FMP framework, nearly all management measures in the EEZ are delegated to the State of Alaska; exceptions include license limitation in federal waters. The fishing season runs from July 1 to February 15 in all registration areas except in Cook Inlet, where the season is August 15 to October 31 in the Kamishak District.

The observer program has proven to be a significant and positive feature of the scallop fishery. Observers collect data on bycatch (notably crab and halibut bycatch), retained and discarded scallop catch, scallop size composition, scallop meat weight recovery, locations and depths fished, and catch rates. Scallop harvests, crab bycatch, tows, and area fished are reported three times a week, and these data are used for inseason management.

Crab bycatch limits are imposed to protect stocks of king, Tanner, and snow crabs, some of which are in depleted or closed status. Depending on area, the bycatch limits are set at 0.5% or 1.0% of estimated crab abundance, or as a fixed number of crabs. In the Bering Sea, the bycatch limits for Tanner and snow crabs are established as fixed numbers of crab in 3 tiers, depending on crab stock abundance.

Statewide harvests are capped at 1.24 million lb of shucked meats, which is the estimate of maximum sustainable yield (MSY), based on the average catch for 1990 to 1997, excluding 1995. In addition to the statewide cap, ADF&G establishes GHRs in 9 registration areas and manages the fishery independently in each one. Currently there are no statewide estimates of stock size, and populations in each area are independently assessed with methods that vary by region.

ADF&G conducts biennial dredge surveys in the Kamishak District of the Cook Inlet Registration Area and near Kayak Island in the Prince William Sound Registration Area. These surveys provide area-swept estimates of abundance that are uncorrected for the proportion of scallops in the dredge path that are not captured; hence, the estimates are conservative. In both areas, estimated abundances in relation to the GHRs are considered in light of biomass trends, age composition, and other factors to set annual guideline harvest levels.

For registration areas without surveys, stocks are assessed and managed conservatively based on data collected by the scallop observer program. Areas may be closed due to concerns about localized depletion, overall trends in CPUE, or high crab bycatch. ADF&G research personnel are also developing methodology for fishery-independent video surveys of scallop stocks, but these methods must undergo further refinement and review before the estimates are used for scallop fishery management. To date, the video assessments have shown promising results in tests conducted in Shelikof Strait, the Yakutat area, and in the Bering Sea.

The Fishing Cooperative

There are currently 10 scallop vessels licensed for the Alaska scallop fishery, but fewer actively participate. In 2000, six of the licensed scallop vessel owners formed a voluntary fishing cooperative that is self-regulatory, allocating harvest shares based on prior fishing history. Several vessels owners chose not to fish and to have their shares caught by other cooperative vessels. With the cooperative program, harvest rates have slowed and fishing extends much longer in the open season. Formation of the cooperative has allowed vessel owners to reduce crab bycatch. They provide confidential catch and bycatch information to an independent

contractor that reviews the catch and location data to identify high crab bycatch areas. This allows the vessels to be directed to other areas and to avoid reaching the bycatch limits.

Gear

Weathervane scallops are captured by vessels towing one or two New Bedford style dredges; when paired, dredges are fished on each side of the vessel. Dredges are similar to trawls, but have a fixed bottom bar, rather than a foot rope, and the "net" on a dredge is composed of metal rings with inside diameters that by regulation must be at least 4 in (102 mm). Dredge openings cannot be more than 15 ft (4.6 m) wide and chafing gear (to protect the bottom of the dredge) is prohibited. Vessels fishing in the Kamishak, Central, and Southern districts of Lower Cook Inlet are limited to just one dredge with an opening of 6 ft (1.8 m).

Recent Harvests and Status

Harvests in the period 1998 to 2002 averaged 686,621 pounds of shucked meats by an average of 8 permitted vessels each year. Given an average value of $5.91/lb, the annual landed value of the harvest was slightly over $4 million statewide. The largest harvests are taken from Yakutat (Area D) and Shelikof Strait (Kodiak) areas, with harvests averaging about 180,000 lb of shucked meats from each area in the past 5 years (1998–2002).

Conservation and Other Issues

In response to a history of scallop overfishing worldwide, state management of the scallop fishery is intentionally conservative, imposing a series of measures including area-specific catch limits that are reviewed annually. In response to concerns regarding bycatch, the fishery requires 100% observer coverage in federal waters, and crab bycatch limits are imposed in areas where incidental catches of crabs have been significant. In response to concerns about habitat degradation by dredges, a number of scallop beds in crab or juvenile fish habitats remain permanently closed to scallop dredging. Research on habitat changes due to dredging has not been conducted in Alaska, and therefore is unknown for beds actively fished; however, research elsewhere has shown that scallop dredges disturb the substrate, reducing habitat complexity and potentially reducing diversity of benthic organisms..

SEA CUCUMBER FISHERIES

The giant red sea cucumber (*Parastichopus californicus*) is the only commercially harvested sea cucumber in Alaska. The species is common in many nearshore areas from Baja California (Mexico) north and west to the Gulf of Alaska to at least Chignik where it inhabits a variety of intertidal and subtidal habitats to at least 816 ft (249 m) (Lambert 1997). Alaska's largest fishery occurs in Southeast Alaska and a smaller scale fishery occurs in the Kodiak and Chignik areas (Figure 13).

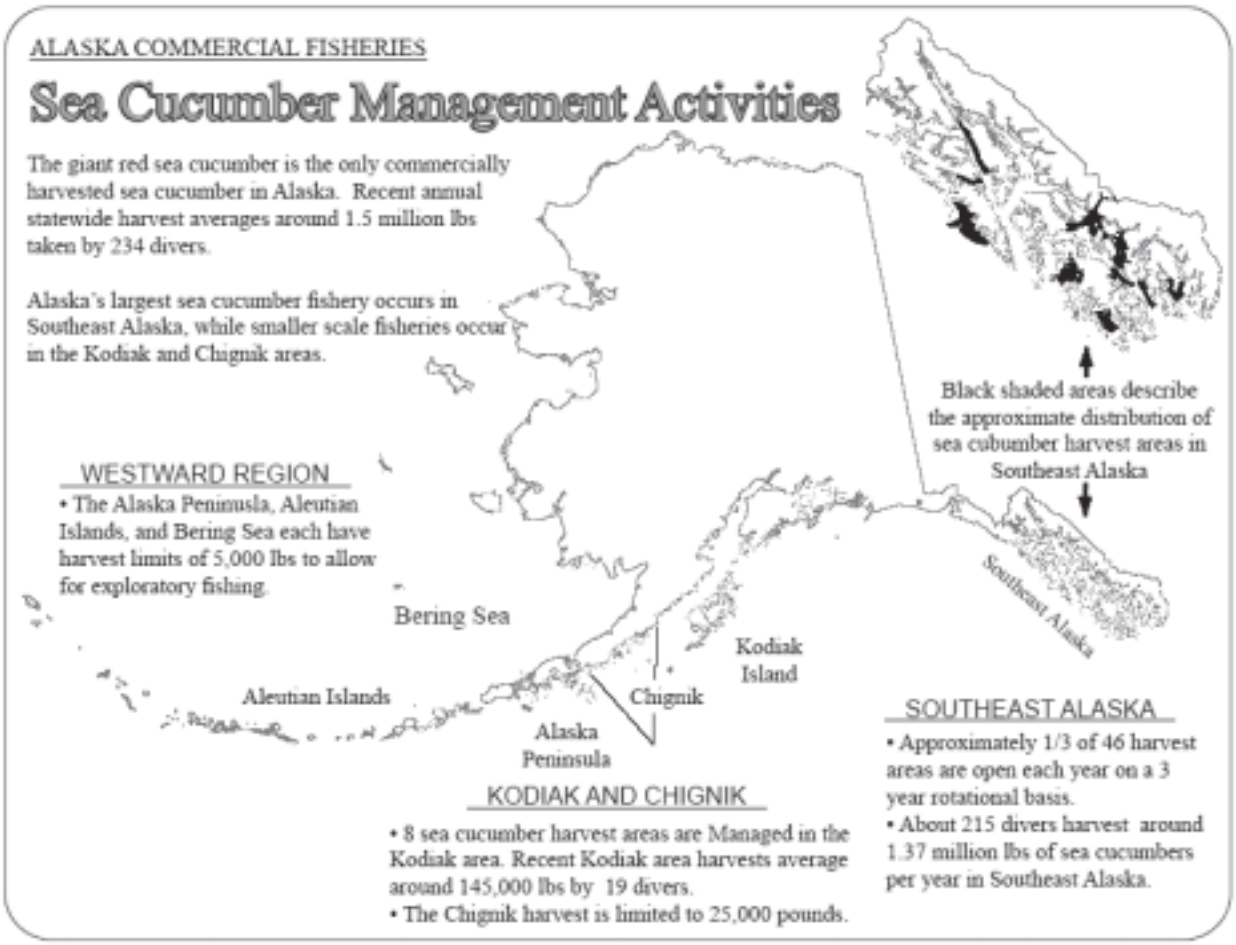

Figure 13.–Locations of major sea cucumber harvests in Alaska.

The red sea cucumber is a slow moving benthic detritus feeder. Ecologically, it functions as a bioturbator, ingesting significant amounts of fine substrate and recycling detritus into nutrients for primary producers in the marine food web. This species is most common in protected embayments on hard and sandy substrates, avoiding mud bottoms and areas with freshwater or glacial runoff. The species is an important subsistence food resource; traditional harvest methods include use of spears on long poles. Commercial harvesting is by divers, who deliver eviscerated but live animals to shore based processors. The animals are processed by hand by separating the five longitudinal muscles bundles from the skin with a scraper or knife. The skin is cooked or boiled and then dried into a product known as *trepang* or *beche de mer*. The frozen muscles and dried skin products are marketed domestically and in Asia.

History

The first commercial harvest of sea cucumbers was in 1983 in the Ketchikan area under an experimental harvest permit. The fishery accelerated beginning in 1986 (Figure 14) with an influx of participants in southern Southeast Alaska, driven in part by increasing restrictions on harvests imposed by rapidly developing sea cucumber fisheries in Washington State and British Columbia. Harvesting peaked in 1989 with 2.3 million pounds of eviscerated product landed by 205 permit holders. The rapid expansion of the fishery in Southeast Alaska and the state's lack of authority to control effort under the existing permit system led to closure of the fishery in May 1990. The fishery reopened in October 1990 following development of the Southeast Alaska Sea Cucumber Commercial Fisheries Management Plan, later adopted by the Board of Fisheries (5 AAC 38.140). This plan seeks to protect subsistence opportunities and provides for sustained commercial fishing harvests. The essence of that plan, requiring abundance surveys and maximum harvest rates, is in effect today.

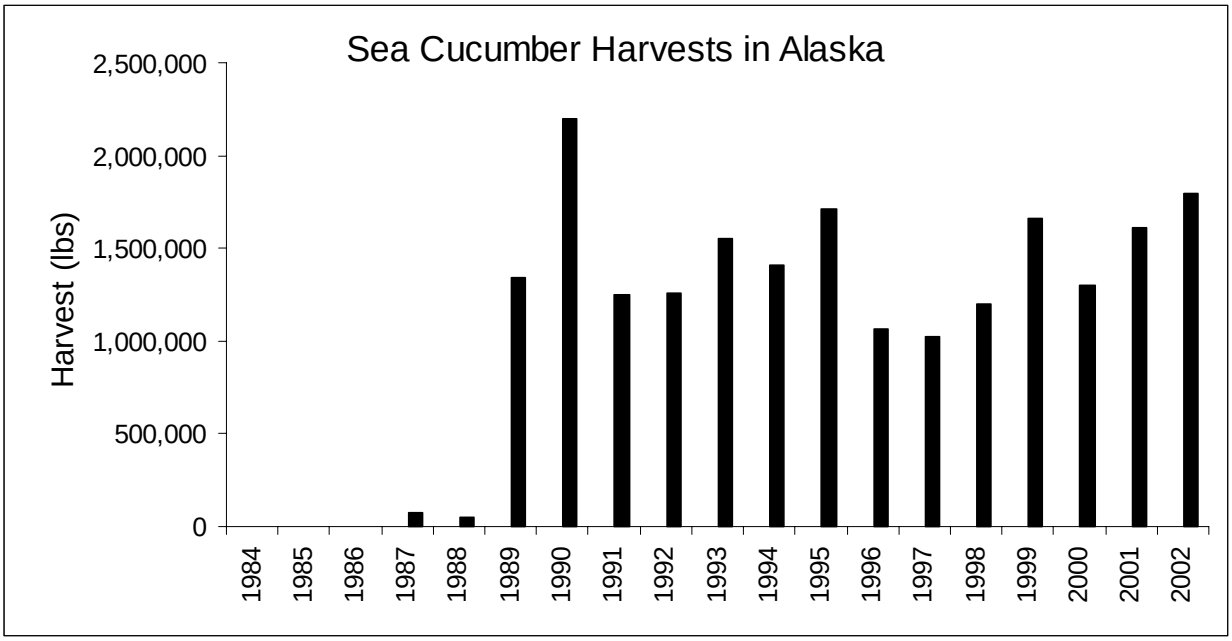

Figure 14.–Commercial harvests of sea cucumbers in Alaska, 1983–2002. Catches in 1983 are confidential and are too small to appear on the chart.

Entry into the fishery was restricted by moratorium in 1996, with entry limited to 436 permit holders in 2000. This relatively large allowance for permits exceeds by about 70 the recent (2003) annual participation. The limit was imposed based largely on overwhelming public opposition to open access, fearing further influx of participants.

An exploratory sea cucumber fishery began in the Kodiak area in 1991. The fishery peaked in 1993 with 564,000 lb (256 mt) harvested by 50 permit holders. Harvests then dropped steeply in subsequent years to a recent average of about 150,000 lb.

Management

The Southeast Alaska sea cucumber fishery management plan (5 AAC 38.140) requires that harvest rates be set as a conservative percentage (maximum of 6%) of the estimated biomass. Biomass surveys are conducted by department divers prior to fishery openings in each

management area, with areas opening on a 3-year rotational basis such that about one-third of approximately 46 areas are open each year, beginning in October. The 3 year rotation was put into place as a means of reducing management costs for surveys and management, and not as a method to allow stock rebuilding between harvests. An additional safeguard is a biomass density threshold of 1 kg of sea cucumbers per linear meter of shoreline. The plan also identifies 20 areas closed to commercial sea cucumber fishing to provide for subsistence harvests and research sites.

Kodiak area harvests are managed using separate GHLs for 8 areas corresponding to Tanner crab management areas. GHLs are set each season depending on fishery performance as measured by catch rate information obtained from logbooks. Recent experimentation with drop video cameras has shown promise for remotely assessing sea cucumber densities but the methods are still under development. Recent (2002/03) season GHLs have totaled 140,000 lb. The Chignik harvest is limited to a GHL of 25,000 lb, and the Alaska Peninsula, Aleutian Islands, and Bering Sea each have GHLs of 5,000 lb to allow for exploratory fishing.

Gear

Sea cucumber harvesting is restricted to hand picking. Divers use scuba or surface supplied air and gather the animals in mesh bags for transport to the surface.

Recent Harvests and Status

Statewide harvests have averaged slightly over 1.5 million lb per year taken by 234 divers. Harvests in Southeast Alaska have stabilized at around 1.37 million lb per year with about 215 divers participating. Kodiak area harvests have averaged around 145,000 lb in the past 5 years with an average of 19 participants. (Table 5).

Table 5.–Recent 5-year average harvests, value, permits, and status for Alaska commercial sea cucumber fisheries by area. Averages are for the period 1998–2002.

Region	Harvest (lb)	Value	Permits	2003 Status[a]
Southeast Alaska	1,368,570	$2,495,634	215	M,S
Kodiak and Westward	145,467	$216,443	19	L,S
Total	1,514,037	$2,712,077	234	

[a] Status abbreviations: L = low, M = medium, S = stable.

Conservation and Other Issues

Commercial harvests of sea cucumbers in tropical areas of the Pacific and elsewhere have generated concerns for over harvest. It was recognition of these and similar concerns that led the department to impose a conservative management program in Southeast Alaska, requiring stock assessments prior to harvests. Commercial divers in Southeast Alaska have expressed concerns that favorite harvest areas are not recovering between each 3 year rotational harvest. These highly localized depletions, occurring principally in areas offering some protection from inclement fall weather and sea conditions, would not be expected to recover during the three year management cycle given the slow growth rates and sporadic recruitment of sea cucumbers. The goal of the current management approach is to provide sustained harvests over larger areas of approximately 100 km of shoreline. An alternative management strategy will be needed if concerns of highly localized depletions are to be addressed.

SEA URCHIN FISHERIES

Two sea urchins species are commercially harvested in Alaska. The red sea urchin (*Strongylocentrotus franciscanus*) is the larger, longer-spined species and is the target in the state's largest urchin fishery in Southeast Alaska (Figure 15). The green sea urchin (*S. droebachiensis*) is a smaller species with shorter spines taken in a small commercial fishery principally in the Kodiak area. Red sea urchins occur from Baja California north to the Gulf of Alaska and sparingly to Kodiak, whereas the green sea urchin is circumpolar in the northern hemisphere, occurring in the eastern Pacific from Washington State to the Arctic Ocean. Red sea urchins occur primarily on rocky shorelines of the outside coast with highest densities in the subtidal range down to 40 feet. Green sea urchins are found in a wider variety of habitats, and especially in more protected waters and embayments. Highest concentrations occur from the intertidal to depths of 30 feet. Both species feed on kelps and other algae.

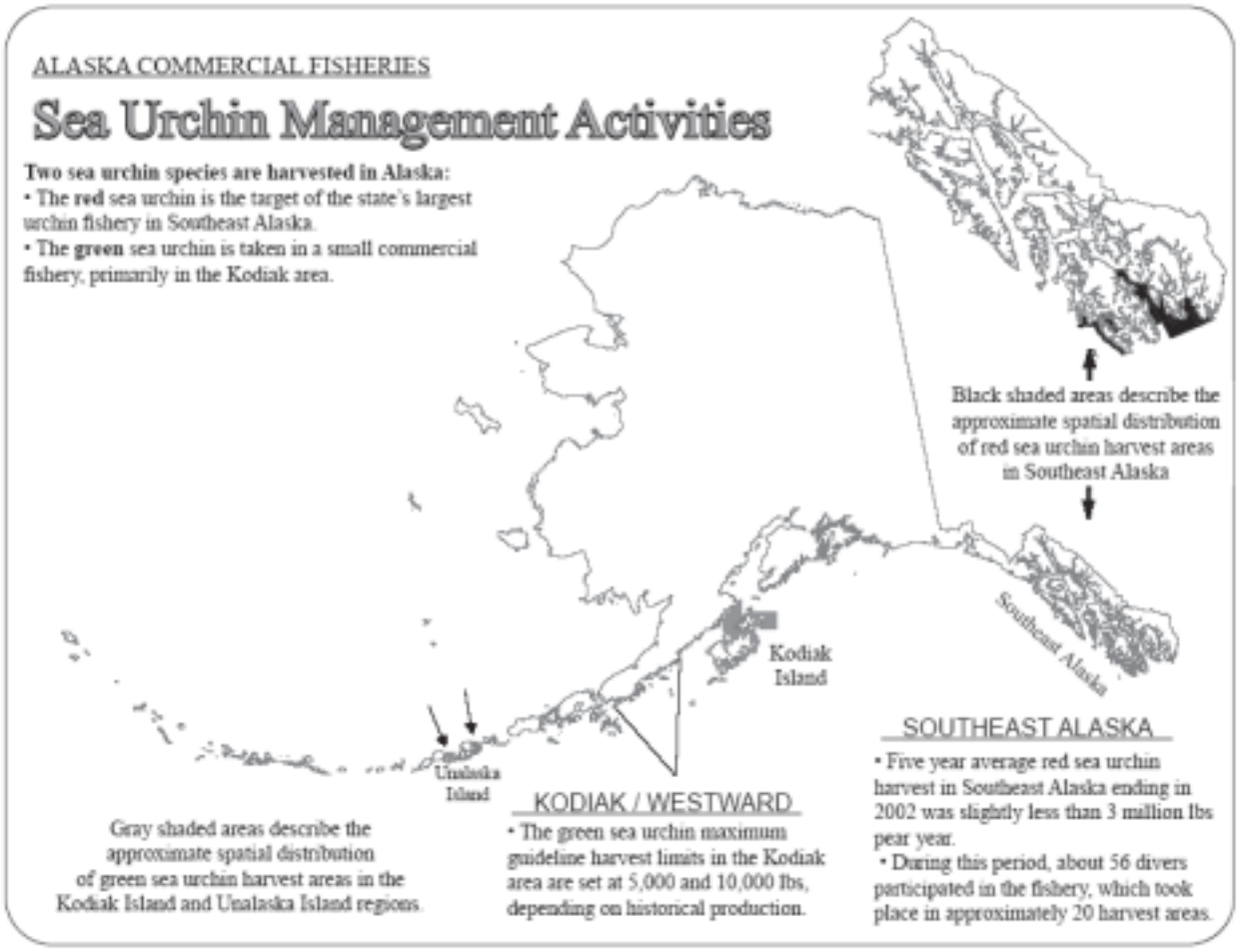

Figure 15.–Locations of major sea urchin fisheries in Alaska.

Urchins are favored prey for sea otters. When otters are present, urchin populations are reduced, allowing kelp to thrive and to support kelp bed species, including fish. In the absence of otters, urchins can drastically reduce the extent of kelp beds, modifying the nearshore community.

Urchins are harvested for their roe, which in fact are gonads that are largely indistinguishable between both male and female animals. In their more desirable condition the gonads are orange

and resemble small granular orange sections, 5 to each animal. Green urchins are shipped live to Japan for processing, whereas red sea urchins, being larger and more expensive to ship, are processed at least to the point of gonad removal. The product is most valuable fresh and is marketed primarily in Japan as uni for the sushi trade.

History

The urchin fishery on the west coast of North America began in Southern California where urchins were originally considered pests. Prior to the realization that urchin roe was a valuable commodity, kelp harvesters would spread lime to kill urchins, and divers would manually crush urchins to promote kelp bed growth. As the Japanese market developed for California urchins in the 1970s, fisheries expanded north to include Oregon, Washington, and British Columbia.

Harvests of urchins in Alaska began in 1980 in the Kodiak area where a small green sea urchin fishery began and continues at a minimal level to this day (Figure 16). Harvests in Southeast Alaska began in 1981 near Ketchikan, for both red and green sea urchins, with the vast majority of the harvest comprised of red urchins. This fishery closed in 1989 in the Ketchikan area due to marketing difficulties. A subsequent small scale harvest of red sea urchins in the Sitka area from 1991 to 1993 succumbed to marketing difficulties and extreme predation by sea otters.

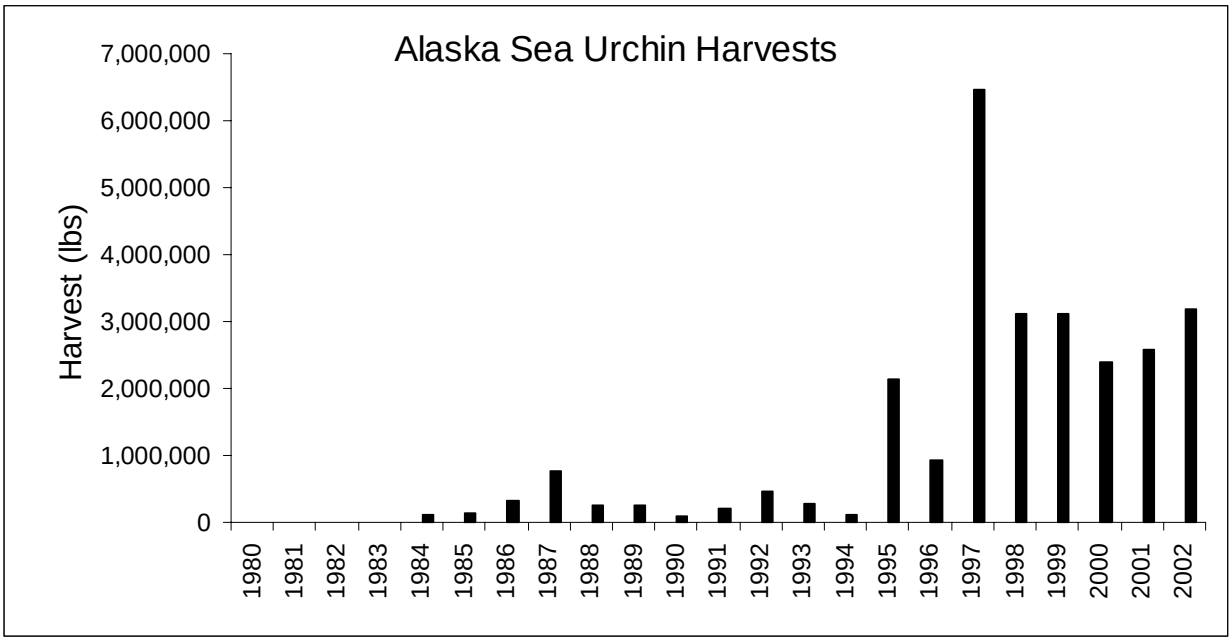

Figure 16.–Commercial harvests of sea urchins in Alaska, 1980–2002. Harvests in 1995 and 1996 were largely by a test fishery for red urchins in the Ketchikan area.

The Southeast Alaska fishery was jump-started in 1995–1996 when a large, 3 million lb test fishery for red sea urchins was conducted in the Ketchikan area to evaluate the economic feasibility of the fishery and to provide funds for stock assessments. A management plan was adopted by the Board of Fisheries in 1997 establishing a conservative harvest rate approach, and requiring stock assessment surveys prior to harvests. The Commercial Fisheries Entry Commission limited entry of harvesters into the fishery in 2000.

In response to interests in developing a green sea urchin fishery in Southeast Alaska, the department, in consultation with the Southeast Alaska Regional Dive Fishery Association

(SARDFA) developed an exploratory stock assessment program funded largely with Federal monies beginning in 1999. The program included reconnaissance surveys by commercial dive harvesters and subsequent biomass surveys conducted by the department. The conclusion from these assessments was that the green urchin resource was inadequate to support a commercial dive fishery, primarily because population densities were too low and urchin sizes were too small.

Management

Red sea urchin management in the panhandle is guided by the Southeastern Alaska Red Sea Urchin Fishery Management Plan (5 AAC 38.145), which specifies a conservative harvest rate of no more than 6% of the biomass of large (> 60mm shell diameter) red sea urchins. Biomass estimates are made once every three years in 20 or more harvest areas coinciding with salmon statistical areas that average roughly 75 km in length. Several control areas where no harvests occur are also monitored for environmental effects on urchin populations that are independent of urchin harvesting. The department works in close cooperation with SARDFA in developing proposals for new or revised regulations to present to the Board of Fisheries for consideration.

The green sea urchin fishery in Kodiak and areas westward is managed under the authority of a Commissioner's permit for miscellaneous species (5 AAC 38.062) that specifies harvest locations, season length, and guideline harvest levels. Boundary lines established for Tanner crab and sea cucumbers are used for green urchin management in the Kodiak area, with maximum GHLs of 10,000 and 5,000 lb depending on historical production.

Gear

Urchin harvests are limited to hand picking and use of an urchin rake. Divers typically use surface supplied air or scuba gear and collect urchins in mesh bags that are lifted to the surface.

Recent Harvests and Status

Statewide urchin harvests have been tailing off due to lower market demand for uni. Average harvests in the 5-year period ending in 2002 have been slightly less than 3 million lb at an average price of about 38 cents per lb. (Table 6).

Table 6.–Recent 5-year average harvest, value, permits, and status for Southeast Alaska commercial red sea urchin fisheries. Averages are for the period 1998–2002.

Region - Species	Harvests (lb)	Value	Permits	Status[a]
Southeast Alaska – Red sea urchins	2,876,078	$1,078,588	56	S
Kodiak – Green sea urchins	[b]	[b]	2	L,Dc

[a] Status abbreviations: Dc = declining, L = low, S = stable.
[b] Green sea urchin fisheries in the Kodiak area are small; harvest and value data (*) are confidential for this period.

Conservation and Other Issues

The major emphasis of the management program for red sea urchins in Southeast Alaska has been to avoid over harvest as has occurred in urchin fisheries elsewhere; however, the impact of expanding sea otter populations may be of much greater magnitude. Fishery development efforts in the Sitka area in the early 1990s were thwarted when the local sea otter population underwent a significant expansion south of town, decimating urchin stocks. Sea otter populations are just a few miles outside the boundaries of existing stocks of red sea urchins in southern Southeast Alaska that now support much of the fishery.

CLAM FISHERIES

Commercial clam fisheries in Alaska include a dive fishery for Geoduck clams (*Panopea abrupta*) in Southeast Alaska and intertidal fisheries for hard shell clams (principally littleneck clams, *Protothaca staminea*) and razor clams (*Siliqua patula and S. alta*) in Cook Inlet.

Geoducks are large clams found from southern California to the Gulf of Alaska, with commercial quantities in Washington, British Columbia, and Southeast Alaska. The shells are up to 20 cm long and the animals can live well over 100 years. The meat of geoducks is prized as a fresh product, but due to paralytic shellfish poisoning concerns, requirements for testing, and the large distance between the state's testing lab in Palmer and harvest areas in Southeast Alaska, it is difficult to market live clams. The dive fishery for geoducks has historic roots similar to those of the sea cucumber and urchin dive fisheries in Southeast Alaska, that is, the fishery developed in Alaska once similar fisheries developed and markets were established in Washington and British Columbia. Geoducks are managed according to the Southeastern Alaska Geoduck Fishery Management Plan, which requires that GHLs to be based on surveys done within the preceding 12 years. The maximum harvest rate is about 2% and openings are established for discreet beds. Divers use a handheld water jet to dig the clams out from the substrate where the clams may be over a meter deep.

Littleneck and other hard shell clams (cockles and butter clams) are dug by hand shovel in the Kachemak Bay area. A commissioner's permit is required. GHLs are set annually based on intertidal clam surveys conducted by the department. Razor clams are dug with shovels and clam "guns." Current and historical harvest areas are sandy beaches of lower Cook Inlet, the Alaska Peninsula, and near Cordova.

Recent statewide clam harvests have averaged about 625,000 lb worth slightly more than $650,000 (Table 7, Figure 17).

Table 7.–Recent 5-year average harvest, value, permits, and fishery status for Alaska commercial clam fisheries. Averages are for the period 1998–2002.

Species	Harvest (lb)	Value	Permits	Status
Geoduck clams	243,075	$423,603	58	Stable
Razor clams	356,408	$195,080	26	Stable
Other clams	25,087	$36,965	11	Stable
Total	624,570	$655,648	96	

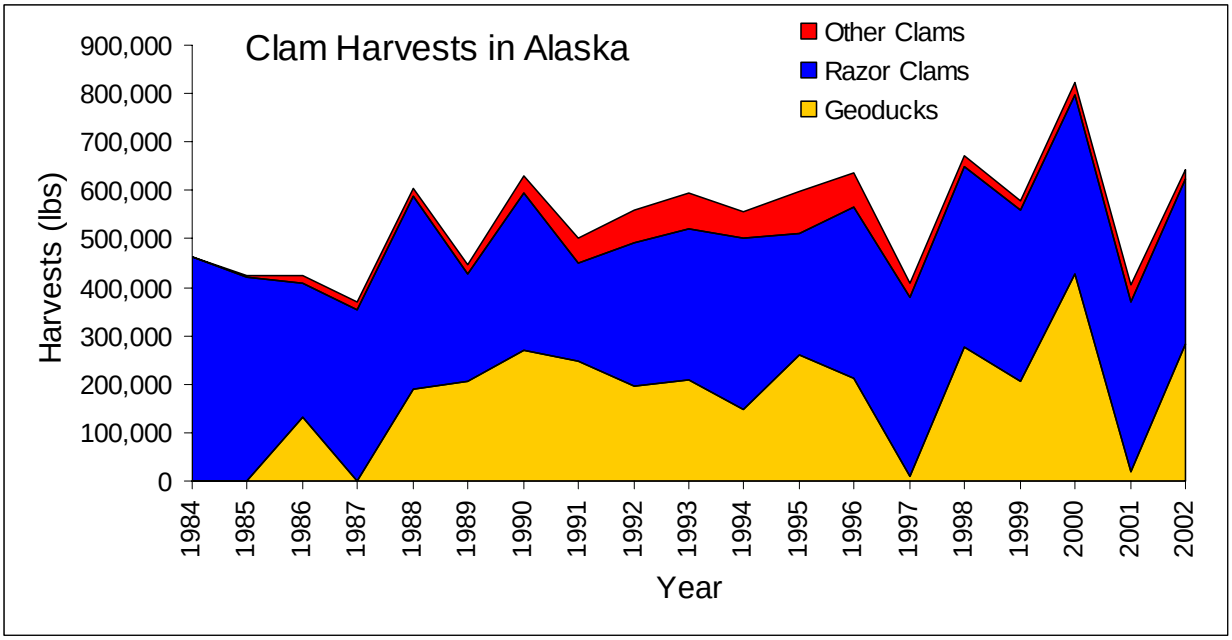

Figure 17.–Commercial harvests of clams in Alaska, 1984–2002.

OCTOPUS AND SQUID FISHERIES

The giant Pacific octopus (*Octopus dofleini*) and squid (mainly *Berryteuthis magister*) belong to the class known as cephalopods and occur in nearly all Alaskan waters. Octopus are taken primarily as bycatch in pot fisheries for cod and crab, as well as in bottom trawl and longline fisheries. Bycatch of octopi is limited to 20% of the directed species catch. Squid are mostly taken incidentally in shrimp trawls and in both bottom and pelagic trawls for finfish. Both species are used as bait in halibut and cod fisheries.

Octopus harvests spiked in the early 1990s when pot fishermen switched from depressed crab stocks to cod fishing in the late fall to early spring, and began landing incidentally caught octopus (Table 8).

Table 8.–Recent 5-year average harvest, value, permits and status for Alaska commercial octopus and squid. Averages are for the period 1998–2002. Squid data are for 1997–2001 (no landings in 2002).

Species	Harvest (lb)	Value ($)	Permits	Status
Octopus	286,326	$129,702	219	Unknown
Squid	1,730,458	$60,733	129	Unknown

Vessels wishing to target octopus require a Commissioner's permit, and these are only issued for the Alaska Peninsula and other Gulf waters excluding Cook Inlet and Southeast Alaska. Vessels targeting octopus cannot also be targeting other species, which prevents fishing beyond the 20% bycatch limit when actually fishing for other species.

Additional information on octopus harvests can be found in the annual management reports for the shellfish fisheries of the Westward region (e.g., ADF&G 2001, 2002) and in the annual stock assessment reports of the NPFMC (e.g., NPFMC 2004).

GROUNDFISH FISHERIES

Among Alaska's marine fisheries the groundfish fisheries target the greatest diversity of species, including pollock, Pacific cod, sablefish, Atka mackerel, lingcod and numerous rockfish and flatfish species. Alaskan groundfish fisheries occur in the Gulf of Alaska (GOA), the Bering Sea/Aleutian Islands (BSAI) and in many bays, sounds and straits that dissect the coastline and constitute the internal waters of Alaska (Figure 18).

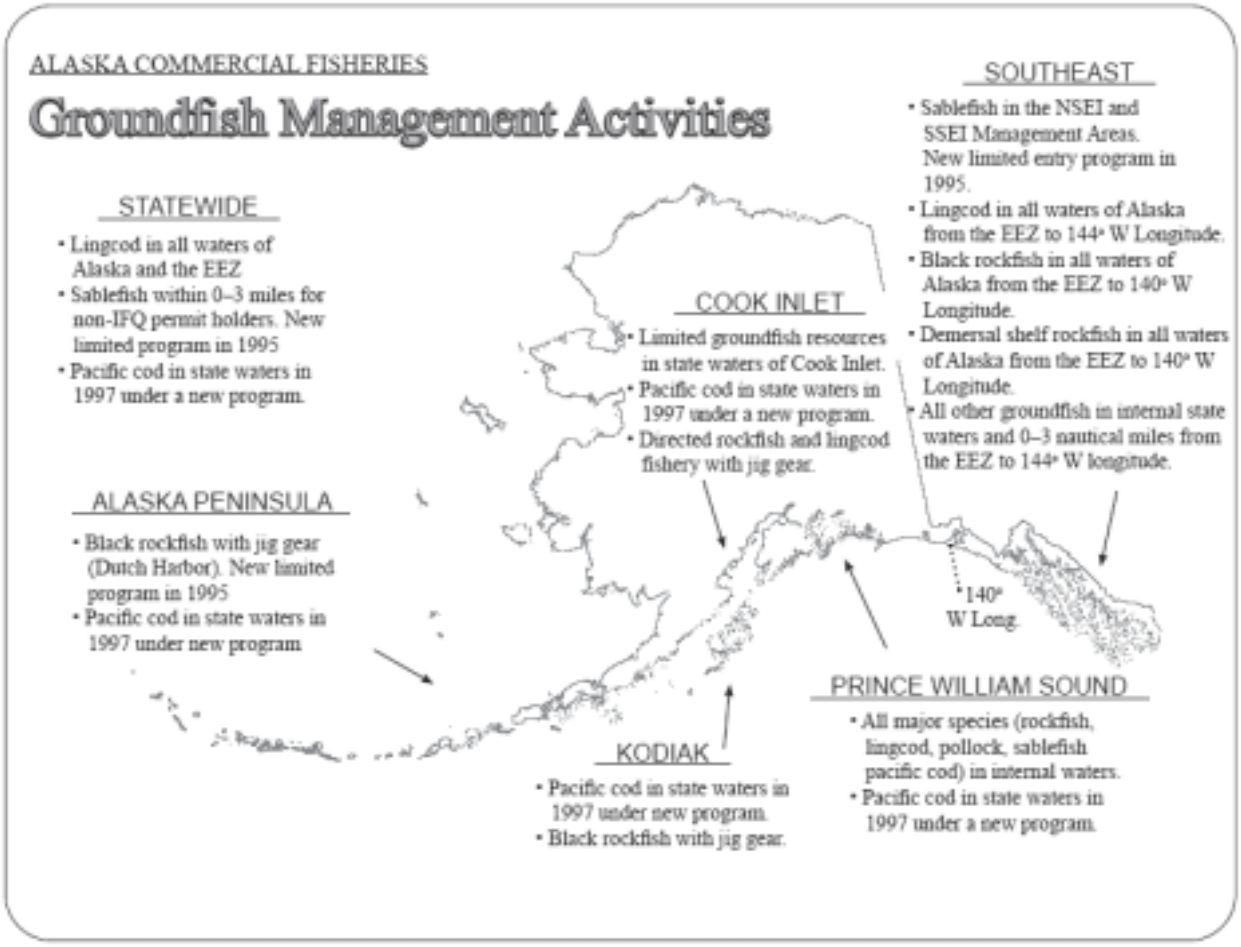

Figure 18.–Locations of major groundfish fisheries in Alaska.

Most groundfish fisheries off the Alaskan coast are managed by the NMFS under federal Fishery Management Plans (FMPs) adopted by the North Pacific Fishery Management Council (NPFMC). The status of groundfish stocks and federally-managed fisheries in the GOA and BSAI areas are summarized in annual stock assessment and fishery evaluation (SAFE) reports (e.g., NPFMC 2003a,b).

In general, groundfish fisheries in the U.S. Exclusive Economic Zone (EEZ; 3–200 nm offshore) fall under federal authority (Figure 18), whereas the State of Alaska manages groundfish fishery resources within state territorial (0–3 nm) waters. For most federal groundfish fisheries, ADF&G issues emergency orders for state waters that duplicate NMFS management actions, except that gear or other restrictions may vary. These emergency orders establish parallel fishing seasons (termed "parallel fisheries") allowing vessels to fish for groundfish (primarily Pacific cod,

walleye pollock, and Atka mackerel) in state waters with the same seasons as the federal fisheries. In other instances, the State of Alaska establishes “state waters” (or state-managed) fisheries with separate catch quotas (termed GHLs in state management), and fishing seasons under state groundfish regulations (Kruse et al. 2000). Where there is a federal and parallel fishery for a species, the state waters fishery usually opens after the parallel fishery closes.

The state has separate GHLs and seasons for sablefish, lingcod (*Ophiodon elongatus*), Pacific cod (*Gadus macrocephalus*), black rockfish (*Sebastes melanops*), and blue rockfish (*S. mystinus*) fisheries. State-managed fisheries for sablefish and Pacific cod occur within 3 nm of shore, and the state has full management authority extending throughout the EEZ for species (e.g., lingcod and black and blue rockfish) not covered by a federal FMP. Lingcod were never covered by the groundfish FMPs whereas black and blue rockfish were removed from them in 1998. In the central GOA, state-managed fisheries in state waters consist of pollock in Prince William Sound and Pacific cod, sablefish, and all rockfish species in state waters of Prince William Sound and Cook Inlet. As in the western GOA, the state has full management authority for lingcod and black and blue rockfish fisheries. In the eastern GOA the state has immediate management authority for demersal shelf rockfish, with cooperative oversight of the NPFMC under the GOA FMP.

PACIFIC COD FISHERIES

Pacific cod range from about 34° to 63° N latitude throughout the GOA and BSAI areas. They are mostly demersal (15–550 m deep) and concentrate on the outer continental shelf (100–200 m) where they spawn from January through April. They move to shallower waters (<100 m) in the summer. Cod feed opportunistically, mostly on polychaetes, amphipods, shrimp, and fish. They are prey for halibut, sharks, seabirds, and marine mammals such as fur seals *(Callorhinus ursinus)*. Cod enter the fishery about age 7 and may live 19 years or more. Primary products from the cod fishery include a headed and gutted (H&G) product, fillets, and to a lesser extent salted, whole fish, and roe (Kruse et al. 2000).

History

The oldest groundfish fishery off Alaska targets Pacific cod. The developing fishery peaked during 1916–1920 and steadily declined to 1950 (Kruse et al. 2000). Pacific cod supported large foreign fisheries in the Bering Sea during the 1960s and early 1970s. In the 1970s, foreign fishing fleets focused on sablefish and Pacific cod in the GOA. (Kruse et al. 2000). In the early 1980s a U.S. domestic trawl fishery and joint venture fisheries were operating in the BSAI, with the domestic fishery playing an increasingly dominant role over time. By 1991 the Pacific cod fishery was a completely domestic fishery (NPFMC 2004).

Management

Pacific cod fisheries in Alaska are managed by both the federal and state governments. The federally-managed fisheries for Pacific cod occur in both the Gulf of Alaska and Bering Sea/Aleutian Islands, with the bulk of the Gulf catch coming from the Central regulatory area (Thompson et al. 2003), and most of the BSAI catch coming from the eastern Bering Sea (EBS; Thompson and Dorn 2003). Parallel fisheries for Pacific cod occur in state waters at the same time as the federal fisheries in Prince William Sound, Cook Inlet, and in the vicinities of Kodiak Island, Chignik and the South Alaska Peninsula (Ruccio et al. 2004), as well as in the Aleutian Islands (Failor-Rounds 2004). For these parallel fisheries, NMFS management, allowable gear, bycatch levels, and fishing season actions are also "paralleled" for Pacific cod in state waters (Ruccio et al. 2004). The total allowable catch (TAC) set by the NPFMC applies to both the federal and parallel fisheries.

In the GOA, the annual federal TAC for Pacific cod is apportioned among seasons and regulatory areas, and on the basis of processor type, either inshore or offshore. Some apportionments were designed to try to limit possible negative impacts of the fishery on the endangered western population of Steller sea lion, *Eumetopias jubatus* (Thompson et al. 2003). The BSAI TAC is apportioned among the same gear types used in the GOA, but also among vessel size-classes (Thompson and Dorn 2003). The Pacific halibut mortality limit sometimes constrains the harvest of Pacific cod by longline and trawl fisheries (Thompson et al. 2003).

State-waters fisheries for Pacific cod began in 1997 in the Prince William Sound, Cook Inlet, Chignik, Kodiak, and the South Alaska Peninsula districts, and these are distinct from the parallel fisheries. Management plans approved by the Alaska Board of Fisheries for all five districts have some common elements focused on gear and area limitations. Vessels participating in the South Alaska Peninsula and Chignik areas are limited to no more than 58 feet in length. Catches are allocated on a percentage basis to various gear types. Guideline harvest limits (GHLs) for each of the 5 state-waters district are set by ADF&G as a percentage (2.25% to 15%)

of the GOA Pacific cod allowable biological catch (ABC) set by the NPFMC for federal fisheries (Ruccio et al. 2004). If the GHL is attained it may be increased in increments of the ABC in successive years. Pacific cod are also harvested under state regulations in Southeast Alaskan waters independent of the federal fishery.

Relationship of State to Federal management

In general, once the federal and parallel fisheries close, the state water fisheries are opened (except that there is no state-waters cod fishery in the Bering Sea/Aleutian Islands area) and these are not currently subject to limits on the number of licensed fisherman who can participate. To accommodate the catch in the state-waters fisheries since 1997, TACs in the federally-managed fisheries have been set well below the ABC (Thompson et al. 2003).

Gear

Pacific cod are harvested using trawls, longlines, pots and jigs in both the federal and parallel fisheries, while in state-waters fisheries only pots and jigs are allowed. Trawls account for approximately two thirds the federal fishery harvests (Thompson et al. 2003). Most state waters in the Gulf of Alaska, excluding parts of the Alaska Peninsula, are closed to bottom trawling, and parallel fisheries in those areas (including Prince William Sound and Cook Inlet) are dominated by longline and pot catches. During the parallel fishery in the western GOA, catches are taken by all four gear types with trawls and pots accounting for most of the catches in the South Alaska Peninsula area, pots and longlines dominating Kodiak landings, and pots accounting for most of the Chignik area catches. In the state-managed cod fisheries, including those opening after closure of parallel fisheries, no trawling is allowed; and the majority of the harvest is by pots.

Recent Harvests

During the 5-year period ending 2002 an average of 743 permitted vessels harvested 530,000 lb of Pacific cod in the federal and parallel fisheries for an average exvessel value of almost $138 million. In state-waters fisheries for Pacific cod, 495 permits yielded an average of about 25,000 lb with an exvessel value of $6.5 million (Table 9, Figure 19).

Conservation and other Issues

Stocks of Pacific cod are currently relatively low, although Pacific cod in the GOA and BSAI are neither overfished nor approaching that condition. Preliminary examination of Pacific cod tagging data suggests the possibility of some greater separation of Pacific cod population segments, nearshore and farther offshore, than is currently thought to exist. This may warrant some greater level of state assessment activity in the future than currently occurs. Management of Pacific cod and distribution of allowable catch between state, parallel and federal fisheries figure prominently in ongoing deliberations about groundfish “rationalization” (i.e., rationing rights to fish). Pacific cod is considered essential prey for Steller sea lions and management measures have been implemented to mitigate negative impacts of Pacific cod fisheries on Steller sea lions.

Table 9.–Recent 5-year average harvests, value, permits, and status for Alaska commercial groundfish fisheries. Averages are for the period 1998–2002.

Species	Management Agency[a]	Harvest (lb)	Permits (State)	Vessels (Federal)	Value	Status[b]
Pacific cod	State	25,534,484	495	---	$6,551,684	U
	Federal	529,788,705	---	743	$138,840,000	L/L, S/Dc[1]
Walleye pollock	State	1,960,276	6	---	$214,850	U
	Federal	2,869,911,705	---	196	$266,840,000	M/L, Dc/S
Sablefish	State	4,049,149	95	---	$12,342,235	L/S
	Federal	31,961,699	---	435	$66,300,000	L/L, S/S
Demersal shelf rockfish	State/Federal	905,309	1,047	---	$820,206	L, S
Black rockfish	State	494,872	235	---	$186,285	U
Rockfish[2]	State	836,710	907	---	$476,914	U
	Federal	104,174,909	---	184	$9,640,000	
Lingcod	State	398,157	646	---	$303,230	U
Atka mackerel	State	151,166	18	---	(confidential)	U
	Federal	118,998,333	---	13	$11,960,000	M/U, Dc/Dc
Flatfish	State	658,672	226	---	$102,146	U
	Federal	482,984,622	---	104	$ 36,600,000	
Total		4,172,808,768			$551,177,550	

[a] State indicates harvests within state waters, including parallel fisheries and fisheries managed by the State of Alaska in state waters. Federal indicates harvests in the EEZ beyond 3 nautical miles of shore.

[b] For federally-managed fisheries for the Bering Sea-Aleutian Islands (BSAI) and Gulf of Alaska (GOA) status is indicated with the format: BSAI biomass level/GOA biomass level, BSAI biomass trend/GOA biomass trend. Status abbreviations: Dc = declining, L = low, M = medium, S = stable, U = unknown.

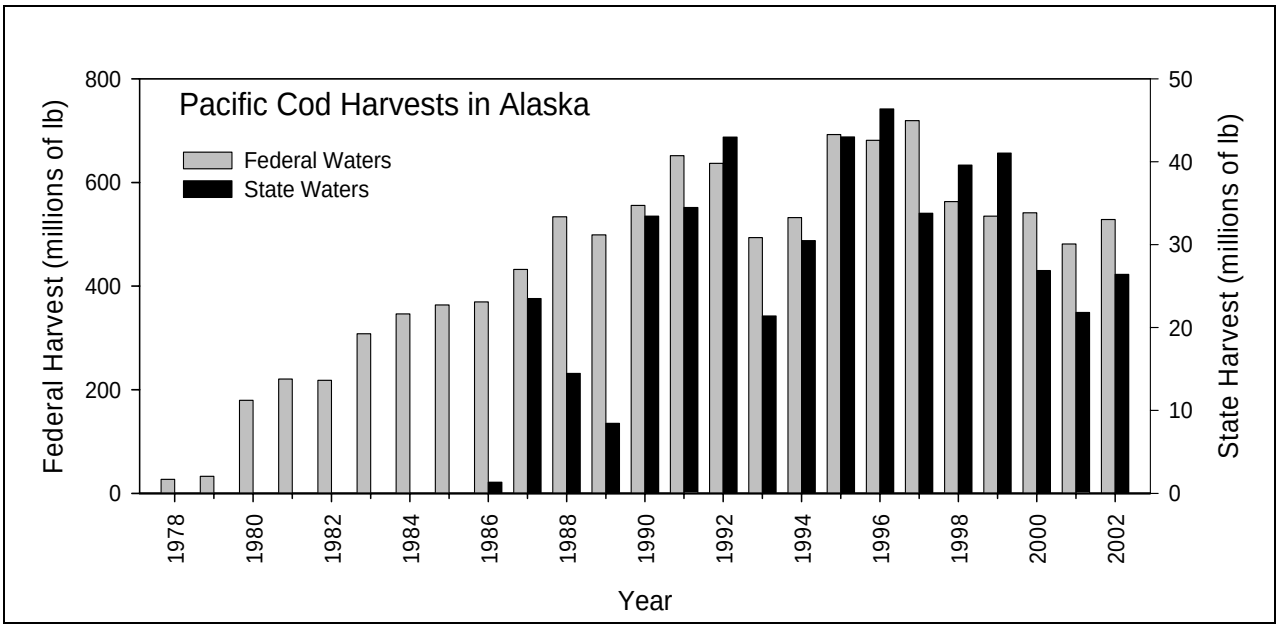

Figure 19.–Commercial harvests of Pacific cod in state- and federally-managed fisheries in Alaska, 1986–2002.

WALLEYE POLLOCK FISHERIES

Walleye pollock (*Theragra chalcogramma*) are distributed broadly in the North Pacific Ocean and eastern and western Bering Sea. In the Gulf of Alaska, pollock are considered as a single stock separate from those in the Bering Sea and Aleutian Islands. They are semidemersal (i.e., semi-bottom dwelling) distributed from near the surface to depths of 500 m. In the BSAI region, three areas are identified for pollock management purposes. These include the eastern Bering Sea shelf, the Aleutian Islands Region and the Central Bering Sea—Bogoslof Island area. In late winter/early spring pollock form huge spawning aggregations, including those found in Shelikof Strait and the eastern Bering Sea northwest of Unimak Island. Smaller aggregations in the Gulf of Alaska include those at the Shumagin Islands, the entrance to Prince William Sound, and near Middleton Island. In summer, large aggregations have been found on the east side of Kodiak Island, nearshore along the southern Alaska Peninsula, and other areas. Pollock migrate seasonally between spawning and feeding areas. They feed on copepods, euphausiids, and fish, and are preyed on by other fish, marine mammals, and seabirds. Pollock enter the fishery around age 3 and live to 15 years or more. Primary products from the pollock fishery include surimi, minced product, fillets, meal, oil and roe (Kruse et al. 2000).

History

Following early exploratory fishing in the Bering Sea in 1930, Japan fished for pollock during 1933–1937. By the early 1960s Japanese trawlers began targeting pollock. Bering Sea foreign (Japan, Russia and Korea) fisheries reached a record 4.8 billion lb (2.2 million mt) of pollock, flatfish, rockfish, cod, and other groundfish in 1972. Thereafter, total groundfish harvests dropped sharply in the BSAI (Kruse et al. 2000).

In 1995, a state-managed directed pollock fishery was initiated in Prince William Sound (Kruse et al. 2000), and harvests have averaged 4.98 million lb (2,259 mt) annually.

Management

Federal fisheries for walleye pollock occur in the GOA and BSAI. In the GOA, winter fishing has traditionally targeted pre-spawning aggregations in Shelikof Strait and the Shumagin Islands (Dorn et al. 2003). Summer fishing has often occurred on the east side of Kodiak Island and along the Alaska Peninsula. (Dorn et al. 2003). Beginning in 1992, the GOA pollock TAC has been apportioned temporally and spatially to try to reduce negative impacts on Steller sea lions (Dorn et al. 2003). All of the GOA pollock quota is allocated to the inshore sector.

Winter fishing in the BSAI is concentrated on spawning aggregations on the continental shelf of the eastern Bering Sea (EBS), mainly north and west of Unimak Island (Ianelli et al. 2003). Fall fishing has recently concentrated near Unimak Island and along the 100 m contour northwest of the Pribilof Islands (Ianelli et al. 2003). Measures have been taken to try to reduce potential negative impacts of the pollock fishery on endangered Steller sea lions. These measures have included fishery exclusion zones around sea lion rookeries and haulouts and changes in seasonal apportionments to reduce catch near critical habitat and temporally disperse the fishery (Ianelli et al. 2003). Former fishing grounds in the Aleutian Islands were closed to pollock fishing in 2000 (Ianelli et al. 2003). Limitations have been placed on the number of vessels participating in the BSAI pollock fisheries. The BSAI quota has been allocated among the western Alaska community development quota (CDQ) program and the inshore, offshore and mothership sectors of the industry.

The Prince William Sound pollock fishery is managed using a harvest rate strategy, where the GHL is the product of the biomass estimate, instantaneous natural mortality rate (0.3) and a precautionary factor of 0.75 (Table 7.1 in Bechtol 1999). Biomass is estimated by bottom trawl surveys in summer and hydroacoustic surveys in winter. In 1999 the BOF directed the ADF&G to establish a Prince William Sound pollock trawl fishery management plan to reduce potential impacts on the endangered population of Steller sea lions by geographically apportioning the catch. Although pollock in the GOA are considered one stock, pollock in Prince William Sound appear not to be assessed by NMFS surveys in the GOA. Therefore, ADF&G surveys of pollock in Prince William Sound are used to set the GHL, rather than setting the GHL in Prince William Sound as a fraction of the federal TAC for the GOA (Kruse et al. 2000).

Parallel fisheries for pollock take place in state waters around Kodiak Island, in the Chignik Area and along the South Alaska Peninsula (Lowe and Lauth 2003).

Gear

Over 95% of the pollock catch in the BSAI is taken with pelagic trawls. In the Gulf of Alaska 90% of the catch is also taken using pelagic trawls (Dorn et al. 2002). In both the GOA and BSAI there is a small incidental catch with hook and line and pot gear. Since 1995, a pelagic trawl fishery in Prince William Sound has targeted pollock.

Recent Harvests and Status

In the 5-year period ending 2002 pollock harvests have averaged almost 2.9 billion pounds (1.3 million mt) in the federal fishery and have varied from a high of almost 118 million pounds (53,000 mt) in the state fishery in 1998 to a recent low of about 2.5 million pounds (1,200 mt) in 2002 (Table 9, Figure 20). The federal fishery had an average of 196 permitted vessels and the catch yielded an average exvessel value of almost $267 million. Counterpart values for the state fishery were six permits and almost $215 thousand (Table 9).

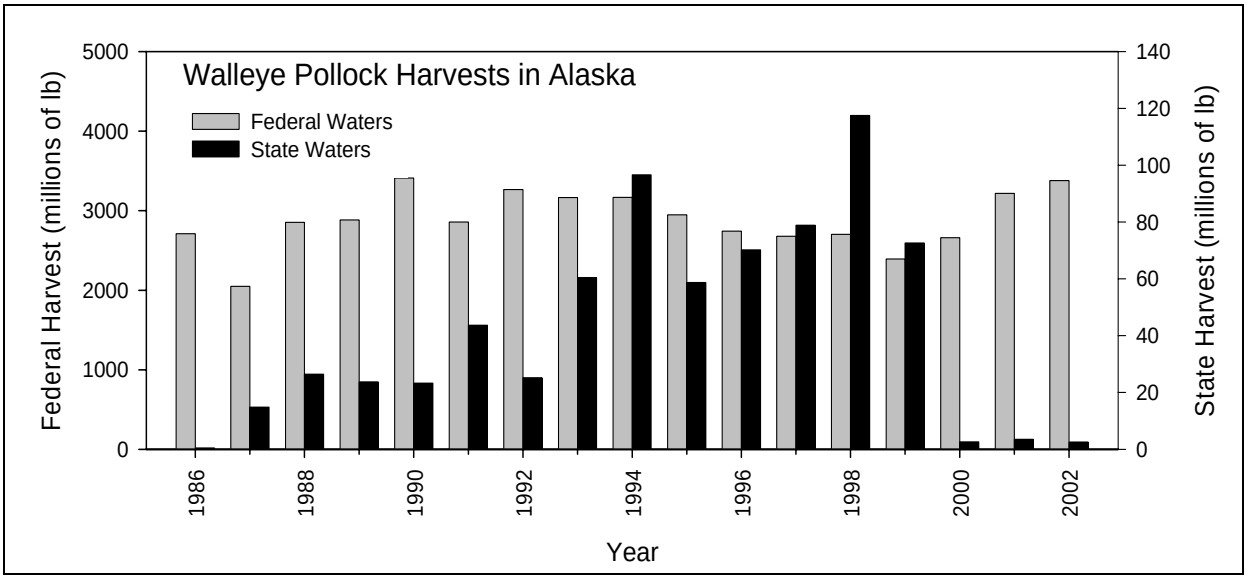

Figure 20.–Commercial harvests of walleye pollock in state- and federally-managed fisheries in Alaska, 1986–2002.

Conservation and Other Issues

The biomass of pollock in the eastern Bering Sea is currently at a medium level relative to recent (post-1978) levels and appears to be decreasing. Pollock biomass in the GOA is relatively low but increasing. Populations in neither area are considered overfished nor approaching overfished conditions. Although localized depletion of pollock in the EBS may occur as a result of commercial exploitation, pollock apparently have the ability to rapidly repopulate areas where localized depletion may have occurred. In Prince William Sound, where a relatively small, state-managed fishery occurs, pollock survey biomass estimates from the biennial bottom trawl survey have declined recently, and fishery harvest levels have been reduced as a result. Recent genetic studies provided evidence suggesting that spawning aggregations in some areas in or adjacent to the Gulf of Alaska, such as Prince William Sound, may be sufficiently different to merit management as distinct stocks. Concerns about habitat degradation of the ocean bottom resulting from bottom trawling for pollock have largely been addressed by conversion of the fishery in the EBS to pelagic trawl gear. Similar concerns about habitat degradation in the GOA led to a prohibition on trawling east of 140° W longitude. Pollock is considered essential prey for Steller sea lions and management measures, such as fishery time and area closures around critical sea lion habitat, as well as reductions in seasonal proportions of pollock TAC that can be taken from critical habitat, have been implemented to mitigate possible negative impacts of pollock fisheries on Steller sea lions.

ATKA MACKEREL FISHERY

Atka mackerel range from the Kamchatka Peninsula in the west, through the eastern Bering Sea and eastward through the Gulf of Alaska to Southeast Alaska. The center of abundance is in the Aleutian Islands (Lowe et al. 2002). The predominately pelagic behavior of Atka mackerel changes during spawning when they become demersal. During spawning they move from the edge of the continental shelf to shallow, nearshore waters, where they form dense spawning aggregations (Lowe et al. 2002). In the waters off Alaska, spawning peaks from July to October (Lowe et al. 2002).

Little is known of the early life history of Atka mackerel. They first appear in trawl surveys and the fishery at ages 2–3 (Lowe et al. 2002). The diet of Atka mackerel varies but is dominated by copepods and euphausiids. Other fish, marine mammals and sea birds prey upon Atka mackerel (Lowe et al. 2002).

Although genetic studies suggest no substantive differences in Atka mackerel between the BSAI and GOA, there are differences in geographic distribution, body size and recruitment patterns in the two areas. The population in the BSAI also appears more resilient to fishing than that in the GOA (Lowe, et al. 2002).

History

Fisheries for Atka mackerel evolved from strictly foreign fisheries in the 1970s, largely by fishermen from the U.S.S.R., Japan and the Republic of Korea. These were followed by joint venture fisheries with American catchers and foreign processing ships in the 1980s, and those were replaced by a wholly domestic fishery since 1990 (Lowe, et al. 2002).

Management

Fisheries for Atka mackerel take place primarily in federal waters of the EEZ, although some harvest also occurs in state waters of the Aleutian Islands as a parallel fishery under the jurisdiction of the State of Alaska (Failor-Rounds 2004). Parallel fisheries conducted elsewhere in state waters, primarily for Pacific cod and pollock, also yield catches of Atka mackerel.

A bycatch-only fishery for Atka mackerel is prosecuted in the GOA, with apparent targeting for Atka mackerel in the Western and Central GOA (Lowe and Lauth 2003). In the BSAI, catches of Atka mackerel are concentrated in the vicinities of Unimak and Akutan Passes and along the Aleutian Islands between Seguam and Attu Islands (Lowe and Lauth 2003).

The TAC for Atka mackerel is dispersed temporally and geographically to reduce possible adverse impacts of the fishery on the endangered western Steller sea lion (Lowe and Lauth 2003). The level of fishing for Atka mackerel in critical Steller sea lion habitat was also reduced (Lowe and Lauth 2003). Fishing effort in the Central and Western Aleutians is reduced by allowing only half of the fleet to fish at one time within Steller sea lion critical habitat (Lowe and Lauth 2003). In addition, trawling is prohibited within specified distances from rookeries and haulouts (Lowe and Lauth 2003).

Recent Harvests and Status

In the 5-year period ending 2002 Atka mackerel harvest in federal fisheries has averaged almost 119 million pounds (54,000 mt) worth an average of almost $12 million (Table 9, Figure 21).

State-waters catches average less than one tenth of a percent of the federal catches. There was an average of 13 vessels in this fishery (Table 9).

Conservation and Other Issues

The estimated biomass of Atka mackerel in the Aleutian Islands is at or near historic, post-1977 highs. Atka mackerel are not overfished nor nearing an overfished condition. An Atka mackerel population in the GOA, in the Kodiak, Chirikof and Shumagin areas supported a large foreign fishery through the early 1980s. This population had apparently disappeared by the mid-1980s. Recent reappearance of Atka mackerel in surveys has led to the suggestion that the GOA may be at the edge of the range for the species. Because of generally low and fluctuating populations, the fishery for Atka mackerel in the GOA is a bycatch-only fishery. Like pollock and Pacific cod, Atka mackerel is an essential prey item for Steller sea lions. As a result, measures were implemented for the Atka mackerel fisheries in the BSAI that included prohibitions on trawling within specified distances from rookeries and temporal and spatial dispersion and reduction of fishing within sea lion critical habitat. Fishing effort has also been dispersed through management action to reduce the chance of localized depletions of Atka mackerel.

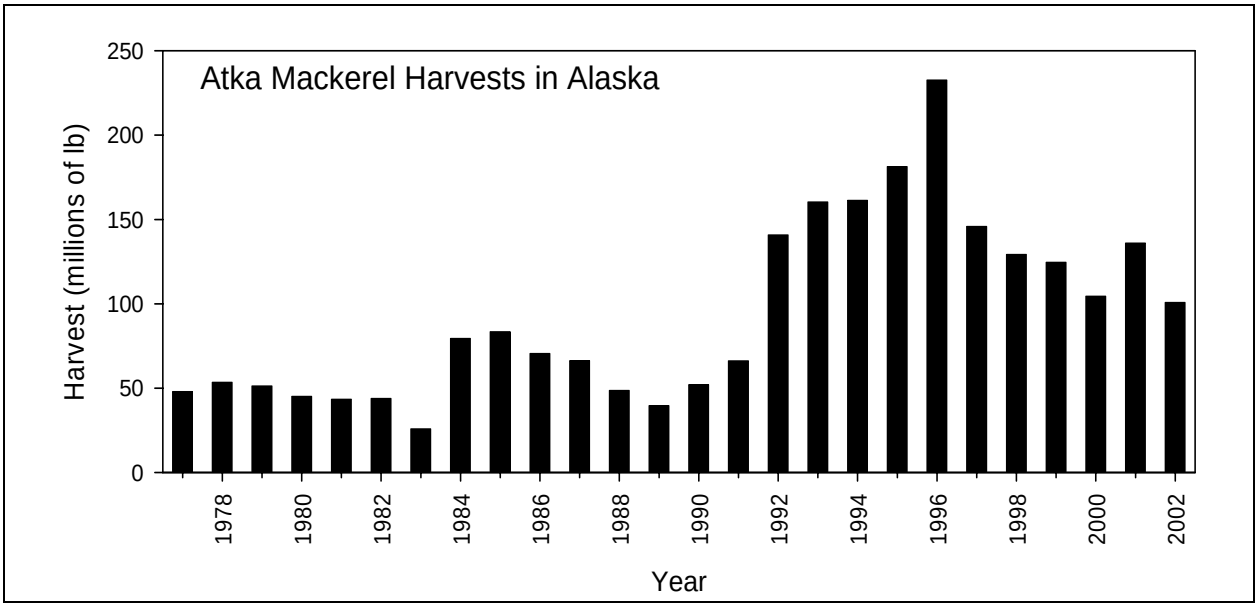

Figure 21.–Commercial harvests of Atka mackerel in federally-managed fisheries in Alaska, 1986–2002.

SABLEFISH FISHERIES

Sablefish are distributed throughout the GOA, and BSAI areas off the coast of Alaska. Adults generally live in waters of 150–1,500 m, but are primarily concentrated at 400–1,000 m along the continental slope. Juveniles tend to be pelagic or semipelagic, living in shallower, nearshore waters, and moving deeper with age. Sablefish spawn during late winter to early spring. Substantial migration of sablefish among the GOA and BSAI areas has been documented. Sablefish are often considered to be a single population along the west coast of the U.S. and into Alaska, but they are managed as four stocks. They are opportunistic feeders, and prey includes fish, crustaceans, and cephalopods. Juvenile sablefish are eaten by a wide variety of fish, by sea birds and pinnipeds. Pacific halibut, cod, lingcod, hagfishes (*Eptatretus* sp.), sharks, and killer whales (*Orcinus orca*) reportedly eat adults. Sablefish reach a maximum age of 62 years in Alaska. The primary product is a headed and gutted fish, but otherwise whole fish for Japanese markets with small amounts distributed in specialty domestic markets (Kruse et al. 2000).

History

In the 1880s a commercial fishery began for halibut (*Hippoglossus stenolepis*) with sablefish (*Anoplopoma fimbria*) targeted as a secondary fishery in the inside waters of Southeast Alaska (Kruse et al. 2000, Sigler et al. 2003). In 1958, Japanese longliners began harvesting sablefish in the eastern Bering Sea, moving to the Aleutian Islands and GOA as Japaneses trawl fisheries preempted the fishing grounds (Sigler et al. 2003). In the 1970s, Japanese, Russian, Korean, and Taiwanese longliners focused on sablefish and cod in the GOA. (Kruse et al. 2000). The U.S. longline fishery began expanding in the early 80s in the GOA, and by the late 80s almost all sablefish harvested in Alaska were taken by the U.S. fleet. Ever decreasing season lengths accompanied complete domestication of the federal until an individual fishing quota (IFQ) program and 8-month season for the fixed (longline and pot) gear fishery was implemented in 1995. In 2003, the season length was extended to eight and a half months, beginning on March 1. (NPFMC 2004).

Management

In federally-managed sablefish fisheries, most of the sablefish catch in the GOA comes from the central Gulf, followed by Southeast. Catches from the Bering Sea and Aleutian Islands portions of the BSAI area were similar in 2002. In the GOA sablefish are caught primarily in a directed longline fishery and as bycatch in trawl fisheries (DiCosimo and Kimball 2001). In both the GOA and BSAI, the TAC is allocated differentially among gear types in different management areas (DiCosimo and Kimball 2001; Witherell 2000). In the federally-managed BSAI sablefish fishery, 20% of the BSAI fixed gear quota is allocated to Community Development Quota (CDQ) communities (Witherell 2000).

Fixed gear (longlines and pots) sablefish fisheries in both the GOA and BSAI are conducted under Individual Fishing Quota (IFQ) programs. The fixed gears seasons open March 15 and close November 15, concurrent with the halibut fishery (DiCosimo and Kimball 2001; Witherell 2000).

State-managed sablefish fisheries in the Southeast Region (Chatham and Clarence Straits) are managed under a shared quota system. All permit holders receive an equal share of the annually determined catch quota. The Chatham Strait fishery is a longline fishery. The Clarence strait fishery is primarily a longline fishery with some catch in pots. In recent years, the sablefish

season in Chatham Strait opened on September 1 and closed November 15. Beginning in 2003, the Chatham Strait fishery opened on August 15 and closed on November 15. The sablefish longine fishery in Clarence Strait runs from June 1 to August 15 and the pot fishery from September 1 to November 15.

Sablefish fisheries managed by ADF&G west of 144° W longitude include a limited entry fishery in Prince William Sound and open access fisheries in the Cook Inlet and Aleutian Island areas. The Prince William Sound sablefish fishery is managed for a GHL set as the midpoint of a guideline harvest range derived from the estimated area of sablefish habitat and a yield-per-unit-area model (Berceli et al. 1999). Fishing season length is based on the GHL, estimated number of participants, and past catch rates. In Cook Inlet, the first GHL was set in 1997 based on the recent 10-year average harvest of 96,000 lb (43.5 mt) adjusted up or down annually in proportion to the federal TAC set for the central GOA (Trowbridge 1998). The Aleutian Islands sablefish management area includes all state waters west of Scotch Cap Light (164° 44" W. longitude) and south of Cape Sarichef (54° 36" N. latitude). The fishery opens May 15 and closes concurrent with the federal fishery unless closed earlier by emergency order when the state GHL is attained. In the Aleutian Islands the GHL is based on a combination of harvest history, fishery performance, and the federal TAC based on NMFS surveys.

Relationship of state to federal management

In contrast to parallel fisheries for pollock and Pacific cod, there are no parallel sablefish fisheries managed by the state. Quotas and seasons separate from those established for the federally-managed sablefish fisheries are established for the state waters fisheries in the Aleutian Islands (Westward Region) and the state-managed fisheries in Prince William Sound (Central Region) and Chatham and Clarence Straits (Southeast Region).

Gear

The state-managed, directed fishery for sablefish in Chatham Strait is restricted to longlines. The Clarence Strait sablefish fishery has separate seasons during which longline and pot gears are allowed. In the Prince William Sound districts, the majority of the catch is taken with longlines, although one bottom trawl vessel qualifies for the limited entry sablefish fishery (Berceli et al. 2002). In state-managed fisheries in the BSAI area, longline, pot, jig, and hand troll are legal gear types (Failor-Rounds 2004).

In the federally-managed sablefish fisheries in the GOA, sablefish are caught primarily by longline gear in the directed fishery and as bycatch in trawls. In the BSAI sablefish are caught with trawl, longline, and pot gear.

Recent Harvests and Status

In the 5-year period ending 2002 harvest of sablefish has averaged almost 32 million pounds (14,000 mt) in the federal fishery and have varied from a high of over 5.4 million pounds (2,000 mt) in the state fishery in 1998 to a recent low of about 3.3 million pounds (1,200 mt) in 2002 (Figure 22). There was an average of 435 permitted vessels in the federal sablefish fishery producing catch with an average exvessel value of $66 million. An average of 95 permits in the state fishery yielded $12 million.

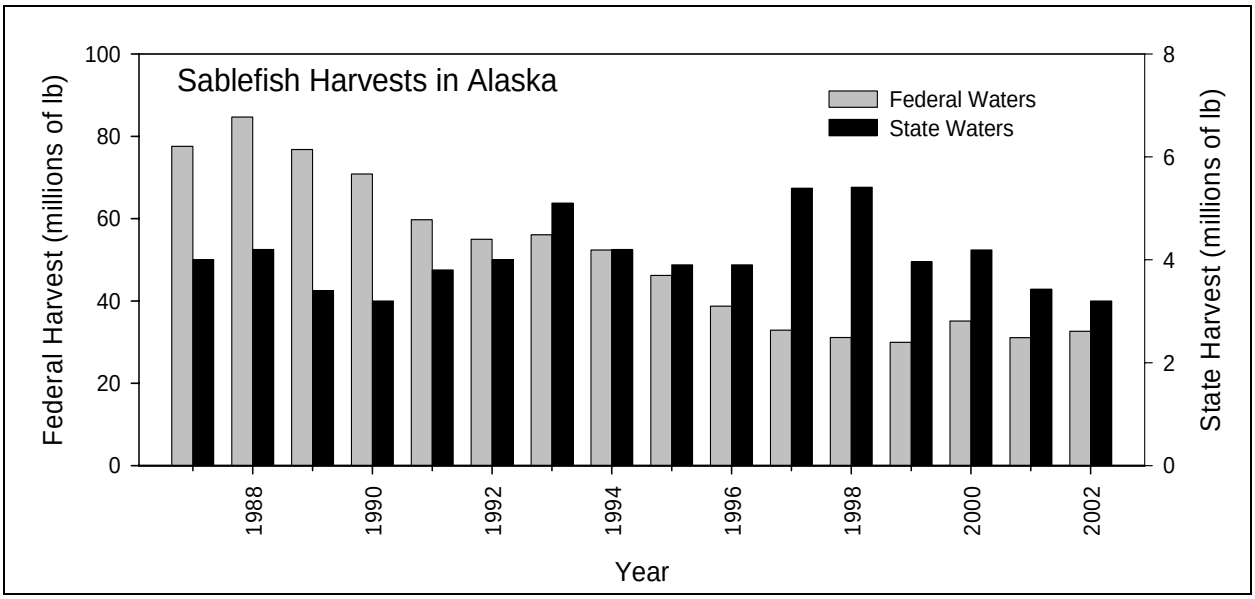

Figure 22.–Commercial harvests of sablefish in state- and federally-managed fisheries in Alaska, 1986–2002.

Conservation and Other Issues

Although at a low level relative to the peak abundances of the late 1980s and early 1990s, the sablefish population in the GOA and BSAI is relatively stable. The population is neither overfished nor approaching an overfished condition. There are currently small, open access fisheries for sablefish in state waters in the North Gulf District of Cook Inlet and the Aleutian Island District. Although not currently problematic, such open access fisheries for high valued sablefish could result in fishing pressure sufficient to overtax management capabilities and/or result in localized depletion. Due to funding constraints and assessment complexity, there is currently an adequate stock assessment program for only one of five discrete sablefish fisheries within state waters. Increased interest in sablefish aquaculture, in Canada and the United States, is raising issues—similar to those raised by salmon farming—about the potential negative impacts of sablefish farming on the health of wild stocks of sablefish and on the market for wild sablefish.

ROCKFISH FISHERIES

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

1. demersal shelf rockfish (DSR), predominated by yelloweye rockfish (*Sebastes ruberrimus*) in the commercial catch, are those that live in nearshore, shallow waters, over rocky bottoms;
2. pelagic shelf rockfish (PSR), including dusky rockfish (*S. variabilis*), widow rockfish (*S. entomelas*), yellowtail rockfish (*S. flavidus*), black rockfish, and blue rockfish, also live in nearshore waters, but mostly off the bottom. All five species had been under the jurisdiction of the NPFMC until 1998 when black and blue rockfish were removed from the federal FMP and placed under management jurisdiction of the state of Alaska; and
3. slope rockfish, which live on the edge of the continental shelf in depths greater than 150–200 m. From an ecological standpoint, the group includes Pacific ocean perch (POP; *S. alutus*), shortraker rockfish (*S. borealis*), rougheye rockfish (*S. aleutianus*), northern rockfish (*S. polyspinus*), and other species. For federally-managed fisheries, the NPFMC split these rockfishes into four groups primarily to avoid overfishing: POP, shortraker/rougheye, northern, and other slope rockfish. Also common in this depth zone are short-spined thornyhead rockfish (*Sebastolobus alascancus*)

Rockfish feed on a variety of prey. Juveniles eat mostly plankton, such as small crustaceans and copepods, as well as fish eggs. Adults eat fish, and crustaceans. Predators include sablefish, Pacific halibut and other fish species. Rockfish are a very long-lived group of fishes. Maximum ages differ by species with some species living as long as 140 years or more. Because of their longevity and the fact that most rockfish species are very site-specific and migrate little, rockfish populations are extremely vulnerable to overfishing. The primary commercial product for DSR is fresh, whole iced fish. Other rockfish species tend to be marketed as frozen (or fresh) fillets.

History

Since rockfish fisheries in the U.S. EEZ have become wholly domestic, most management species groupings have changed through splitting larger into smaller groups. The intent of these actions has generally been to prevent overfishing of certain higher valued species targeted within the formerly larger groups. In the GOA, examples are the removals of the demersal shelf rockfish assemblage from the “other rockfish” complex in 1987, and removals from the slope rockfish category—shortraker and rougheye rockfish in 1991 and northern rockfish in 1993. In the BSAI, species included in the “other rockfish” were removed from the POP complex in 1999, leaving POP as a single species management category.

With changing management regimes rockfish catches have often fluctuated markedly over the past four decades. There were high catches of many species of rockfishes during the 1960s through 1980s when fishing fleets from Japan, the Soviet Union and the Republic of Korea heavily targeted species such as POP, and thornyheads. Over time, reductions in catch were often associated with the phase out of foreign fishing effort in the EEZ due to limitations placed on foreign catch and/or probable fishery-related reductions in rockfish populations (e.g., POP). These declines were followed in some instances by increases to new peak catches with full domestication of the fisheries. Examples of fisheries that have exhibited this general pattern

include thornyheads, “other red rockfish” and POP in the BSAI and “other slope rockfish” and POP in the GOA.

Management

More than 30 species of rockfish in the genera Sebastes and Sebastolobus are harvested in the U.S. EEZ off Alaska. For management purposes rockfish in the GOA and BSAI are divided into management assemblages based on their habitat, habits, distribution and, in some cases, to reduce the chances of overharvest of certain more economically valuable species (DiCosimo and Kimball 2001, Witherell 2000; Table 9.).

Slope rockfish in the GOA inhabit waters of the outer continental shelf and shelf slope. To prevent their overharvest, shortraker and rougheye rockfish were removed from the slope rockfish assemblage, assessed independently and assigned a TAC separate from the slope assemblage. Pacific Ocean perch (POP) and northern rockfish were also removed from the slope assemblage and placed in their own management categories to reduce the chance of overharvest (DiCosimo and Kimball 2001). As in the GOA, POP constitute a single species management category in the BSAI (Witherell 2000).

Species in the pelagic shelf rockfish (PSR) assemblage in the GOA also inhabit the waters of the shelf but have a more pelagic distribution. While most rockfish in the PSR assemblage are harvested with trawls, beginning in 1991, PSR have been harvested by jig and longline gear, mainly near Kodiak and along the south shore of the Kenai Peninsula (DiCosimo and Kimball 2001).

The demersal shelf rockfish (DSR) assemblage includes seven species inhabiting nearshore waters of the GOA. (DiCosimo and Kimball 2001). Two species, yelloweye and quillback, make up 90% and 8% of the catch (DiCosimo and Kimball 2001). Demersal shelf rockfish are caught in a directed longline fishery in the Southeast Outside District and the internal State waters of Southeast Alaska, and as bycatch in the halibut longline fishery and trawl fisheries (DiCosimo and Kimball 2001).

Comprising a separate management assemblage in the GOA, shortraker and rougheye rockfish in the BSAI, are included along with northern rockfish in an “other red rockfish” assemblage (Witherell 2000), although TACs are now set individually for each of these species. “Other red rockfish” are caught by trawl catcher–processors and longline vessels (Witherell 2000).

Total allowable catches of some rockfish management assemblages are apportioned over time, among geographic areas and to CDQ groups (Witherell 2000).

The Prince William Sound rockfish management plan, includes three main components: (1) a 150,000 lb (68 mt) annual harvest cap for all species, (2) bycatch allowance for low-level retention once the directed fishery is closed, and (3) vessel trip limits.

Demersal shelf rockfish are managed jointly by the State of Alaska (ADF&G) and NMFS. (DiCosimo and Kimball 2001). Prior to 1998, black rockfish (S. melanops) and blue rockfish (S. mystinus) were included in the pelagic shelf rockfish assemblage in the GOA. However, in 1998 these two species were removed from the federal management plan and management jurisdiction for these species throughout Alaska was transferred to the state (Clausen et al. 2002). The state also manages rockfish (all species) in Prince William Sound and Cook Inlet.

Gear

Most rockfishes are harvested by trawls and to lesser extent by fixed gears, mainly longlines (DiCosimo and Kimball 2001). Substantial portions of the TAC of some species are taken as bycatch in other fisheries, as is the case with shortraker rockfish in the sablefish and halibut longline fisheries (DiCosimo and Kimball 2001).

Gear regulations vary across state waters. In the western GOA, rockfish may not be taken with seines. Rockfish may only be taken by mechanical jigging machines and hand troll gear in directed fisheries for these species in Cook Inlet. A directed longline fishery for DSR occurs in the Southeast Outside District and the internal waters of Southeast Alaska. DSR are taken is bycatch in the halibut longline fishery, and to a lesser extent in trawl fisheries.

Recent Harvests and Status

In the 5-year period ending 2002, an average of 184 permitted vessels produced rockfish harvests that have averaged 104.2 million lb (47,300 mt) worth $9.6 million in the federal fishery. In the state-managed (federal oversight) demersal shelf rockfish fishery 1,047 permitted fishermen produced an average catch of 905,000 lb (338 mt) worth $820,000 (Table 9, Figure 23). In the state-managed black rockfish fishery, 235 permitted fishermen produced an average catch of 495,000 lb (185 mt) worth $186,000 (Table 9.)

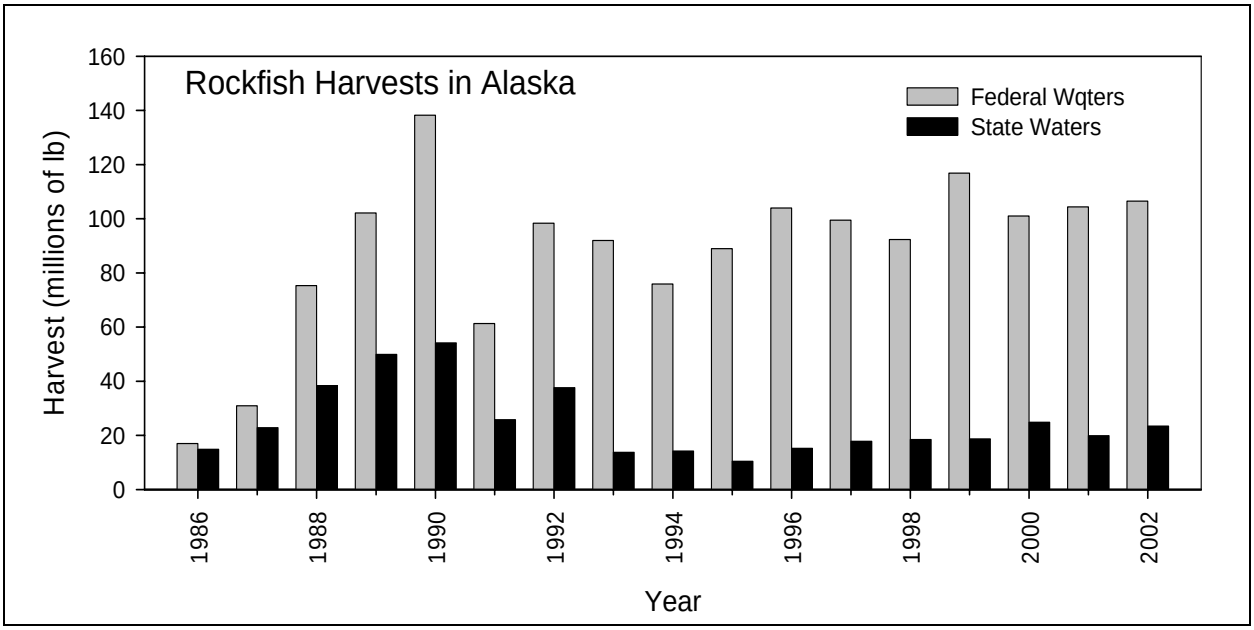

Figure 23.–Commercial harvests of rockfish in state- and federally-managed fisheries in Alaska, 1986–2002.

Conservation and Other Issues

Several life history characteristics of rockfish make them vulnerable to overfishing, so rockfish management requires a precautionary approach. For example, most Alaskan rockfishes are in the genus Sebastes, and species in this genus have a closed swim bladder that expands when the fish are brought to surface from depth. Fish injured in this way will often have their swim bladders protruding from their mouths. This can crush vital organs in the gut cavity and often leads to death, even for those rockfish discarded as bycatch. Bycatch of rockfish in some groundfish

trawl fisheries is very high, including an estimated 9 million lb of northern rockfish discarded in 2003, mostly in the Atka Mackeral fishery in the Aleutian Islands (NPFMC 2004).

Rockfish typically take much longer to become reproductively mature than many other commercial species, and have life spans that may exceed 100 years, including a phenomenal maximum age estimate of 205 years for rougheye rockfish (S. aleutianus; Munk 2001). Such longevity may be a bet-hedging strategy for ensuring some reproduction is successful despite various long periods with environmental conditions that are not favorable for larval survival (Leaman and Beamish 1984). These life history trait leads to slow recovery of populations that have been over-exploited, and this may be exacerbated when populations are sedentary such that local populations can be easily depleted. Recent groundfish fishery closures on the Pacific coast of the U.S. to protect depleted rockfish stocks highlight this problem.

LINGCOD FISHERIES

Lingcod are common in marine waters of Southeast Alaska, Prince William Sound, the outer Kenai Peninsula, and the Kodiak area. They occur at depths to 300 m, but more typically inhabit nearshore rocky reefs from 10–100 m. Most spawning occurs during January through March. Lingcod eat many other species of fish, including other lingcod. Male lingcod guard their egg nests and, if left unguarded, the eggs are preyed upon by rockfish, starfish, sculpins, kelp greenling, and cod. Salmon, rockfish, and other lingcod eat young lingcod. Maximum reported age is 25 years. Lingcod appear mostly sedentary and are not known to migrate extensively. Their sedentary habits, coupled to nest-guarding behavior, renders the species easily overfished. Lingcod are prized by commercial and recreational fishers for their high-quality white flesh. Primary seafood products are fresh and frozen fillets. ADF&G manages all lingcod fisheries in state and EEZ waters off Alaska.

History

Before 1987 the majority of the commercial lingcod catch in Southeast Alaska was incidental in fisheries targeting other species. Since 1987, the lingcod harvest has become increasingly important both in the direct fishery and as bycatch (Gordon 1994). Management plans adopted beginning in the 1990s in the Southeast and Central Regions have included winter closures to protect nest guarding males, localized closures to prevent overharvest of local aggregations, presumptive conservative guideline harvest levels, apportionment of GHLs among user groups, and minimum size limits (Coonradt et al. 2003).

Management

The minimum legal size of lingcod is 35” total length or 28” measured from the front of the dorsal fin to the tip of the tail. This size restriction is intended to allow lingcod to spawn at least two years prior to becoming vulnerable to the fishery (Trowbridge 1998). In the Prince William Sound Management Area, the lingcod fishery is split among two districts: the Inside and the Outside Districts. For each district, a conservative GHL is established based on 75% of the recent 10-year average harvest. In Prince William Sound lingcod are primarily caught as bycatch by longline vessels. In Cook Inlet, a GHL was 50% of recent 5-year harvest, and only mechanical jig and hand jig (hand troll) gear may be used to target lingcod. During the open fishing season in Prince William Sound and Cook Inlet, lingcod may be retained as bycatch in other directed fisheries in an amount that does not exceed 20% by weight of the directed groundfish species aboard the vessel.

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

Management regulations for lingcod in Southeast Alaska include a winter closure for all users except longliners between December 1 and May 15, a 27-inch minimum size limit, and allocations between directed commercial, sport, longline, and salmon troll fisheries. The winter closure is intended to protect nest-guarding males. Vessel registration and trip limits are allowed when needed to stay within allocations. A super-exclusive directed fishery for lingcod in the Icy Bay Subdistrict (IBS) was implemented in 2003 (Coonradt et al. 2003).

Gear

Lingcod are the target of a "dinglebar" troll fishery in Southeast Alaska. Dinglebar gear is salmon power troll gear modified with a heavy metal bar to fish for groundfish. As it bounces along the ocean bottom, the bar provides the weight necessary to keep the jigs near the bottom,. Additionally lingcod are landed as significant bycatch in the DSR longline fishery and as a limited bycatch in the halibut fishery (Coonradt et al. 2003). Lingcod may only be taken by mechanical jigging machines and hand troll gear in directed fisheries for this species in Cook Inlet.

Recent Harvests and Status

During the 1998–2002 period the average annual lingcod catch in the state-managed commercial fishery was 398,000 pounds (148.5 mt) (Figure 24). The average numbers of permits and exvessel value during the period were 646 and $303,000 (Table 9).

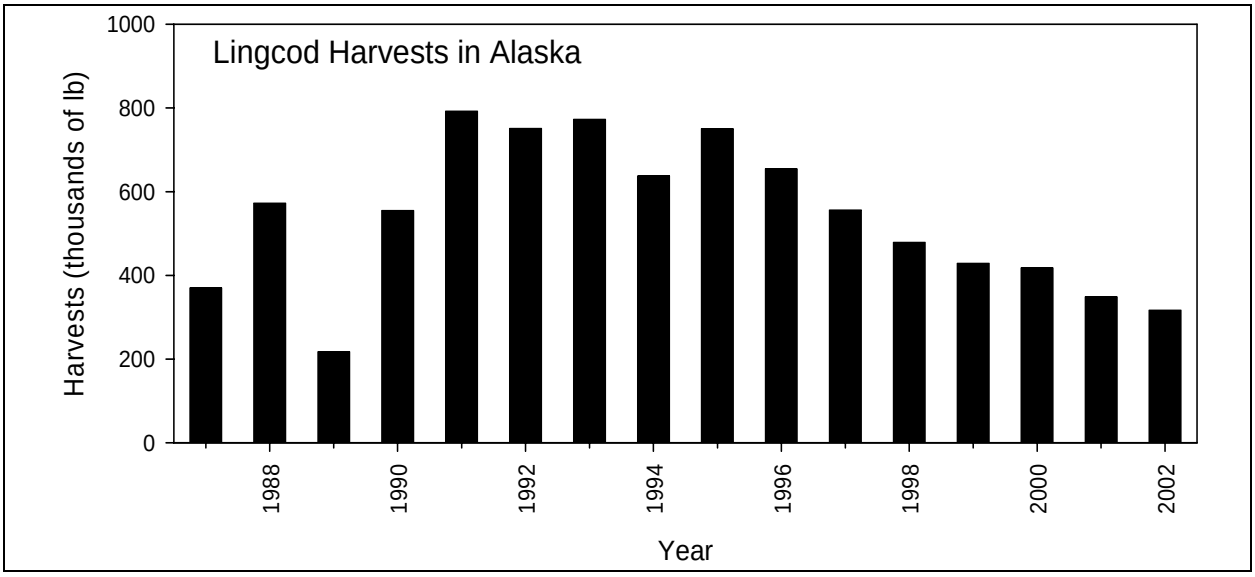

Figure 24.–Commercial harvests of lingcod in state-managed fisheries in Alaska, 1986–2002.

Conservation and Other Issues

There are currently no sufficiently accurate abundance estimates for lingcod in Alaska. This lack of adequate population information necessitates what are thought to be very conservative management actions. Such management actions include minimum size limits, winter fishery closures to protect nest-guarding males and total closures in some areas, such as Resurrection Bay along the outer Kenai Peninsula, to allow population rebuilding. However recent declines in CPUE in the directed commercial lingcod fishery in Southeast Alaska, suggested that further restrictions were necessary to prevent stock decline and serial depletion. Subsequently, the guideline harvest limits were reduced for the commercial fishery. Similarly bag and possession limits in the Southeast sport fishery have been reduced in recent years. There is great need for development of stock assessment methods to estimate abundance of lingcod and enhance the understanding of lingcod population dynamics.

FLATFISH FISHERIES

The marine waters of Alaska abound with over 30 species of flatfish (Mecklenburg et al. 2002). There is significant commercial harvest of at least a third of that number, including Pacific halibut, yellowfin, flathead and rock soles, Greenland turbot, Alaska plaice and arrowtooth flounder. Arrowtooth flounder, is currently the single most abundant groundfish species in the Gulf of Alaska, with a 2003 estimated biomass of almost 2.4 million metric tons (Turnock et al. 2003).

History

Up until the early 1980s the major commercial fisheries that yielded large harvests of flatfishes were those prosecuted by foreign fleets, primarily from Japan and Russia, targeting other groundfish species (DiCosimo and Kimball 2001, Witherell 2001). After cessation of foreign fishing in 1986 a brief span of joint venture fishing ensued from 1986 through 1988. Since 1989 all flatfish catch from the EEZ has been taken in domestic fisheries.

A small directed fishery for flatfish has occurred in the internal waters of Southeast Alaska since at least 1987, but there has been no significant effort in this fishery since 1999.

Management

Excluding halibut, over a dozen species of flatfish are caught as either target or bycatch species in federally-managed fisheries in the GOA and BSAI. For management purposes flatfish are included in species groups that differ between the GOA and BSAI (Table 1). Because of overlap of flatfish and halibut habitats and habits, flatfish fisheries catches are often constrained by halibut bycatch limits. (DiCosimo and Kimball 2001).

Most flatfish catch in the GOA occurs in the Central Gulf. Catch from the deep water flatfish category is comprised primarily of Dover sole from the continental shelf and slope east of Kodiak Island. The area east of Kodiak Island also yields most of the rex sole caught in the GOA (DiCosimo and Kimball 2001). Although there is little or no directed effort for the species, the largest flatfish catches are arrowtooth flounder, the most abundant groundfish species in the GOA (DiCosimo and Kimball 2001).

In 2002 in the BSAI, yellowfin sole comprised the largest catch of flatfish species, followed by rock sole, and flathead sole. Fishing for yellowfin sole occurs throughout the shelf area (Witherell 2000). In addition to being constrained by halibut and crab bycatch caps fragmented sentence. The rock sole fishery targets roe bearing females during the late winter. Most effort for this species is concentrated in outer Bristol Bay and north of Unimak Island (Witherell 2000).

Formerly targeted by both trawl and longline gear in the BSAI, Greenland turbot has been more recently targeted only by longline gear. There is significant bycatch of Greenland turbot in other fisheries. Most fishing for this species takes place along the shelf edge and slope, and along the Aleutian Islands. (Witherell 2000)

Halibut are harvested throughout the GOA and the BSAI EEZ, as well as from state waters. Halibut are managed, and stocks assessed, by the International Pacific Halibut Commission (IPHC). The ADF&G Division of Commercial fisheries does not include halibut as a groundfish species.

A small scale flatfish fishery occurs in three small areas in the internal waters of Southeast Alaska. The primary catch in this fishery is starry flounder, used as bait in other groundfish

fisheries. There has been almost no effort in the Southeast fishery for the past five years, with no harvest reported for the 2002–2003 season. When open, the fishery is restricted to use of beam trawls under a special permit stipulating time, area, gear, trip limits, mandatory logbooks, and if needed, ADF&G observers. These restrictions are in place because of a history of high bycatch rates of prohibited species such as crab and halibut (Coonradt et al. 2004).

A flatfish fishery in Prince William Sound harvests a mixture of shallow-water species (Coonradt et al. 2004).

Gear

With the exception of the longline fishery for halibut, the majority of the flatfish catch in Alaska is taken with trawl gear.

Recent Harvests and Status

In the 5-year period ending 2002 flatfish harvests in the federal fisheries have averaged 483 million lb (180,000 mt) with a value of almost $37 million. There was an average number of 104 permitted vessels fishing for flatfish during the period. During the same period an annual average of almost 659,000 lb (250 mt), worth $102,000 were caught in the state fisheries, with negligible catches during the period 2000–2002 (Table 9, Figure 25). There was an average of 226 permitted fishermen in state-managed fisheries for flatfish.

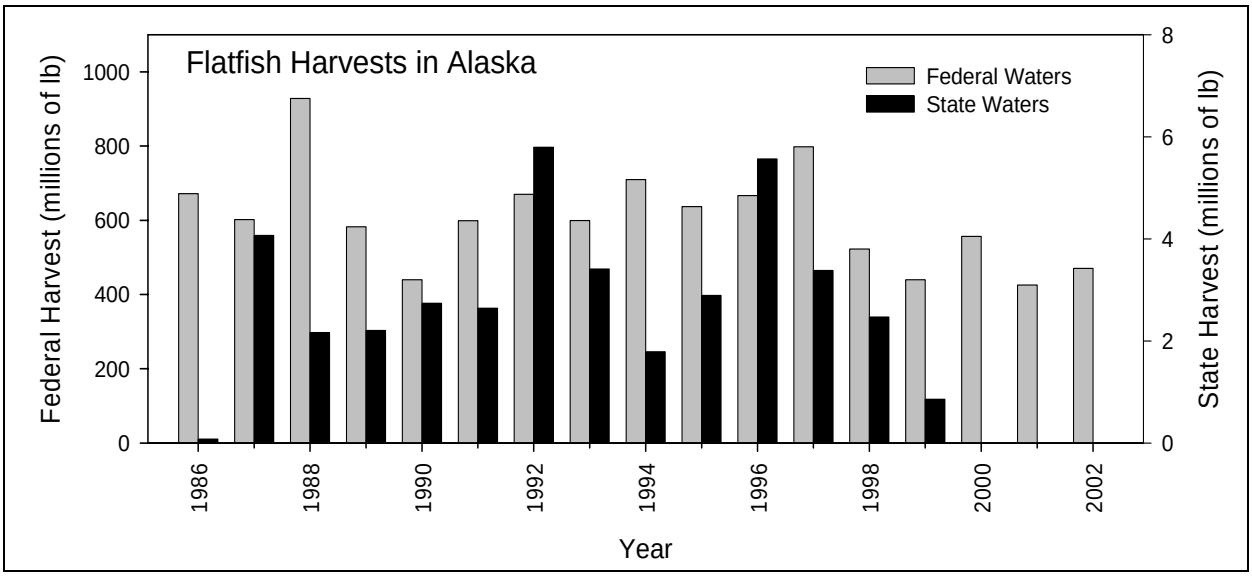

Figure 25.–Commercial harvests of flatfish in state- and federally-managed flatfish fisheries in Alaska, 1986–2002.

Conservation and Other Issues

Flatfish trawl fisheries, particularly in the eastern Bering Sea, have a history of substantial catch of nontarget species. In response to this potential wastage and incidental mortality, the NPFMC has instituted limits ("caps") on catch of prohibited species as well as improved retention and improved utilization (IR/IU) standards for other nontarget species. The most commonly caught of the prohibited species include halibut, red king crab, Tanner crabs, and snow crabs. Catches of these species are actively monitored, and the flatfish trawl fleet will move away from areas of high incidental catches to prevent reaching caps.

ACKNOWLEDGMENTS

This report was prepared with the assistance of numerous ADF&G staff in the Commercial Fisheries Division. In particular, we thank Denby Lloyd, Kurt Savikko, Gretchen Bishop and a host of reviewers.

REFERENCES CITED

ADF&G. 2001. Annual management report for the shellfish fisheries of the westward region, 2000. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K01-45, Kodiak.

ADF&G. 2002. Annual management report for the shellfish fisheries of the westward region, 2001. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K02-54, Kodiak.

Anderson, P. J. and J. F. Piatt (1999). Community reorganization in the Gulf of Alaska following ocean climate regime shift. Marine Ecology Progress Series 189:117–123.

Barnhart, J. P. (2000). Annual management report for the weathervane scallop fisheries of the westward region, 1999/00. Pages 262–300 *in* Annual management report for the shellfish fisheries of the westward region, 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4K00-55. Kodiak.

Barnhart, J. P. and G. Rosenkranz (2000). Summary and analysis of onboard observer collected data from the 1998/1999 statewide commercial weathervane scallop fishery. Alaska Department of Fish and Game, Division of Commercial Fisheries. Regional Information Report 4K00-8. Kodiak,

Bechtol, W. R. 1999. Prince William Sound walleye pollock: Current assessment and 2000 management recommendations. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A99-33, Anchorage.

Berceli, R., C. Trowbridge, M. A. Lambdin, W. Dunne, and W. R. Bechtol. 2002. Review of groundfish fisheries in the Prince William Sound management area: 2002 report to the Alaska Board of Fisheries. Alaska Department of Fish and Game..RIR No. 2A02-33.

Clausen, D., C. Lunsford and J. Fujioka. 2002. Pelagic shelf rockfish. In Stock Assessment and Evaluation Report for the Groundfish Resources of the Gulf of Alaska. p. 383–418. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, Alaska, 99510.

Coonradt, E., D. Urban, C. Trowbridge, W. Dunne, V. O'Connell, T. Brookover, C. Brylinsky, S. Meyer, K. Munk, M. Jaenicke, B. Piorkowski, L. Seeb, T. Haverland, B. Bechtol, and M. Ruccio. 2004. State of Alaska groundfish fisheries associated investigations in 2003. Prepared for the Forty Fifth Annual Meeting of the Technical Sub-committee of the Canada-United States Groundfish Committee. May 4–5, 2004. A joint publication of the Division of Commercial Fisheries and Division of Sport Fisheries, Alaska Dept. of Fish and Game, Juneau.

DiCosimo, J. and N. Kimball. 2001. Groundfish of the Gulf of Alaska: A Species Profile. North Pacific Fishery Management Council. Anchorage, AK. 99501.

Dorn, M., S. Barbeaux, M. Guttormsen, B. Megrey, A. Hollowed, M. Wilkins, and K. Spalinger. 2003. Assessment of the walleye pollock stock in the Gulf of Alaska. In Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Failor-Rounds, B. J. 2004. Bering Sea-Aleutian Islands area state-waters groundfish fisheries and groundfish harvest from parallel seasons in 2003. Alaska Department of Fish and Game, Division of Commercial Fisheries. Regional Information Report 4K04-45, Kodiak.

Funk, F. 1990. Migration of Pacific herring in the eastern Bering Sea as inferred from 1983–88 joint venture and foreign observer information. Alaska Department of Fish and Game, Division of Commercial Fisheries. Regional Information Report 5J90-04, Juneau.

Funk, F. 1991. Harvest policy implications of yield per recruit models for Pacific herring in Alaska. p. 453–462 in: Proceedings of the International Herring Symposium, Alaska Sea Grant Report AK-SG-91-01, Fairbanks, Alaska.

Funk, F. 2003. Overview of State-Managed Marine Fisheries in Southwestern Alaska, with reference to the Southwest Stock of Sea Otters. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 5J03-02.

Gordon, D. A. 1994. Lingcod fishery and fishery monitoring in Southeast Alaska. Alaska Fishery Research Bulletin. 1:140–152.

Ianelli, J. N., S. Barbeaux, G. Walters, and N. Williamson. 2003. Eastern Bering Sea Walleye Pollock Stock Assessment. In Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. p. 39–126. North Pacific Fisheries Management Council, Anchorage, AK

Jackson, D. R. and M. P. Ruccio (2003). Kodiak, Chignik, and South Peninsula shrimp fisheries and their management: a report to the Alaska Board of Fisheries. Alaska Department of Fish and Game Regional Information Report 4K03-7. Kodiak.

Kruse, G. H., F. C. Funk, H. J. Geiger, K.R. Mabry, H.M. Savikko, and S.M. Siddeek. 2000. Overview of State-Managed Marine Fisheries in the Central and Western Gulf of Alaska, Aleutian Islands, and Southeastern Bering Sea, with reference to Steller Sea Lions. Alaska Department of Fish and Game, Division of Commercial Fisheries Regional Information Report 5J00-10.

Leaman, B. M., and R .J. Beamish. 1984. Ecological and management implications of longevity in some northeast Pacific groundfishes. International North Pacific Fisheries Commission Bulletin 42:85–97.

Lambert, P. (1997). Sea cucumbers of British Columbia, Southeast Alaska, and Puget Sound. Vancouver, University of British Columbia.

Lowe, S. A., and R. Lauth. 2003. Atka mackerel. In Stock Assessment and Evaluation Report for the Groundfish Resources of the Gulf of Alaska. p. 699–718. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, Alaska, 99510.

Lowe, S.A., J. Ianelli, H. Zenger and R. Reuter. 2002. Atka mackerel. In Stock Assessment and Evaluation Report for the Groundfish Resources of the Gulf of Alaska. p. 609–668. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, Alaska, 99510.

Marty, G. D., M. S. Okihiro, E. D. Brown, D. Hanes, and D.E. Hinton. 1999. Histopathology of adult Pacific herring in Prince William Sound, Alaska, after the Exxon Valdez oil spill. Canadian Journal of Fisheries and Aquatic Sciences 56: 419–426.

Mecklenburg, C.W., T.A. Mecklenburg and L.K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society. Bethesda, MD.

Munk, K. M. 2001. Maximum ages of groundfishes in waters off Alaska and British Columbia and considerations of age determinations. Alaska Fishery Research Bulletin 8:12–21.

NPFMC. 2003a. Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. Compiled by The Plan Team for the Groundfish Fisheries of the Bering Sea/Aleutian Islands. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, Alaska, 99510

NPFMC. 2003b. Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. Compiled by the Plan Team for the Groundfish Fisheries of the Gulf of Alaska. North Pacific Fishery Management Council, Anchorage, Alaska.

NPFMC. 2004. Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands Region. Compiled by the Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands. North Pacific Fishery Management Council, Anchorage, Alaska.

NPFMC. 2004. DRAFT Environmental assessment/regulatory impact review/regulatory flexibility analysis for Amendments 84/76/19/11/8 to the BSAI Groundfish FMP (#84), GOA Groundfish FMP (#76), BSAI Crab FMP (#19), Scallop FMP (#11), and the Salmon FMP (#8) and regulatory amendments to provide Habitat Areas of Particular Concern. North Pacific Fishery Management Council, Anchorage, Alaska.

Pete, M. C. 1990. Subsistence herring fishing in the Nelson Island and Nunivak Island districts, 1990. Technical Paper No. 196, Division of Subsistence, Alaska Department of Fish and Game, Juneau.

Rigby et al., 1995. Management of Marine Fisheries Resources of Alaska: A Report to the Northern Forum. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 5J95-04.

Ruccio, M. P., K., A. Spalinger, and M. E. Cavin, Jr. 2004. Annual management report for the groundfish fisheries in the Kodiak, Chignik, and South Alaska Peninsula Management Areas, 2003. Alaska Department of Fish and Game Regional Information Report 4K04-44, Kodiak.

Shirley, S. M. and G. H. Kruse (1995). "Development of the fishery for weathervane scallops *Patinopecten caurinus* (Gould, 1850), in Alaska." Journal of Shellfish Research 14(1):71–78.

Thompson, G. G., H. H. Zenger, and M. K. Dorn. 2003. Assessment of the Pacific cod stock in the Gulf of Alaska. In Plan Team for the Groundfish Fisheries of the Gulf of Alaska (compiler), Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska p. 149–242. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Thompson, G. G., and M. K. Dorn. 2003. Assessment of the Pacific cod stock in the eastern Bering Sea and Aleutian Islands area. In Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (compiler), Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions, p. 127–222. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Turk, T. A. (2000). Distribution, abundance, and spatial management of the weathervane scallop (*Patinopecten caurinus*) fishery in Alaska. School of Fisheries. Seattle, University of Washington**:** 231.

Turnock, B. J., T. K. Wilderbuer and E. S. Brown. 2003. Arrowtooth flounder. In Plan Team for the Groundfish Fisheries of the Gulf of Alaska (compiler), Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska p. 369–406. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Witherell, D. 2000. Groundfish of the Bering Sea and Aleutian Islands Area: Species Profiles 2001. North Pacific Fishery Management Council. Anchorage, AK 99501.