ANNUAL STATUS OF THE FISHERIES REPORT
THROUGH 2003

Report to the Fish and Game Commission
as directed by the
Marine Life Management Act of 1998

Prepared by
California Department of Fish and Game
Marine Region
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Acknowledgements

Many of the fishery reviews in this *Annual Status of the Fisheries Report* are based upon reviews first presented in four previous reports that address the status of California's living marine resources:

- *California Ocean Fisheries Resources to the Year 1960* (published in 1961)
- *California's Living Marine Resources and Their Utilization* (published in 1971)
- *California's Living Marine Resources and Their Utilization* (published in 1992)
- *California's Living Marine Resources: A Status Report* (published in 2001)

The authors of the 1961, 1971, 1992 or 2001 editions are credited if significant portions of the text from an earlier review are included in the 2002 review. Authors' names and affiliations at the time they wrote or revised the review are listed at the end of each review.

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Annual Status of the Fisheries Report
Introduction

The Marine Life Management Act (MLMA) of 1998 recognized that one of the keys to effective fisheries management is periodic review. The MLMA mandated that the California Department of Fish and Game (DFG) review at least one quarter of state-managed marine fisheries annually, review each restricted access program at least every five years, and provide an annual report to the Fish and Game Commission. The *Annual Status of the Fisheries Report* (ASFR) is required to:

- Identify any fishery that does not meet the sustainability policies of the MLMA
- Evaluate whether the management system in place is fair and reasonable in its interactions with the people affected by management of the fishery
- Provide information on landings and fishing effort
- Identify areas where each fishery occurs
- Identify causes for any depressed fishery, and steps being taken to rebuild the fishery
- Recommend, to the extent practicable, additional steps that may be taken to rebuild the fishery
- Determine the consistency of restricted access fishery programs with the Fish and Game Commission's policies on restricted access fisheries (Fish and Game Code §7065 and §7066)

The focus of the ASFR is on state-managed marine species that are the subject of a directed recreational or commercial fishery. To determine the species of marine life to include in the annual ASFRs, the ASFR editors reviewed the list of state-managed marine life in the MLMA Master Plan (Appendix A). This list, which includes 375 categories of marine fish, invertebrates, plants and algae, was used as a basis for developing the list of species to be reviewed in ASFRs. ASFR editors modified the MLMA Master Plan list such that:

- Species that reside primarily outside state waters or in freshwater habitats were eliminated
- Species included in a Pacific Fishery Management Council (PFMC) fishery management plan were eliminated. However, species that are the subject of both a PFMC fishery management plan and a state fishery management plan were included
- Species with a prohibition on recreational and commercial harvest were eliminated
- Species not the subject of a directed marine fishery at present or in the foreseeable future were eliminated. However, species taken incidentally as bycatch, or that were previously the subject of a directed fishery, were included in the list of species to monitor

The ASFR list of species was divided into four groups. Every year, one group will be reviewed in a ASFR (Table 1), so that each group will be reviewed every four years. The ASFR list was further subdivided into species that will receive a detailed review (full review) and species that will be monitored and receive a limited review (Table 1). Each restricted access program will be reviewed in conjunction with the fishery to which it applies.

The ASFR list of species is a dynamic document that currently contains over 150 species (Table 1). As fisheries change, this list will be modified. For example, fishery landings will be monitored for new and emerging fisheries, and new species may be added to the list. Conversely, species no longer supporting a directed fishery, or species that become the subject of a PFMC fishery management plan, will be removed.

The MLMA mandate for periodic reports on the status of California's living marine resources was not created until 1998; however, the DFG has undertaken such reports previous to that time. The DFG has published four reports that address the status of California's living marine resources, often in conjunction with the University of California Sea Grant Extension Program:

- *California Ocean Fisheries Resources to the Year 1960* (published in 1961)
- *California's Living Marine Resources and Their Utilization* (published in 1971)
- *California's Living Marine Resources and Their Utilization* (published in 1992)
- *California's Living Marine Resources: A Status Report* (published in 2001)

In 2001, DFG collaborated with the University of California Sea Grant Extension Program to produce *California's Living Marine Resources: A Status Report*. This report presented the best information available for state-managed marine fisheries, federally-managed fisheries, anadromous fisheries, and marine wildlife. It also presented information about oceanic, environmental, regulatory, and socioeconomic factors that affect California's living marine resources. This ASFR builds upon and updates the information presented in the 2001 report.

This ASFR includes 14 reviews covering 42 species and 3 restricted access programs. Each review addresses the specific items required per Fish and Game Code §7065 and §7066 and provides:

- An overview of human use and harvest, including information on landings, fishing effort, and location of the fishery
- An overview of the biological characteristics of the species
- Our current understanding of the status of the population(s), identifying fisheries that are depressed or not sustainable
- A description of current management activities, factors that might affect management, and management activities that could be considered to sustain healthy populations, enhance populations or improve the fishery.

Three primary types of fishery-dependent data (that is, data collected directly from fishery activities) (Appendix B) were used in this ASFR:

- Commercial landing receipts for commercial fisheries

- Marine Recreational Fisheries Statistics Survey (MRFSS) estimates of recreational catch
- Commercial passenger fishing vessel (CPFV) logbook landings of recreational catch from CPFVs

Some reviews used other fishery-dependent and fishery-independent data sources; these sources are described in the individual reviews.

Table 1. List of fisheries reviewed in the *Annual Status of the Fisheries Reports*

Review title	Species in the review		Type of review[1]	Includes a review of a restricted access program[2]	Report cycle[3]
	Common name	Scientific name			
ALGAE					
Giant Kelp	giant kelp	*Macrocystis pyrifera*	Full		1
Bull Kelp	bull kelp	*Nerocystis luetkeana*	Full		1
Sea Palm	sea palm	*Postelsia palmaeformis*	Full		1
INVERTEBRATES					
Abalones	black	*Haliotis cracherodii*	Full		1
	flat	*Haliotis walallensis*	Full		
	green	*Haliotis fulgens*	Full		
	pink	*Haliotis corrugata*	Full		
	pinto	*Haliotis kamtschatkana*	Full		
	red	*Haliotis rufescens*	Full		
	white	*Haliotis sorenseni*	Full		
Intertidal Invertebrates	giant limpet	*Lottia gigantea*	Full		2
	multiple species of top shell	*Tegula funebralis, T. eiseni, T. gallina, T. aureotincta*	Full		
Subtidal Snails	wavy turban snail	*Megastraea undosa*	Full		2
	Kellet's whelk	*Kelletia kelletii*	Full		
Moon Snail	multiple species of moon snails	*Polinices spp.*	Limited		4
Hermissenda Nudibranch	hermissenda nudibranch	*Hermissenda crassicornis*	Limited		4
Littleneck Clams	banded chione	*Chione californiensis*	Full		3
	smooth chione	*Chione fluctifraga*	Full		
	wavy chione	*Chione undatella*	Full		
	common littleneck clam	*Protothaca staminea*	Full		
	Japanese (Manila) littleneck clam	*Tapes japonica, T. philippinarum*	Full		
	rough-sided littleneck clam	*Protothaca laciniata*	Full		
	thin-shelled littleneck clam	*Protothaca tenerrima*	Full		

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Review title	**Species in the review**		**Type of review[1]**	**Includes a review of a restricted access program[2]**	**Report cycle[3]**
	Common name	**Scientific name**			
Washington Clams	Washington clam	*Saxidomus nuttalli*	Full		3
	butter clam	*Saxidomus giganteus*	Limited		
Gaper Clams	Pacific gaper clam	*Tresus nuttalli*	Full		3
	fat gaper clam	*Tresus capax*	Full		
California Jackknife Clam	California jackknife clam	*Tagelus californianus*	Limited		4
Northern Quahog Clam	northern quahog clam	*Mercenaria mercenaria*	Limited		4
Goeduck Clam	goeduck clam	*Panopea genersoa*	Full		3
Pismo Clam	Pismo clam	*Tivela stultorum*	Full		4
Northern Razor Clam	northern razor clam	*Siliqua patula*	Limited		4
Softshell Clam	softshell clam	*Mya arenaria*	Limited		4
Rock Scallop	rock scallop	*Crassadoma gigantea*	Limited		4
Mussels	multiple species of mussels	*Mytilus galloprovincialis, M. trossulus, M. californianus*	Limited		4
Market Squid	market squid	*Loligo opalescens*	Full	X	4
Two-spot Octopus	two-spot octopus	*Octopus bimaculoides, O. bimaculatus*	Limited		4
Bay Shrimp	California bay shrimp	*Crangon franciscorum*	Full		2
	blacktail bay shrimp	*Crangon nigricauda*	Full		
	blackspotted bay shrimp	*Crangon nigromaculata*	Full		
	oriental shrimp	*Palaemon macrodactylus*	Full		
Prawns	golden prawn	*Penaeus californiensis*	Full	X	4
	ridgeback prawn	*Sicyonia ingentis*	Full		
	spot prawn	*Pandalus platyceros*	Full		
Coonstriped Shrimp	coonstriped shrimp	*Pandalus danae*	Full		4
Pink Shrimp	ocean shrimp	*Pandalus jordani*	Full	X	4
Red Rock Shrimp	red rock shrimp	*Lysmata californica*	Full		4
Blue Mud Shrimp	blue mud shrimp	*Upogebia pugettensis*	Limited		4
Ghost Shrimp	multiple species of ghost shrimp	*Callianassa californiensis, Callianassa affinis, C. gigas*	Limited		4
California Spiny Lobster	California spiny lobster	*Panulirus interruptus*	Full	X	1
Sand Crab	sand crab	*Emerita analoga*	Limited		4
Rock Crabs	brown rock crab	*Cancer antennarius*	Full		1
	red rock crab	*Cancer productus*	Full		
	yellow rock crab	*Cancer anthonyi*	Full		

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Review title	**Species in the review**		**Type of review[1]**	**Includes a review of a restricted access program[2]**	**Report cycle[3]**
	Common name	**Scientific name**			
Dungeness Crab	Dungeness crab	*Cancer magister*	Full	X	1
Slender Crab	slender crab	*Cancer gracilis*	Limited		4
Tanner Crab	tanner crab	*Chionoecetes tanneri*	Limited		4
Sheep Crab	sheep crab	*Loxorhynchus grandis*	Full		1
Box Crab	box crab	*Lopholithodes foraminatus*	Limited		4
Sea Urchins	red sea urchin	*Strongylocentrotus franciscanus*	Full	X	1
	purple sea urchin	*Strongylocentrotus purpuratus*	Full		
Sea Cucumbers	California sea cucumber	*Parastichopus californicus*	Full	X	2
	warty sea cucumber	*Parastichopus parvimensis*	Full		
FISHES					
Hagfish	black hagfish	*Eptatretus deani*	Limited		4
	Pacific hagfish	*Eptatretus stouti*	Limited		
Cow Sharks	sevengill shark	*Notorynchus cepedianus*	Full		2
	sixgill shark	*Hexanchus griseus*	Full		
Nearshore Sharks and Rays	brown smoothhound	*Mustelus henlei*	Full		2
	gray smoothhound	*Mustelus californicus*	Full		
	angel shark	*Squatina californica*	Full		
	shovelnose guitarfish	*Rhinobatos productus*	Full		
	thornback	*Platyrhinoidis triseriata*	Full		
	bat ray	*Myliobatis californica*	Full		
Pacific Electric Ray	Pacific electric ray	*Torpedo californica*	Limited		4
Pacific Herring	Pacific herring	*Clupea pallasi*	Full	X	3
True Smelt	night smelt	*Spirinchus starksi*	Full		4
	surf smelt	*Hypomesus pretiosus*	Full		
	whitebait smelt	*Allosmerus elongatus*	Full		
California Lizardfish	California lizardfish	*Synodus lucioceps*	Limited		4
Pacific tomcod	Pacific tomcod	*Microgadus proximus*	Limited		4
Silversides	California grunion	*Leuresthes tenuis*	Full		4
	jacksmelt	*Atherinopsis californiensis*	Full		
	topsmelt	*Atherinops affinis*	Full		

Table 1. List of fisheries reviewed in the *Annual Status of the Fisheries Reports*					
Review title	**Species in the review**		**Type of review[1]**	**Includes a review of a restricted access program[2]**	**Report cycle[3]**
	Common name	**Scientific name**			
Nearshore Rockfishes and Scorpionfishes	black rockfish	*Sebastes melanops*	Full	X (Nearshore and Deeper Nearshore)	3
	black-and-yellow rockfish	*Sebastes chrysomelas*	Full		
	blue rockfish	*Sebastes mystinus*	Full		
	brown rockfish	*Sebastes auriculatus*	Full		
	calico rockfish	*Sebastes dalli*	Full		
	China rockfish	*Sebastes nebulosus*	Full		
	copper rockfish	*Sebastes caurinus*	Full		
	gopher rockfish	*Sebastes carnatus*	Full		
	grass rockfish	*Sebastes rastrelliger*	Full		
	kelp rockfish	*Sebastes atrovirens*	Full		
	olive rockfish	*Sebastes serranoides*	Full		
	quillback rockfish	*Sebastes maliger*	Full		
	treefish	*Sebastes serriceps*	Full		
	California scorpionfish	*Scorpaena guttata*	Full		
Greenlings	kelp greenling	*Hexagrammos decagrammus*	Full	X (Nearshore)	3
	rock greenling	*Hexagrammos lagocephalus*	Full		
Cabezon	cabezon	*Scorpaenichthys marmoratus*	Full	X (Nearshore)	3
Pacific Staghorn Sculpin	Pacific staghorn sculpin	*Leptocottus armatus*	Full		2
Sea Basses	barred sand bass	*Paralabrax nebulifer*	Full		1
	kelp bass	*Paralabrax clathratus*	Full		
	spotted sand bass	*Paralabrax maculatofasciatus*	Full		
Ocean Whitefish	ocean whitefish	*Caulolatilus princeps*	Full		1
Yellowtail	yellowtail	*Seriola lalandi*	Full		4
Sargo	sargo	*Anisotremus davidsoni*	Full		2
California sheephead	California sheephead	*Semicossyphus pulcher*	Full	X (Nearshore)	3
Drums	California corbina	*Menticirrhus undulatus*	Full		3
	spotfin croaker	*Roncador stearnsi*	Full		
	white croaker	*Genyonemus lineatus*	Full		
	yellowfin croaker	*Umbrina roncador*	Full		
	queenfish	*Seriphus politus*	Full		
White Seabass	white seabass	*Atractoscion nobilis*	Full		3
Sea Chubs	halfmoon	*Medialuna californiensis*	Full		4
	opaleye	*Girella nigricans*	Full		

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	Common name	**Scientific name**			
Surfperches	barred surfperch	*Amphistichus argenteus*	Full		1
	black perch	*Embiotoca jacksoni*	Full		
	calico surfperch	*Amphistichus koelzi*	Full		
	dwarf perch	*Micrometrus minimus*	Full		
	kelp perch	*Brachyistius frenatus*	Full		
	pile perch	*Rhacochilus vacca*	Full		
	pink seaperch	*Zalembius rosaceus*	Full		
	rainbow seaperch	*Hypsurus caryi*	Full		
	redtail surfperch	*Amphistichus rhodoterus*	Full		
	reef perch	*Micrometrus aurora*	Full		
	rubberlip seaperch	*Rhacochilus toxotes*	Full		
	sharpnose seaperch	*Phanerodon atripes*	Full		
	shiner perch	*Cymatogaster aggregata*	Full		
	silver surfperch	*Hyperprosopon ellipticum*	Full		
	spotfin surfperch	*Hyperprosopon anale*	Full		
	striped seaperch	*Embiotoca lateralis*	Full		
	walleye surfperch	*Hyperprosopon argenteum*	Full		
	white seaperch	*Phanerodon furcatus*	Full		
Blacksmith	blacksmith	*Chromis punctipinnis*	Limited		4
Striped Mullet	striped mullet	*Mugil cephalus*	Limited		4
Pacific Barracuda	pacific barracuda	*Sphyraena argentea*	Full		4
Monkeyface Prickleback	monkeyface prickleback	*Cebidichthys violaceus*	Full		3
Wolf eel	wolf eel	*Anarrhichthys ocellatus*	Limited		4
Pacific bonito	Pacific bonito	*Sarda chiliensis*	Full		2
Pacific Pompano	Pacific pompano	*Peprilus simillimus*	Full		2
Sanddabs	longfin sanddab	*Citharichthys xanthostigma*	Full		2
	speckled sanddab	*Citharichthys stigmaeus*	Full		
California Halibut	California halibut	*Paralichthys californicus*	Full		1
Diamond Turbot	diamond turbot	*Hypsopsetta guttulata*	Limited		4
Fantail Sole	fantail sole	*Xystreurys liolepis*	Limited		4
OTHER REVIEWS					
Scientific Collection	multiple species		Full		2
Aquarium Trade	multiple species		Full		3
Emerging Fisheries	multiple species		Limited		4

Table 1. List of fisheries reviewed in the *Annual Status of the Fisheries Reports*

Review title	Species in the review		Type of review[1]	Includes a review of a restricted access program[2]	Report cycle[3]
	Common name	Scientific name			
General Gill and Trammel Net Restricted Access	Not applicable	Not applicable	Restricted Access Review only	X	2
Drift Gillnet (shark and swordfish) Restricted Access	Not applicable	Not applicable	Restricted Access Review only	X	4
Finfish Trap Restricted Access	Not applicable	Not applicable	Restricted Access Review only	X	3
Salmon Vessel Restricted Access	Not applicable	Not applicable	Restricted Access Review only	X	4

1. Each species will receive either a detailed review (full review) or a limited review. Species that are not the subject of a directed fishery, but are taken as bycatch or were previously the subject of a directed fishery will be monitored and receive a limited review.
2. Restricted access programs that are directly connected with a particular species or group of species on the *Annual Status of the Fisheries Reports* list of species will be reviewed in conjunction with that species or group of species. Other restricted access programs will be reviewed separately.
3. The list of reviews is divided into four groups (#1, 2, 3, and 4). Every year, one group will be reviewed.

1. GIANT KELP

Overview of Use and Harvest

Kelp is an important food source for humans and animals around the world. In Asia, Europe, and Australia, kelp has historically been used not only as a food source, but also as fertilizer and a component in gunpowder. Algin, a substance found in the cell walls of kelp, is an efficient thickening, stabilizing, suspending, and gelling agent used in a wide range of food and industrial applications. It can be found in various desserts, gels, milk-shake mixes, dairy products, and canned foods. It is also used to emulsify and stabilize salad dressings, to retain moisture and improve the texture of bakery products, to insure smooth consistency and uniform thawing in frozen foods, and to stabilize beer foam. In industrial applications, algin is used for paper and welding-rod coatings, sizing, and textile printing. In pharmaceutical and cosmetic applications, it is used to make tablets, dental impressions, antacid formulations, and facial creams and lotions. Giant kelp, *Macrocystis pyrifera*, is not only an important source of algin in California, it is also harvested and fed to cultured abalone, and used in the herring-roe-on-kelp fishery in San Francisco Bay.

Giant kelp was first harvested along the California coast during the early 1900s. Several harvesting companies operated from San Diego (San Diego County) to Santa Barbara (Santa Barbara County) beginning in 1911. These companies primarily extracted potash and acetone from kelp to use in the manufacture of explosives during World War I.

Kelp harvesting virtually stopped in the early 1920s, after the end of the war. In 1928, Philip R. Park Inc. of San Pedro began harvesting kelp and adding it to livestock and poultry food. In 1929, Kelco Company of San Diego (now ISP Alginates Inc.) began harvesting and processing giant kelp for livestock feed and algin.

Since 1917, kelp harvesting has been managed by the California Department of Fish and Game (DFG) under regulations adopted by the Fish and Game Commission (Commission). Regulations currently allow kelp to be cut no deeper than 4 ft beneath the surface, although the surface canopy can be harvested several times each year without damaging kelp beds. Kelp harvesting licenses are required to take kelp for commercial use. There are 74 designated giant kelp beds which can be leased for up to 20 years; however, no more than 25 sq. mi. or 50% of the total kelp bed area (whichever is greater) can be exclusively leased by any one harvester. In addition to leased beds, there are open beds that can be harvested by anyone with a valid kelp harvesting license. Harvesters pay a royalty of $1.71 to $10.00 per wet ton of kelp harvested.

In 2001, DFG completed an environmental review of giant and bull kelp sport and commercial regulations. As a result of this review, and of public and inter-agency input, a number of amendments were adopted addressing the commercial harvest of kelp. The more substantial amendments include:

- Requiring harvesters to obtain Commission approval of a harvest plan before a mechanical harvester can be used to harvest giant kelp in central and northern California
- Increasing the number of beds closed to harvest

- Closing a portion of a bed in Monterey County which experiences heavy seasonal harvest pressure
- Creating a mechanism for restricting harvest by imposing temporary harvest controls where necessary for resource protection

Giant kelp is one of California's most valuable living marine resources. In 2001, the kelp harvesting industry was valued at more than $30 million annually. Today, giant kelp is harvested from Imperial Beach in San Diego County, near the U.S.-Mexico border, to Santa Cruz (Santa Cruz County). Mexican harvesters in Ensenada provide another source of kelp from beds off Baja California.

The annual harvest has varied from a high of 395,000 tons in 1918 to a low of less than 1,000 tons in 1931 (Figure 1.1, Table 1.1). Such fluctuations are primarily due to climate change and natural growth cycles as well as market supply and demand. During the 10-year period from 1970 to 1979, the harvest averaged nearly 150,000 tons, while from 1980 to 1989 the average harvest was only 66,000 tons. During the 1980s, kelp harvests were devastated by the 1982-1984 El Niño event and accompanying storms, and the 200-year storm that occurred in January 1988. In most areas, giant kelp recovered quickly with the return of cooler, nutrient rich waters. Harvests in California increased to more than 130,000 tons in 1989 and to over 150,000 tons in 1990. During the 1990s, increased competition from Japan for "low end" or less-purified alginate caused ISP Alginates Inc. to reduce harvests by about half. ISP Alginates Inc. anticipates harvesting approximately 50,000 tons of giant kelp annually from California waters over the next several years.

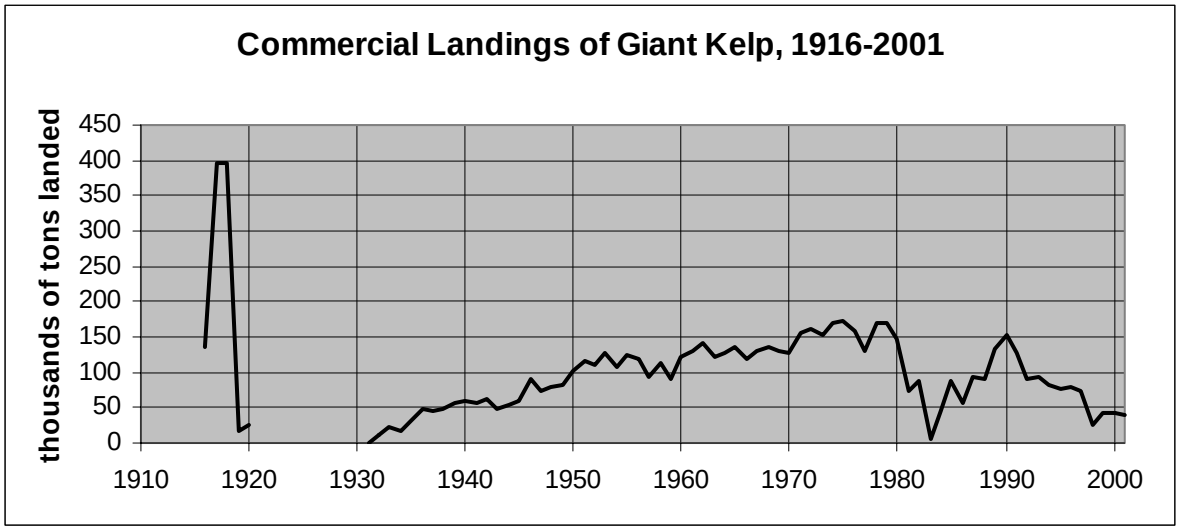

Figure 1.1. Annual commercial landings (tons) of giant kelp from 1916 to 2001. Data source is the Kelp Harvester's Monthly Report (logbook) and data is not available from 1921 to 1930. Kelp landings consist primarily of giant kelp (*Macrocystis pyrifera*).

Kelp harvesters use harvesting methods that best suit their purposes and needs. For example, ISP Alginates Inc. uses specially designed vessels with cutting mechanisms on the stern, and a conveyor system that places the cut kelp into a harvester bin. Blades mounted at the base of the conveyor are lowered 3 ft into the

kelp bed while propellers on the bow slowly push the harvester stern-first through the bed. These vessels can collect up to 600 tons of kelp per day. To facilitate its harvesting operations, the company conducts regular aerial surveys from June through November. This survey information is used to direct harvesting vessels to mature areas of kelp canopy that have sufficient density for harvesting. Another kelp harvesting company, The Abalone Farm, harvests kelp to feed cultured abalone using a modified U.S. Navy landing craft with a cutting device and conveyor system mounted on the bow. For the herring roe-on-kelp fishery, however, kelp is hand-harvested from small boats, loaded carefully into bins and transported by truck to San Francisco Bay.

Status of Biological Knowledge

Giant kelp forests occur in the temperate oceans of the Northern and Southern Hemispheres. These forests are especially well developed along the west coast of North America from Punta Abreojos in Baja California, Mexico, to Point Año Nuevo, San Mateo County, California. They create a unique habitat that provides food, shelter, substrate, and nursery areas for nearly 800 species of animals and plants. Many of these animals and some plants are of importance to sport and commercial fisheries.

Typically, giant kelp flourishes in wave-exposed areas of nutrient-rich, cool water ranging from 20 to 120 ft deep. The kelp attaches to rocky areas on the sea floor by means of a root-like structure called a holdfast. Along the protected shoreline of Santa Barbara County, however, giant kelp also grows on sand. Here, it attaches to exposed worm tubes or the remains of old holdfasts. Kelp fronds grow from the holdfast towards the sea surface. A frond is composed of a stem-like stipe which has numerous leaf-like blades springing from it. A gas-filled bladder at the base of each blade, called the pneumatocyst, helps buoy the frond in the water column.

Giant kelp absorbs nutrients from the water through all its surfaces. Under optimal conditions with high nutrient levels and low ocean temperatures (50° to 60° F), fronds can grow up to 2 ft per day. Fronds can reach a length of more than 150 ft, and large plants can have more than 100 fronds. As the fronds mature, die, and break away, young fronds take their place. Although giant kelp plants can live for up to 8 years, individual fronds last for only about 6 to 9 months, and individual blades live only about 4 months.

Giant kelp reproduction involves two very different growth forms, the large canopy-forming sporophyte and the microscopic gametophyte (Figure 1.2). Specialized reproductive blades, located just above the holdfast on an adult sporophyte, release trillions of microscopic spores each year. The spores settle on the bottom and develop into microscopic “male” and “female” gametophyte plants. Fertilization of the female gametophyte produces a small sporophyte. This tiny plant will develop into a canopy-forming adult within 7 to 14 months if it survives competition with other plants, and is not destroyed by undesirable environmental factors or eaten by grazers.

Status of the Beds

The density and abundance of kelp canopy varies by location, year, and season. In central California, natural plant deterioration occurs in late summer and early fall. Canopies virtually disappear during the late fall and winter, when storms cause frond and plant loss. Canopies usually begin forming again in the spring, and by summer are

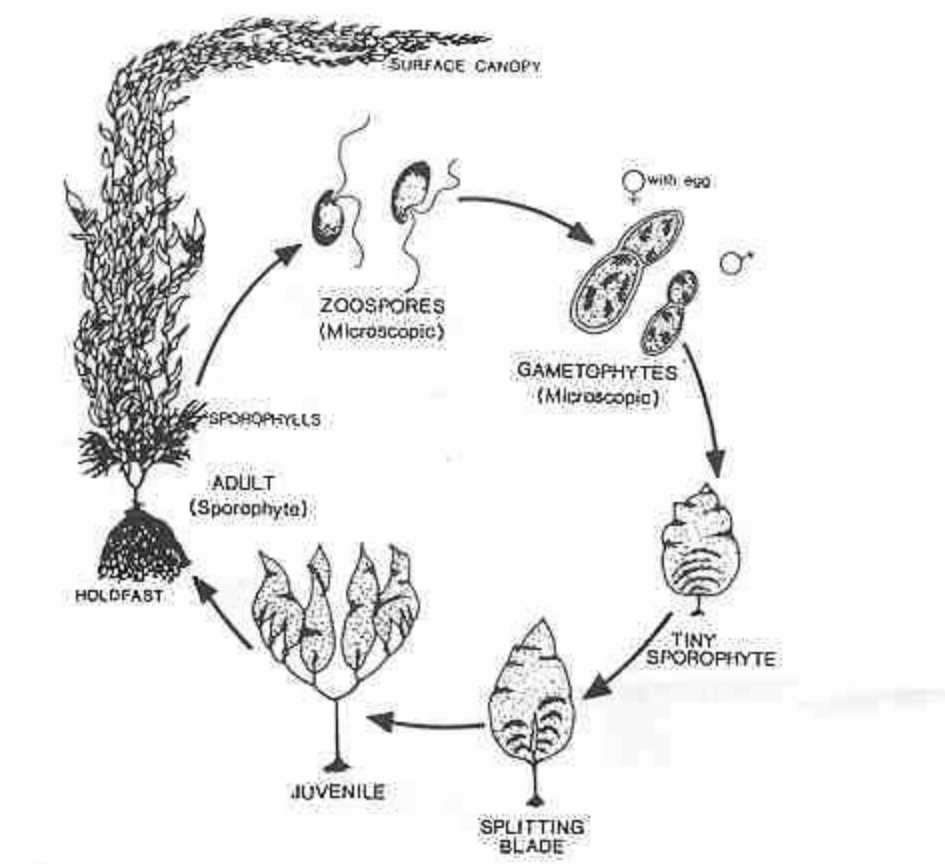

Figure 1.2. The life cycle of giant kelp. Foster, M.S. and D.R. Schiel. 1985. The Ecology of Giant Kelp Forests in California: A Community Profile. Fish and Wildlife Service. U.S. Dept. of the Interior, Biological Report 85(7.2).

quite dense. Off southern California, however, kelp canopies frequently grow throughout the year in the mild weather conditions. Dense canopies can develop during the winter, especially during mild years when storms and large swell events are infrequent.

The health and long-term survival of giant kelp forests is influenced by a variety of factors, including storms and climatic events, grazing, competition, sedimentation, pollution, and disease. These factors can be divided into two different types: naturally occurring, and human-induced. Southern California's giant kelp beds are influenced by both natural and human-induced factors.

Fluctuations in water temperature influence kelp survival in southern California to a great extent. South of Point Arguello (Santa Barbara County), in an area called the Southern California Bight, water temperatures are considerably warmer than for the rest of the State. The warmer water temperatures in this area tend to negatively affect kelp survival. Human influences on giant kelp also tend to be greater in southern California due to the concentration of the State's population within this region, and associated pollution and coastal development.

During the last 30 years, the size, distribution, and location of the kelp canopy throughout California has fluctuated considerably. An aerial survey conducted in 1967 showed a total of 70 sq. mi. of kelp canopy from around Point Montara (San Mateo

County) to the U.S.-Mexico border, with 53.9 sq. mi. of the total in southern California (Figure 1.3). In southern California, 33 sq. mi. occurred along the mainland coast and 20.9 sq. mi. occurred around the Channel Islands. A survey conducted in 1989 reported 40.7 sq. mi. of kelp canopy along the entire California coast. Of this, 17.5 sq. mi. were recorded for southern California. The Channel Islands accounted for 9.8 sq. mi., while the mainland coast of southern California totaled 7.7 sq. mi. During the most recent statewide kelp forest survey conducted in 1999, a total of 17.8 sq. mi. of giant kelp canopy was charted along the California coast, with 11.4 sq. mi. off southern California, including the offshore islands. The 1999 survey showed only 3.7 sq. mi. of giant kelp canopy along the mainland coast of southern California, and 7.7 sq. mi. off the Channel Islands.

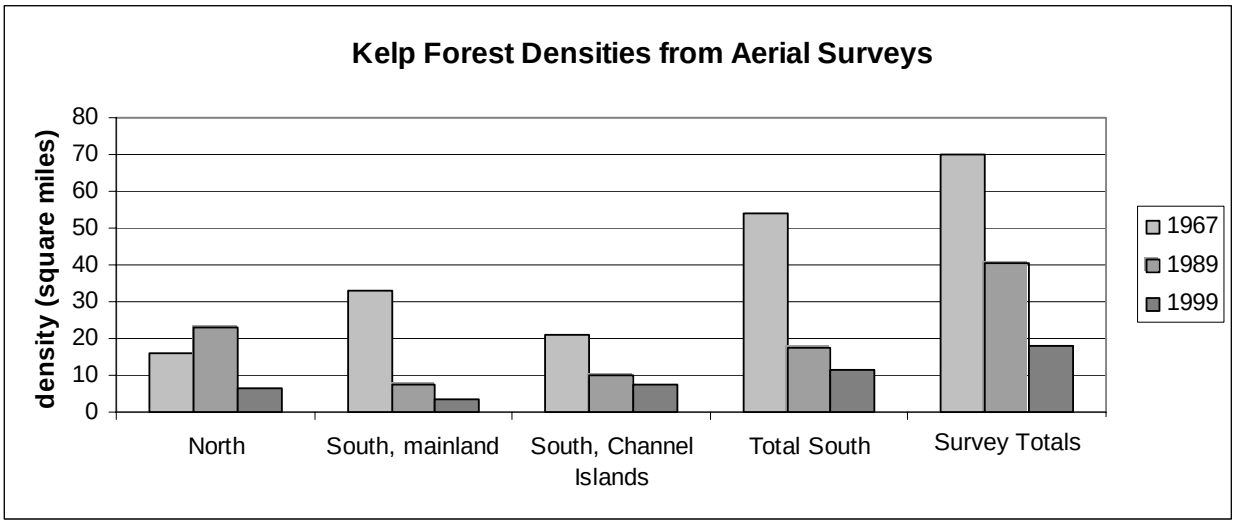

Figure 1.3. Kelp forest densities from aerial surveys completed in 1967, 1989, and 1999. South refers to areas south of Point Arguello, and north refers to areas north of Point Arguello.

The methodology used to conduct photographic aerial surveys is subject to a high degree of error. During these surveys, infrared film is used to highlight temperature differences between the kelp canopy at the water's surface and the background water temperature. Kelp immediately below the surface is invisible using this method. Results from these surveys may also vary due to wind waves and local currents. The degree of error in aerial kelp surveys could be greatly reduced by conducting surveys more frequently, and by using new technology such as digital multi-spectral imaging.

This being said, it is still evident that kelp forests are declining, particularly in southern California. The decline can be at least partly explained by the warming trend over the past 20 years and the frequency of severe El Niño events. However, the warming trend cannot explain differences in kelp canopy distribution between the Channel Islands and the mainland coast in southern California, since both areas are likely to experience the same oceanographic conditions in a given year. This suggests that the change in the relative abundance of kelp in these two areas may be due to factors other than warming trends.

During the 1980s and 1990s, many major oceanographic events affected kelp beds, including an El Niño event from 1982 through 1984, a devastating storm within that same period, and a large swell event in 1988. Excessive wave action from storms and surge can break kelp fronds and dislodge entire plants. Dislodged plants can also become entangled with other, nearby plants, pulling them from the substrate. Two more El Niño events occurred from 1992 through 1994 and from 1997 through 1998, with the 1992-1994 El Niño event followed by severe storms. The most recent El Niño event, from 1997 through 1998, was the warmest of the three.

The warm water and storms associated with the El Niño events destroyed plants, inhibited kelp growth, and resulted in minimal canopy development throughout southern California. During the 18-year period from 1981 to 1998, sea surface temperatures exceeded the previous 60-year mean in all but a single year (1988). In 1967, there were approximately 18 sq. mi. of kelp canopy near Santa Barbara, compared to only 6 sq. mi. in 1989. When last checked in 2000, the giant kelp forests that had been anchored in sand substrate near Santa Barbara had not returned.

Fishes such as opaleye and halfmoon regularly graze upon kelp. These fish can damage kelp forests when present in large numbers, especially when conditions are unfavorable for kelp growth. Invertebrates such as sea urchins, amphipods, isopods, and crabs also graze on kelp and may cause damage. The removal of the southern sea otter from southern California eliminated a major predator on sea urchins, and changed the balance of predator-prey relationships in the kelp bed community.

In addition, intensive fishing for some of the remaining sea urchin predators, such as California sheephead and California spiny lobster, and fishing for sea urchin competitors such as abalone has significantly altered the sea urchin population dynamics in kelp forests. Sea urchin populations increased exponentially in some areas and overgrazed the kelp, creating areas referred to as “urchin barrens.”

Human activities may also influence the health and distribution of kelp beds. Human-caused disturbances include pollution, sedimentation, wastewater discharge and thermal (warm-water) discharge. Sedimentation of the rocky bottom can retard kelp growth and even bury young plants, preventing development and reproduction. Pollution can affect kelp forests in a variety of ways. Industrial and domestic wastewater discharges carry toxins such as pesticides and heavy metals, which can accumulate in nearshore sediments. Chemicals such as these alter the physical and chemical environment near the discharge site, and may decrease the growth and survival of kelp forests. Thermal discharges from power plants can have localized effects on kelp forests. Wastewater and thermal discharges can increase turbidity and redistribute sediments into nearby kelp forests, affecting kelp growth and survival. A variety of pathogens are known to affect kelp, but their broad impacts on kelp forests have not been studied. While tumors, galls, and lesions have been observed on kelp, only occasionally have they caused severe damage.

Short- and long-term declines and, in one case, the complete disappearance of a kelp bed in southern California have been associated with human activity. An extensive kelp bed, known as Horseshoe Kelp Bed, existed off the coast of what is now Los Angeles Harbor prior to the 1920s. The bed reportedly measured a quarter-mile to a half-mile wide, and two miles long. A DFG Information Bulletin reported interviews with “old-time fishermen” who recalled that the kelp bed began to decline during the 1920s

and 1930s. During this time period, the main channel and West Basin of Los Angeles Harbor was widened, and an entire island (Deadman's Island) was removed by dredging. Some fishermen recalled that the White's Point Sewer Outfall, which began discharging in 1934, was associated with the disappearance of the last remnants of this bed. The Horseshoe Kelp Bed grew in water 80 to 90 ft deep. While kelp still commonly grows at this depth off the Channel Islands, kelp does not grow at this depth along the southern California mainland coast today. Several years of decline in kelp beds near Salt Creek in Orange County and Barn Kelp Bed near Las Pulgas Canyon (off Camp Pendleton Marine Base) in San Diego County were associated with extensive grading of land around drainages adjacent to those beds.

The most thoroughly documented decline of giant kelp beds from human-induced causes was associated with the San Onofre Nuclear Generating Station in northern San Diego County. The discharge of heated and turbid cooling water caused the loss of approximately 150 acres of kelp. This single event was the only instance where damage to California kelp beds was documented well enough for mitigation to be required as compensation for the loss.

In the 1950s and 1960s, once-productive kelp forests off Point Loma and La Jolla (San Diego County) and along the Palos Verdes Peninsula (Los Angeles County) began to deteriorate. This, too, was attributed to biological and physical factors related primarily to human activities. Currently, there are several areas where the status of kelp is of concern, including the entire coastline of Santa Barbara and Ventura Counties, the Malibu coast in Los Angeles County, portions of the Palos Verdes Peninsula, the coast between Newport and Laguna Beach in Orange County, and San Onofre, south Carlsbad and La Jolla in San Diego County. Other kelp losses have undoubtedly occurred as a direct result of human activities along the southern California coastline, but the lack of strong baseline data prevents resource agencies from proving damages and seeking compensation. The development of a computerized Geographic Information System (GIS) that links known discharge and coastal development sites to aerial photographs of kelp canopies may provide effective tools to document and analyze such damage.

Kelp Restoration

In 1963, the Scripps Institution of Oceanography and Kelco Company began to develop techniques to protect and restore kelp forests off San Diego. Sea urchin control was achieved by crushing or spreading lime on urchins, and transplanting kelp. Later experimentation between 1991 and 1992 involved feeding urchins along a front to discourage feeding on attached plants, and increasing urchin reproduction so that commercial harvesting could be encouraged. These methods appear to have succeeded in restoring kelp beds off San Diego. However, there are indications that the urchin fronts will redevelop when these labor-intensive efforts cease. This drawback calls into question the long-term benefits of any one-time restoration effort, as well as the economic feasibility of such an effort as a long-term solution covering a broad area.

Between 1967 and 1980, kelp restoration was conducted along the Palos Verdes Peninsula by the Institute of Marine Resources and the DFG. This work combined sea urchin control and kelp transplanting, with the objective of establishing several small stands of kelp that would provide seed stock for new and expanding beds. In 1974, the

first naturally expanding kelp stand in 20 years was observed off the Palos Verdes Peninsula. By 1980, when restoration work was discontinued, the stand had developed into a kelp bed covering nearly 600 acres. In 1989, aerial surveys found over 1,100 acres of kelp off the Palos Verdes Peninsula. Two subsequent El Niño events have severely decreased the size of these beds, however.

Kelp restoration work has also been conducted in storm-damaged areas off Santa Barbara and Orange Counties. Shortly after the 1982-1984 El Niño event, Kelco Company began developing techniques for restoring kelp beds in Santa Barbara County. In 1987, under contract with DFG, Kelco Company began anchoring giant kelp in the sandy habitat near Santa Barbara. Several kelp forest nuclei were established; however, sea urchin grazing and unfavorable water conditions impeded progress. By the early 1990s, this restoration attempt had failed.

Loss of Orange County kelp forests from Newport Harbor south to San Mateo Point was caused by urchin grazing, by heavy rainfall and siltation in 1980, and by the 1982-1984 El Niño event. Under contract with DFG, the MBC Applied Environmental Sciences Company established kelp forest nuclei from Laguna Beach north to Newport Harbor. Despite transplanting adult and juvenile giant kelp and keeping sea urchin populations under control, the beds north of Laguna Beach never recovered. The kelp forests south of Laguna Beach, however, recovered naturally after a few years.

In 1992, the DFG Artificial Reef Program built a ten-acre reef, around 3 ft in height, outside the harbor entrance channel to Mission Bay (San Diego County). The reef was constructed of broken slabs of concrete from nearby roadway demolition. By 1993 a kelp bed had become established on the reef without human assistance. This bed has persisted at least through the spring of 2000.

During the fall of 1999, the Southern California Edison Company built a 22-acre experimental reef off the City of San Clemente (Orange County) to mitigate damage that the San Onofre Nuclear Power Station had inflicted on local kelp beds. The experiment has had tremendous success as of spring 2003, with thick kelp canopies covering all of the experimental modules. The reef will be expanded to a minimum of 150 acres after the 5-year experimental phase is completed. It appears that the creation of new reef substrate may be a valuable mechanism for kelp bed expansion throughout southern California.

Management Considerations

For the purpose of management, the kelp beds off California represent more than just a single species of interest; they represent an important nearshore ecosystem. Giant kelp forests provide essential habitat for a diverse assemblage of marine fishes and invertebrates, and their loss would reduce the populations of many marine species. Kelp forests are not only important to sport fishermen, commercial fishermen, and kelp harvesters; they are also important to recreational divers, photographers, and tourists who value them for aesthetic reasons.

During the latter half of the twentieth century, California kelp forests (especially in the south) have been subjected to increasing environmental stress. Warm water El Niño events apply naturally caused stress. Other environmental stress is clearly the result of human activity. Human-caused environmental stress is brought about by pollution and sedimentation from power plants, sewage discharge, and coastal

development practices. While the causes of decline are complex and masked by seasonal fluctuations, it is generally agreed that there is now much less kelp along the southern California coast than there was when DFG first began conducting surveys in the early 1900s.

At least three areas of management offer some hope for reversing this trend of decline:

- Large numbers of sea urchins can damage kelp forests. DFG may consider applying more stringent limits on the take of sea urchin predators, such as California sheephead and California spiny lobster. The southern sea otter may eventually return to its southern California habitat, but whether this will, or should be allowed, to happen is highly controversial.
- Coast-wide photographic flights should be conducted at least annually (preferably quarterly or biannually, during canopy maximum and minimum). The causes for the apparent declines in kelp beds, particularly in southern California, cannot be thoroughly analyzed or understood without a better time series of data. Once gathered, the data should be incorporated into a statewide GIS. A similar database should be instituted for coastal development. This information should be available through the California Coastal Commission, since all coastal development requires a permit from the Commission. Once established, the GIS should be frequently reviewed for evidence of kelp bed damage tied to onshore activities.
- Provide additional substrate (constructed reefs) over widespread areas for establishment of new kelp beds. These may also serve as sources of giant kelp spores for re-establishment of former, natural kelp communities.

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Table 1.1. Commercial landings (tons) of giant kelp, 1916-2001

Year	Tons	Year	Tons	Year	Tons	Year	Tons	Year	Tons
1916	134,537	**1933**	21,622	**1950**	100,602	**1967**	131,495	**1984**	46,479
1917	394,974	**1934**	15,880	**1951**	114,760	**1968**	134,853	**1985**	87,300
1918	395,098	**1935**	30,602	**1952**	110,158	**1969**	131,239	**1986**	56,832
1919	16,673	**1936**	49,317	**1953**	126,649	**1970**	127,039	**1987**	93,264
1920	25,464	**1937**	43,954	**1954**	106,215	**1971**	155,559	**1988**	90,615
1921	------	**1938**	47,697	**1955**	124,063	**1972**	162,511	**1989**	132,761
1922	------	**1939**	56,736	**1956**	117,815	**1973**	153,080	**1990**	151,439
1923	------	**1940**	59,004	**1957**	94,207	**1974**	170,181	**1991**	127,505
1924	------	**1941**	55,717	**1958**	114,062	**1975**	171,597	**1992**	91,247
1925	------	**1942**	61,898	**1959**	89,599	**1976**	158,371	**1993**	92,940
1926	------	**1943**	47,958	**1960**	120,300	**1977**	130,597	**1994**	81,006
1927	------	**1944**	53,030	**1961**	129,256	**1978**	169,029	**1995**	77,753
1928	------	**1945**	59,181	**1962**	140,233	**1979**	171,020	**1996**	78,461
1929	------	**1946**	91,069	**1963**	121,032	**1980**	147,636	**1997**	73,165
1930	------	**1947**	74,237	**1964**	127,254	**1981**	73,064	**1998**	25,313
1931	260	**1948**	78,641	**1965**	135,129	**1982**	86,503	**1999**	42,211
1932	10,315	**1949**	83,346	**1966**	119,464	**1983**	5,271	**2000**	41,943
								2001	40,116

------ Landings data not available from 1921 to 1930.
1. Data source: Kelp Harvester's Monthly Report (logbook).
2. Kelp landings consist primarily of giant kelp (*Macrocystis pyrifera*).

2. BULL KELP

Overview of Use and Harvest

Bull kelp, *Nereocystis luetkeana*, has commercial and recreational value as a harvestable resource, intrinsic value as habitat and food for hundreds of species in the nearshore ecosystem, and aesthetic value for non-consumptive users such as scuba divers. Because of the multiple uses of bull kelp, management concerns are much more complex than for most species.

Until the late 1980s, there was little targeted harvest of bull kelp in California except as a small component of the localized edible seaweed industry. In central California, bull kelp and giant kelp, *Macrocystis pyrifera*, often occupy the same beds. It is likely that bull kelp is incidentally harvested in these beds, although no separate records are kept of bull kelp harvest. Department of Fish and Game (DFG) records indicate that between 1993 and 1999 about 19 tons of kelp, probably a mixture of bull kelp and giant kelp, were harvested from bed 302 in the Bodega Bay/Tomales Bay area (Marin County) and used by local abalone culturists. The bull kelp's thick, central stalk (called the stipe) is pickled and marketed as a specialty food product, and the dried parts are used for arts and crafts. In southern Oregon, bull kelp was harvested from Orford Reef in the mid-1990s for use in liquid fertilizer (the Oregon Division of State Lands no longer permits this harvest).

California's kelp bed management strategy has been largely passive, with effort spent on giant kelp restoration and intermittent aerial surveys of the giant kelp canopy. The Fish and Game Code (§6654) gives the Commission authority to close a kelp bed to harvest for up to one year if it is determined that the bed is being damaged. However, the information necessary for sustained-yield management—regular and formal stock assessments of the State's kelp resources—has been largely unavailable.

In 1996 the Fish and Game Commission (Commission) developed a "300 series" numbering system for all the kelp beds north of San Francisco and established a kelp bed leasing program similar to the program for giant kelp in central and southern California. Before 1996 no such program existed, and any northern kelp bed could be harvested for commercial purposes.

In anticipation of increasing demand for large-scale harvest of the northern California bull kelp resource, the Commission acted in a precautionary manner in 1996 by closing beds 303 through 307 to future commercial harvest. The Commission also required limiting the remaining beds in the 300 series to a maximum harvest of 15% of the biomass as determined by a DFG-approved annual survey conducted by the lessee. In 2001, the Commission provided further protection for the bull kelp resource by adopting a new suite of regulations that:

- Closed beds 301, 302, 310, and 311
- Restricted the harvest from April 1 through July 31 within the boundary of the Monterey Bay National Marine Sanctuary
- Required a harvester to have a Commission-approved harvest plan prior to taking kelp with a mechanical harvester in open beds north of Santa Rosa Creek (San Luis Obispo County)

The Commission can also respond more quickly to potential resource concerns by designating open beds, or portions thereof, as harvest control areas where harvest is limited for a specified period of time. These regulations have created a *de facto* bull kelp reserve along much of the northern California coastline, protecting essential kelp bed habitat for resident species such as heavily-exploited sea urchins and abalones.

As of 2002, only three of the State's 13 beds that mostly contain bull kelp were open to harvest. Of these three, only one is currently leased, with one firm harvesting significant quantities of bull kelp. Since leasing the bed, the firm's peak harvest has been 149 tons, with only 11 and 44 tons landed in 2000 and 2001, respectively. This low harvest rate is due to a reduced demand for kelp and is not indicative of the resource available in the area.

Status of Biological Knowledge

Bull kelp is primarily found adjacent to exposed shorelines along the Pacific coast of North America, ranging from Unalaska Island, Alaska to Point Conception, California (Santa Barbara County). Along the central California coast, giant kelp and bull kelp occur together, forming extensive kelp forests. However, from the Monterey Bay area northward to Alaska, bull kelp becomes the dominant canopy kelp species in coastal waters. Within the nearshore environment, bull kelp, like giant kelp, is associated with hard substrates at depths of approximately 10 to 70 ft, where it provides habitat and food for hundreds of species, many of them commercially and recreationally valuable.

Distribution of marine algae is restricted by the availability of hard substrate and a number of other factors within the nearshore environment, including water movement, light, temperature, nutrients, pollution, competition, and predation. The complex feeding interactions among sea otters, larger kelp grazers and kelp have been documented by a number of researchers. Generally, sea otter predation on invertebrate kelp grazers such as abalone limits the population of these grazers in a kelp forest community, thereby increasing kelp productivity. In northern California, where sea otters are absent, commercial and sport fishermen have significantly reduced populations of sea urchins and abalone, which are two major kelp grazers. Although kelp populations off California generally seem to have increased, the competition among marine plants for space and light makes it impossible to determine the specific impacts of grazer populations on bull kelp.

The appearance of bull kelp is quite different from that of giant kelp. The most notable difference is that bull kelp possess only one gas-filled flotation bladder (called a pneumatocyst) located on the end of the hollow stipe. In contrast, giant kelp have many such bladders running the entire length of the kelp. The bull kelp's pneumatocyst typically bears from 30 to 64 blades, which resemble long, flat leaves. This canopy of blades provides most of the photosynthetic and nutrient-absorbing surface for energy production. Blade lengths of more than 13 ft have been reported for mature kelp, but it is typical to find a range of blade sizes (from 2 to 11 ft).

Although both giant kelp and bull kelp are attached to the substrate by holdfasts (root-like growths) the size of the holdfast is much smaller in bull kelp. Bull kelp stipes can reach lengths of up to 130 ft. The bull kelp's stipe does not have the same tensile strength as giant kelp's, but it is more elastic under stress. The bull kelp stipe can stretch more than 38% of its length before breaking.

Reproduction in bull kelp undergoes a cyclic alternation of generations similar to that of other kelp and other algae in the order Laminariales. The large plant commonly referred to as bull kelp represents the spore-producing (or sporophytic) generation, while the gamete-producing (or gametophytic) generation is microscopic. Bull kelp reproductive structures (called sporangia) are located on the blades of sporophytic plants in aggregations called *sori*. Mature sori are located in patches near the tip of the blade, and immature sori are located near the base of the blade. Production of spores within the sori usually begins several weeks after the blades reach the surface. As the spores mature during the summer and fall, the sori are shed from the blades and the spores released. They germinate upon settlement, and over the course of several weeks develop into gametophytic plants. After about 11 weeks, sperm and eggs are released from "male" and "female" gametophytic plants, and fertilization takes place. The resulting young plants (termed zygotes) grow into tall, familiar, sporophytic bull kelp. Once the plant reaches the surface, stipe and blade elongation rates decrease while the weight, or biomass, of the kelp increases.

As an annual plant, bull kelp has evolved an optimal reproductive strategy that involves accelerated stipe growth to reach the ocean surface where it can initiate spore production and release. Kelp that begins growing in late March may develop sori prior to reaching the surface in May, and can release spores as early as June. Maximum bull kelp growth occurs under optimal light, nutrient and water clarity levels. Bull kelp stipes can grow up to 5 in. per day, while blades may grow up to about 3.5 in. per day just prior to reaching the surface. The holdfasts of mature bull kelp can grow an average of about 0.2 in. per day.

The biggest factor in the growth of bull kelp is the availability and quantity of light. Light levels below the surface canopy have been shown to decrease by almost 100%; below secondary canopy, light levels are well below the minimum level necessary for growth. Thus, in established kelp communities there can be insufficient light and hard substrate available for recruitment and growth of new bull kelp plants.

Bull kelp is an opportunistic colonizer that takes advantage of substrate clearing caused by storms, sand scouring, and other disturbances. While bull kelp can rapidly colonize a newly-cleared location, its longevity as the dominant canopy-forming species depends on environmental conditions that favor it over major competitors.

Water temperature also plays an important role in the growth of bull kelp. Mean sea surface temperatures over the kelp's distributional range vary from a high of 59° F off southern California to a low of 39° F off the Aleutian Islands. The introduction of unusually warm water can have a negative effect on bull kelp. For example, the bull kelp population in Diablo Cove (San Luis Obispo County) has been adversely affected by the warm water discharge from the Diablo Canyon power plant, which began in 1985. Plants in contact with the discharge experienced deterioration of blade tissue, which resulted in early death. This observation helps to explain the decline of bull kelp that occurs during El Niño events.

Status of the Beds

The kelp resources of the eastern Pacific coast, from the Gulf of Alaska to Cedros Island, Baja California, were first mapped in 1912. Subsequent surveys along the central coast of California between Point Montara (San Mateo County) and Point

Conception (Santa Barbara County) have not differentiated between bull kelp and giant kelp. Since the first survey in 1912, little work has been done along the north coast of California, primarily due to the absence of the more valuable giant kelp in this region. A 1967 kelp survey from Point Montara to the U.S.-Mexico border did not differentiate between bull kelp and giant kelp, and did not extend far north into the preferred bull kelp habitat. Current knowledge of the population levels of bull kelp off the north coast is based on 1989 and 1999 surveys of the California coast, and information provided by a kelp harvester in the Crescent City area (Del Norte County).

Despite the high spatial and temporal variability in bull kelp coverage, both the 1912 and the 1989 surveys estimated approximately 6.5 sq. mi. of canopy north of Point Montara. The 1999 survey, however, indicated a sharp drop in canopy coverage in most beds north of Point Montara, which may be attributed to several factors. The apparent decline may be due in part to the timing of the 1999 survey, which was conducted after a major storm had passed through the region, destroying portions of the kelp beds. Also, improved interpretation methods for aerial photographs probably resulted in more accurate estimates of kelp canopy coverage in 1999. Comparing the estimates from these latest surveys with previous surveys raises questions about the accuracy of previous canopy estimates, which may have been too great. An additional consideration is that kelp bed coverage and density naturally varies from year to year.

The 1912 survey estimated that about 32% of the 17.55 sq. mi. kelp canopy in central California was bull kelp. Recent surveys have not been undertaken to estimate the proportion of bull kelp in central California kelp beds. In central California, bull kelp is generally restricted to areas unsuitable for giant kelp such as the outer edges of giant kelp beds and within the surge zone. However, following winter storms with heavy wave disturbance, bull kelp can become more abundant as it replaces the giant kelp removed by the storms. The DFG has recently acquired new technology which will hopefully allow biologists to more accurately differentiate between bull kelp and giant kelp in aerial images.

Kelp abundance has changed in various locations over time. For example, during the period from 1975 to 1982, the amount of bull kelp at Diablo Cove declined from 200 tons per acre to 4.8 tons per acre. In the Crescent City area, peak abundances ranged from 24 to 28 tons per acre from 1994 to 1996. South of Fort Bragg (Mendocino County), bull kelp beds decreased sharply from 1989 to 1999, whereas beds north of Fort Bragg increased sharply. The Fort Bragg area kelp beds appeared to increase in size and density between 1985 and 1988 based on aerial photographic surveys of the area. Bull kelp beds were thought to have reached their maximum potential during this period. The increase coincided with the removal of over 32,500 tons of red sea urchins from areas off Mendocino and Sonoma Counties by commercial divers. In 1992, the same beds showed delayed and reduced kelp recruitment and growth. The causes of the poor recruitment in 1992 may have been associated with the El Niño event of that year. These examples illustrate the kind of fluctuations that occur in the recruitment of bull kelp along the north coast and the factors that may play a role in the variability of the resource.

Management Considerations

The DFG conducted a review of the commercial and sport bull kelp "fisheries" in 2000 and 2001, and recommended a number of management changes for the commercial fishery. The Commission adopted a new suite of regulations in 2001 based on the DFG review and public comments; these regulations are described in the "Overview of Use and Harvest" section. Other management measures that should be considered to ensure a productive future for California's bull kelp resource and the species dependent on it include:

- Minimizing local impacts by modifying the present 15% harvest limit on the lease-only 300-series beds to require distribution of the harvest throughout the bed
- Prohibiting harvest of bull kelp in beds where the bull kelp resource has been chronically diminished during the past several decades
- Encouraging the use of alternative feeds, such as those already developed for cultured species such as red abalone
- Conducting at least one annual statewide aerial survey, preferably during the late summer, to document abundance and distribution of kelp canopy
- Conducting research to examine the impacts of various harvest strategies on kelp abundance, distribution and long-term stability

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3. SEA PALM

Overview of Use and Harvest

The sea palm, *Postelsia palmaeformis*, is a brown alga first described by Franz Joseph Ruprecht in 1852 from specimens collected near Bodega Bay (Sonoma County). Although it is illegal to harvest sea palm for recreational use, it is an important component of the commercial harvest of edible seaweed. Edible seaweed harvesting is a cottage industry which began in the late 1970s. Within the last several years, demand for edible seaweed has increased, particularly for sea palm fronds. In 2001, there were four licensed edible seaweed harvesters who actively harvested sea palm. Currently, edible seaweed landings are not recorded by species; however, it is estimated that between 2 and 3 tons of sea palm were taken in both 2000 and 2001.

Sea palm is harvested primarily in Mendocino County using small cutting instruments. It is consumed raw, or is dried and sold in health food stores and Asian markets. Dried sea palm blades are used in soups and salads, and typically sell for $24 to $30 per lb.

Regulatory authority over marine plants has been granted to the Fish and Game Commission (Commission) by the Legislature. Current regulations require that edible seaweed harvesters purchase an annual license for $100, pay a royalty rate to the State of $24 per wet ton of algae harvested, and submit a monthly harvest log containing the wet weight and location of each harvest.

Status of Biological Knowledge

Sea palm is an annual kelp that thrives in exposed coastal locations. It is abundant in upper to mid-tidal zones from Vancouver Island, British Columbia, Canada to Morro Bay, California (San Luis Obispo County), but is restricted to rocks exposed to heavy surf and high disturbance. Sea palms are usually found in dense aggregations. Adult spore-producing plants (called sporophytes) can grow to 2 ft tall and possess up to 100 leaf-like blades. They begin producing spores in early spring. The sea palm appears to have a limited ability to form new beds, and most dispersal seems to occur over distances of 3 to 16 ft.

Several studies have documented the sea palm's relationship to its unique habitat. The sea palm is unusual because it tolerates—indeed, depends on— heavy surf, and because of its association with the California mussel, *Mytilus californicus*. It often colonizes new rocky areas when objects such as logs and other debris strike and dislodge the competitive, dominant mussel. Although there is little known about the reproduction and genetic structure of the sea palm, it is thought that individuals within a cluster are siblings, and that distinguishable populations are present along the coast. Research is under way to determine whether genetic connections exist among populations in different coastal areas.

Status of the Beds

Although individuals can regenerate blades, they cannot survive when cut near the base of the stem-like portion of the plant (called the stipe). Cutting the stipe prior to spore production and release can negatively impact recruitment and threaten local populations. Fortunately, most harvesters use the blade-cut method, which provides for

multiple harvests during the spring and summer growing season and can provide for spore production and release.

Sea palms cannot tolerate heavy harvesting pressure due to their restricted habitat, short life span, local dispersal, and limited powers of regeneration. Although many stands of sea palm are difficult to access, others are in or adjacent to recreational areas where they are at risk from human disturbance.

Management Considerations

Public education and outreach is the best defense for the conservation of this charismatic and ecologically interesting alga. The primary management measures that should be considered at this time involve improving the documentation of sea palm harvest, and of other species of algae harvested by the edible seaweed fishery. This can be accomplished by:

- Modifying the monthly harvest log (Kelp Harvester's Monthly Report) to include the weight of each species harvested, the nearest landmark or easily recognizable permanent feature, and the Fish and Game Block number where harvesting occurred.
- Compiling and analyzing logbook information annually to monitor trends in species composition and total take.

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Further Reading

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4. CALIFORNIA SPINY LOBSTER

Overview of the Fishery

In California waters, the spiny lobster, *Panulirus interruptus*, occurs in shallow, rocky coastal areas from Point Conception (Santa Barbara County) to the U.S.-Mexico border, and off southern California islands and banks.

Lobster fishing season runs from early October to mid-March. More lobster is taken by the commercial and sport fisheries in October than in any other month. Effort and landings drop sharply in January, and continue to decline through mid-March when the season ends.

Currently, most of the lobsters landed in the commercial fishery weigh between 1.25 and 2.0 lb. Lobsters in this weight range produce the tail size desired by the export market and restaurant trade. Lobster fishermen are paid between $6.75 and $8.00 per lb for their catch, most of which is exported to French and Asian markets. However, depressed markets overseas have resulted in efforts to re-establish domestic markets.

Southern California has supported a spiny lobster fishery since the late 1800s. At that time, spiny lobsters weighed between 3.5 and 4 lb on average, and were so abundant that a single person could catch 500 lb in just two hours. By 1900, legislation was enacted to protect dwindling spiny lobster stocks. A closed season and a size limit were instituted, and take of egg-bearing females was prohibited. Despite legislation, abundance continued to decline. As a result, the fishery was closed for two years (1909 and 1910). When the fishery re-opened in 1911, spiny lobsters were once again abundant. From 1916 until 1942, annual landings were generally in the 200,000 to 400,000 lb range (Figure 4.1 and Table 4.1).

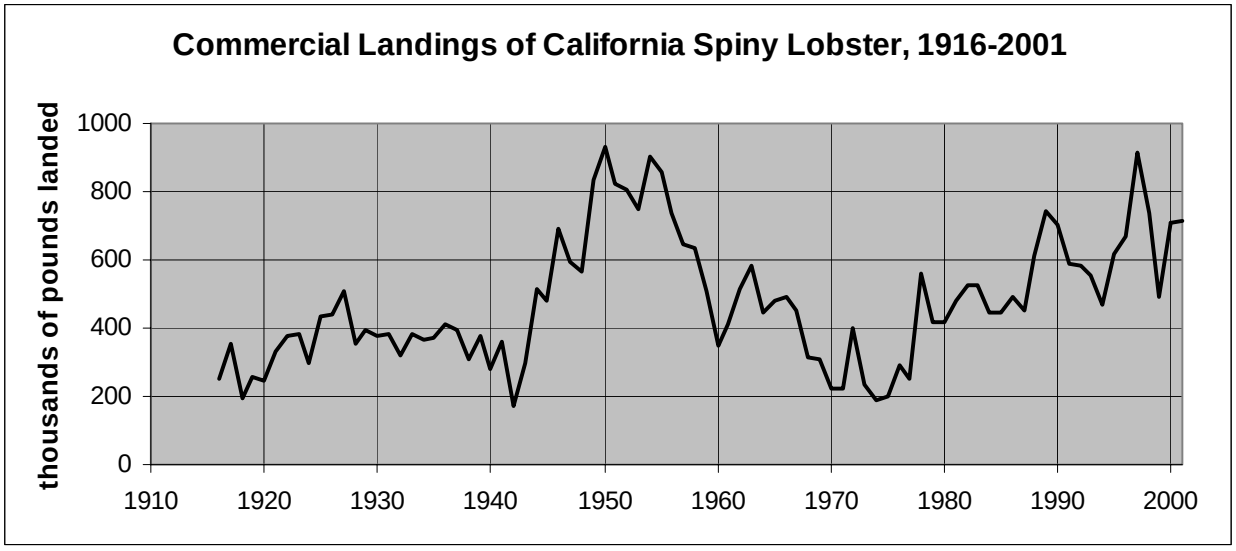

Figure 4.1. Annual (calendar year) commercial landings (pounds) of California spiny lobster from 1916 to 2001. Data from California Department of Fish and Game (DFG) Catch Bulletins (1916-1983) and the DFG commercial landing receipt database (1984-2001).

Following World War II, seasonal landings increased, peaking in the 1949-1950 season at a record 1.05 million lb (Figure 4.2). A general decline followed for 25 seasons, reaching a low of 152,000 lb for the 1974-1975 season. After this poor season, landings increased for four seasons (from the 1975-1976 season through the 1978-1979 season), and then remained between 400,000 and 500,000 lb per season through the 1987-1988 season. From the 1987-1988 season to the 2000-2001 season, landings have ranged from a low of 510,000 lb (1999-2000 season) to a peak of 970,000 lb (1997-1998 season). Increases and declines in landings are not unexpected in the lobster fishery, which is strongly influenced by weather, El Niño and La Niña events, and the export market.

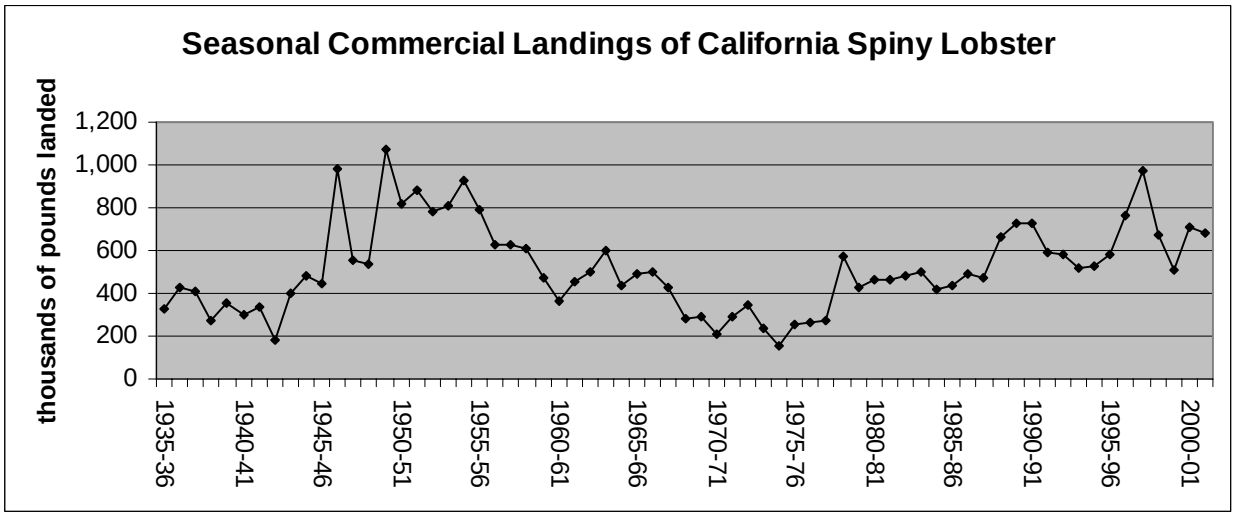

Figure 4.2. Commercial landings (pounds) of California spiny lobster by season (early October to mid-March) from the 1935-1936 season to the 2000-2001 season. Data sources are California Department of Fish and Game Catch Bulletins.

Each lobster fisherman typically uses from 100 to 500 traps, although some fishermen may use as many as 750 traps at the peak of the season. Lobster traps are box-like devices usually constructed of heavy wire mesh, although other materials (such as plastic) may be used. Traps are baited with whole or cut fish, and placed on the sea floor using cement, bricks, or steel as ballast. Each trap is marked with a buoy bearing the fisherman's license number followed by a "P".

High speed boats from 20 to 40 ft in length are popular in the fishery, but boats range in size from 15 ft skiffs to 50 ft vessels. Most lobster boats are equipped with a davit and hydraulics to pull traps from the water, and sophisticated electronic equipment that allows fishermen to find good lobster habitat and locate their traps. Traps are usually fished along depth contours in water less than 100 ft in depth, or clustered around rocky outcrops. Some marine-life refuges and reserves do not allow the take of lobster; in addition, commercial lobster traps are prohibited in certain parts of Santa Catalina Island, Santa Monica Bay and Newport Bay. Fishermen set traps closer to shore when the season opens, and farther from shore, at depths of up to 300 ft, by season's end.

A number of management measures have been enacted to protect the resource. Commercial fishery management measures include:

- A size limit of 3.25 in. carapace length (CL), measured from the rear edge of the eye socket to the rear edge of the body shell. The minimum size limit ensures the existence of several year-classes of younger broodstock, even if all legal-size lobsters are caught each season.
- The commercial lobster fishery runs from early October through mid-March. The closed season from early spring to early fall protects egg-carrying females and molting lobsters.
- Lobster traps must have a destruct device that is approved by the Department of Fish and Game (DFG) to ensure that lost or abandoned traps do not continue to capture marine life indefinitely.
- Lobster traps must have escape ports (measuring 2.38 in. x 11.5 in.). Escape ports effectively minimize the retention of undersized lobsters, and have been required since the 1976-1977 season. The escape port has been credited with reversing downward trends in landings prior to 1976.
- A restricted access program (see following sub-section).

Lobster fishermen are required to possess operator permits ($265), and deckhands must have lobster crewmember permits ($125).

Divers take most of the lobsters in the recreational fishery. Some commercial passenger fishing vessels schedule special recreational dive trips during lobster season. The total recreational take of spiny lobster is unknown. Recreational fishery management measures that protect this resource include:

- A size limit of 3.25 in. CL. The minimum size limit ensures that there will be several year-classes of younger broodstock, even if all legal-size lobsters are caught each season.
- The recreational fishery for lobster runs from early October through mid-March, same as the commercial season. The closed season protects egg-carrying females and molting lobsters.
- Recreational fishermen must possess a valid sport-fishing license with an ocean enhancement stamp.
- Skin and scuba divers may only use bare (or gloved) hands to take lobster. No fish spears, short hooked poles, or similar appliances may be used to remove lobsters from crevices and caves. Baited hoop nets may also be used to take lobster. South of Point Arguello (Santa Barbara County) no more than five hoop nets may be fished per person, and no more than 10 may be fished from any boat.
- Divers may take seven lobsters per day (reduced from 10 lobsters in 1971).
- Some marine reserves and conservation areas prohibit the take of lobster.

Restricted Access Program

A permit system for the commercial take of spiny lobster began in 1961, but no limit was placed on the number of permits that could be issued. In 1986, the State Legislature granted the Fish and Game Commission (Commission) the authority to limit the number of permits to prevent overfishing or to ensure efficient and economic operation of the fishery. The restricted access program for spiny lobster was initiated in 1996.

Historical timeline for the California spiny lobster restricted access program

1961	State Legislature requires a permit for the commercial take of California spiny lobster. The Legislature also delegates authority to the Fish and Game Commission for managing the fishery.
1986	State Legislature gives the Fish and Game Commission authority to limit the number of permits.
1994	The Fish and Game Commission places a moratorium on new permits.
1996	Restricted access program begins.

The program currently provides for two types of permits: a restricted access lobster operator permit and an unrestricted lobster crewmember permit. A lobster operator permit, which is non-transferable, is required for the commercial take of spiny lobster. A lobster crewmember permit is required to assist an operator. Any licensed fisherman may buy a lobster crewmember permit; however, an operator permit is only issued to fishermen who held a permit in the previous season.

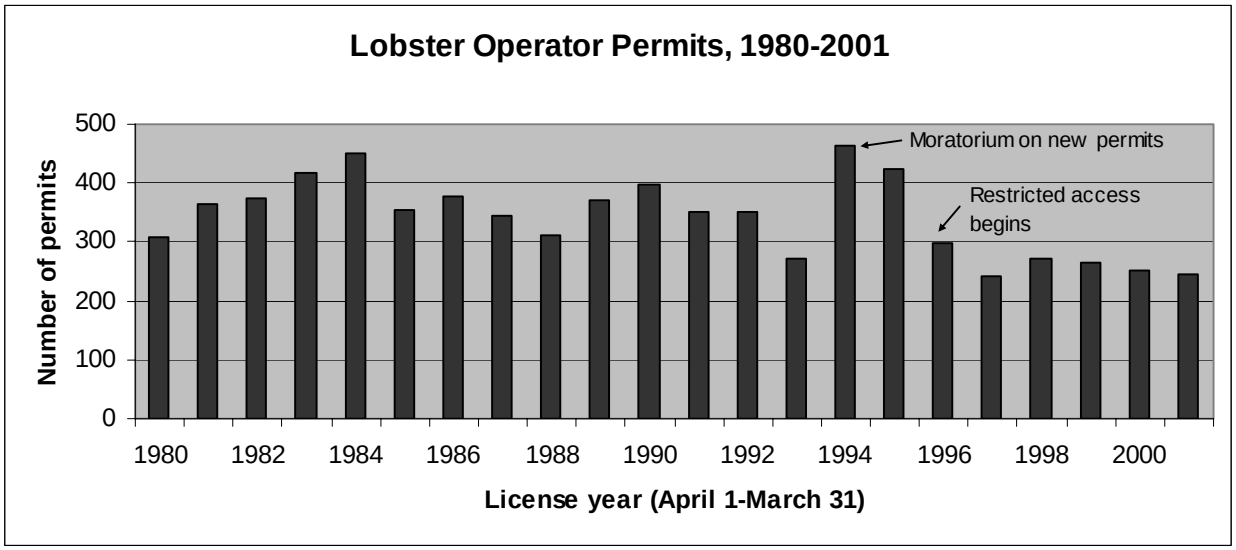

Figure 4.3. Number of lobster operator permits issued for the commercial California spiny lobster fishery from the 1980-1981 season to the 2001-2002 season. A permit was required beginning in 1961, and the restricted access program began in 1996. Data sources are the California Department of Fish and Game license reports.

The capacity goal (upper limit of fishing capacity) was 225 fishermen (or lobster operator permits) from September 1996 until February 2003. Attrition was the primary means for achieving the capacity goal. The number of permits has decreased since the program's inception (Figure 4.3). For the 2001-2002 season, 246 permits were issued. There is no minimum landing requirement. The permit must be renewed annually, but not all permittees participate in the fishery every year; this latent capacity causes concern because of the possibility of increased effort as other fishing opportunities diminish. In addition, while the restricted access program is reducing the number of permits, it may not be reducing effort in terms of the number of traps being fished. Current regulations do not limit the number of traps that can be fished by each permittee.

Prior to 2003, new permits were issued via a lottery drawing. In February 2003, the Commission adopted regulations that repealed the lobster permit lottery and the capacity goal of 225 fishermen. A new capacity goal will be established by the Commission after DFG reviews the restricted access program for spiny lobster.

The DFG had intended to review this program several years after its initiation to ensure that it was accomplishing its goals. The review, however, did not take place as soon as planned. It is anticipated that a formal review of the spiny lobster restricted access program will be undertaken in 2005. The review will evaluate the appropriate capacity goal, consider whether fishing effort is adequately limited, and consider whether permits should be transferable.

State law (Fish and Game Code §7065) requires that each restricted access program be reviewed at least every five years to make sure that it is consistent with the Commission's policy on restricted access. Table 4.2 lists the Commission's restricted access policies, and the lobster restricted access program's degree of consistency with each policy. Even though the lobster restricted access program was implemented before the Commission adopted a policy on restricted access, the program is consistent with most of the Commission's policies.

It is the policy of the Commission that each restricted access program should have an equitable and practicable system for reducing fishing capacity. Although constituent satisfaction with the current system has not been measured in this regard, the system was developed with constituent input. The California Lobster and Trap Fishermen's Association worked with DFG to develop the current management program. In addition to formalizing a trap-retrieval program for traps washed into the surf or onto the beach, association members regularly participate in the Commission process to resolve industry problems or improve current regulations.

Status of Biological Knowledge

The California spiny lobster ranges from Monterey Bay, California to Manzanillo, Mexico. There is also a small, isolated population of this species at the northwestern end of the Gulf of California. The majority of the population is found between Point Conception, California (Santa Barbara County) and Magdalena Bay, Baja California, Mexico. Adult lobsters usually inhabit rocky areas from the intertidal zone to depths of 240 ft or more.

Spiny lobsters mate from November through May. The male attaches a putty-like packet of sperm, called a spermatophore, to the underside of the female's carapace

(body shell). When the female releases her eggs, she uses the small claws on her last pair of walking legs to open the spermatophore and fertilize the eggs. Fertilized eggs are attached to the underside of the female's tail primarily in May and June. Egg-carrying females generally inhabit water less than 30 ft deep and carry their eggs for about 10 weeks, with larger females producing more eggs. For example, at San Clemente Island, a female with a CL of 2.6 in. might carry about 120,000 eggs, while a female with a CL of 3.6 in. might carry 680,000 eggs.

Spiny lobster eggs hatch into tiny, transparent larvae with flattened bodies and spider-like legs. They drift with the prevailing currents, feeding on other tiny animals. They may drift 350 mi offshore, and are found from the surface to a depth of over 400 ft.

As with many crustaceans, spiny lobsters must shed their outer shell to grow. This process, known as "molting", is preceded by the formation of a new, soft shell under the old one. Lobsters take in water to expand the new shell before it hardens. They are more vulnerable to predation and physical damage right after they molt, until their shell becomes hard.

In the five to nine months after hatching, larvae molt 12 times, slowly transforming into juveniles that look like miniature, transparent adults with extremely long antennae. Juvenile lobsters actively swim inshore where they settle on the sea floor and start to grow. They usually spend their first two years in nearshore surf grass beds, although they have also been found in shallow rocky crevices and mussel beds.

Molt rates for the California spiny lobster are assumed to be similar to those of the Japanese spiny lobster. A 0.24-inch CL Japanese spiny lobster goes through 20 molts to reach 1.18 in. CL at the end of its first year. Four molts during the second year expand carapace length to 2 in., followed by three molts in the third year. Once they reach 2.5 in. CL, spiny lobsters usually molt once per year following their reproductive period; however, growth rates between molts are highly variable and have been correlated with food availability, sex and size (the larger an animal, the slower it grows). Injuries or disease will often result in a slowing or complete cessation of growth until the injury has healed.

Lobsters (of both sexes) generally reach sexual maturity in 5 or 6 years at 2.5 in. CL, and reach a legal size of 3.25 in. CL in 7 to 11 years. Mature male lobsters grow faster, live longer, and reach larger sizes than females. Males can live up to 30 years, and females at least 20 years. Records exist of male California spiny lobsters that weighed over 26 lb and attained lengths of 3 ft. Today, lobsters over 5 lb are considered trophy sized.

Adult lobsters are found in rocky habitat, although they will also search sandy areas for food. During the day, spiny lobsters usually reside in crevices or holes, called "dens". More than one lobster is usually found in a den. At night, the animals leave their dens to search for a wide range of food. Adult lobsters are omnivorous. They consume algae, fish, and a wide variety of marine invertebrates such as snails, mussels, sea urchins, clams, and injured or newly molted lobsters. Lobsters are eaten by California sheephead, cabezon, kelp bass, octopuses, California moray eels, horn sharks, leopard sharks, rockfish and giant sea bass.

A large portion of the spiny lobster population makes annual offshore-nearshore migrations that are stimulated by changes in water temperature. During winter months, most male and female lobsters are found offshore at depths of 50 ft or more, although

individuals of both sexes have also been found in shallow water in winter. In late March, April, and May, lobsters move into warmer nearshore waters less than 30 ft in depth. Higher temperatures closer to shore shorten the development time for lobster eggs. Nearshore waters also have a more plentiful food supply. In late October and November, the waters close to shore cool, and most lobsters move offshore again. Winter storms that cause increased wave action in shallow waters encourage this movement. Lobsters generally move after dark in small groups to cross the sand.

Status of the Population

Population size is unknown for the California spiny lobster. Commercial landings have fluctuated through the years (Figure 4.1 and Table 4.1), and are influenced by some factors that are independent of the health of the population (such as weather, oceanographic patterns, and the export market). The total recreational catch is unknown.

An illegal market has always existed for “shorts” (sub-legal-sized lobsters). Public education and adequate warden enforcement are key elements in reducing this problem.

The DFG has had a commercial logbook system in place since 1973. Required information in the logbooks include:

- Number of legal lobsters taken
- Number of shorts released
- Number of nights traps are in water
- Date traps were pulled from water
- Location of traps (by landmark and DFG fishing block number)
- Depth the traps are fished
- Number of traps fished

The release of numerous shorts is generally a good indicator of the strength of younger year classes in a population.

Management Considerations

The spiny lobster is the only invertebrate in California that is subject to both a significant recreational and commercial fishery. The magnitude of the recreational fishery take is unknown. Spiny lobsters are long-lived and slow-growing. Future management activities that should be considered to insure the health of this resource and of the sport and commercial fisheries include:

- Initiating a program to determine the total recreational take of spiny lobster.
- Maintaining the current logbook program for both the commercial fishery and commercial passenger fishing vessel dive boats.
- Annually reviewing and analyzing all the lobster logbook data collected, especially catch and effort data.
- Conducting a formal review of the current restricted access program.
    - Conduct a capacity goal analysis to determine the goal that best matches

the resource.

- o Determine whether other effort controls, such as limits on the number of traps, need to be enacted to reduce capacity.
- o Evaluate the potential impacts of the latent capacity in the fishery (the capacity of the permits that are not used each season).
- o Evaluate the impacts of making permits transferable.

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Section on Restricted Access Program added December 2002
Revised May 2003
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Further Reading

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Table 4.1. Commercial landings (pounds) of California spiny lobster, 1916-2001									
Year	**Pounds**	**Year**	**Pounds**	**Year**	**Pounds**	**Year**	**Pounds**	**Year**	**Pounds**
1916	250,632	**1933**	380,014	**1950**	933,449	**1967**	449,874	**1984**	444,998
1917	355,259	**1934**	366,651	**1951**	824,611	**1968**	312,483	**1985**	447,848
1918	195,750	**1935**	371,661	**1952**	807,070	**1969**	309,472	**1986**	488,804
1919	256,894	**1936**	414,183	**1953**	749,245	**1970**	225,399	**1987**	449,778
1920	247,156	**1937**	393,242	**1954**	901,293	**1971**	224,486	**1988**	610,859
1921	334,271	**1938**	308,378	**1955**	855,416	**1972**	398,217	**1989**	742,571
1922	376,310	**1939**	376,928	**1956**	735,869	**1973**	233,179	**1990**	705,341
1923	384,381	**1940**	281,102	**1957**	647,281	**1974**	190,950	**1991**	589,240
1924	294,356	**1941**	357,334	**1958**	632,618	**1975**	201,412	**1992**	585,556
1925	432,059	**1942**	168,641	**1959**	505,947	**1976**	292,534	**1993**	554,438
1926	442,198	**1943**	298,377	**1960**	351,032	**1977**	251,568	**1994**	470,144
1927	508,123	**1944**	512,490	**1961**	412,453	**1978**	560,986	**1995**	616,382
1928	355,800	**1945**	478,619	**1962**	515,816	**1979**	419,529	**1996**	668,453
1929	396,764	**1946**	690,272	**1963**	584,192	**1980**	416,249	**1997**	915,272
1930	374,450	**1947**	593,401	**1964**	446,655	**1981**	478,863	**1998**	735,703
1931	383,697	**1948**	563,520	**1965**	480,325	**1982**	524,710	**1999**	493,201
1932	319,307	**1949**	834,658	**1966**	489,088	**1983**	525,087	**2000**	706,234
								2001	716,655

Data sources: DFG Catch Bulletins (1916-1983) and DFG commercial landing receipt database (1984-2001).

Table 4.2. Consistency of the restricted access program for the California spiny lobster commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)	
Fish and Game Commission policies	**California spiny lobster restricted access program's consistency with the policies**
Restricted access as a management tool	
POLICY 1.1: The Fish and Game Commission (Commission) and the Department of Fish and Game (DFG) may use restricted access programs as one of a number of tools to conserve and manage fisheries as a public trust resource.	CONSISTENT The commercial restricted access program is one of the tools used to conserve and manage spiny lobster. Other tools include: time and area closures, commercial gear restrictions, recreational bag limits, commercial and recreational size limits.
Goals and objectives of restricted access programs	
POLICY 2.1: The Commission may develop restricted access programs for fisheries that retain the public ownership status of the resource for one or more of the following purposes: 1) to promote sustainability; 2) to create an orderly fishery; 3) to promote conservation among fishery participants; 4) to maintain the long-term economic viability of fisheries.	CONSISTENT The State Legislature granted the Commission authority to limit the number of permits to prevent overfishing or to ensure efficient and economic operation of the fishery.
Development and review of restricted access programs	
POLICY 3.1: Restricted access programs shall be developed with the substantial involvement of participants in the affected fishery and others, consistent with the stakeholder participation requirements of Fish and Game Code §7059. This approach shall balance the specific	NOT APPLICABLE The program was developed prior to the adoption of this policy or the enactment of Fish and Game Code §7059. However, participants were involved in the development of the program and subsequent

Table 4.2. Consistency of the restricted access program for the California spiny lobster commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)

Fish and Game Commission policies	California spiny lobster restricted access program's consistency with the policies
needs of the fishery with the desirability of increasing uniformity among restricted access programs in order to reduce administrative complexity.	modifications. The lobster restricted access program was modeled after the sea urchin program.
POLICY 3.2: Each restricted access program shall be reviewed at least every four years and, if appropriate, revised to ensure that it continues to meet the objectives of the State and the fishery participants. Review of each restricted access program shall occur at least as often as the particular fishery is reviewed in the annual fishery status report required by Fish and Game Code §7065. The general restricted access policy should be reviewed at a regularly scheduled Commission meeting at least once every four years following its adoption.	CONSISTENT IN PART The program started before the adoption of this policy, and has not been formally reviewed since its inception in 1996. The DFG plans to review the program in 2005. This report (*Annual Status of the Fisheries Report* required by Fish and Game Code §7065) briefly reviews the program, but does not formally measure participants' perceptions on whether the program is meeting its goals and objectives.
Elements of restricted access programs	
POLICY 4.1: Each new restricted access program shall be based either on one or more species or species groups targeted by the fishery or on a type of gear. In programs based on a type of gear an endorsement may be required for one or more species or species groups targeted by the gear type. Each restricted access program should take into account possible impacts of the program on other fisheries.	CONSISTENT • The program is based on a single species and gear type. • The program was not expected to displace any participants, and thus, was not expected to impact other fisheries.
POLICY 4.2: Each restricted access program that is not based on harvest rights shall have a capacity goal. The Commission, DFG and stakeholders will use the best available biological and economic information in determining each capacity goal.	NOT CONSISTENT Currently, the program does not have a capacity goal. A new capacity goal needs to be established.
POLICY 4.3: Each restricted access fishery system shall have an equitable, practicable, and enforceable system for reducing fishing capacity when the fishery is exceeding its participation goal and for increasing fishing capacity when the fishery is below its fishery capacity goal.	CONSISTENT IN PART Eligibility requirements were set for the initial permit, and since then attrition has been the means of reducing capacity. No system currently exists for increasing capacity.
POLICY 4.4: In fisheries that exceed their fishery capacity goals, permit transfers will be allowed only if they are consistent with the means for achieving the fishery capacity goal.	CONSISTENT Permits are not transferable.
Permits	
POLICY 5.1: The Commission will give adequate public notice of intent to establish a restricted access program. The Commission may set a Control Date for determining qualification for a restricted access program. A new restricted access program shall not allow fishing effort to increase beyond recent levels. Some level of fishery participation may be required to qualify for an initial permit. Fishery qualification can be based upon fishery participation during a period of time preceding notification of intent or on other factors relevant to the particular fishery. Affidavits of fishery participation or medical statements of inability to meet qualification standards shall not be accepted. Vessels under construction or inoperable during the qualification period shall not be considered for a	NOT APPLICABLE The program was developed before the adoption of this policy.

Table 4.2. Consistency of the restricted access program for the California spiny lobster commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)

Fish and Game Commission policies	California spiny lobster restricted access program's consistency with the policies
permit.	
POLICY 5.2: New permits in a restricted access fishery shall only be issued when the fishery is below its fishery capacity goal.	CONSISTENT IN PART There are no provisions for issuing new lobster permits.
POLICY 5.3: Restricted access fishery permits shall be of one year duration and are renewed upon annual application and payment of the permit fee and shall be valid, provided they are annually renewed and the permit holder meets the requirements of the restricted access program for the life of the program.	CONSISTENT • The permit must be renewed annually and is valid for the period of the commercial lobster season. • A permit fee is required.
POLICY 5.4: Each fisherman-based program shall determine in what circumstances, if any, a substitute may fish the permit.	CONSISTENT No substitution is allowed; the holder of the operator permit must be onboard.
Permit transfers	
POLICY 6.1: Restricted access permits may be transferable. In fisheries in which the permit is transferable, transfer may be subject to conditions that contribute to the objectives of the restricted access program. In new restricted access programs, permit transfers will not be allowed unless a fishery capacity goal and a system for achieving that goal are part of the restricted access program. In existing restricted access programs, the objective is to review and revise those programs to include fishery capacity goals and systems to achieve those goals. A restricted access program may include a fee on the transfer of permits, in excess of actual administrative costs for the permit change, to offset other costs involved in the conservation and management of that fishery.	CONSISTENT • The permit is not transferable. • The program does not have a capacity goal. • A new capacity goal needs to be determined. The DFG and the Commission will consider transferability of the permit when it reviews the program.
Vessel issues	
POLICY 7.1: Vessels requested to be retired by the vessel owner will no longer be eligible to participate in commercial fisheries in California.	NOT APPLICABLE The permit is not vessel-based.
POLICY 7.2: Replacement vessels of the same or lower fishing capacity as the permitted vessel will be allowed only if the permitted vessel is lost, stolen, retired or no longer able to participate as a commercial fishing vessel.	NOT APPLICABLE The permit is not vessel-based.
POLICY 7.3: Each restricted access program that allows for vessel permit transfers may allow for vessel upgrades provided a permit consolidation/vessel retirement process consistent with the fishery capacity goal is made part of the program.	NOT APPLICABLE The permit is not vessel-based.
POLICY 7.4: A restricted access program may prohibit the use of support vessels or require that they be permitted in the fishery or that they pay a fee comparable to the permit fee.	NOT APPLICABLE The permit is not vessel-based.
Harvest rights	
POLICY 8.1: It is the policy of the Commission that harvest rights systems such as individual transferable quotas may be considered only after careful consideration of	NOT APPLICABLE The program is not based on harvest rights.

Table 4.2. Consistency of the restricted access program for the California spiny lobster commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)	
Fish and Game Commission policies	**California spiny lobster restricted access program's consistency with the policies**
stakeholder input. In establishing such management systems, the State should consider: (1) fair and equitable initial allocation of quota shares which considers past participation in the fishery, (2) resource assessment for establishing total allowable catch estimates, (3) fishery participation goals and aggregation limits, (4) cost recovery from quota owners, (5) quota transferability, and (6) recreational fisheries issues.	
Administration of restricted access programs	
POLICY 9.1: Administrative costs shall be minimized and those costs shall be borne by the respective programs. Review or advisory boards may be considered on a program-by-program basis. The programs shall be administered in their entirety within an existing department unit.	CONSISTENT • The DFG License and Revenue Branch issues permits. • No formal review or advisory board exists. However, there is an active fishermen's association. • The Commission's hearing process is used for permit appeals.
POLICY 9.2: Fees collected from restricted access initiatives may, for cost accounting and reporting purposes, be deposited in a single dedicated Restricted Access Fishery Account within the Fish and Game Preservation Fund. A fund condition and activity report should be published annually.	CONSISTENT There is no dedicated account.
POLICY 9.3: Restricted access programs should provide specific disincentives for violations of pertinent laws and regulations. Enforcement costs of restricted access programs should be minimized through the use of new technologies or other means.	CONSISTENT All provisions of the Fish and Game Code and regulations are a condition of the permit. The Commission can revoke a permit for violation of the laws or regulations. A condition of the permit renewal is the submission of all required activity logs.

5. ROCK CRABS

Overview of the Fishery

Rock crabs are fished along the entire California coast. The catch includes three species: the yellow rock crab, *Cancer anthonyi*; the brown rock crab, *C. antennarius*; and the red rock crab, *C. productus*. The commercial fishery is most active in southern California (from Morro Bay south), where 85% to 90% of the landings occur. Fisheries in Monterey, Half Moon Bay, and Eureka yield 10% to 15% of the rock crab landings. In northern California, fishing is focused more on the valuable Dungeness crab. A major recreational fishery has not developed for rock crab, but recreational crabbing is popular in some areas and is often conducted in conjunction with other fishing activities.

Rock crabs do not appear in Department of Fish and Game records until 1928, and prior to 1950 there was no separate market category for reporting rock crab landings. Crabs landed to the south of Santa Barbara were recorded as rock crabs, and crabs landed to the north of Santa Barbara were recorded as Dungeness crab, regardless of the actual species landed. In 1950, a separate reporting category for commercial rock crab landings was established. Landings rose from 20,000 lb in 1950 to 1.9 million lb in 1986 (Figure 5.1 and Table 5.1). Between 1950 and 1986, a portion of the recorded landings were actually calculated whole-crab weights based on landings of claws. Since 1986, however, whole crabs and claws have been reported separately (Table 7.2). In 1991, it became illegal to land rock crab claws alone. Rock crab landings were approximately 1.1 million lb in 2000 and 1.2 million lb in 2001, and have averaged 1.2 million lb per year since 1991.

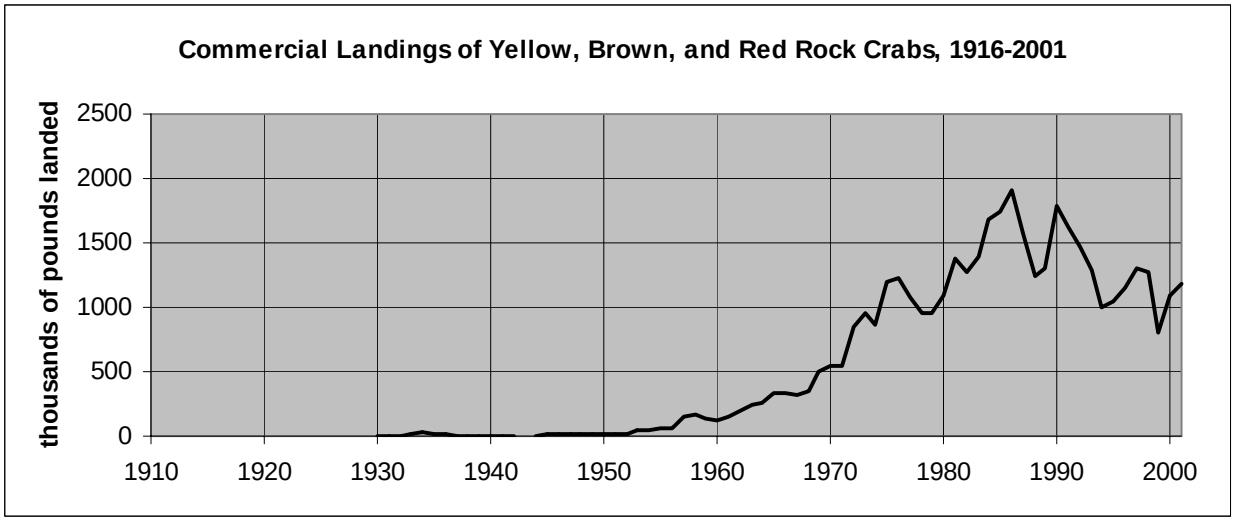

Figure 5.1. Annual commercial landings (pounds) of yellow, brown, and red rock crabs from 1916 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1916-1985) and the DFG commercial landing receipt database (1986-2001).

Commercial rock crabbing has expanded from nearshore areas around major ports such as San Diego, San Pedro, Santa Barbara, and Morro Bay to more distant mainland areas and the Channel Islands. Most rock crabs are landed alive for retail sale in fresh fish markets. Often the crabs are cooked and eaten on site and,

depending on the tastes of the consumer, muscle tissue as well as other organs (ovaries in particular) are consumed. Frozen or canned rock crab meat has not yet been successfully marketed. During 2001, ex-vessel prices for rock crabs averaged around $1.29 per lb.

Several trap designs are used in the rock crab fishery. The most popular is a single chamber, rectangular trap of two-by-four- or two-by-two-in. welded wire mesh. Molded plastic traps that collapse or nest together are used by some fishermen for ease of storage. Traps are set and buoyed singly or in pairs. Most trapping occurs in depths of 90 to 240 ft on open sandy bottom or near rocky reefs. Two hundred or more traps may be fished by one boat, with a portion pulled up and emptied each day. Traps are usually left in the ocean for 48 to 96 hr prior to pulling. Commercial crab boats are usually small, but range from skiff-sized boats to vessels of 40 ft or more.

Recreational gear for trapping rock crab includes baited hoop nets, collapsible star traps, or scaled-down commercial-type traps (north of Point Arguello) fished from piers, jetties, and boats. Rock crabs are also captured by hand in the intertidal zone, and when diving. Most recreational effort takes place along the shallow, nearshore open coast and in bays. Some increased recreational take has occurred in central and northern California in recent years as commercial passenger fishing vessels combine finfishing trips with crab trapping. These combination trips mainly target Dungeness crabs; however, depending on location and season, rock crabs (brown and red) are often taken as well.

Commercial laws and regulations protect crabs that are below reproductive size. The law presently requires a minimum harvest size of 4.25-in. carapace width (widest part of the body shell), and each trap must include escape rings that measure 3.25 in. across. The minimum harvest size and escape ring size were chosen to accommodate the different characteristics of the three rock crab species. Other laws and regulations designed to conserve crab populations include requiring that traps be raised and emptied every 96 hr, weather permitting, and prohibiting the use of commercial rock crab traps in portions of Humboldt, San Pedro and San Diego bays, in Santa Monica Bay, and in certain areas around Santa Catalina Island. Recreational rock crab fishery regulations include a 4-in. minimum carapace width and a bag and possession limit of 35 crabs per day.

A law was enacted in 2002 that authorized the Fish and Game Commission to adopt regulations to manage the rock crab resource in a manner consistent with the Marine Life Management Act of 1998. To date, no regulations have been proposed for this purpose.

Status of Biological Knowledge

Yellow rock crabs range from Humboldt Bay (Humboldt County) to southern Baja California, Mexico, brown rock crabs from northern Washington to central Baja California, and red rock crabs from Kodiak Island, Alaska to central Baja California. All three species inhabit waters from the low intertidal zone to depths of 300 ft or more. Although these species may occur together throughout much of their range, yellow rock crabs are most abundant in southern California, brown rock crabs in central California and red rock crabs in northern California. Yellow rock crabs prefer open sand or soft-bottom habitat, while brown and red rock crabs prefer rocky or reef-type habitat.

Rock crabs, like other crustaceans, grow in a step-wise fashion with each molt (shedding of the external shell). Yellow and brown rock crabs molt 10 to 12 times before reaching sexual maturity at about 3-in. carapace width. Crabs of this size may molt twice a year, but as they grow older and larger they molt less frequently. Crabs as large as 6 in. across may molt once a year or less. Molting frequency and size at maturity is not known for the red rock crab.

Growth per molt decreases with size and age. Males of all three species attain sizes 10% to 15% larger than females. Yellow rock crabs grow to exceed 7 in. in carapace width, brown rock crabs reach 6.5 in., and red rock crabs 8 in. While the longevity of rock crabs is not well known, they are thought to live for at least five or six years.

Mating takes place when females are in soft-shell condition, after molting. In southern California, mating is most common in the spring, but occurs throughout the year. About three months after mating, the female lays eggs and then fertilizes them with a sperm packet left by the male during mating. The developing eggs are carried in a mass attached to the female's abdomen. Depending on size and species, nearly four million eggs may be carried by a female rock crab. A nemertean worm is known to prey on eggs carried by female rock crabs, but egg mortalities are generally low, averaging less than 6%. After six to eight weeks, the eggs hatch into tiny free-floating larvae which undergo seven developmental molts before settling to the bottom as juveniles.

Rock crabs are both predators and scavengers, feeding on a variety of other invertebrates. Strong, crushing claws allow them to prey on heavy-shelled animals such as snails, clams, abalone, barnacles, and oysters. Rock crabs have a well-developed sense of smell, which allows them to detect and locate food at a distance.

Rock crabs, especially juveniles, are preyed upon by a variety of other marine organisms. Fishes such as cabezon, barred sand bass and several species of rockfish are known to feed on rock crabs. Invertebrate predators include octopus and certain sea stars. As rock crabs grow, they generally become less susceptible to predators except during the soft-shelled, post-molt period. Sea otters are one of the few effective predators on large, hard-shelled rock crabs.

Rock crabs do not appear to migrate or undertake large-scale movements. Tagged adults have moved several miles, but no pattern is apparent. Some local movements may also occur during mating or molting. Egg-bearing yellow rock crabs are known to congregate in rock-sand interface habitats.

Status of the Populations

Information is not available on the stock sizes, recruitment rates, mortality rates, the effects of different oceanographic regimes, or potential yield for any of the three of rock crab species. The commercial fishery, however, has had a localized effect on crab abundance and size. Areas intensively exploited over an extended period produce fewer crabs per trap, and have a reduced size-frequency distribution compared to lightly-exploited areas. In Santa Monica Bay, which has been closed to commercial crab fishing for decades, experimental catch rates were higher, crab sizes larger and size-frequencies broader than in adjacent areas open to commercial trapping. Further research should increase our understanding of rock crab population parameters.

Management Considerations

The rock crab fishery is currently one of the few remaining significant nearshore fisheries not subject to some form of restricted access. Open access and relatively low capital requirements for entry could result in large increases in effort for rock crabs as fishermen seek opportunities to diversify their fishing activities. The multi-species nature of the rock crab fishery presents a number of challenges to implementing meaningful management measures. Future management activities that could be considered to enhance the health of this resource and fishery include:

- Establishing a system for obtaining periodic fishery-independent data on rock crab abundance, species and size composition, recruitment patterns, and bycatch characteristics.
- Monitoring the commercial fishery for species and size composition, geographic and temporal patterns in catch and effort, and bycatch characteristics.
- Investigating whether a restricted access program for the commercial fishery is needed. Currently, rock crabs may be taken under a general trap permit which is issued annually. The Fish and Game Commission has authority over trap permits.
- Exploring gear modifications to reduce bycatch of other species.

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Revised May 2002

Further Reading

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Table 5.1. Commercial landings (pounds) of yellow, brown, and red rock crabs, 1916-2001

Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds
1916	------	**1933**	14,818	**1950**	20,007	**1967**	324,386	**1984**	1,676,298
1917	------	**1934**	24,570	**1951**	22,592	**1968**	351,657	**1985**	1,739,835
1918	------	**1935**	12,817	**1952**	16,977	**1969**	504,076	**1986**	1,913,788
1919	------	**1936**	16,202	**1953**	49,300	**1970**	539,579	**1987**	1,567,101
1920	------	**1937**	1,710	**1954**	39,058	**1971**	542,732	**1988**	1,239,273
1921	------	**1938**	3,847	**1955**	54,051	**1972**	843,530	**1989**	1,309,975
1922	------	**1939**	3,984	**1956**	59,171	**1973**	955,788	**1990**	1,788,657
1923	------	**1940**	3,460	**1957**	151,131	**1974**	864,033	**1991**	1,623,246
1924	------	**1941**	2,645	**1958**	166,962	**1975**	1,201,867	**1992**	1,468,309
1925	------	**1942**	80	**1959**	129,534	**1976**	1,227,766	**1993**	1,287,378
1926	------	**1943**	------	**1960**	120,903	**1977**	1,083,015	**1994**	1,002,373
1927	------	**1944**	540	**1961**	151,782	**1978**	956,874	**1995**	1,047,316
1928	270	**1945**	12,188	**1962**	200,304	**1979**	953,590	**1996**	1,154,869
1929	------	**1946**	11,600	**1963**	240,611	**1980**	1,083,957	**1997**	1,296,764
1930	12	**1947**	15,244	**1964**	263,885	**1981**	1,375,227	**1998**	1,276,863
1931	56	**1948**	20,938	**1965**	328,686	**1982**	1,277,872	**1999**	798,096
1932	145	**1949**	18,636	**1966**	330,843	**1983**	1,397,109	**2000**	1,090,763
								2001	1,184,739

------ No landings were reported from 1916 to 1927, 1929, and 1943.

1. Data sources: DFG Catch Bulletins (1916-1985) and DFG commercial landing receipt database (1986-2001).
2. Only one market category (reporting category) existed for crabs from 1916 to 1949. All crab landed in the San Diego, Los Angeles and Santa Barbara regions were assumed to be rock crab, and all crab landed in the Monterey, San Francisco and Eureka regions were assumed to be Dungeness crab.
3. In 1950, a separate market category was created for rock crab; all three species of rock crab were combined in this category.
4. From 1950 through 1985, the landings of rock crab also include any crab claws that were landed. The crab claws converted to whole crab weight using a 1:4 ratio (one pound of crab claws equaled four pounds of whole crab).
5. In 1986, a new market category was created for crab claws. Between 1986 and 1990, this category contained claws from both sheep crab (spider crab) and rock crab, with sheep crab claws more prevalent than rock crab claws. On January 1, 1991, it became illegal to take rock crab claws and the category became exclusively sheep crab claws. In this table, landings from 1928 to 1949 and from 1986 to 2001 do not include crab claws.
6. In 1994, three additional market categories were created: red rock crab, yellow rock crab, and brown rock crab. The landings from 1994 through 2001 are the sum of the combined rock crab market category and the three additional categories.

6. DUNGENESS CRAB

Overview of the Fishery

Dungeness crab, *Cancer magister*, also known as market crab or edible crab, was first taken commercially off San Francisco around 1848. Currently, Dungeness crab is fished from Avila (San Luis Obispo County) to the California-Oregon border, with commercial and recreational seasons beginning in late fall and ending in early summer.

Before the 1944-1945 season, the commercial fishery was centered in the San Francisco area, with average annual statewide landings of 2.6 million lb (Figure 6.1 and Table 6.1). As the fishery expanded into the Eureka-Crescent City area near the end of World War II, landings significantly increased. Since 1945, annual statewide landings have averaged about 9.7 million lb (Figure 6.1 and Table 6.1), fueled partly by the replacement of hoop nets with crab traps in the early 1940s. Annual ex-vessel value of Dungeness crab landings have ranged from less than $10 million to about $20 million during the last decade. Approximately three-quarters of the catch is sold as whole crab (live, fresh-cooked or frozen), and the remainder is processed to remove the meat and the meat is vacuum packed before being sold.

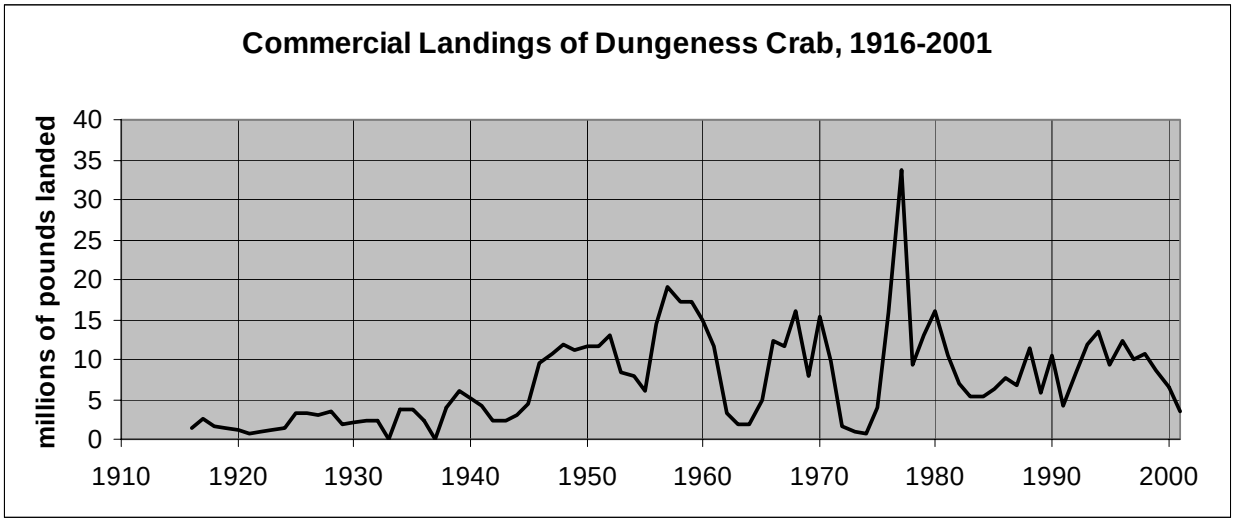

Figure 6.1. Annual (calendar year) commercial landings (pounds) of Dungeness crab from 1916 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1916-1983) and the DFG commercial landing receipt database (1984-2001).

The commercial fishery for Dungeness crab occurs in two main areas: northern California and central California. Central California fishing areas include Avila-Morro Bay, Monterey, and San Francisco-Bodega Bay. The Morro Bay and Monterey fisheries are minor compared to the San Francisco-Bodega Bay fishery. Central California landings were relatively stable from the 1945-1946 season to the 1955-1956 season, peaking at 9.3 million lb during the 1956-1957 season (Figure 6.2). Thereafter, landings declined by more than one million lb per season through the 1961-1962 season, when only 735,000 lb of Dungeness crab were landed. The central California fishery remained depressed from the 1962-1963 season through the 1985-1986 season, with landings averaging less than 1 million lb per season. Since the 1986-1987 season,

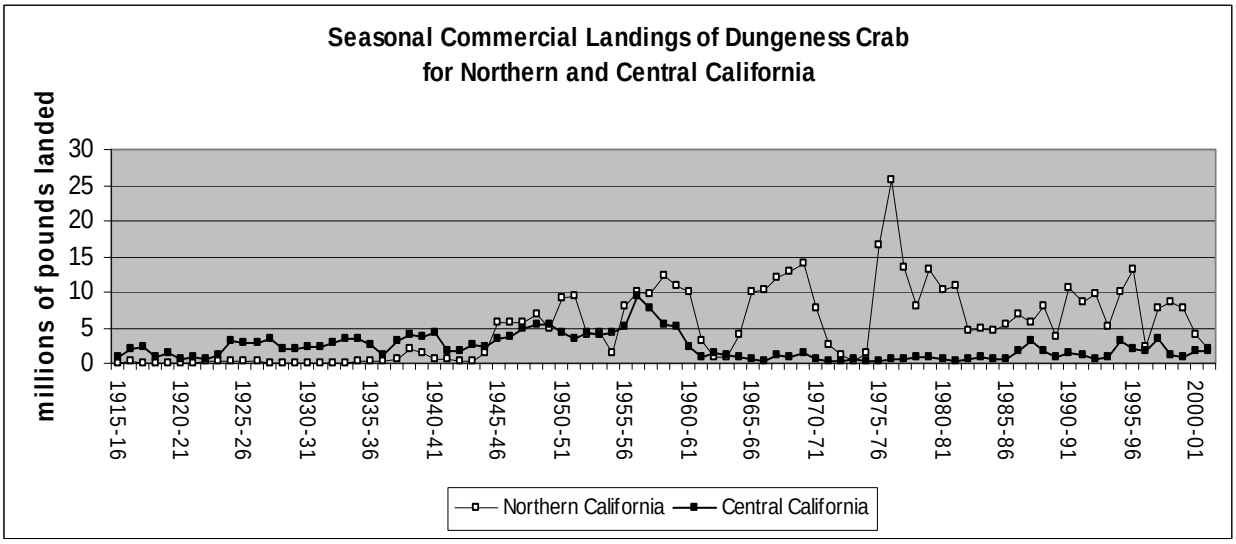

Figure 6.2. Commercial landings of Dungeness crab by season (late fall to early summer) for northern California (includes Eureka, Crescent City, and Fort Bragg) and central California (includes Bodega Bay, San Francisco area, Monterey, and Morro Bay). Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1916-1983) and the DFG commercial landing receipt database. The 2001-2002 season data is preliminary.

however, landings have ranged from slightly less than 500,000 lb to more than 3 million lb with an average 1.7 million lb.

The central California fishery uses a 400 sq. mi area, including the Gulf of the Farallones and waters north to the Russian River (Sonoma County). During the 1950s, the Dungeness crab fleet consisted of 200 to 250 boats. A number of boats left the fleet as the fishery began to decline in the 1960s. Currently, the fleet consists of about 190 vessels.

The northern California fishery increased substantially after 1945, reaching its peak in the late 1950s. Unlike the central California fishery, which peaked and then experienced low production levels for many years, the north coast fishery exhibited three 10-to-11-year “cycles” of production between 1945 and 1982. These repeating cycles consisted of about 6 years of good to outstanding landings (as high as 25.6 million lb in the 1976-1977 season) followed by about 4 years of poor to extremely poor landings (as low as 354,000 lb in the 1973-1974 season). Since the 1982-1983 season, landings have fluctuated, but they have not been clearly cyclic. From the 1982-1983 season to the 2001-2002 season, landings have ranged from 1.9 to 13.1 million lb, averaging about 6.9 million lb per season (Figure 6.2).

Dungeness crab fishing grounds off northern California are more than twice as large as those in central California. Northern California fishing grounds extend from Fort Bragg to the California-Oregon border, with the prime area located between Eureka and Crescent City. The size of the northern California fleet fluctuated between 100 and 200 vessels in the 1950s and 1960s. Fleet size dropped to a low of 61 during the 1973-1974 season, and then rose to 410 during the 1976-1977 season. Since then, effort has been high. Between the 1991-1992 season and the 2001-2002 season the number of boats in the fleet has ranged from 201 to 449. Before the mid-1970s, most vessels in the northern California crab fleet were converted salmon trollers that measured 30 to 60

ft in length; however, the composition of the fleet shifted during the record production years of the 1970s. With the boom in landings, boats as small as 22-ft dories and as large as 100 ft also entered the fishery.

The dividing line for management of the northern and central California areas is the Mendocino-Sonoma County border. Both areas are managed on the basis of the "3-S" principles— sex, season, and size. Only male crabs may be retained in the commercial fishery (thus protecting the reproductive potential of the populations). The fishery has open and closed seasons, and a minimum size limit is imposed (6.25 in. across the widest part of the carapace). The central California season opens November 15 and continues through June 30, whereas the northern California season opens December 1 and continues through July 15. The summer/fall closed periods are intended to prevent fishing for soft-shelled (recently molted) male crabs. During the closed seasons, male crabs are more vulnerable to fishery-related handling mortality and have a lower market quality (low meat content). During open seasons, however, male crabs are usually in prime condition for the market (high meat content). The season opens two to three weeks earlier in central California than in northern California because crabs in central California molt earlier and achieve adequate market condition earlier than northern crabs. The Director of the California Department of Fish and Game (DFG) may delay the northern California season opening to January 15 at the latest, if the market condition of crabs is not sufficiently high on December 1. Depending on crab condition, marketable crabs typically yield from 20% to 28% of their body weight as cooked meat.

Commercial traps for Dungeness crab are essentially the same throughout California. The average circular steel crab trap is 3 to 3.5 ft in diameter and weighs 60 to 120 lb. Each trap is required to have two circular openings that measure 4.25 in. in diameter. Sub-legal male and small female crabs escape through these "escape ports", which reduce the amount of potentially harmful handling that undersized crabs may be exposed to, and increases the likelihood that the crabs captured will be mostly males that meet or exceed the minimum size limit. Traps must also possess a destruction device that will release captured crabs should the trap become lost. The traps are heavily-weighted and rest on the sea floor; each trap is independently marked with a numbered buoy that floats on the surface. Traps are fished overnight or longer, depending on sea conditions. Most traps are fished at depths ranging from 60 to 240 ft, but some traps are fished in shallower or deeper waters.

Almost all of California's commercial Dungeness crab catch is landed in the trap fishery. Trawl vessels north of Point Reyes (Marin County) are allowed an incidental take of 500 lb per trip during the regular season, but only a few thousand pounds of trawl-caught crab is landed annually in California. Incidental landings of Dungeness crab are generally small due to the prohibition on commercial trawling within three miles of shore, where the vast majority of Dungeness are captured.

There is limited sport take of Dungeness crab in central and northern California. The total annual recreational harvest is unknown, but it is believed to be less than 1% of the commercial take. The recreational fishery is managed through seasonal and area closures, gear restrictions, size limits, and a limit on the number of crabs that may be possessed. Either sex may be taken in the recreational fishery. The size limit is 5.75 in. across the widest part of the carapace and the bag/possession limit is 10 crabs,

except when fishing from a commercial passenger fishing vessel in Sonoma, Marin, San Francisco, San Mateo, Santa Cruz and Monterey counties, when the size limit is 6 in. and the bag/possession limit is 6 crabs.

Because Dungeness crabs are caught almost exclusively within 3 mi. of shore in California, and because California, Oregon and Washington often undertake coordinated management activities under the auspices of the Pacific States Marine Fisheries Commission, the fishery has remained under State jurisdiction despite federal concerns regarding harvests beyond the three-mile state jurisdictional authority. Although total landings are not restricted by quota, the commercial restricted access program is designed to achieve an eventual reduction in the number of fishery participants.

Restricted Access Program

In 1992, the State Legislature began the process of developing a restricted access program by requiring that anyone landing Dungeness crab for commercial purposes have an annual Dungeness crab permit, and by establishing qualifying criteria for that permit. During the first three seasons of the program (1992-1993, 1993-1994, and 1994-1995 seasons), the annual Dungeness crab permit was issued to an applicant based on his or her history in the fishery. The initial legislation attempted to slow entry into the fishery while the Legislature evaluated the need for a restricted access program. The initial legislation stipulated that the program would end on January 1, 1995 unless a law was enacted to continue the program.

The Legislature reviewed the restricted access program in 1994 and determined that it was necessary to limit the number of vessels to protect the fishery. With this

Historical timeline for the Dungeness crab restricted access program

1992	State Legislature begins a restricted access program. The permit is based on an individual's landing of Dungeness crab.
1994	State Legislature reviews the program and modifies the program to make it vessel-based beginning with the 1995-1996 season.
1995 - 1997	State Legislature enacts various modifications to the program.
2000	State Legislature extends the program until 2006.
2006	The program will end April 1, 2006 unless a law is enacted to continue the program.

determination, the Legislature revised the restricted access program making it a vessel-based system (that is, the permit became attached to a specific vessel not to an individual). The law required that the Dungeness crab vessel permit be renewed annually, but it did not require that a minimum landing be made each year. The law provided for the transfer of a permit upon sale of the vessel or upon replacement of the vessel with another vessel of equivalent or slightly greater capacity. The vessel-based program became effective with the 1995-1996 season. The 1994 law specified that the program would end on April 1, 1998 unless subsequent legislation extended or repealed the program. The program was modified in 1995, 1996 and 1997, and extended until

April 1, 2001. In 2000, the program was again extended, and is now scheduled to end on April 1, 2006.

In the season prior to the initiation of the restricted access program (1991-1992), 769 vessels made commercial landings of Dungeness crab. During the first season of the initial restricted access program (1992-1993), 805 permits were issued (Figure 6.3). During the first season of the vessel-based system (1995-1996), 681 permits were issued (Figure 6.3). The number of permits increased during the next two seasons, and then gradually declined. For the 2001-2002 season, 654 permits were issued. The number of vessels actually making landings has been far less than the number of permits issued in recent years; only 59% of the permits were used in the 2001-2002 season.

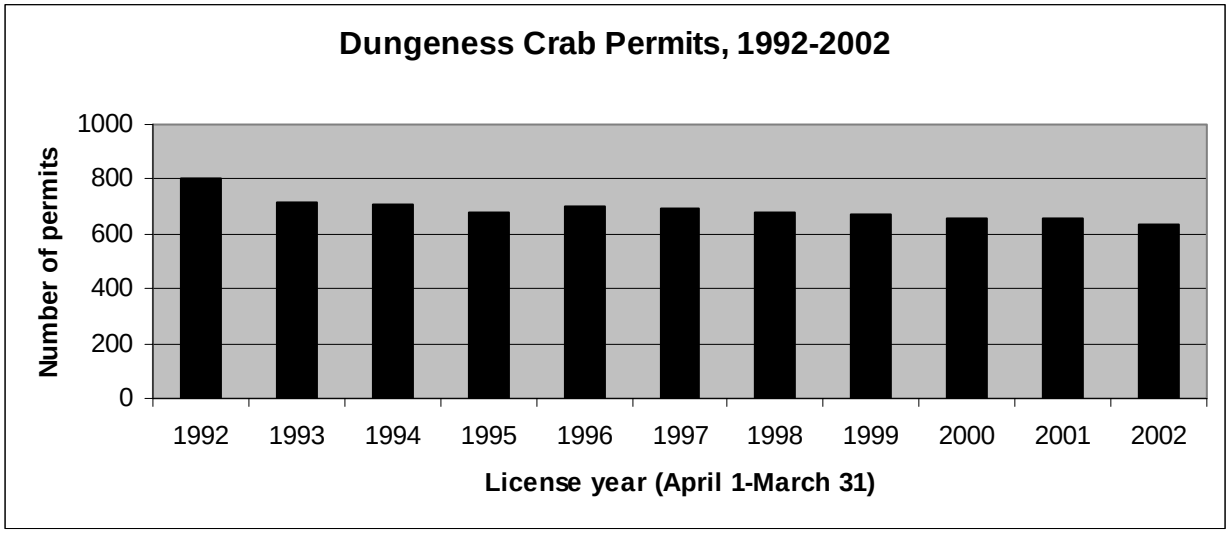

Figure 6.3. Total number of permits (resident and non-resident) issued for the commercial Dungeness crab fishery from the 1992-1993 license year (April 1 through March 31) to the 2002-2003 (preliminary) license year. The restricted access program began in 1992. Dungeness crab permits were issued to individuals for the 1992-1993, 1993-1994 and 1994-1995 license year; thereafter, vessel-based permits were issued. Data sources are DFG license reports.

The restricted access program remains under the authority of the State Legislature. However, the Marine Life Management Act (passed by the Legislature in 1998) requires that each restricted access program be reviewed for consistency with the Fish and Game Commission's (Commission's) policies on restricted access at least every five years (Fish and Game Code §7065(b)). Table 6.2 provides an evaluation of the current restricted access program's consistency with the Commission's policies on restricted access. The primary feature of the restricted access program that is inconsistent with the Commission's policies is that the program lacks a capacity goal.

Although the imposition of restricted access in California should prevent any further increases in the total number of vessels that participate in the Dungeness crab fishery, it does not prevent increases in fishing effort. There is currently no limit to the number of traps that may be fished, or the intensity with which they are fished. As the allowable take of groundfish has declined, many larger multi-purpose vessels have devoted more effort to the Dungeness crab fishery. Some of these vessels can fish

upwards of 1,000 traps. Early in the season, these larger vessels fish continuously, day and night, even in heavy seas. Total annual landings of Dungeness crab are largely unaffected by such increases in concentrated fishing effort, but it has changed the distribution of the catch over time. Prior to about 1980, crab landings in northern California were normally spread throughout the entire open season. Now, in a typical season in northern California, more than 80% of total landings are made during the month of December.

Uncontrolled increases in the numbers of traps fished by individual vessels and the front-loading of annual landings may have important consequences with respect to the allocation of fishery income among Dungeness crab vessel permit holders. Also, the shortened period of substantial crab landings means that live Dungeness crabs, the fishery's most valuable products, are only available for a relatively short time period, which could diminish the total economic value of the fishery. These and other fishery economics issues are currently being researched.

Status of Biological Knowledge

Dungeness crabs range from the eastern Aleutian Islands, Alaska, to around Santa Barbara (Santa Barbara County); however, the species is considered rare south of Point Conception (Santa Barbara County). Temperature apparently determines this species' distribution, with the 38° to 65° F surface temperature defining the range. The geographic range of the species probably depends more on the temperature tolerance range of larvae than of adults. Optimal temperatures for larval growth and development are 50° to 57° F.

Dungeness crabs have a preference for sandy and sand-mud bottoms but may be found on almost any bottom type. They may range from the intertidal zone to a depth of at least 750 ft, but are not abundant beyond 300 ft.

The Dungeness crab population off California, as demonstrated by tagging experiments, consists of five sub-populations, located in Avila-Morro Bay, Monterey, San Francisco, Fort Bragg, and Eureka-Crescent City. Only the latter three are commercially important. DFG surveys indicate that the San Francisco and Fort Bragg sub-populations combined are smaller than the sub-population extending from Eureka into Oregon. Little or no intermixing of the sub-populations occurs. Tagging studies have also demonstrated random movement by both sexes. At times, an inshore or offshore migration may be observed, but most movement is restricted to less than 10 mi. Movement of up to 100 mi. has been noted for individual males, but female movement seems much more limited.

Female molting and mating occurs from February through June in California. Male crabs are able to sense when females are about to molt (presumably through detection of pheromones released by females). When male crabs find pre-molt females, they carry the females in a protective pre-mating embrace for several days until they molt. Hard-shelled males then mate with the freshly molted, soft-shell females. Male sperm is stored inside the female. Fertilization of the eggs takes place when the female pushes the eggs outside of her body sometime between October and December. Thereafter, the eggs are carried under the abdominal flap of the female. The smallest females carry about 500,000 eggs, while the largest females carry from 1.5 to 2.0 million eggs. Freshly-molted females carry larger numbers of eggs than egg-

bearing females that have missed a molt. “Skip-molt” females that have extruded eggs but have not molted recently must rely on stored sperm for fertilization of their eggs. Females may store viable sperm for at least 2.5 years. The eggs, which are about the size of small sand grains (0.016 to 0.024 in.), are bright orange after extrusion and become progressively darker as they develop. Hatching occurs between November and February.

Newly hatched larvae pass through six different larval stages before taking on the adult form. Larval development takes from 105 to 125 days in central California, and is inversely related to water temperature. It is believed that larvae are carried offshore during the first five larval stages, and that this movement is regulated by ocean currents, depth, temperature, and salinity. Larvae are found near the surface at night and at depths of up to 80 ft during the day. From April through June, larvae are transported to nearshore waters, where they change into adult form. Estuaries such as Humboldt Bay and San Francisco Bay are important nursery areas for young Dungeness crabs, but most rearing must take place in nearshore coastal waters.

Growth is accomplished through a series of discrete molts. In northern California, Dungeness crabs of both sexes molt an average of six times during their first year and attain an average width (at the widest part of the carapace) of 1 in. Six more molts are required to reach sexual maturity at the end of the second year, when crabs are approximately 4 in. in width. Once mature, females grow more slowly than males. Females molt once per year at most after reaching maturity and rarely exceed the legal size for males. The maximum size for females is about 7 in.in width. Male crabs usually molt twice during their third year and once per year thereafter. The average width of males three, four and five years of age is about 6, 7 and 8 in., respectively. Males may undergo a total of 16 molts during a lifetime, reaching a maximum width of 9 in. at 6 to 8 years of age.

Dungeness crabs are opportunistic feeders not limited by the abundance or scarcity of a particular prey. Clams, fish, isopods and amphipods are preferred, and cannibalism is prevalent among all age groups. Predators of Dungeness crabs, especially larvae and small juveniles, include octopuses, larger crabs and as many as 28 species of fish, including coho and chinook salmon, flatfishes, lingcod, cabezon and various rockfishes.

Status of the Population

Dungeness crab populations in California have been fully exploited for at least 40 years and intensity of effort is extreme. In most years, from 80% to 90% of all available legal-sized male crabs are captured in the fisheries. Although such high exploitation rates on adult males might give rise to concerns that female mating success might be reduced as a consequence, recent studies have shown that essentially all molting females receive attention from males in northern California. Usually one or two year-classes of male crabs dominate annual landings. Thus, since about 1960, annual landings have provided a reasonable notion of abundance of legal-sized males and also a strong signal of variation in year-class strength of recruited crabs.

The dramatic decline in Dungeness crab catches in the central California fishery during the late 1950s caused considerable research attention to be focused on this resource during the 1970s. No definitive reason for the decline in the central California

fishery has been established. Researchers have assessed the effects of changes in ocean climate on survival and development of crab eggs and larvae, the role of nemertean worm predation on egg survival, the effects of pollution on survival of juvenile crabs in San Francisco Bay, and the possibility of unstable internal population dynamics. Of these possible causes, a shift to warmer waters during and following the decline in the late 1950s seems the most plausible. If this is the cause, it is reasonable to assume that the abundance of crabs in the central California fishery may improve over the next two decades if California coastal water temperatures remain cooler as a consequence of apparent ocean regime shifts.

The dramatic and periodic landings cycles in the northern California fishery from about 1945 to 1982 have caused this fishery to receive even greater attention from population dynamics modelers. Possible causes for the fluctuations in this fishery are infestation by nemertean worms, various internal density-dependent processes that reflect fluctuations in the abundance of unharvested females or cannibalism by adults on juveniles, and combinations of internal density-dependent controls and fluctuating oceanographic factors. There seems little doubt that crab populations, with their ability to produce large amounts of eggs and their extreme vulnerability in the early larval stages, are prone to great natural fluctuations in abundance. It also seems that variable oceanographic factors (such as temperature, wind, and currents) have significant impacts on the survival of year classes.

Although many crustacean fisheries throughout the world have been overexploited and are now at low abundance levels, Dungeness crab populations off northern California, Oregon and Washington have produced landings that have fluctuated around a fairly stable long-term mean for more than 30 years. One might, therefore, consider this resource to have a healthy status. Formal fishery management plans and stock assessments have not been produced for any West Coast population. Fishery management has rested on the very simple, though biologically sound, “3-S” principles (sex, season, and size). Typically restrictive fishery regulations such as landing quotas have never been used in this fishery. A casually assigned healthy status therefore rests on limited information.

Management Considerations

The Dungeness crab resource is fully exploited in California. Responsibility for managing the commercial Dungeness crab fishery lies with the State Legislature. While the Legislature has authorized the Commission to regulate the recreational fishery, it has not authorized the Commission to regulate the commercial fishery. The commercial restricted access program will expire on April 1, 2006 unless the Legislature extends the program. It would be beneficial to conduct a formal review of the current restricted access program before the Legislature decides whether to extend the program. Issues that could be considered during the review include:

- The creation of a capacity goal. No goal currently exists.
- Whether other effort controls, such as limits on the number of traps, need to be enacted to reduce capacity.
- The potential impacts of the latent capacity in the fishery (the capacity of the permits that are not used each season).

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by ***Patrick Collier***
California Department of Fish and Game

Section on Restricted Access Program added December 2002
by ***Connie Ryan*** *and* ***David Hankin***
California Department of Fish and Game, and Humboldt State University

Further Reading

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Table 6.1. Commercial landings (pounds) of Dungeness crab, 1916-2001

Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds
1916	1,296,912	**1933**	3,208,494	**1950**	11,704,648	**1967**	11,716,488	**1984**	5,340,031
1917	2,580,840	**1934**	3,768,081	**1951**	11,568,353	**1968**	16,015,581	**1985**	6,210,359
1918	1,619,280	**1935**	3,680,188	**1952**	12,997,451	**1969**	7,938,996	**1986**	7,758,251
1919	1,304,904	**1936**	2,311,802	**1953**	8,278,519	**1970**	15,413,589	**1987**	6,857,070
1920	1,220,568	**1937**	1,627,753	**1954**	7,829,651	**1971**	9,662,265	**1988**	11,297,696
1921	800,952	**1938**	3,873,600	**1955**	6,119,320	**1972**	1,563,006	**1989**	5,718,017
1922	860,328	**1939**	5,953,361	**1956**	14,320,549	**1973**	1,022,873	**1990**	10,369,518
1923	1,075,800	**1940**	5,151,014	**1957**	19,118,484	**1974**	685,000	**1991**	4,246,044
1924	1,506,816	**1941**	4,260,340	**1958**	17,282,766	**1975**	3,934,663	**1992**	8,327,150
1925	3,234,312	**1942**	2,414,110	**1959**	17,262,261	**1976**	15,726,774	**1993**	11,958,039
1926	3,296,280	**1943**	2,315,338	**1960**	14,876,148	**1977**	33,647,863	**1994**	13,491,363
1927	2,960,712	**1944**	2,934,776	**1961**	11,711,327	**1978**	9,362,197	**1995**	9,236,191
1928	3,574,464	**1945**	4,334,383	**1962**	3,222,580	**1979**	12,978,505	**1996**	12,331,365
1929	1,792,776	**1946**	9,624,368	**1963**	1,951,461	**1980**	15,934,778	**1997**	9,908,520
1930	1,992,384	**1947**	10,733,398	**1964**	1,815,363	**1981**	10,435,441	**1998**	10,692,760
1931	2,231,384	**1948**	11,892,891	**1965**	4,803,906	**1982**	6,973,679	**1999**	8,713,823
1932	2,433,987	**1949**	11,115,476	**1966**	12,376,390	**1983**	5,301,828	**2000**	6,476,494
								2001	3,536,099

Data sources: DFG Catch Bulletins (1916-1983) and DFG commercial landing receipt database (1984-2001).

Table 6.2. Consistency of the restricted access program for the Dungeness crab commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)

Fish and Game Commission policies	Dungeness crab restricted access program's consistency with the policies
Restricted access as a management tool	
POLICY 1.1: The Fish and Game Commission (Commission) and the Department of Fish and Game (DFG) may use restricted access programs as one of a number of tools to conserve and manage fisheries as a public trust resource.	CONSISTENT The program was established by the State Legislature and remains under the authority of the Legislature. However, restricted access is one of the tools used to manage the fishery and conserve the resource. The program is due to end on April 1, 2006 unless the Legislature extends the program.
Goals and objectives of restricted access programs	
POLICY 2.1: The Commission may develop restricted access programs for fisheries that retain the public ownership status of the resource for one or more of the following purposes: 1) to promote sustainability; 2) to create an orderly fishery; 3) to promote conservation among fishery participants; 4) to maintain the long-term economic viability of fisheries.	CONSISTENT The legislative intent as stated in Fish and Game Code §8280 was "to protect the Dungeness crab fishery". However, there is some question whether the program is meeting the legislative intent for an orderly fishery and for the long-term economic viability of the fishery.
Development and review of restricted access programs	
POLICY 3.1: Restricted access programs shall be developed with the substantial involvement of participants in the affected fishery and others, consistent with the	NOT APPLICABLE The program was developed prior to the adoption of Fish and Game Code §7059 or the Commission policy

Table 6.2. Consistency of the restricted access program for the Dungeness crab commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)

Fish and Game Commission policies	Dungeness crab restricted access program's consistency with the policies
stakeholder participation requirements of Fish and Game Code §7059. This approach shall balance the specific needs of the fishery with the desirability of increasing uniformity among restricted access programs in order to reduce administrative complexity.	on restricted access. However, constituents were involved in the development of the initial and subsequent legislation regarding the Dungeness crab program.
POLICY 3.2: Each restricted access program shall be reviewed at least every four years and, if appropriate, revised to ensure that it continues to meet the objectives of the State and the fishery participants. Review of each restricted access program shall occur at least as often as the particular fishery is reviewed in the annual fishery status report required by Fish and Game Code §7065. The general restricted access policy should be reviewed at a regularly scheduled Commission meeting at least once every four years following its adoption.	CONSISTENT IN PART • The program has been reviewed and revised by the State Legislature a number of times. • This report (*Annual Status of the Fisheries Report* required by Fish and Game Code §7065) briefly reviews the program, but does not formally measure participants' perceptions on whether the program is meeting its goals and objectives.
Elements of restricted access programs	
POLICY 4.1: Each new restricted access program shall be based either on one or more species or species groups targeted by the fishery or on a type of gear. In programs based on a type of gear an endorsement may be required for one or more species or species groups targeted by the gear type. Each restricted access program should take into account possible impacts of the program on other fisheries.	CONSISTENT IN PART • The program is based on one species and one gear type. • It is not clear whether the impacts on other fisheries were evaluated during the development of the program.
POLICY 4.2: Each restricted access program that is not based on harvest rights shall have a capacity goal. The Commission, Department and stakeholders will use the best available biological and economic information in determining each capacity goal.	NOT CONSISTENT No capacity goal was set by the State Legislature. The Legislature limited the number of permits, but this may not have limited capacity or effort.
POLICY 4.3: Each restricted access fishery system shall have an equitable, practicable, and enforceable system for reducing fishing capacity when the fishery is exceeding its participation goal and for increasing fishing capacity when the fishery is below its fishery capacity goal.	NOT CONSISTENT No capacity goal exists, and there is no method to increase or decrease capacity. Under the program, capacity, in terms of numbers of permits, is decreasing by attrition. However, it is not clear if capacity, in terms of number of traps or size of vessels, is increasing or decreasing.
POLICY 4.4: In fisheries that exceed their fishery capacity goals, permit transfers will be allowed only if they are consistent with the means for achieving the fishery capacity goal.	NOT CONSISTENT No capacity goal exists, and permit transfer is allowed.
Permits	
POLICY 5.1: The Commission will give adequate public notice of intent to establish a restricted access program. The Commission may set a Control Date for determining qualification for a restricted access program. A new restricted access program shall not allow fishing effort to increase beyond recent levels. Some level of fishery participation may be required to qualify for an initial permit. Fishery qualification can be based upon fishery participation during a period of time preceding notification of intent or on other factors relevant to the particular	NOT APPLICABLE The program was established by the State Legislature.

Table 6.2. Consistency of the restricted access program for the Dungeness crab commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)

Fish and Game Commission policies	Dungeness crab restricted access program's consistency with the policies
fishery. Affidavits of fishery participation or medical statements of inability to meet qualification standards shall not be accepted. Vessels under construction or inoperable during the qualification period shall not be considered for a permit.	
POLICY 5.2: New permits in a restricted access fishery shall only be issued when the fishery is below its fishery capacity goal.	NOT CONSISTENT No capacity goal exists, and there are no provisions for issuing new permits.
POLICY 5.3: Restricted access fishery permits shall be of one year duration and are renewed upon annual application and payment of the permit fee and shall be valid, provided they are annually renewed and the permit holder meets the requirements of the restricted access program for the life of the program.	CONSISTENT Annual renewal is required.
POLICY 5.4: Each fisherman-based program shall determine in what circumstances, if any, a substitute may fish the permit.	NOT APPLICABLE This is a vessel-based program.
Permit transfers	
POLICY 6.1: Restricted access permits may be transferable. In fisheries in which the permit is transferable, transfer may be subject to conditions that contribute to the objectives of the restricted access program. In new restricted access programs, permit transfers will not be allowed unless a fishery capacity goal and a system for achieving that goal are part of the restricted access program. In existing restricted access programs, the objective is to review and revise those programs to include fishery capacity goals and systems to achieve those goals. A restricted access program may include a fee on the transfer of permits, in excess of actual administrative costs for the permit change, to offset other costs involved in the conservation and management of that fishery.	NOT CONSISTENT • Permits are transferable under certain conditions, and transfers are subject to a fee. • The program has not been revised to include a capacity goal and a system to achieve that goal.
Vessel issues	
POLICY 7.1: Vessels requested to be retired by the vessel owner will no longer be eligible to participate in commercial fisheries in California.	NOT CONSISTENT A permit may be transferred to a replacement vessel. The program does not restrict the use of the "replaced" vessel.
POLICY 7.2: Replacement vessels of the same or lower fishing capacity as the permitted vessel will be allowed only if the permitted vessel is lost, stolen, retired or no longer able to participate as a commercial fishing vessel.	NOT CONSISTENT The program provides for increase in capacity under certain circumstances.
POLICY 7.3: Each restricted access program that allows for vessel permit transfers may allow for vessel upgrades provided a permit consolidation/vessel retirement process consistent with the fishery capacity goal is made part of the program.	NOT CONSISTENT • No permit consolidation or retirement process exists. • No capacity goal exists.
POLICY 7.4: A restricted access program may prohibit the use of support vessels or require that they be permitted in the fishery or that they pay a fee comparable to the permit fee.	CONSISTENT The program allows vessels without permits to deploy traps, but not to retrieve traps.

Table 6.2. Consistency of the restricted access program for the Dungeness crab commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)

Fish and Game Commission policies	Dungeness crab restricted access program's consistency with the policies
Harvest rights	
POLICY 8.1: It is the policy of the Commission that harvest rights systems such as individual transferable quotas may be considered only after careful consideration of stakeholder input. In establishing such management systems, the State should consider: (1) fair and equitable initial allocation of quota shares which considers past participation in the fishery, (2) resource assessment for establishing total allowable catch estimates, (3) fishery participation goals and aggregation limits, (4) cost recovery from quota owners, (5) quota transferability, and (6) recreational fisheries issues.	NOT APPLICABLE The program is not based on harvest rights.
Administration of restricted access programs	
POLICY 9.1: Administrative costs shall be minimized and those costs shall be borne by the respective programs. Review or advisory boards may be considered on a program-by-program basis. The programs shall be administered in their entirety within an existing department unit.	CONSISTENT • The program is administered through the DFG Marine Region. • The Dungeness Crab Review Panel reviewed applications for permits.
POLICY 9.2: Fees collected from restricted access initiatives may, for cost accounting and reporting purposes, be deposited in a single dedicated Restricted Access Fishery Account within the Fish and Game Preservation Fund. A fund condition and activity report should be published annually.	CONSISTENT There is no dedicated account.
POLICY 9.3: Restricted access programs should provide specific disincentives for violations of pertinent laws and regulations. Enforcement costs of restricted access programs should be minimized through the use of new technologies or other means.	CONSISTENT IN PART • If a person submits false information to obtain a permit, DFG must revoke the permit and revoke the person's commercial fishing license and commercial boat registration for at least five years. • The Commission may revoke the commercial fishing license and commercial boat registration of anyone owning a boat used to take or land Dungeness crab without a permit.

7. SHEEP CRAB

Overview of the Fishery

The sheep crab, *Loxorhynchus grandis,* commonly known as the spider crab, is trapped mainly in the Santa Barbara Channel and off the northern Channel Islands. The bulk of landings occur in Santa Barbara and Ventura Counties, although most crabs are marketed in San Pedro (Los Angeles County) and the greater Los Angeles area. Crab traps are set primarily in shallow, sandy-bottom areas (30-70 ft) in spring and summer, and moved to deeper waters (120-240 ft) in fall and winter.

Before the late 1970s, sheep crabs were occasionally taken as bycatch in commercial gill and trammel net fisheries, and were infrequently taken by recreational divers. They were a nuisance to net fishermen as they often became tangled in gear. Santa Barbara fishermen and processors developed an experimental market for sheep crab, which grew rapidly because of high demand for the claws.

Two types of fisheries exist for sheep crab: one for claws alone, and one for whole crabs. Gill net and trammel net fishermen supplied the claw market, usually killing the crab in the claw-removal process. With development of the claw fishery, sheep crab became a valuable product for gill net fishermen. Only male crabs are used in the claw fishery, as adult female and small adult male claws do not reach market size.

For the whole crab fishery, both males and females are taken, with crab and lobster trap fishermen supplying the bulk of live crabs. Modified rock crab or lobster traps with enlarged funnels are used to trap sheep crab.

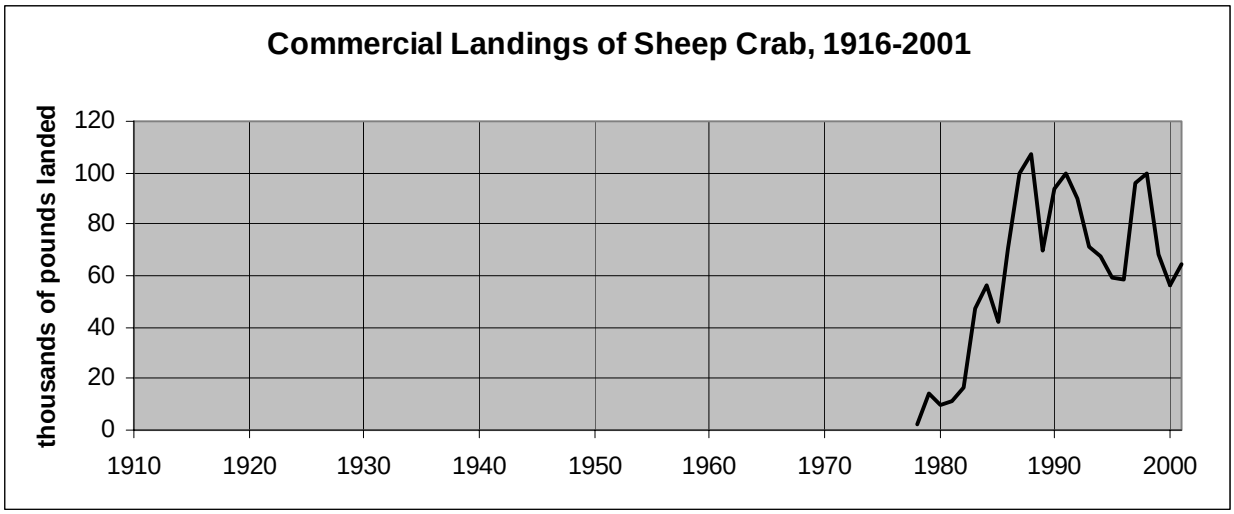

Figure 7.1. Annual commercial landings (pounds) of sheep crab from 1916 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1916-1983) and the DFG commercial landing receipt database (1984-2001).

Fishery landings peaked in 1988 with landings of 108,000 lb of whole crabs (Figure 7.1 and Table 7.1), and 96,000 lb of claws (Table 7.2). From 1986 through 1990, the crab claw market category contained claws from both sheep crab and rock crab, with sheep crab claws more prevalent than rock crab claws. The retail value of

the combined catch was about $1.9 million, with claws being sold for $5.75 per lb and whole crabs going for $3.00 per lb live and $4.25 per lb cooked. The 1988 claw landings represented approximately 362,000 lb of whole crabs. When the claw fishery was at its peak, the sheep crab fishery was the only fishery in the United States with sizeable landings of both claws and whole crabs.

In 1990, the Marine Resources Protection Act (California ballot initiative Proposition 132) established a three year phase-out of gill and trammel nets within three miles of the mainland shore south of Point Arguello (Santa Barbara County) and in areas around the Channel Islands. Subsequently, landings of sheep crab claws plummeted. Since the phase-out of gill and trammel nets in 1994, crab claw landings have averaged 4,000 lb per year, while the annual landings of whole crabs has not changed substantially.

While claws commanded a higher price per lb than whole crab before the phase-out of gill and trammel nets, the price of claws fell along with landings after the phase-out in 1994. In 1999 the retail value of fishery landings was approximately $310,000, with whole, live crabs being sold for up to $4.00 per lb and claws up to $3.00 per lb.

Any future increase in claw landings seems unlikely given that the fishery was developed to provide some value to a bycatch species. Also, when it became illegal to take rock crab claws in 1991, landings of sheep crab claws did not increase to compensate for the loss of rock crab claws in the market, probably because the law banning take of rock crab claws was implemented at the same time as the ban on using gill and trammel nets in shallow waters. Thus, the ban on the primary gear used to take sheep crab claws incidentally seems to have stemmed any possible increase in claw landings.

Fishing effort for whole crabs and landings of whole crabs remains relatively low since fishermen generally must establish their own live markets and must be able to hold the live crabs for up to a week or more. In addition, because of the heavy, thick shell of the crab, processing the body meat is uneconomical at present. Landings of whole crabs may increase if new marketing efforts expand the live markets or if processing becomes economically feasible. Increased landings seem possible given the continued interest in the California fishery and the recent development of an experimental sheep crab fishery off Baja California, Mexico.

Status of Biological Knowledge

"Sheep crab" is the common name of one species within a family of crabs (Majidae), collectively known as spider crabs. Consequently, the sheep crab, which is the largest member of the California majid crabs, is often called "spider crab". They range from Cordell Bank (off Marin County) south to Cape Thurloe, Baja California, in depths of 20 to 410 ft. It is not known whether the sheep crab resource consists of more than one population. Sheep crabs are apparently most abundant off southern California.

Longevity of this crab is currently unknown, but many adults appear to be at least four years old. In contrast to most other commercially-important crustaceans, sheep crabs are believed to cease "molting", or shedding their shells, upon reaching maturity. After the final molt, crabs do not increase in size nor do they regenerate limbs.

Because of this characteristic, sheep crabs may require a different management regime than other crabs.

Maturation is currently defined only by the relative size of external body parts. At maturity, the width of the abdomen in females and the length of the claw in males increase markedly when compared to carapace length. Females become mature between 4.2 and 6.8 in. carapace length. Adult males range in size from 4.2 to 9.6 in. carapace length. However, juvenile male crabs can reach a length of 6.8 in., so size alone cannot determine maturity. The presence of a gap in the serration on the claw of adult male crabs also distinguishes them from juvenile males. It is uncertain how maturity, as determined by the relative size of external body parts, relates to physiological and behavioral maturity.

The number of egg-bearing females peaks in late spring and remains high throughout the summer, although they can be found throughout the year. Adult females are able to mate when soft- or hard-shelled. Sperm storage allows for multiple broods to be laid even in the absence of males. Egg numbers probably increase with the size of brooding female crabs. Small broods may contain 125,000 eggs, whereas large broods can contain up to 500,000 eggs.

Laboratory observations suggest that sheep crabs feed on a variety of prey. They readily eat dead fish, crushed mussels, and kelp. Cannibalism of newly-molted animals occurs in the laboratory when crabs are not well fed. No observations are available on foraging behavior in the wild, nor have gut contents been analyzed.

Predatory interactions have not been observed in the field, but it is likely that small crabs are preyed upon by cabezon, California sheephead, octopus, sharks and rays. Small sheep crabs disguise themselves by decorating their carapace with algae, sponges, or other encrusting materials. Large crabs probably have few predators.

Two parasitic infections could potentially impact the number of individuals reaching later life stages: an undescribed species of nemertean worm, also know as the ribbon worm, and the rhizocephalan barnacle. The ribbon worm consumes developing embryos in eggs, while the barnacle eliminates reproductive output and also inhibits growth of the crab. Preliminary observations indicate that certain areas contain a high prevalence of individuals parasitized by these barnacles, and that crabs become infected as juveniles.

Male crabs winter in deep water. Both sexes migrate onshore in early spring, and piles of adult females have been observed in shallow water in spring and summer. Large adult males have been seen on the perimeter of these aggregations, which are apparently related to mating. Within these aggregations, the majority of females bear eggs, and the males often exhibit competitive behavior for mates. Male and female crabs have been observed hooked together, back-to-back, by the male's hindmost limbs. Similar aggregate mating behavior has been reported for other spider crabs.

Status of the Population

The abundance of sheep crabs is unknown. Abundant populations have been reported off Los Angeles (Los Angeles County) and San Diego (San Diego County). Although this crab has been harvested as bycatch for many years, there is no evidence of declining populations in the Santa Barbara Channel where most of the crab fishing takes place. However, there are reports of a decrease in overall crab size. This decline

could be due to the immense fishing pressure for large males at the height of the fishery. Because this species stops molting at maturity, removal of large crabs may leave only small animals to contribute to the gene pool. If the terminal molt is genetically regulated, this could result in a population of smaller crabs. However, this is presently a hypothesis. The true state of populations and size distributions remains unknown.

Management Considerations

Additional biological information, including a better understanding of physiological and behavioral reproduction, is needed to develop sound management policies. Nevertheless, limited management recommendations can be made based on certain biological characteristics of the sheep crab:

- Sheep crab stop molting upon reaching adulthood. Thus, the claws will not regenerate once removed from adult crabs.
- The cessation of molting and other characteristics have implications for management of the live, whole body fishery. For example, size limits would likely need to include both an upper and lower limit. This would leave the largest and smallest crabs to mate and maintain recruitment. The lower limit would need to protect large juvenile males which overlap in size with the smaller adults.
- Protection of seasonal spawning aggregations may need to be incorporated into a management plan for this species.
- After sheep crab stop molting, the shell and limbs of the crabs become abraded over time. The level of abrasion (called “abrasion stage”) can be used to distinguish between juveniles and adults. Use of abrasion stages may also provide a good tool for management. However, duration of the various abrasion stages and their association with gonadal development and reproductive success needs to be determined before considering this management strategy.

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Further Reading

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Culver, Carolynn S. 1991. Growth of the spider crab, *Loxorhynchus grandis*. M.A. Thesis, Univ. of Calif. Santa Barbara, California. 101 p.

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Table 7.1. Commercial landings (pounds) of sheep crab, 1916-2001

Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds
1916	------	**1933**	------	**1950**	------	**1967**	------	**1984**	56,328
1917	------	**1934**	------	**1951**	------	**1968**	------	**1985**	41,760
1918	------	**1935**	------	**1952**	------	**1969**	------	**1986**	70,465
1919	------	**1936**	------	**1953**	------	**1970**	1,032	**1987**	99,546
1920	------	**1937**	------	**1954**	------	**1971**	------	**1988**	107,569
1921	------	**1938**	------	**1955**	------	**1972**	------	**1989**	70,057
1922	------	**1939**	------	**1956**	------	**1973**	------	**1990**	93,444
1923	------	**1940**	------	**1957**	------	**1974**	52	**1991**	99,500
1924	------	**1941**	------	**1958**	------	**1975**	------	**1992**	89,871
1925	------	**1942**	------	**1959**	------	**1976**	------	**1993**	71,173
1926	------	**1943**	------	**1960**	------	**1977**	------	**1994**	67,290
1927	------	**1944**	------	**1961**	------	**1978**	1,919	**1995**	59,427
1928	------	**1945**	------	**1962**	------	**1979**	14,402	**1996**	58,852
1929	------	**1946**	------	**1963**	------	**1980**	9,869	**1997**	95,801
1930	------	**1947**	------	**1964**	------	**1981**	10,914	**1998**	99,797
1931	------	**1948**	------	**1965**	------	**1982**	16,495	**1999**	68,602
1932	------	**1949**	------	**1966**	------	**1983**	47,108	**2000**	55,995
								2001	64,564

------ No landings were reported.
1. Data sources: DFG Catch Bulletins (1916-1983) and commercial landing receipt database (1984-2001).
2. Sheep crab landings are reported as spider crab by DFG.

Table 7.2. Commercial landings (pounds) of crab claws, 1986-2001

Year	Pounds	Year	Pounds	Year	Pounds
1986	46,167	**1991**	28,805	**1996**	6,490
1987	82,931	**1992**	27,368	**1997**	4,958
1988	96,471	**1993**	19,482	**1998**	5,447
1989	76,090	**1994**	4,423	**1999**	3,347
1990	64,556	**1995**	3,812	**2000**	3,258
				2001	2,750

1. Data source: DFG commercial landing receipt database.
2. In 1986, a new market category (reporting category) was created for crab claws. Between 1986 and 1990, this category contained claws from both sheep crab (spider crab) and rock crab, with sheep crab claws more prevalent than rock crab claws. On January 1, 1991, it became illegal to take rock crab claws and the category became exclusively sheep crab claws.
3. Landings reported as weight of the claws and are not an estimate of whole weight of the crab.

8. ABALONES

Overview of the Fishery

Seven species of abalone are found in California: red abalone, *Haliotis rufescens*; pink abalone, *H. corrugata;* green abalone, *H. fulgens*; black abalone, *H. cracherodii*; white abalone, *H. sorenseni*; pinto abalone, *H. kamtschatkana*; and flat abalone, *H. walallensis*. Threaded abalone, *H. kamtschatkana assimilis*, was once thought to be a separate species, but is now considered to be synonymous with the pinto abalone.

Archaeological evidence indicates that Native Americans fished extensively for abalone from coastal areas and the Channel Islands prior to European settlement of California. During the 1850s, Chinese-Americans began fishing commercially for intertidal green and black abalones. Fishermen worked shallow waters with skiffs, dislodging abalone with long poles tipped with wedges, and landing them with gaffs. This fishery hit peak landings of 4.1 million lb[1] in 1879, but was eliminated in 1900 by the closure of shallow waters to commercial harvest.

In the early 1900s, Japanese-American divers began fishing virgin stocks of subtidal abalone, first as free divers from surface floats and later, more successfully, as hard-hat divers. Landings peaked at about 3.9 million lb in 1935 and then declined to under 200,000 lb by 1942 as fishermen of Japanese heritage were moved to relocation camps during the early part of World War II (Figure 8.1 and Table 8.1). Commercial abalone fishing increased later in World War II when abalone was used as a source of war-time food. Landings rapidly increased between 1942 and 1951. Landings appeared relatively stable from 1952 to 1968, averaging about 4.5 million lb per year, but began declining rapidly in 1969. By 1996, the last full year the commercial fishery was open, landings had fallen to about 229,500 lb, only 4% of the fishery's peak landings of 5.4 million lb.

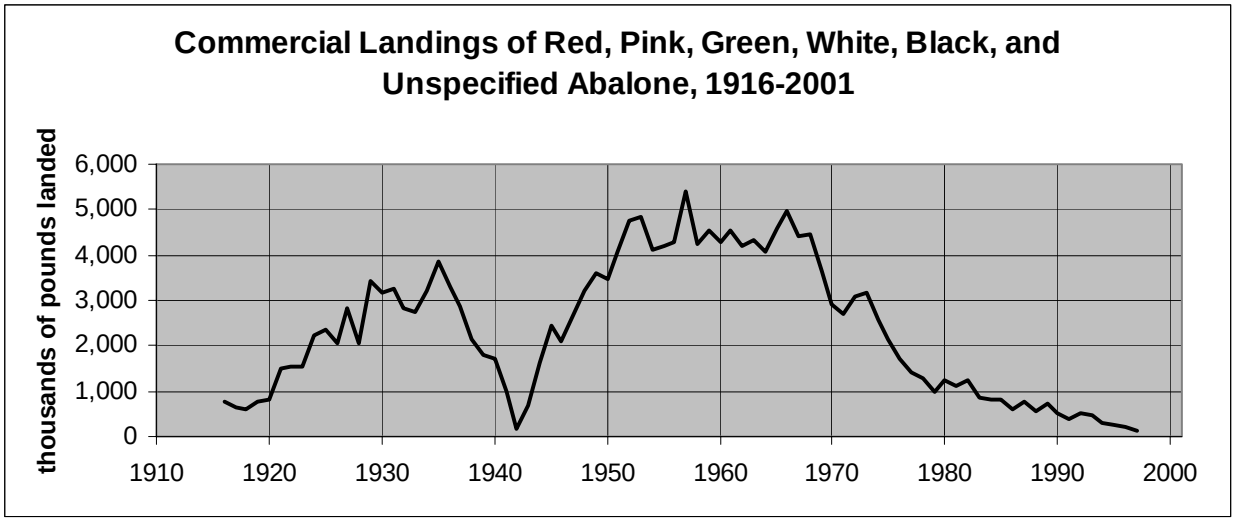

Figure 8.1. Annual commercial landings (pounds) of red, pink, green, white, black, and unspecified abalone from 1916 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1916-1983) and the DFG commercial landing receipt database (1984-2001).

1 Unless otherwise noted, all weights include both shell and meat.

Abalone Serial Depletion

Five species of abalone were commercially fished: red, pink, green, black, and white. When combined, landing numbers from these five species give the appearance of a stable fishery; however, individual species landings actually increased and fell in a sequential manner (an occurrence known as serial depletion). The commercial abalone fishery south of San Francisco provides an example of serial depletion that was masked by combining landings for multiple species and multiple fishing areas. When the abalone landings are divided by species, a pattern of depletion over time becomes evident (Figure 8.2 through Figure 8.6, and Table 8.2). From 1952 to 1968, combined landings appeared stable because pink abalone landing decreases were offset by increases in red abalone landings. In 1971, pink abalone landings declined abruptly when pink abalone size limits were raised to protect stocks. This decline was offset by increases in green abalone landings, the result of a lower green abalone size limit. Red abalone landings began to decline in 1968, but the drop was masked by increased commercial fishing for green, black, and white abalones. Landings for these three species rapidly peaked and then declined in the 1970s. In the early 1970s, substantial increases in black abalone landings helped to maintain the appearance of stability in the abalone fishery.

Serial depletion also occurred by area. As nearshore areas were depleted, fishermen traveled to more distant locations for abalone, until stocks in most areas had collapsed. From 1952 to 1968, most red abalone were caught in central California. Catches declined on the central coast due to fishing pressure from humans and an expanding sea otter population. This decline caused the fishery to shift to the southern California mainland and to Santa Rosa, Santa Cruz, San Nicolas, and San Miguel Islands. The pink abalone fishery persisted for some time as fishing

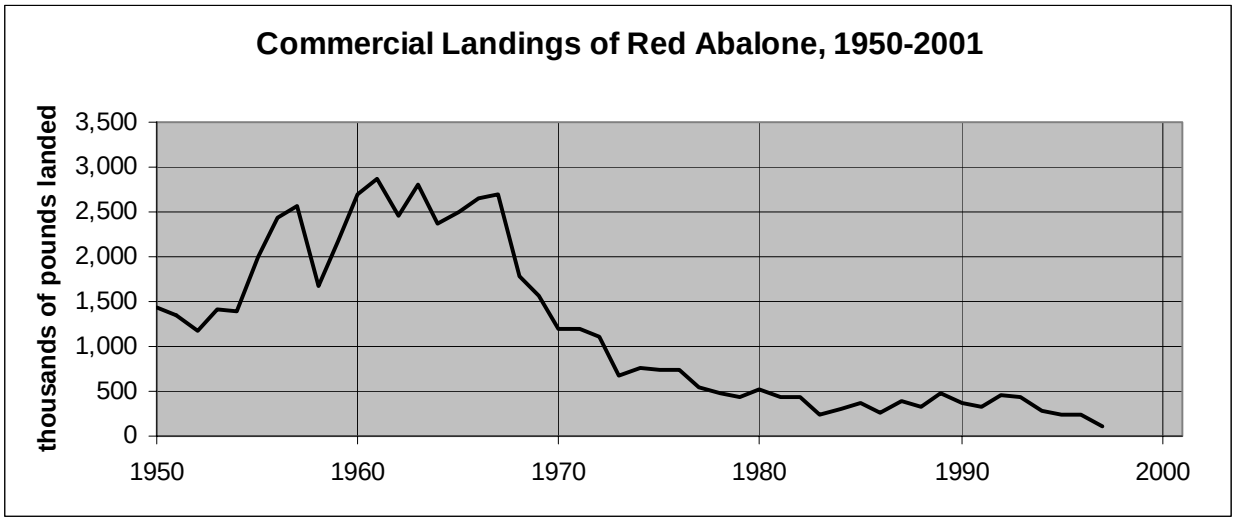

Figure 8.2. Annual commercial landings (pounds) of red abalone from 1950 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1950-1983) and the DFG commercial landing receipt database (1984-2001). Red abalone were required to be sorted and weighed separately beginning in 1950. Early landings of abalone from 1916 to 1949 primarily consisted of red abalone. The commercial red abalone fishery closed in 1997.

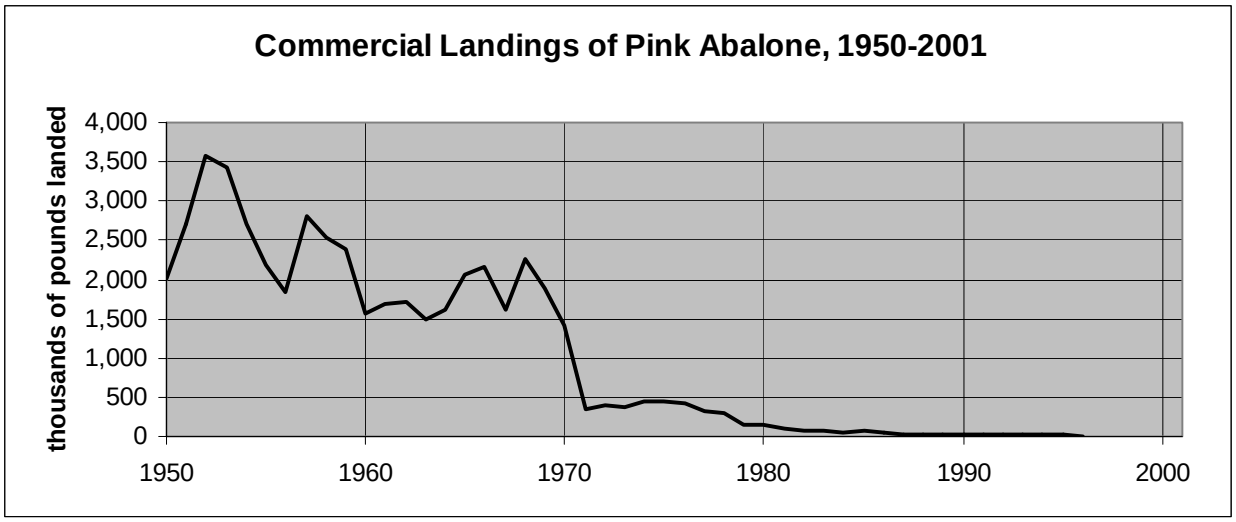

Figure 8.3. Annual commercial landings (pounds) of pink abalone from 1950 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1950-1983) and the DFG commercial landing receipt database (1984-2001). Pink abalone were required to be sorted and weighed separately beginning in 1950. Early landings of abalone from 1916 to 1949 primarily consisted of red abalone. The commercial pink abalone fishery closed in 1996.

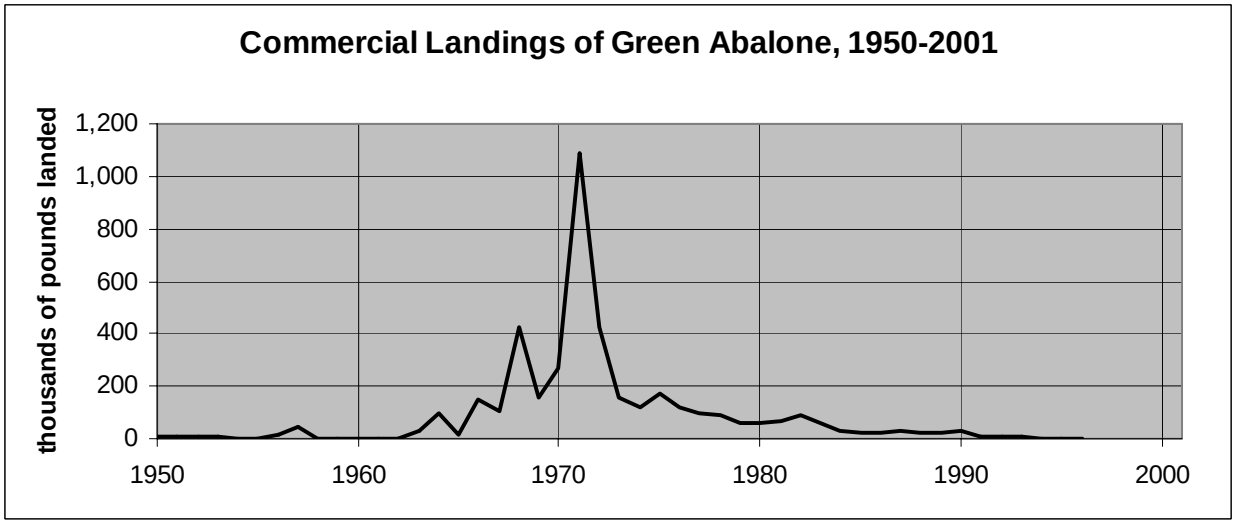

Figure 8.4. Annual commercial landings (pounds) of green abalone from 1950 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1950-1983) and the DFG commercial landing receipt database (1984-2001). Green abalone were required to be sorted and weighed separately beginning in 1950. Early landings of abalone from 1916 to 1949 primarily consisted of red abalone. The commercial green abalone fishery closed in 1996.

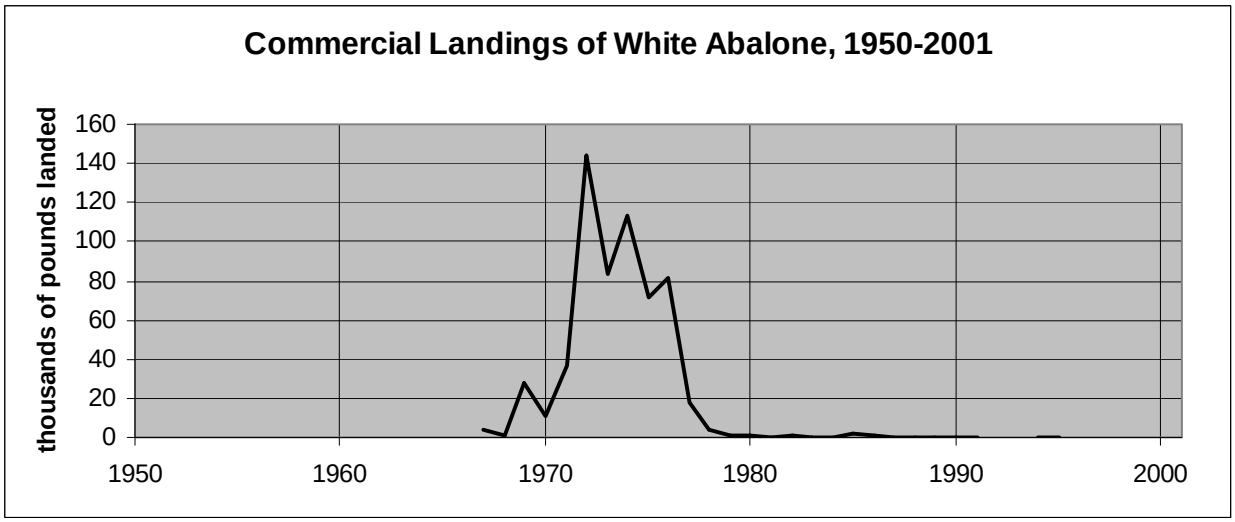

Figure 8.5. Annual commercial landings (pounds) of white abalone from 1950 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1950-1983) and the DFG commercial landing receipt database (1984-2001). White abalone were required to be sorted and weighed separately beginning in 1950. Early landings of abalone from 1916 to 1949 primarily consisted of red abalone. The commercial white abalone fishery closed in 1996.

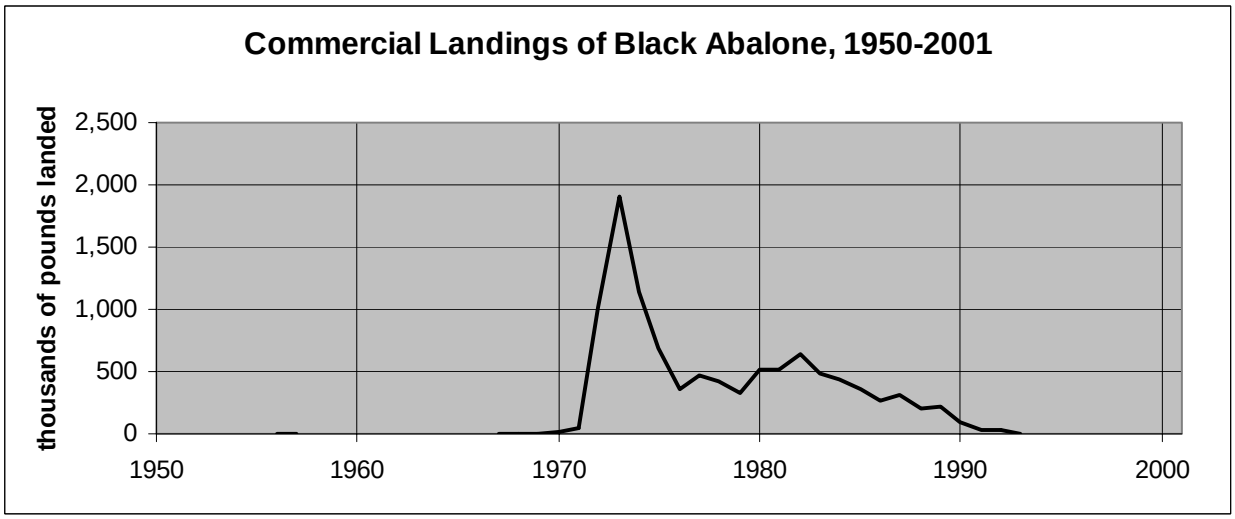

Figure 8.6. Annual commercial landings (pounds) of black abalone from 1950 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1950-1983) and the DFG commercial landing receipt database (1984-2001). Black abalone were required to be sorted and weighed separately beginning in 1950. Early landings of abalone from 1916 to 1949 primarily consisted of red abalone. The commercial black abalone fishery closed in 1993.

effort expanded into unfished areas. By the early 1980s, the commercial pink abalone fishery had expanded throughout the available range, but landings had dwindled to almost nothing. Green and white abalone landings were limited to specific areas, suggesting that these species were limited in distribution before they were fished. Overall, declines varied by area and species, but most landings had decreased to a level that caused serious concern by 1995.

Abalone Fishery Regulation Overview

Commercial take of abalone was first regulated in 1900 when shallow waters were closed to fishing. In 1901, a size limit of 15 in. circumference was instated for all abalone. A commercial fishing license for the take of abalone was established in 1909. These early regulations have been followed by various combinations of management measures, including landing requirements, restrictions on diving gear and other gear, size limits, open/closed seasons, and open/closed areas. In 1949, commercial abalone fishing was prohibited from Point Lobos (San Francisco County) to the California-Oregon border. The commercial black abalone fishery was closed in 1993, and the commercial fisheries for green, pink, and white abalones were closed in 1996. In 1997, fishing for all species of abalone was prohibited from San Francisco to the U.S.-Mexico border, effectively ending commercial fishing in California.

Recreational take of abalone first became regulated in 1911 when fishing seasons were established. In 1913 the first bag limit of 10 abalone was introduced for all species in southern California. A recreational fishing license requirement for the take of abalone was established in 1931. The black abalone recreational fishery was closed in 1993. In 1996, the recreational fisheries for green, pink, and white abalones were closed. By 1997 the entire recreational abalone fishery was closed south of San Francisco.

Commercial fishing was prohibited north of Point Lobos in San Francisco County in 1949. Since then, the northern California red abalone populations have supported a viable recreational fishery with the help of management measures including the prohibition of scuba or other underwater breathing devices, species-specific management (red abalone only), seasonal closure, strict take limits, and most recently, a take reporting system. Northern California recreational abalone fishermen have been limited to breath-hold diving (scuba is prohibited) since 1953, which protects deep-water stocks beyond the range of free-divers. In 1998 an abalone stamp was introduced to generate revenue for population assessments, management, and enforcement. In 2000 an abalone report card became mandatory to help control illegal take and to document catch and effort. An annual limit of 100 abalone was established for 2000. In 2002 the daily bag limit for red abalone was reduced from 4 to 3, and the annual limit was reduced from 100 to 24 per person due to concerns about the status of stocks. The red abalone season is open from April through June, and August through November.

Recreational abalone landings have been difficult to monitor without a state-wide, mandatory landing reporting system. One of the only sources for estimating recreational landings in southern California was the commercial passenger diving boat (CPDB) log book system, which provided only gross trends in the CPDB industry. These trends indicate that green and pink abalones dominated the diving boat catch before 1983. From 1986 to 1990 the number of pink abalone landings declined, leaving green abalone as the predominant species. Red abalone landings increased steadily during this time period, while small landings of black abalone and white abalone declined and eventually disappeared.

Creel and telephone surveys have been used in northern California to estimate annual harvest and effort by recreational divers. Between 1983 and 1989, estimates indicate that abalone divers harvested an average of 685,000 red abalone during 235,000 trips (or “effort days”) per year. For 2000, preliminary estimates from

incomplete abalone report cards indicate that 728,000 red abalone were taken during 202,000 effort days by approximately 38,276 recreational divers. Ninety-six percent of abalone fishing effort occurred in Mendocino and Sonoma counties in 2000. Diver and shore-picker effort data from 1995 to 2000 show a pattern of serial depletion as abalone were taken from progressively deeper water and from more remote populations at Sonoma County and southern Mendocino county creel survey sites.

Status of Biological Knowledge

Abalones occur in the coastal waters of California from the intertidal zone to depths of 200 ft. The red abalone range extends from Oregon into Baja California, Mexico. Red abalone inhabit intertidal and shallow subtidal areas in northern and central California; however, they are exclusively subtidal in southern California, where they prefer cooler, upwelling locations along the mainland and the northwestern Channel Islands. Black abalone is found from Mendocino County, California to Baja California, Mexico, and is largely intertidal, extending to a depth of about 20 ft in southern California. Pink, green, and white abalones are associated with the warm, temperate waters south of Point Conception. Their range extends into Baja California, Mexico and the southeastern Channel Islands, although they are stratified by depth: green abalone is more abundant at shallower depths than pink abalone, and pink abalone occur at shallower depths than white abalone. White abalone occur at the deepest depths of all California species. They are often found on rocky substrata near the interface of sand and rock at depths of 75 to 200 ft, although they have been found as shallow as 25 ft. The less-common flat and pinto abalones are generally found north of Point Conception, where water temperatures are predominately cooler. Most California abalones are found in the boulder and rock habitat associated with kelp forests. Abalone abundance is highest where physical conditions allow good kelp growth and where drift kelp is available.

Abalones live as long as 30 years. Growth is slow and highly variable; for example, 6 to 12 years are required to reach the minimum sport legal size (7 in.) for red abalone. Age at sexual maturity varies among species, ranging from 1 to 5 years.

Male and female abalones release their sperm and eggs into the sea at the same time (an event called “synchronous broadcast spawning”). The duration and timing of spawning varies by species (Table 8.1). A minimum density of spawners is essential for successful broadcast spawning. When only a few, widely-spaced animals are present, they can be too far apart for successful mixing of eggs and sperm; successful fertilization dramatically decreases when abalone are more than about 5 ft apart. Thus, when population densities drop below a critical threshold, population declines and local extinction can result despite the presence of actively spawning individuals. This explains why abalones are especially vulnerable to collapse at low densities.

Once fertilized, abalone eggs sink to the bottom and hatch into larvae. Larvae spend several days to a week in the water column, then settle to the bottom again, changing into juveniles when they encounter suitable habitat with encrusting coralline algae. Larvae are retained in the vicinity of appropriate habitat by the short larval period and by the dampening of local currents that occurs in kelp forest habitat. This limited dispersal reduces abalone larvae’s ability to repopulate depleted areas.

Mortality rates for larval and juvenile abalone are very high. Studies in both southern and northern California have shown that major recruitment events (successful spawning, settlement, and survival of juvenile abalone to the adult stage) occur only occasionally.

Table 8.1. Abalone biological information summary

Species	Current Range	Depth	Spawning season	Foods
Red	southern Oregon to Baja California, Mexico (considered absent from southern California mainland)	intertidal to 24 m	N. CA: Oct. - Feb. S. CA: year-round	bull kelp, giant kelp *Laminaria, Egregia, Pterygophora, Ulva*
Pink	Pt. Conception to Baja California, Mexico	lower intertidal to 60 m	March – November	*Plocamium, Eisenia, Macrocystis, Dictyopteris*
Green	Pt. Conception to Baja California, Mexico	low tide line to 18 m	early summer to early fall	*Gelidium, Pterocladia, Plocamium, Gigartina*, red algae, bull kelp, giant kelp
Black	Mendocino County, California to Baja California, Mexico	intertidal	late spring and summer	giant kelp*, Egregia*
White	Pt. Conception to Baja California, Mexico	25 to 60 m	late winter to early spring	*Laminaria, Agarum fimbriatum*
Pinto	Alaska to Baja California, Mexico	Shallow water in north; deep colder water in south	April to June	small algae
Flat	Oregon to San Diego, California	6 to 21 m	not known	not known

from the draft Abalone Recovery and Management Plan*, 30 Dec. 2002 version*

Very small juvenile abalone feed on bacterial and diatom films. Older juveniles and adults feed primarily on drift algae. Abalone feed preferentially on giant and other kelps (Table 8.1). Because abalone and sea urchins share a common food source, they compete for food and space.

Environmental conditions can have a profound effect on abalone habitat and populations. Storms can kill abalone, and limit distribution in areas of greatest storm exposure. El Niño events bring warm, nutrient-poor seawater northward along the coast, which is detrimental to kelp growth. When food availability is reduced, abalone growth rates can slow dramatically. In addition, red abalone experiences decreased settlement of larvae and recruitment of juveniles during El Niño periods.

Abalones, especially juveniles, are preyed upon by a wide variety of animals including crabs, lobsters, gastropods, octopuses, sea stars, sea otters, and fishes.

Larger abalones are partially protected from most of these predators by their size; however, the bat ray in southern California and the sea otter in central California prey selectively on larger abalone. Along the Central Coast, sea otters have removed most large, exposed abalone.

Withering syndrome, an abalone disease, is a major source of abalone deaths in some populations. This disease can severely impact abalones throughout large areas, as it did with black abalone at the Channel Islands. Research has been directed at developing resistant strains and treatment to protect stock in culture facilities.

Status of the Populations

The status of California abalone varies from fairly robust populations (red abalone in northern California) to near extinction (white abalone). The status of each abalone species is discussed below.

Red Abalone

Northern California - Red abalone populations in northern California have supported a viable recreational fishery for decades. While legal-sized adults (7 in.) are still relatively abundant, population and fishery data analyzed in 2001 revealed four trends that are of concern:

- Concentration of fishery effort and increased take
- Evidence of poor recruitment
- Declines in deep-water stocks
- Local depletion

Estimates of average take and effort for 1998 through 2000 have shown an increase compared to 1983 through 1989, with substantial concentration of fishery effort in Sonoma and Mendocino counties. This effort shift has been accompanied by a 25% increase in take. When poaching estimates (217,000 lb) are added to the estimated recreational take, the total take exceeds 1.7 million lb. This level of take approaches the average red abalone harvest in southern California, which was unsustainable and preceded fishery collapse.

Recruitment events are necessary to ensure replacement of animals removed by fishermen and predators. Significant recruitment of red abalone (large numbers of animals measuring less than 4 in.) was last observed between 1986 and 1992 at Van Damme State Park in Mendocino County. Since 1992, the abundance of abalone between 2 and 5 in. has declined substantially at this location. Recent surveys at four other northern coastal sites (Point Cabrillo Reserve in Mendocino County, and Bodega Bay Marine Reserve, Salt Point State Park and Fort Ross State Park in Sonoma County) revealed few young-of-the-year (abalone less than one year old) and emergent (not hidden; seen without moving habitat or using lights) recruits. The reduced number of sub-legal animals implies poor recruitment over the last ten years. Given the slow growth rates of abalone, a successful spawn in any year would not reach sport-legal size (7 in.) for 6 to 12 years.

The prohibition of the use of scuba and surface-supplied air while taking abalone establishes a depth refuge for a portion of the stock, because free divers generally cannot dive deeper than 28 ft. However, declines in deep-water stocks are evident at two of four sites surveyed between 1986 and 2000. Decreases in deep-water stocks mean that "refuge by depth" may not provide sufficient population protection.

Catch and effort data provide evidence of depletion at heavily fished sites. Increased take of abalone from deeper water and from more distant locations resulted in a decline in the number of abalone taken per trip. At one heavily impacted location (Moat Creek in Mendocino County), the distance traveled from access points to take locations doubled for shore-pickers between the 1989 and 1994, and between 1995 and 2000. Aerial surveys completed between 1975 and 1985 showed a significant decline in the number of shore-pickers, while diving effort increased significantly. This represents a shift from intertidal to subtidal fishing as shallow stocks are depleted.

Central and Southern California - Based on long-term studies, the trend in red abalone abundance is one of decline in all locations surveyed except San Miguel Island. Stocks in key areas in southern California (Santa Rosa Island, Santa Cruz Island, and the California mainland) appear to have been eliminated, and stocks in the remaining areas show little evidence of recovery. In a 2001 survey at Santa Rosa Island and Santa Cruz Island, red abalone abundance (the number of abalone encountered by one diver per hour) ranged from 0 to 7.6 abalone at Santa Rosa Island, and 0 to 1.4 abalone at Santa Cruz Island. San Miguel Island is the only location in southern California that has a self-sustaining population.

In central California, which is occupied by sea otters, abalone populations are stable but do not provide fishable stocks. The red abalone population decreased by approximately 84% after the return of the sea otters. Abalone populations in central California "otter areas" appear sustainable, but have a lower average size of 3 in. (half that of abalone in areas devoid of otters).

North of the sea otter range in central California and at the Farallon Islands, abalone stocks are depressed. In a dive survey at Fitzgerald Marine Reserve in central California, densities of red abalone were 0.02 /m^2 , which is one-tenth of the lowest density found in heavily fished areas off northern California. At the Farallon Islands, surveys in 2000 found that areas of historic high abalone abundance (based on commercial diver observations) had low densities.

Pink Abalone

The pink abalone was once common in southern California. Monitoring sites in the Channel Islands show that the abundance of pink abalone has declined since 1985. In timed swims conducted in 1996 and 1997, an average of 1 to 1.5 pink abalone per hour were found. Anacapa Island had the highest number of pink abalone of the five islands monitored.

Green Abalone

The green abalone was once common in southern California, particularly in the warmer parts of the southern California Bight (San Clemente, Santa Catalina, and Santa Barbara Islands; Cortez Bank; and along the mainland from the Palos Verdes

Peninsula in Los Angeles County, south). Green abalone were rare in surveys at San Clemente and Santa Catalina Islands from 1995 through 1999 and in 2001. Densities ranged from 0 to less than 40 abalone/hectare (0.004/m^2). Withering syndrome may have affected green abalone at these islands.

Black Abalone

The black abalone was an abundant species in California until the mid-1980s; it once occurred in such high concentrations that individuals were regularly observed stacked on top of one another. Due to population declines, the National Marine Fisheries Service designated the black abalone as a candidate for listing under the federal Endangered Species Act.

Withering syndrome spread throughout the Channel Islands and the remaining mainland populations of black abalone as far north as Pacifica in San Mateo County. At most locations, black abalone have virtually disappeared. At Point Arguello in Santa Barbara County, black abalone densities increased from 1992 to 1993; however, after withering syndrome was first observed in 1994, densities started to decline and remained at a low level (1,000 abalone/ha, or 0.1/m^2) through November 2000. Densities at Point Arguello increased in 2001 to 2,500 abalone/ha (0.25/m^2), but this is far lower than historic population levels.

White Abalone

On 29 May 2001, the National Marine Fisheries Service listed the white abalone as a federally endangered species under the federal Endangered Species Act, making it the first marine invertebrate listed as a result of human harvest. Despite the fact that part of the white abalone fishery has been closed since 1977, densities have continued to fall. Current population estimates indicate that white abalone have declined by as much as 99% since the 1970s. An abundance estimate based on deep survey data from 1997 was 1,600 animals; in comparison, a conservative estimate of the former baseline white abalone population abundance derived from commercial landings data (1969-1978) is 363,000 animals.

Remnant populations of adult white abalone remain only at the deepest portions (greater than 108 ft) of their former distribution. Their distribution also appears to be limited to a narrow strip of habitat along the rock/sand interface of isolated boulders. There is no evidence of a significant recruitment event since the late 1960s or early 1970s. As the white abalone life span is estimated at about 35 to 40 years, the remaining individuals are likely approaching the end of their lives.

With densities too low for successful reproduction, and because of natural mortality, recovery of the white abalone is unlikely without significant human intervention. Other complications that may hinder or preclude recovery despite human intervention include reduced genetic diversity due to the small size of the gene pool, and outbreaks of withering syndrome.

A captive rearing program is now underway. In 1999, 18 adult broodstock were collected from deep habitats and brought to two culturing facilities. Three of these animals have been successfully spawned, producing more than 100,000 juveniles. A significant portion of these cultured white abalone recently succumbed to withering

syndrome, although it is not known whether wild populations are also affected. Genetic, disease and legal concerns must be addressed before outplanting of cultured abalone

can begin. In July 2002, a federal recovery team was convened by National Marine Fisheries Service to manage recovery of white abalone.

Pinto Abalone

Pinto abalone are more common in northern California than in southern California. In 1970 this species comprised about 13% of the abalone landings. Today pinto abalone are very rare throughout northern California, making up less that 1% of the population. This species was not a major component of the commercial or recreational catch.

Flat Abalone

Little is known about flat abalone. In central California, abundances within sea otter range appear to have declined steadily since the 1970s, when 31% to 38% of abalone populations consisted of flat abalone. Recent surveys reveal that flat abalone currently comprise only 5% of the total population, which is now dominated by red abalone in deep crevice habitat. In northern California, flat abalone have always been rare, making up less than 5% of the population. Due to their small size, flat abalone is not usually targeted by the recreational fishery.

Management Considerations

The California Department of Fish and Game prepared a draft Abalone Recovery and Management Plan (ARMP) for all California abalones in 2002. The ARMP was mandated by the California Legislature (Fish and Game Code §5522). It provides a cohesive framework for recovery of depleted stocks in central and southern California, for the management of the existing northern California fishery, and for the management of any future fisheries. The draft ARMP was developed with the input of various constituents including: the Recreational Abalone Advisory Committee, commercial abalone fishermen, the ARMP Advisory Panel, and members of the general public. The Fish and Game Commission (Commission) is responsible for the management of abalone in California, and will adopt a final version of the ARMP. Once the ARMP is adopted by the Commission, it will guide abalone assessment, research, regulatory and enforcement activities.

The history of the California abalone fishery points to the need for defined recovery and management guidelines. Abalone species in central and southern California experienced stock collapse due to both natural and human-related causes, resulting in the 1997 closure of all abalone fishing in those areas. The only abalone fishery currently open in the state is the northern California red abalone recreational fishery.

The five formerly fished species in central and southern California (red, pink, green, black and white) are at risk of further population declines and, in one case, extinction. The white abalone has been listed as an endangered species under the federal Endangered Species Act, while the black abalone is a candidate for listing.

Without human intervention, and possibly even with it, these species may never recover.

For the only remaining abalone fishery (the northern red abalone), it is critical to maintain a sustainable resource. In the future, some of the depleted abalone species may recover to levels considered sustainable for fishing. Therefore, management guidelines such as those presented in the draft ARMP are needed for determining allowable take levels and for closing and reopening fisheries.

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Table 8.2. Commercial landings (pounds) of red, pink, green, white, black, and unidentified abalone, 1916-2001

Year	Unidentified abalone	Red abalone	Pink abalone	Green abalone	White abalone	Black abalone	Total abalone	Year
1916	762,001	------	------	------	------	------	762,001	**1916**
1917	637,780	------	------	------	------	------	637,780	**1917**
1918	602,919	------	------	------	------	------	602,919	**1918**
1919	759,203	------	------	------	------	------	759,203	**1919**
1920	806,716	------	------	------	------	------	806,716	**1920**
1921	1,481,170	------	------	------	------	------	1,481,170	**1921**
1922	1,523,394	------	------	------	------	------	1,523,394	**1922**
1923	1,555,134	------	------	------	------	------	1,555,134	**1923**
1924	2,241,812	------	------	------	------	------	2,241,812	**1924**
1925	2,352,861	------	------	------	------	------	2,352,861	**1925**
1926	2,060,770	------	------	------	------	------	2,060,770	**1926**
1927	2,816,530	------	------	------	------	------	2,816,530	**1927**

Table 8.2. Commercial landings (pounds) of red, pink, green, white, black, and unidentified abalone, 1916-2001

Year	Unidentified abalone	Red abalone	Pink abalone	Green abalone	White abalone	Black abalone	Total abalone	Year
1928	2,066,243	------	------	------	------	------	2,066,243	**1928**
1929	3,438,858	------	------	------	------	------	3,438,858	**1929**
1930	3,176,513	------	------	------	------	------	3,176,513	**1930**
1931	3,262,166	------	------	------	------	------	3,262,166	**1931**
1932	2,817,345	------	------	------	------	------	2,817,345	**1932**
1933	2,756,188	------	------	------	------	------	2,756,188	**1933**
1934	3,223,492	------	------	------	------	------	3,223,492	**1934**
1935	3,870,921	------	------	------	------	------	3,870,921	**1935**
1936	3,302,195	------	------	------	------	------	3,302,195	**1936**
1937	2,863,175	------	------	------	------	------	2,863,175	**1937**
1938	2,121,468	------	------	------	------	------	2,121,468	**1938**
1939	1,804,440	------	------	------	------	------	1,804,440	**1939**
1940	1,724,084	------	------	------	------	------	1,724,084	**1940**
1941	1,002,330	------	------	------	------	------	1,002,330	**1941**
1942	164,462	------	------	------	------	------	164,462	**1942**
1943	680,274	------	------	------	------	------	680,274	**1943**
1944	1,630,402	------	------	------	------	------	1,630,402	**1944**
1945	2,429,312	------	------	------	------	------	2,429,312	**1945**
1946	2,095,762	------	------	------	------	------	2,095,762	**1946**
1947	2,669,285	------	------	------	------	------	2,669,285	**1947**
1948	3,195,852	------	------	------	------	------	3,195,852	**1948**
1949	3,599,998	------	------	------	------	------	3,599,998	**1949**
1950	------	1,431,071	2,019,710	9,958	------	------	3,460,739	**1950**
1951	------	1,352,317	2,719,381	8,367	------	------	4,080,065	**1951**
1952	------	1,182,022	3,587,636	4,186	------	------	4,773,844	**1952**
1953	------	1,412,948	3,439,657	5,852	------	------	4,858,457	**1953**
1954	108	1,394,595	2,703,219	1,223	------	------	4,099,145	**1954**
1955	------	1,996,511	2,189,039	1,225	------	------	4,186,775	**1955**
1956	------	2,428,393	1,845,006	14,002	------	660	4,288,061	**1956**
1957	------	2,566,813	2,804,111	47,880	------	1,950	5,420,754	**1957**
1958	------	1,677,404	2,545,709	905	------	------	4,224,018	**1958**
1959	------	2,180,658	2,375,531	560	5,075	------	4,561,824	**1959**
1960	------	2,693,857	1,572,096	455	------	------	4,266,408	**1960**
1961	------	2,873,628	1,678,275	526	1,337	------	4,553,766	**1961**
1962	------	2,462,200	1,717,271	3,710	------	------	4,183,181	**1962**
1963	------	2,807,920	1,502,639	33,319	------	------	4,343,878	**1963**
1964	------	2,369,564	1,612,376	97,273	------	------	4,079,213	**1964**
1965	------	2,490,875	2,071,242	12,129	438	------	4,574,684	**1965**
1966	------	2,656,408	2,162,941	145,420	------	------	4,964,769	**1966**
1967	------	2,697,610	1,619,746	106,545	4,100	200	4,428,201	**1967**
1968	------	1,776,054	2,270,108	427,135	845	700	4,474,842	**1968**
1969	------	1,564,205	1,900,206	157,263	28,009	4,991	3,654,674	**1969**
1970	------	1,194,788	1,408,921	270,200	11,212	15,327	2,900,448	**1970**
1971	------	1,193,948	347,983	1,089,706	36,741	46,650	2,715,028	**1971**
1972	------	1,104,462	403,709	424,808	143,819	1,014,892	3,091,690	**1972**

Table 8.2. Commercial landings (pounds) of red, pink, green, white, black, and unidentified abalone, 1916-2001

Year	Unidentified abalone	Red abalone	Pink abalone	Green abalone	White abalone	Black abalone	Total abalone	Year
1973	------	663,919	371,352	156,804	83,112	1,912,519	3,187,706	**1973**
1974	------	751,060	455,324	121,563	113,765	1,145,396	2,587,108	**1974**
1975	------	742,769	458,235	170,927	71,821	684,793	2,128,545	**1975**
1976	------	739,621	431,143	120,489	81,907	356,951	1,730,111	**1976**
1977	------	537,450	318,494	97,457	17,603	463,301	1,434,305	**1977**
1978	------	488,800	287,052	92,987	3,633	420,045	1,292,517	**1978**
1979	------	439,476	156,491	61,166	502	331,489	989,124	**1979**
1980	------	516,304	139,267	63,234	1,071	518,619	1,238,495	**1980**
1981	112	429,922	94,257	64,003	162	521,007	1,109,463	**1981**
1982	256	430,902	86,282	88,696	907	633,400	1,240,443	**1982**
1983	55	230,973	67,239	56,910	482	484,366	840,025	**1983**
1984	1,156	299,477	57,128	31,946	449	436,359	826,514	**1984**
1985	1,015	368,499	68,731	24,133	1,655	359,898	823,931	**1985**
1986	5,777	263,070	51,872	25,854	876	267,514	614,962	**1986**
1987	1,550	391,030	31,597	28,985	2	309,786	762,951	**1987**
1988	75	324,434	19,025	23,521	2	201,660	568,716	**1988**
1989	775	474,978	22,554	20,150	22	222,671	741,150	**1989**
1990	217	378,914	23,268	27,333	17	94,193	523,942	**1990**
1991	1,350	330,974	12,883	8,162	3	27,220	380,593	**1991**
1992	------	448,593	18,229	10,304	------	37,714	514,840	**1992**
1993	------	428,518	19,932	10,858	------	2,031	461,340	**1993**
1994	15	285,969	15,575	992	47	------	302,596	**1994**
1995	------	244,807	16,398	1,073	37	------	262,314	**1995**
1996	67	229,252	4	56	------	------	229,379	**1996**
1997	------	112,323	------	------	------	------	112,323	**1997**
1998	------	------	------	------	------	------	------	**1998**
1999	------	------	------	------	------	------	------	**1999**
2000	------	------	------	------	------	------	------	**2000**
2001	------	------	------	------	------	------	------	**2001**

------ Landings data not available.

1. Data sources: DFG Catch Bulletins (1916-1983) and DFG commercial landing receipt database (1984-2001).
2. Identification of abalone species landed was not required prior to 1950, however commercial abalone landings from 1916 to 1949 consisted primarily of red abalone.
3. The first reported landings for species other than red were as follows: green (1950), pink (1950), black (1956), and white (1959). Insignificant commercial landings of pinto and flat abalone (less than 100 pounds) were made in a few years, but are not included in this summary table.
4. The commercial take of black abalone was prohibited in 1993.
5. The commercial take of green, pink, and white abalone was prohibited in 1996.
6. In 1997, a moratorium was placed on the commercial take of all abalone.

9. RED SEA URCHIN

Overview of the Fishery

The commercial fishery for the red sea urchin, *Strongylocentrotus franciscanus*, has been one of California's most valuable fisheries for more than a decade. This fishery is relatively new, having developed over the last 30 years (Figure 9.1 and Table 9.1), and caters mainly to the Japanese export market. Archaeological evidence, however, suggests that sea urchins in California have been fished by coastal Native Americans for centuries.

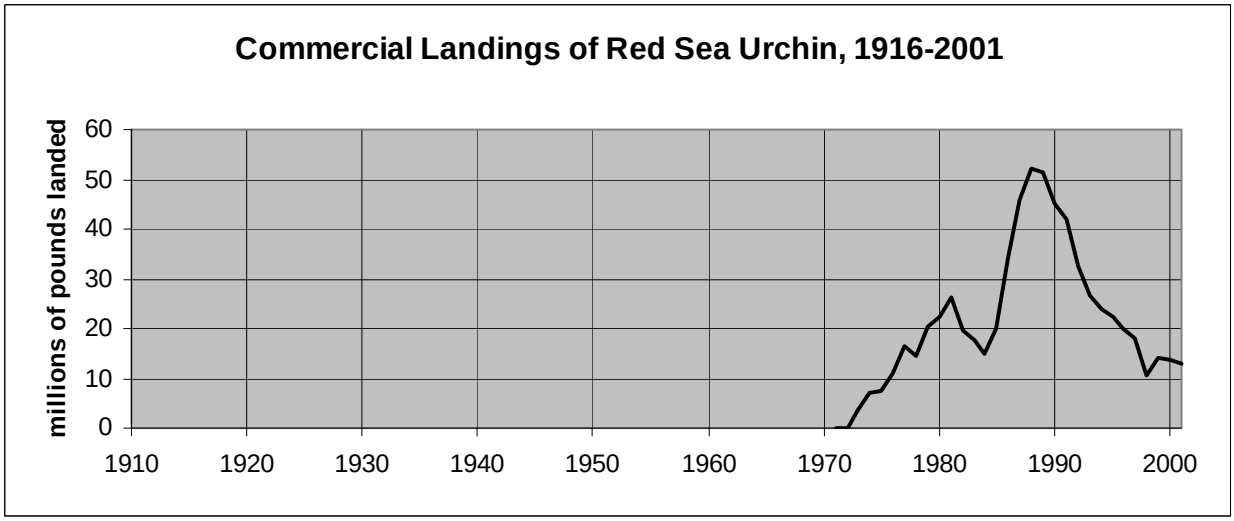

Figure 9.1. Annual commercial landings (pounds) of red sea urchin from 1916 to 2001. Data sources are the California Department of Fish and Game (DFG) Catch Bulletins (1916-1983) and the DFG commercial landing receipt database (1984-2001).

The gonads of both male and female urchin are the object of the fishery and are referred to as "roe", or "uni" in Japanese. Sea urchins are collected by divers operating in near shore waters. Divers are size-selective, and check gonad quality while fishing to ensure marketability. The price paid to fishermen for gonads is based on quality. Gonads are graded by size, color, texture and firmness, all of which are affected by the urchin's stage of gonad development and food supply. Fishermen are paid less than $0.20 to more than $2.00 per lb for whole urchins, with the highest prices garnered during the Japanese New Year holidays.

In the last few years, the red urchin fishery has become fully exploited throughout its range in northern and southern California. Because of predation by sea otters, sea urchin stocks in central California occur at densities too low to sustain a commercial fishery. The purple sea urchin, *S. purpuratus*, which occurs over the same geographical range as the red sea urchin, is also harvested in California on a limited basis (see purple sea urchin status report).

Southern California Fishery

The fishery in southern California began in 1971 as part of a National Marine Fisheries Service program to develop fisheries for underutilized marine species. The

fishery was also seen as a way to curb the destructive grazing of sea urchins on giant kelp. Prices for southern California urchin are typically higher than for northern California urchin due to the longer market presence of the southern urchin, and consistently higher gonad quality (smaller size and sweeter taste).

There have been two periods of rapid fishery expansion, one in southern California and one in northern California. The first rapid expansion culminated in 1981 when landings peaked at 25 million lb in southern California (Figure 9.2). Fishermen entering the fishery from the declining commercial abalone fishery contributed to the rapid escalation of the urchin fishery. Sea urchin landings decreased following the El Niño event of 1982-1983 when warm water weakened or killed kelp, the primary food

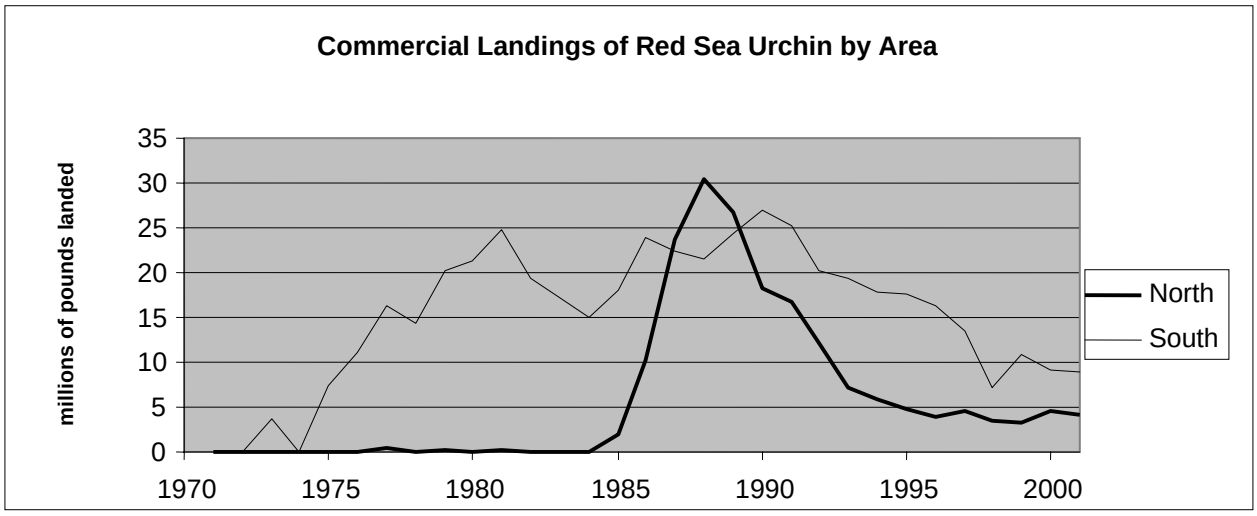

Figure 9.2. Annual commercial landings (pounds) of red sea urchin in northern California and southern California from 1971 to 2001. Data source is the California Department of Fish and Game (DFG) commercial landing receipt database.

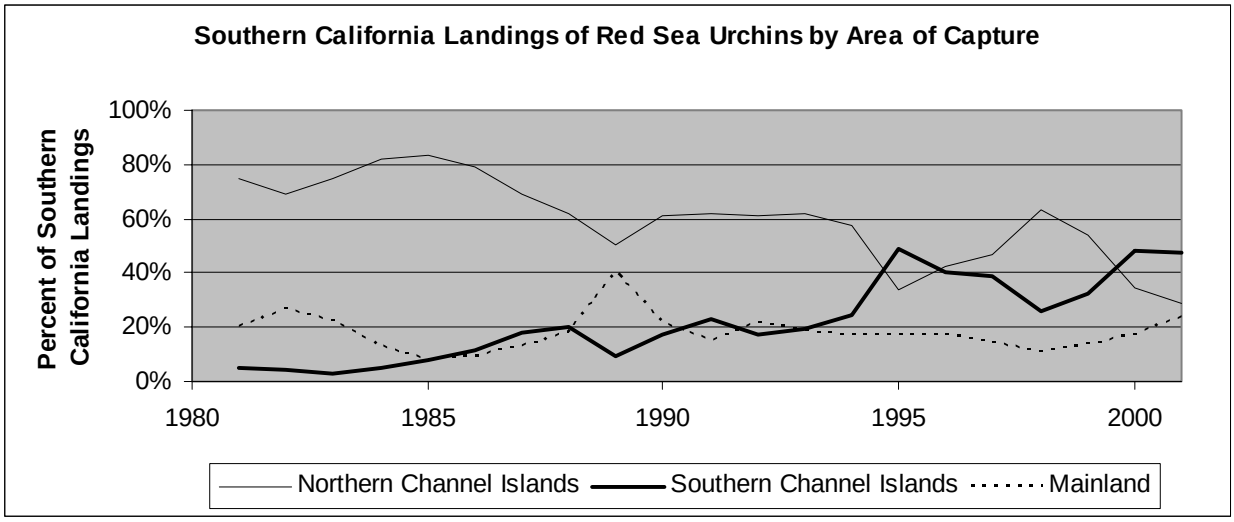

Figure 9.3. The proportion of commercial red sea urchin landings in southern California taken from the northern Channel Islands, southern Channel Islands, and mainland from 1981 to 2001. Data source is California Department of Fish and Game (DFG) commercial landing receipt database.

source for sea urchins. Landings did not recover until the 1985-1986 season, due in part to the strengthening of the Japanese yen relative to the US dollar, which gave California fishermen and exporters more economic incentives.

The majority of southern California sea urchin landings have come from the northern Channel Islands off Santa Barbara. This area, with its large, accessible stocks nurtured by lush kelp beds, supported the red sea urchin fishery in its early years. From 1973 to 1977, 80% to 90% of red urchin landings originated from these islands. Since the late 1990s, however, landings have decreased from the northern Channel Islands as fishing effort shifted south to San Clemente Island, San Nicolas Island, and the San Diego area (Figure 9.3). More recently, there has been a reported reversal of this trend as northern Channel Island kelp beds rebound from the 1997-1998 El Niño. These spatial shifts have been accompanied by catch decreases throughout the region (Figure 9.2). In 1990, the southern California sea urchin catch peaked at over 27 million lb; however, the catch has declined steadily to 8.8 million lb in 2001. In the 1990s, the fishery was impacted by two El Niño events (1992-1994 and 1997-1998) and a weakening Japanese economy that lowered demand and ex-vessel prices; both factors contributed to reduced fishing effort and catches.

Northern California Fishery

The northern California commercial sea urchin fishery began in 1972, and remained insignificant until 1977, when 386,000 lb were landed in the Fort Bragg region. The second major fishery expansion began in 1985 (Figure 9.2), fueled partly by decreasing landings in southern California and favorable monetary exchange rates. The large and unexploited sea urchin biomass in northern California sparked a “gold rush” as hundreds of new fishermen entered the unregulated fishery. In northern California (from Half Moon Bay in San Mateo County to Crescent City in Del Norte County) landings jumped from 1.9 million lb in 1985 to 30.5 million lb in 1988, far

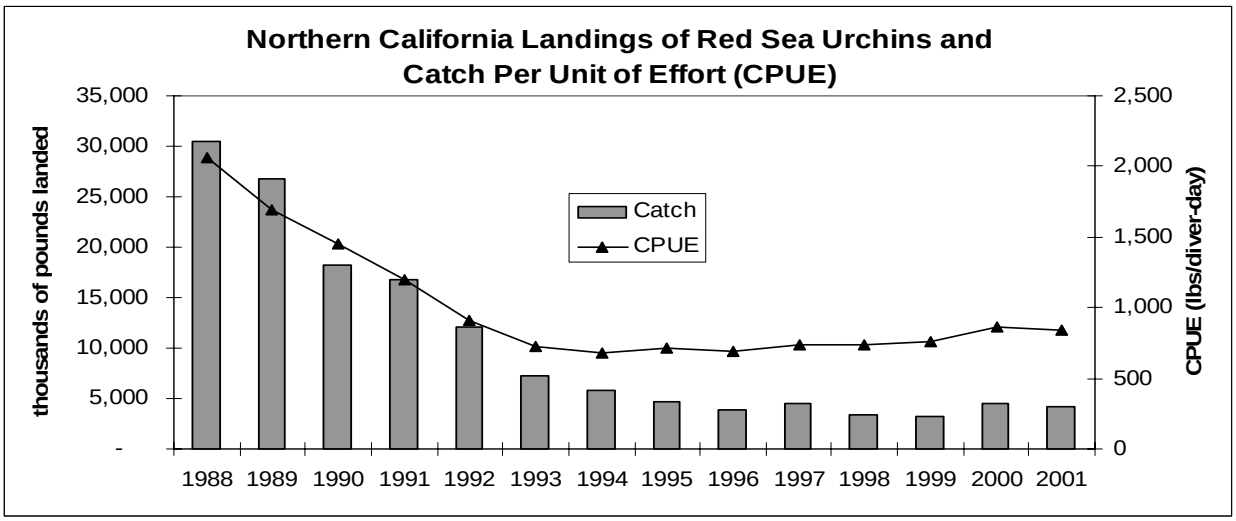

Figure 9.4. Comparison of northern California red sea urchin landings (pounds) and CPUE (pounds per diver-day) from 1988 to 2001. Data sources are California Department of Fish and Game (DFG) commercial landing receipt database (1988-2001) and sea urchin logbooks (1988-1992). There were no logbooks prior to 1988.

exceeding landings from southern California. Northern California sea urchin landings and catch per unit of effort (CPUE) began a steep decline in 1989. Landings leveled off in 1995 at about 3 to 4 million lb annually, and CPUE leveled off in 1993 at about 700 to 800 lb per fishing day (Figure 9.4). Landings data for 2001 show a catch of 4.1 million lb with fishermen earning $3.9 million. In northern California, Fort Bragg has remained the center of the fishery, while the ports of Albion and Point Arena in Mendocino County and Bodega Bay in Marin County together account for about half of the catch. Rocky reefs around Crescent City also support a small fishery.

Management History

Responsibility for managing the sea urchin fishery originally lay with the California Legislature, but was delegated to the Fish and Game Commission (Commission) in 1973. In the early years of the fishery, management focused on reducing sea urchin densities to increase kelp abundance and urchin gonad yield. However, the rapid expansion of the fishery in the mid-1980s spawned a reassessment of this policy. In 1987, the Legislature established the Director's Sea Urchin Advisory Committee (DSUAC) which consisted of representatives from the fishing industry, California Department of Fish and Game (DFG), and California Sea Grant. DSUAC was the decision-making body for industry-funded research projects aimed at enhancing and managing the fishery, and acted as a forum for consensus-based management. In 2002, the self-imposed landing fee law that funded industry-backed research projects was repealed, and DSUAC was reformed through legislation as the Sea Urchin Fishery Advisory Committee. The new committee is charged with disbursing any remaining funds and advising DFG on management matters.

California's sea urchin fishery presently operates without a fishery management plan. Few restrictions have been placed on catch or effort until the late 1980s; the primary management measure prior to 1985 was limiting gear to rakes, airlifts and other hand appliances. Since then, principal management actions have consisted of the following:

- A moratorium on the issue of new permits in 1987, with a restricted access program beginning in 1989
- The introduction of a minimum legal size limit in 1988 (increased in northern California in 1990 and increased in southern California in 1992)
- Establishing a closed fishing season and restricting fishing to specific days. In 1990, northern California fishing was restricted to 233 days per year. In 1992, southern California fishing was restricted to 240 days per year
- An effort-reduction scheme was introduced in 1990 that presently requires 10 permits to be retired for each new entrant

All of these regulations remain in effect. The size limits and closures have been relatively ineffective in reducing total effort, with effort reductions in recent years due largely to a combination of diminished markets and declining urchin populations. While the limited entry program has created a slow but steady decrease in permits, it has probably not significantly reduced effort in the fishery.

Research that examines the feasibility of enhancing stocks by out-planting of juvenile sea urchins, funded primarily by the industry, has shown that out-planting is not cost effective given observed out-plant survival rates and the limited availability and high cost of juvenile urchins. Transplanting naturally occurring juvenile urchins from urchin dominated areas subject to high recruitment rates has shown some promise, however the utility of this strategy will depend on the availability of natural juvenile transplants, and recognition of the consequences of transplanting juvenile urchins into the surrounding ecosystem.

Restricted Access Program

The restricted access dive fishery for sea urchins began in 1989. Divers primarily harvest red sea urchins, although the smaller purple sea urchin is harvested sporadically.

The upper limit on the number of participants (the capacity goal) was originally set at 400 divers, but was later reduced to 300. The Commission placed a moratorium on the issuance of new permits in 1987. The number of permits increased dramatically before the moratorium became effective, with

Historical timeline for the sea urchin restricted access program

1973	State Legislature delegates authority to the Fish and Game Commission for managing the sea urchin fishery.
1984	State Legislature authorizes a permit for the sea urchin fishery, but does not make it restricted access.
1986	State Legislature gives the Fish and Game Commission authority to limit the number of sea urchin diving permits.
1987	Fish and Game Commission places a moratorium on new permits.
1989	Restricted access program begins.

938 permits issued in the 1987 license year. Since then, the number of diving permits issued each year has generally declined (Figure 9.5). In 2001, there were 388 diving permittees, many of whom were not full-time divers.

The annual sea urchin diving permit is $330, and is not transferable. There is an annual landing requirement (20 landings of 300 lb or more) for renewal of the permit. This provision is scheduled for repeal, effective in 2004. In addition, permit holders must submit logbooks that provide details on the location and depth fished, the number of hours spent diving, and the amount of urchins harvested. There is an annual urchin lottery to allow new participants to enter the fishery if any permits are available. Individuals may assist the diver on the vessel if they have a sea urchin crewmember permit ($30).

State law (Fish and Game Code §7065) requires that each restricted access program be reviewed at least every five years for consistency with the Commission's policy on restricted access. Table 9.2 lists the Commission's restricted access policies

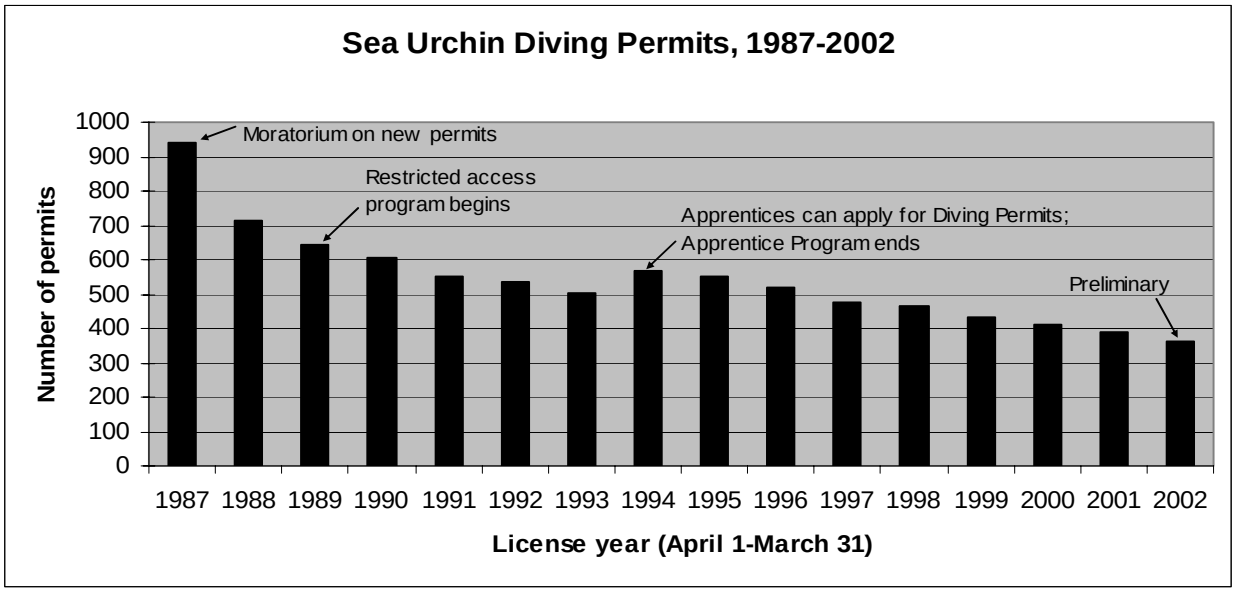

Figure 9.5. Number of sea urchin diving permits issued for the commercial red and purple sea urchin fisheries from the 1987-1988 license year (April 1 through March 31) to the 2002-2003 license year. The restricted access program began in 1989. The current capacity goal is 300 divers. Data sources are the California Department of Fish and Game (DFG) license reports.

and whether the sea urchin restricted access program is consistent with each policy. Even though the restricted access program began before the Commission adopted a policy on restricted access, the program is consistent with most of the Commission's policies. The main feature of the sea urchin restricted access program which is not consistent with the Commission's policies is issuance of new permits when the number of permits is above the capacity goal.

It is the policy of the Commission that each restricted access program must have an equitable and practicable system to reduce fishing capacity. Although constituent satisfaction with the system has not been measured, the system was developed with constituent input. It also provides a means for new participants to gain experience and enter the fishery, and for former permit holders to re-enter the fishery.

Status of Biological Knowledge

Sea urchins play an important ecological role in kelp forest communities. They are found subtidally along the California coast wherever conditions are favorable. Red sea urchins belong to the phylum Echinodermata, which includes sea stars, brittle stars, sea cucumbers, and sand dollars. These urchins have a hard shell called a "test", with spines and small pincers. Tube feet located between the spines are used in respiration, locomotion, and for grasping food and the substrate. The mouth, located at the base of the urchin, consists of five plates that make up a jaw structure commonly known as "Aristotle's lantern". The mouth leads to the digestive system, which voids through the anus on the top of the urchin.

Sea urchins are omnivorous, but mostly eat leafy algae. The perennial giant kelp is their preferred food in southern California, whereas in northern California urchins feed on the annual bull kelp and perennial brown algae. The red sea urchin's ability to survive during periods of food shortage contributes to its ability to persist in high

densities in areas devoid of algae, known as “urchin barrens”. Following oceanographic events such as El Niños, barrens occur in southern California wherever kelp beds die off, causing shortages of standing and drift algae. These food shortages may trigger urchins to aggregate and move in eating “fronts”, denuding the sea floor. Based on examination of long-term aerial photos and on kelp forest ecology studies in northern San Diego County, sea urchin grazing at its most severe probably accounts for about 20% of kelp mortality in a given kelp bed. Conversely, the intense fishery for red sea urchins in northern California appears to have had a positive effect on kelp availability. Aerial photographs of surface kelp at one location in northern California showed a 15-fold increase surface canopy from 1982 to 1989 during a period of concentrated urchin fishing.

Red sea urchins may compete with abalone for both space and food. A recent study on competitive interactions between these species at sites in northern California concluded that there is an inverse relationship between them that favors red sea urchin at sites where neither species is at low densities. Sea urchins may be more successful in competing for limited food because of their aggressive foraging and ability to survive starvation conditions. Fishing for abalone and sea urchins has no doubt altered these relationships.

Red sea urchins have many predators, including sea otters, spiny lobsters, sea stars, crabs, white sea urchins, and fishes such as California sheephead. Within the sea otter’s present range, the red sea urchin resource has been reduced to a level which precludes fishery utilization.

Urchin diseases have decimated the sea urchin populations of Caribbean islands; however, the dynamics of sea urchin diseases in California remains poorly understood. Sea urchins in southern California are especially susceptible to disease during warm-water El Niño events.

Sea urchin growth rates vary depending on food availability. Growth rates must be determined by tagging and recapturing. Internal tags (“PIT” tags), or chemical (fluorescent) tags that bind to calcium have been used to successfully tag sea urchins. Tagging studies reveal that red urchins are long-lived, with large individuals possibly living beyond 100 years. Growth to 3.5 in. (test diameter, exclusive of spines) takes an average of six to eight years. There are no discernable growth patterns along a latitudinal gradient from Baja California to Alaska; however, there is a clear trend in population mortality rates. Mortality estimates for southern populations were found to be greater than for northern populations. Likely mechanisms include higher rates of disease and temperature-related stresses in the south.

Red sea urchins become sexually mature at 2 in. test diameter. The sex ratio in urchins is about 1-to-1. Sea urchin spawning is seasonal, but can vary from year to year and from one locality to another. Food supply and ocean temperatures play roles in the timing and magnitude of spawning. In most southern California locations, spawning generally occurs in winter. In northern California, major spawning occurs in spring and summer, with some spawning activity also in December.

As with many marine invertebrates, fertilization is external and success is highly dependent on density. Subtidal studies suggest that red urchins at densities of less than two per square meter can have poor fertilization success. Females spawn up to several million eggs at a time. Larval development is dependent on temperature and

the abundance of phytoplankton (single-celled algae) and is thought to extend for six to eight weeks. As the larvae mature, they settle to the bottom and progress to the juvenile life-stage; however, they can spend a long time drifting with water currents before settling. This allows juvenile sea urchins to disperse long distances from the adults that spawned them.

Settlement patterns have been studied for red and purple sea urchins on artificial substrates at sites in northern and southern California since 1990. Peak settlement periods tend to be in spring and early summer although there is substantial year-to-year variation in timing and intensity. Settlement also tends to be less variable south of Point Conception, and is depressed during El Niño events. The more variable pattern of settlement in northern California is consistent with the more energetic offshore movement of water during spring periods when larvae are present, especially around headlands. Consequently, El Niño events appear to favor settlement in the north as offshore water movement becomes reduced. Recruitment patterns (that is, individuals reaching a specific life-stage such as legal size) of red sea urchins in northern and southern California generally mirror those of settlement. Recruitment in southern California appears to be relatively constant, while in the north recruitment rates are lower and more sporadic.

Newly settled juvenile urchins are very vulnerable. Juveniles are preyed upon more often in kelp forest habitat, where predators are presumably more abundant than in similar rocky habitats just outside of kelp beds. Adult sea urchins and their spines are important protective structures in subtidal communities. The canopy formed by the spines is a micro-habitat that shelters juvenile sea urchins, shrimps, crabs, brittle stars, fish, abalone, and other invertebrates. The spine canopy is most likely an important habitat for juvenile sea urchins, especially in areas where alternative cryptic habitats (such as crevices and undersides of boulders) are rare or absent.

Status of the Population

In southern California, the red sea urchin resource now produces less than 10 million lb annually, with harvestable stocks (stocks that exceed the minimum legal size and contain marketable gonads) in decline since 1990. Between 1985 and 1995, the percentage of legal-sized red sea urchins at survey sites in the northern Channel Islands declined from 15% to about 7%. Although fishing has significantly reduced density in many areas and CPUE has decreased, replacement of fished stocks by juvenile sea urchins has somewhat mitigated fishing pressure. Consistent settlement rates have been noted on artificial substrates and along subtidal transects over the last decade at monitoring stations along the southern California mainland coast and the northern Channel Islands. This may be partly due to ocean current patterns in the Southern California Bight, which may increase the chances for larvae to encounter suitable habitat for settlement. Continued recruitment at present levels, however, is not guaranteed.

The areas where sea urchins have been harvested in southern California have shifted over time. The northern Channel Islands have supplied most of the catch over the years, but beginning in 1995 catches in the northern Channel Islands began to decline, and effort and harvests started to increase off San Nicolas and San Clemente

Islands to the south, signaling a shift away from the northern Channel Islands (Figure 9.3).

The northern California fishery has been characterized by rapid increase in landings. Thirty million lb were landed in northern California in 1988, with a subsequent decline to less than 5 million lb in the late 1990s. Fishery-dependent modeling of the sea urchin fishery during the period of rapid decline estimated that the 117 million lb of red urchin harvested from 1988 through 1994 represented about 70% of the harvestable stock available in 1988. Effort declined during this period; the number of divers who worked exclusively in northern California declined from 126 in 1991 to 79 in 2000. Annual catch per permittee declined by 40% from 1990 to 2000.

Since 1988, low densities of harvestable stocks have been found at sub-tidal survey sites in the Fort Bragg area. From 1988 to 1997, the number of legal-sized red urchins outside of reserves declined from 47% to 20% of the population, while densities dropped from 0.8 urchins per square meter to 0.2 urchins per square meter. In contrast, densities in two Fort Bragg area reserves during this period averaged over 3.0 red urchins per square meter. These patterns continued during northern California surveys in 1999 and 2000. Episodic and infrequent recruitment combined with intensive harvesting on the north coast has caused the fishery to evolve into a "recruitment" fishery, with fishermen harvesting urchins as soon as they reach legal size (that is, harvesting newly-recruited sea urchins). In 1999 for example, 47% of the catch was less than 3.9 in. wide (test diameter), just over the 3.5 in. minimum size limit for northern California. The size limit and seasonal closures may help prevent fishery collapse, but may not improve recruitment, particularly if recruitment success is dependent on oceanographic factors, spine canopy micro-habitat and the presence of large spawners in the population.

Management Considerations

The Department and the industry have worked for more than a decade to adjust regulations for the red sea urchin fishery as needed. The red sea urchin fishery is fully exploited in California, and evidence from a variety of sources points to an over-fished condition in northern and portions of southern California. The following management activities should be considered to insure the health of the resource and fishery:

- Expand existing fishery-dependent and -independent monitoring programs, and expand collaborative monitoring and research with the industry
  - Collect logbook data at a higher spatial resolution using Global Positioning System (GPS) technology
  - Expand fishery-independent monitoring to allow managers to assess density, abundance of size classes, and poor quality urchins not sampled within the fishery (since the commercial fishery only targets certain sizes)
  - Continue and expand the long-term monitoring of settlement patterns to provide a relative measure of settlement. Industry has funded the settlement work to date
- Develop a red sea urchin fishery management plan. The Marine Life Management Act Master Plan (*The Master Plan: A Guide for the Development of Fishery Management Plans*, August 2001) identified sea

urchins as one of the three fisheries that most need a management plan
- Conduct a capacity goal analysis to evaluate whether the present goal (300 divers) matches the resource. Investigate equitable, practicable and enforceable methods for reducing fishing capacity
- Continue to examine and consider the use of spatial management techniques such as marine protected areas and rotating harvest zones

The following management measures could be implemented on an interim basis before a fishery management plan is in place:

- Evaluate current sea urchin size limits and the establishment of a maximum size limit (that is, a size above which no urchins may be taken). Current regulations prohibit the take of red sea urchins between 1.5 and 3.25 in. for southern California and between 1.5 and 3.5 in. for northern California
- Establish regional management zones for northern and southern California

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Further Reading

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Table 9.1. Commercial landings (pounds) of red sea urchin, 1916-2001

Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds
1916	------	**1933**	------	**1950**	------	**1967**	------	**1984**	14,978,869
1917	------	**1934**	------	**1951**	------	**1968**	------	**1985**	19,994,868
1918	------	**1935**	------	**1952**	------	**1969**	------	**1986**	34,131,614
1919	------	**1936**	------	**1953**	------	**1970**	------	**1987**	46,061,649
1920	------	**1937**	------	**1954**	------	**1971**	200	**1988**	51,987,990
1921	------	**1938**	------	**1955**	------	**1972**	76,457	**1989**	51,200,303
1922	------	**1939**	------	**1956**	------	**1973**	3,594,695	**1990**	45,266,911
1923	------	**1940**	------	**1957**	------	**1974**	7,101,815	**1991**	41,945,432
1924	------	**1941**	------	**1958**	------	**1975**	7,567,154	**1992**	32,366,557
1925	------	**1942**	------	**1959**	------	**1976**	11,106,426	**1993**	26,852,646
1926	------	**1943**	------	**1960**	------	**1977**	16,536,295	**1994**	23,770,707
1927	------	**1944**	------	**1961**	------	**1978**	14,427,547	**1995**	22,260,967
1928	------	**1945**	------	**1962**	------	**1979**	20,558,950	**1996**	20,066,110
1929	------	**1946**	------	**1963**	------	**1980**	22,167,108	**1997**	18,020,775
1930	------	**1947**	------	**1964**	------	**1981**	26,433,986	**1998**	10,555,177
1931	------	**1948**	------	**1965**	------	**1982**	19,441,151	**1999**	14,178,359
1932	------	**1949**	------	**1966**	------	**1983**	17,756,472	**2000**	13,902,110
								2001	13,068,469

------ Landings data not reported from 1916 to 1970. Fishery began in 1971.
Data sources: DFG Catch Bulletins (1916-1983) and DFG commercial landing receipt database (1984-2001).

Table 9.2. Consistency of the restricted access program for the sea urchin commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)

Fish and Game Commission policies	Sea urchin restricted access program's consistency with the policies
Restricted access as a management tool	
POLICY 1.1: The Fish and Game Commission (Commission) and the Department of Fish and Game (DFG) may use restricted access programs as one of a number of tools to conserve and manage fisheries as a public trust resource.	CONSISTENT The commercial restricted access program is one of the tools used to conserve and manage sea urchins. Other tools include: size limits and time and area closures.
Goals and objectives of restricted access programs	
POLICY 2.1: The Commission may develop restricted access programs for fisheries that retain the public ownership status of the resource for one or more of the following purposes: 1) to promote sustainability; 2) to create	CONSISTENT The State Legislature granted the Commission authority to limit the number of permits to prevent overfishing or to ensure efficient and economic

Table 9.2. Consistency of the restricted access program for the sea urchin commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)

Fish and Game Commission policies	Sea urchin restricted access program's consistency with the policies
an orderly fishery; 3) to promote conservation among fishery participants; 4) to maintain the long-term economic viability of fisheries.	operation of the fishery.
Development and review of restricted access programs	
POLICY 3.1: Restricted access programs shall be developed with the substantial involvement of participants in the affected fishery and others, consistent with the stakeholder participation requirements of Fish and Game Code §7059. This approach shall balance the specific needs of the fishery with the desirability of increasing uniformity among restricted access programs in order to reduce administrative complexity.	NOT APPLICABLE The program was developed before the adoption of this policy or the enactment of Fish and Game Code §7059. However, participants were involved in the development of the program and subsequent modifications to the program.
POLICY 3.2: Each restricted access program shall be reviewed at least every four years and, if appropriate, revised to ensure that it continues to meet the objectives of the State and the fishery participants. Review of each restricted access program shall occur at least as often as the particular fishery is reviewed in the annual fishery status report required by Fish and Game Code §7065. The general restricted access policy should be reviewed at a regularly scheduled Commission meeting at least once every four years following its adoption.	CONSISTENT IN PART • The program started before the adoption of this policy, but it has been modified and did receive some review by the Commission, DFG and stakeholders during those modifications. • This report (*Annual Status of the Fisheries Report* required by Fish and Game Code §7065) briefly reviews the program, but does not formally measure participants' perceptions on whether the program is meeting its goals and objectives.
Elements of restricted access programs	
POLICY 4.1: Each new restricted access program shall be based either on one or more species or species groups targeted by the fishery or on a type of gear. In programs based on a type of gear an endorsement may be required for one or more species or species groups targeted by the gear type. Each restricted access program should take into account possible impacts of the program on other fisheries.	CONSISTENT IN PART • The program is based on a species group (red and purple sea urchins). • It is not clear whether the impacts on other fisheries were evaluated during the development of the program.
POLICY 4.2: Each restricted access program that is not based on harvest rights shall have a capacity goal. The Commission, Department and stakeholders will use the best available biological and economic information in determining each capacity goal.	CONSISTENT The capacity goal is currently set at 300 sea urchin diving permits.
POLICY 4.3: Each restricted access fishery system shall have an equitable, practicable, and enforceable system for reducing fishing capacity when the fishery is exceeding its participation goal and for increasing fishing capacity when the fishery is below its fishery capacity goal.	CONSISTENT Systems exist for reducing and increasing capacity. Attrition is the means of reducing capacity. Capacity is increased by the issuance of new permits to eligible applicants. If there are more eligible applicants than new permits available, then a drawing is held to determine which applicants will be able to purchase permits.
POLICY 4.4: In fisheries that exceed their fishery capacity goals, permit transfers will be allowed only if they are consistent with the means for achieving the fishery capacity goal.	CONSISTENT Permits are not transferable.

Table 9.2. Consistency of the restricted access program for the sea urchin commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)

Fish and Game Commission policies	Sea urchin restricted access program's consistency with the policies
Permits	
POLICY 5.1: The Commission will give adequate public notice of intent to establish a restricted access program. The Commission may set a Control Date for determining qualification for a restricted access program. A new restricted access program shall not allow fishing effort to increase beyond recent levels. Some level of fishery participation may be required to qualify for an initial permit. Fishery qualification can be based upon fishery participation during a period of time preceding notification of intent or on other factors relevant to the particular fishery. Affidavits of fishery participation or medical statements of inability to meet qualification standards shall not be accepted. Vessels under construction or inoperable during the qualification period shall not be considered for a permit.	NOT APPLICABLE The program was developed before the adoption of this policy.
POLICY 5.2: New permits in a restricted access fishery shall only be issued when the fishery is below its fishery capacity goal.	NOT CONSISTENT New sea urchin diving permits are issued when the fishery is above the capacity goal. The number of new permits available for issuance is one-tenth the difference between the number of sea urchin diving permits issued prior to August 1 of the current license year and the number of permits issued the immediately preceding license year.
POLICY 5.3: Restricted access fishery permits shall be of one year duration and are renewed upon annual application and payment of the permit fee and shall be valid, provided they are annually renewed and the permit holder meets the requirements of the restricted access program for the life of the program.	CONSISTENT The permit must be renewed annually; the permittee must meet a minimum landing requirement, and must pay a permit fee.
POLICY 5.4: Each fisherman-based program shall determine in what circumstances, if any, a substitute may fish the permit.	CONSISTENT The program provides for a substitute if a diver becomes physically unable to dive because of long-term or permanent injury or disease.
Permit transfers	
POLICY 6.1: Restricted access permits may be transferable. In fisheries in which the permit is transferable, transfer may be subject to conditions that contribute to the objectives of the restricted access program. In new restricted access programs, permit transfers will not be allowed unless a fishery capacity goal and a system for achieving that goal are part of the restricted access program. In existing restricted access programs, the objective is to review and revise those programs to include fishery capacity goals and systems to achieve those goals. A restricted access program may include a fee on the transfer of permits, in excess of actual administrative costs for the permit change, to offset other costs involved in the conservation and management of that fishery.	NOT APPLICABLE Permits are not transferable.

Table 9.2. Consistency of the restricted access program for the sea urchin commercial fishery with the Fish and Game Commission policies on restricted access for commercial fisheries (policy adopted June 18, 1999)

Fish and Game Commission policies	Sea urchin restricted access program's consistency with the policies
Vessel issues	
POLICY 7.1: Vessels requested to be retired by the vessel owner will no longer be eligible to participate in commercial fisheries in California.	NOT APPLICABLE The permit is not vessel-based.
POLICY 7.2: Replacement vessels of the same or lower fishing capacity as the permitted vessel will be allowed only if the permitted vessel is lost, stolen, retired or no longer able to participate as a commercial fishing vessel.	NOT APPLICABLE The permit is not vessel-based.
POLICY 7.3: Each restricted access program that allows for vessel permit transfers may allow for vessel upgrades provided a permit consolidation/vessel retirement process consistent with the fishery capacity goal is made part of the program.	NOT APPLICABLE The permit is not vessel-based.
POLICY 7.4: A restricted access program may prohibit the use of support vessels or require that they be permitted in the fishery or that they pay a fee comparable to the permit fee.	NOT APPLICABLE The permit is not vessel-based.
Harvest rights	
POLICY 8.1: It is the policy of the Commission that harvest rights systems such as individual transferable quotas may be considered only after careful consideration of stakeholder input. In establishing such management systems, the State should consider: (1) fair and equitable initial allocation of quota shares which considers past participation in the fishery, (2) resource assessment for establishing total allowable catch estimates, (3) fishery participation goals and aggregation limits, (4) cost recovery from quota owners, (5) quota transferability, and (6) recreational fisheries issues.	NOT APPLICABLE The program is not based on harvest rights.
Administration of restricted access programs	
POLICY 9.1: Administrative costs shall be minimized and those costs shall be borne by the respective programs. Review or advisory boards may be considered on a program-by-program basis. The programs shall be administered in their entirety within an existing department unit.	CONSISTENT • The DFG License and Revenue Branch issues the permits. • The DFG Director's Sea Urchin Advisory Committee advised DFG for many years; it was recently restructured and is called the Sea Urchin Fishery Advisory Committee.
POLICY 9.2: Fees collected from restricted access initiatives may, for cost accounting and reporting purposes, be deposited in a single dedicated Restricted Access Fishery Account within the Fish and Game Preservation Fund. A fund condition and activity report should be published annually.	CONSISTENT The State Legislature, at the request of industry, created a landing fee specifically for sea urchin enhancement, research and management. That fee was repealed in 2002.
POLICY 9.3: Restricted access programs should provide specific disincentives for violations of pertinent laws and regulations. Enforcement costs of restricted access programs should be minimized through the use of new technologies or other means.	CONSISTENT The Commission can suspend, revoke or cancel a permit if the permittee or his employee or agent violates any regulation regarding sea urchins or abalone.

10. PURPLE SEA URCHIN

Overview of the Fishery

Although the purple sea urchin, *Strongylocentrotus purpuratus*, has been harvested for thousands of years, comparatively few are harvested nowadays. Along with the closely-related red sea urchin, *S. franciscanus*, purple sea urchins were considered pests prior to 1970 because they voraciously consumed kelp.

Purple sea urchin populations today could support a more substantial fishery than currently exists; however, they have only been harvested on a limited and experimental basis in California in association with the much larger and more lucrative red sea urchin fishery. Purple sea urchin roe is reportedly very similar in quality to some of the highly-desirable, domestic Japanese species, and is sought in Mediterranean countries.

Since 1990, annual purple sea urchin landings have ranged from 5,900 lb to 390,000 lb, with an average of about 119,000 lb (Figure 10.1 and Table 10.1). The largest landings (390,000 lb in 1991 and 316,000 lb in 1992) occurred when several attempts were made to establish buyers in the Japanese market. In recent years, purple sea urchin roe has also been exported to markets in the Mediterranean region.

Approximately 60% of purple sea urchin landings originate in northern California, although this species is harvested in southern California as well. A robust fishery for purple sea urchins has not yet developed because this species is smaller, yields less roe, and requires more effort to harvest and process than red sea urchins. The purple sea urchin's marketability in Japan has been limited by these factors and associated costs.

Sea urchin fishery regulations, as described in the report on red sea urchins in this volume, apply to the harvest of purple sea urchins as well, except that there are no minimum size limits or closed periods for purple sea urchins. (For a detailed review

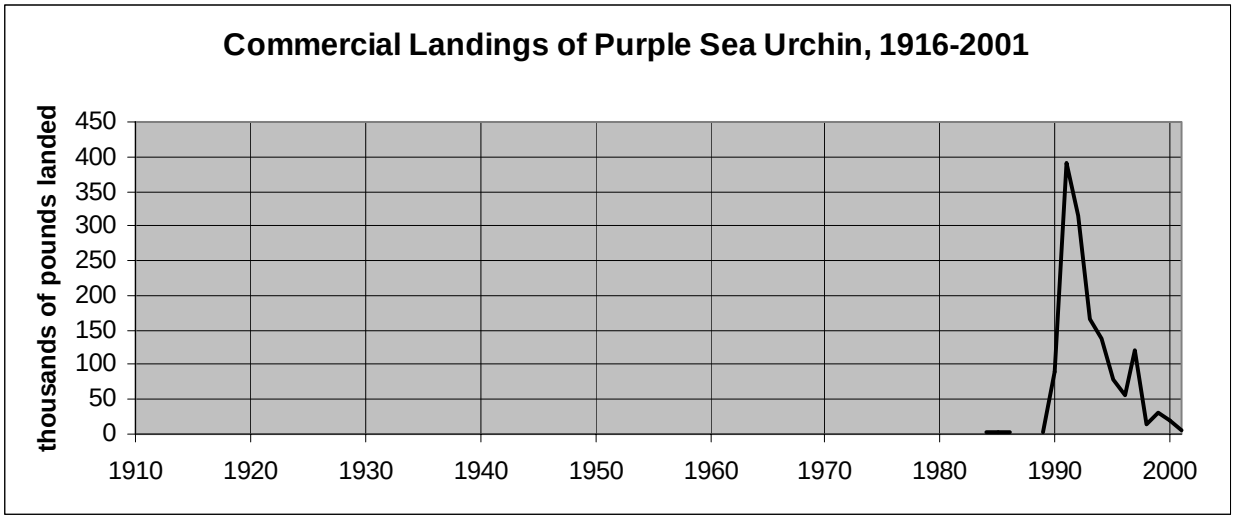

Figure 10.1. Annual commercial landings (pounds) of purple sea urchin from 1916 to 2001. Data sources are the California Department of Fish and Game (DFG) Catch Bulletins (1916-1983) and the DFG commercial landing receipt database (1984-2001).

of the sea urchin restricted access program, see the red sea urchin report.) A minor recreational fishery for purple urchins also takes place in southern California with a daily bag and possession limit of 35 urchins.

Status of Biological Knowledge

Purple sea urchins inhabit waters from Alaska to Cedros Island, Baja California, Mexico, at depths of up to 500 ft; however, they live primarily in shallow water and are the only abundant sea urchin in intertidal areas along the California coast.

General biology of the purple sea urchin is very similar to that of the closely-related red sea urchin (see the report on red sea urchins for a more detailed review of urchin biology). In addition to external color differences, purple sea urchins are much smaller than red sea urchins, rarely attaining a body (or "test") diameter of over 4 in.

Feeding habits and reproduction are quite similar to those found in red sea urchins. Purple sea urchins reach reproductive maturity at around one or two years of age. Larvae drift with the prevailing water currents for an uncertain amount of time, probably about six to eight weeks. As the larvae mature, they settle to the bottom and change into the juvenile form. Peak settlement periods tend to be in spring and early summer, with substantial year-to-year variation in both timing and intensity. Settlement tends to be less variable south of Point Conception (Santa Barbara County) and is depressed during El Niño events. El Niño events appear to favor settlement in northern California, however. Energetic movement of water offshore in northern California has been associated with reduced recruitment.

Growth is highly variable and strongly linked with food availability. At one year, the size of purple sea urchins can range from about 0.4 in. to 1.2 in. After five years, size can range from 1.25 in. to 2.0 in. Growth rates of very small individuals under one year old are not well known.

Predators of purple sea urchins include those for red sea urchins (sea otter, spiny lobster, sea stars, and fishes), however because purple sea urchins are common in the intertidal zone, predators also include sea gulls, oystercatchers, and raccoons. Sea otters, currently found off the coast of central California, are able to reduce sea urchin populations to levels unsuitable for commercial or recreational fishing, but apparently do not threaten the species' continued existence.

When water temperatures exceed 73° F, purple sea urchins exhibit increased mortality, which appears to be partly caused by physiological stress. Elevated temperatures also promote development of one or more urchin pathogens that can cause mass mortalities. These die-offs have been observed more frequently in southern than in northern California, especially in association with elevated water temperatures during El Niño events.

Status of the Population

Larval settlement rates monitored at a number of locations in southern and northern California over the past 10 years do not indicate a change in larval production and settlement patterns, which indicates that the status of this species appears to be stable.

Management Considerations

There are several gaps in basic knowledge concerning purple sea urchins. Although there are scattered studies of growth and survival in the literature, data have not been synthesized in a manner that would assist in setting informed harvest size limits. Studies of early growth and survival up to an age of one year are few. These studies are needed to link settlement information with recruitment to the reproductive population. Studies are also needed to link sources of larvae with sites of settlement – information crucial to developing management plans that involve marine reserves. Both fishery-dependent and -independent monitoring should continue in order to assess changes in stock condition. Fishery-dependent monitoring of commercial landing levels and patterns should detect any trend toward large-scale harvests that might require more specific management measures. At present, the most comprehensive fishery-independent data consists of the long-term monitoring of settlement patterns in northern and southern California. Continuing this monitoring should provide a measure of settlement supply, and an early warning of possible adverse effects of harvesting on recruitment.

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Revised May 2002
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Further Reading

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Table 10.1. Commercial landings (pounds) of purple sea urchin, 1916-2001									
Year	**Pounds**	**Year**	**Pounds**	**Year**	**Pounds**	**Year**	**Pounds**	**Year**	**Pounds**
1916	------	**1933**	------	**1950**	------	**1967**	------	**1984**	2,755
1917	------	**1934**	------	**1951**	------	**1968**	------	**1985**	2,260
1918	------	**1935**	------	**1952**	------	**1969**	------	**1986**	1,424
1919	------	**1936**	------	**1953**	------	**1970**	------	**1987**	------
1920	------	**1937**	------	**1954**	------	**1971**	------	**1988**	------
1921	------	**1938**	------	**1955**	------	**1972**	------	**1989**	2,781
1922	------	**1939**	------	**1956**	------	**1973**	------	**1990**	89,633
1923	------	**1940**	------	**1957**	------	**1974**	------	**1991**	390,186
1924	------	**1941**	------	**1958**	------	**1975**	------	**1992**	316,134
1925	------	**1942**	------	**1959**	------	**1976**	------	**1993**	165,032
1926	------	**1943**	------	**1960**	------	**1977**	------	**1994**	137,613
1927	------	**1944**	------	**1961**	------	**1978**	------	**1995**	79,802
1928	------	**1945**	------	**1962**	------	**1979**	------	**1996**	55,701
1929	------	**1946**	------	**1963**	------	**1980**	------	**1997**	122,004
1930	------	**1947**	------	**1964**	------	**1981**	------	**1998**	14,068
1931	------	**1948**	------	**1965**	------	**1982**	------	**1999**	29,797
1932	------	**1949**	------	**1966**	------	**1983**	------	**2000**	19,095
								2001	5,953

------ No landings data from 1916 to 1983 and from 1987 to 1988. No directed fishery until 1984.
Data sources: DFG Catch Bulletins (1916-1983) and DFG commercial landing receipt database (1984-2001).

11. SEA BASSES

Overview of the Fishery

Three species of the sea bass family Serranidae are common in southern California waters: the barred sand bass, *Paralabrax nebulifer*; the kelp bass, *Paralabrax clathratus*; and the spotted sand bass, *Paralabrax maculatofasciatus*[1]. In the California Department of Fish and Game's (DFG) historic records of commercial and recreational fisheries, these three sea basses' landings were often combined and reported as "rock bass".

A small commercial fishery existed for these species until 1953, when the commercial take of sea basses was prohibited. Commercially-caught sea basses were sold fresh and primarily consisted of kelp bass and barred sand bass. Sea basses were caught using a wide variety of gear including rod-and-reel, hand line, set line, gillnet, trap, and trawl, and were often taken incidentally by boats fishing for other species.

The commercial record for "rock bass" began in 1916 (Figure 11.1 and Table 11.1). As with many of California's commercial fisheries, landings remained relatively high during World War I because of the increased demand for food, and then declined following the war. Landings rose again during the mid- to late 1920s, and then generally declined until the close of the fishery in 1953. The declines in commercial landings may not have been the result of reduced availability, but rather reduced effort. Effort was not consistent over the time period because few commercial fishermen fished full-time for sea basses. In addition, it was common for recreational anglers to sell their

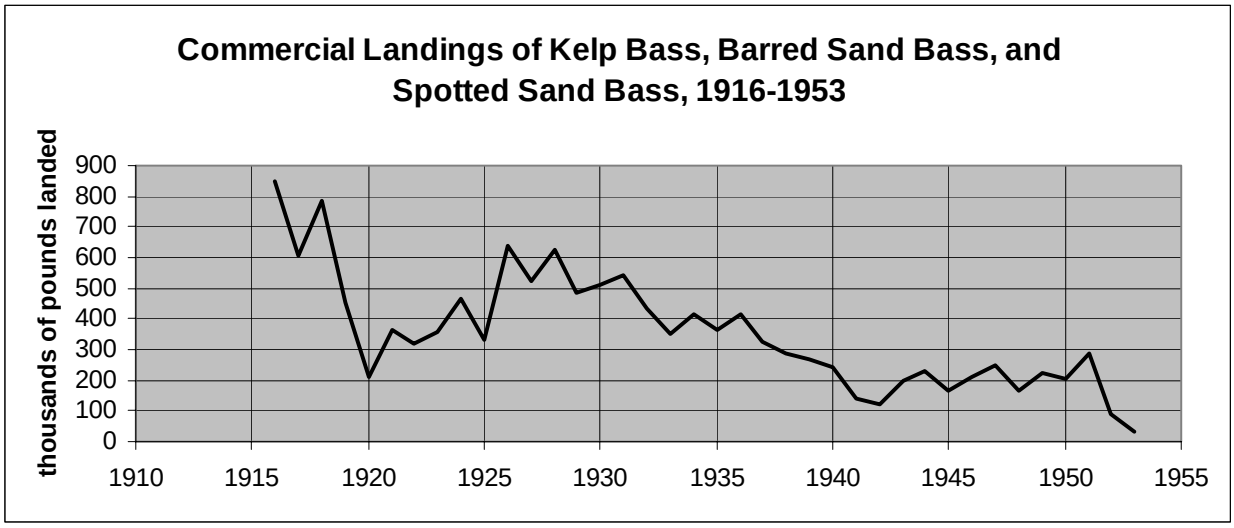

Figure 11.1. Annual commercial landings (pounds) of sea basses (combined landings of kelp bass, barred sand bass, and spotted sand bass) from 1916 to 1953. The commercial fishery was closed in 1953. Data sources are DFG Catch Bulletins.

1 The white sea bass, *Atractoscion nobilis*, and the giant sea bass, *Stereolepis gigas*, are not in the family Serranidae, and are not covered here.

excess catch of sea basses until 1947, when a law was passed that prohibited the sale of sport-caught fish.

The catch data for the recreational fishery come from two sources: commercial passenger fishing vessel (CPFV) logbooks, and the Marine Recreational Fishery Statistics Survey (MRFSS). The MRFSS was conducted in California from 1980 though 1989 and from 1993 through the present, and estimates the catch of each of the sea bass species by fishing mode: man-made structure, beach and bank, CPFV, and private or rental boat. It also provides an overall estimate of recreational catch in terms of total weight and number of fish. Since 1936, CPFV operators in southern California have been required to keep daily records of the number and type of fish caught from their boats in logbooks provided by DFG. From 1936 through 1974, logbooks asked for only the combined catch catches of all three sea bass species. Logbook information was not collected from 1941 through 1946 (during World War II). In 1975, DFG modified the logbook to list barred sand bass and kelp bass separately. To date, a separate category for spotted sand bass has not been added.

According to CPFV logbooks, an average of 737,000 sea basses have been caught annually from 1947 through 2001 (Figure 11.2 and Table 11.2). The largest CPFV catches occurred from 1963 through 1969 when over one million sea basses were caught annually.

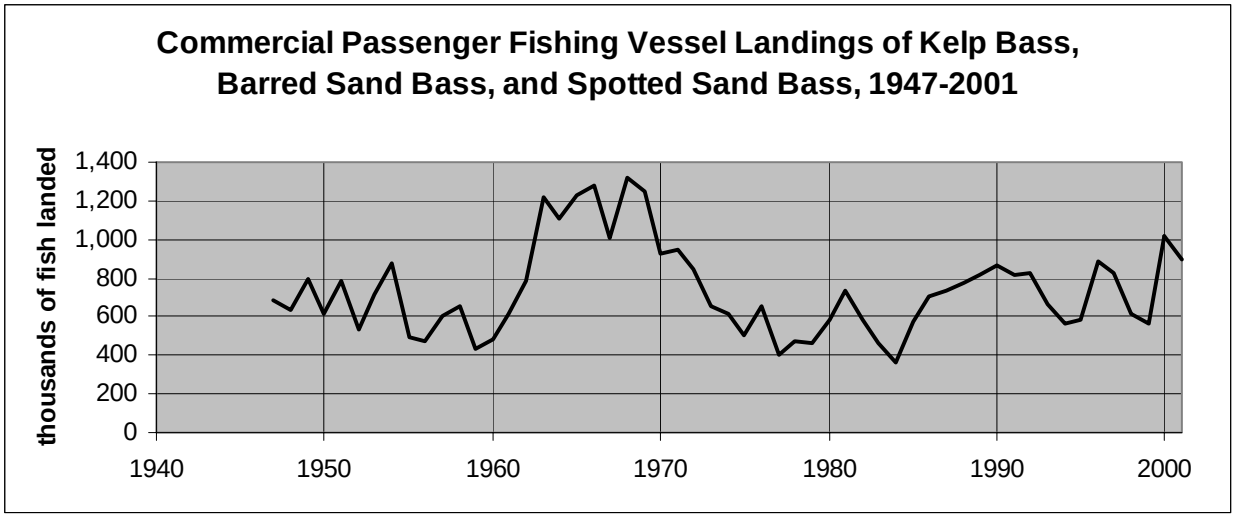

Figure 11.2. Recreational commercial passenger fishing vessel (CPFV) landings (number of fish) as reported on CPFV Logbooks for kelp bass, barred sand bass, and spotted sand bass from 1947 to 2001. Data sources are DFG Catch Bulletins (1947-1978) and DFG Annual Reports of Statewide Fish Landings by the Commercial Passenger Fishing Vessels (CPFV) Fleet (1979-2001).

MRFSS estimates show that the overall recreational catch of sea basses was relatively steady between 1993 and 1995, and then experienced four years of decline (Figure 11.3). Catches rose sharply in 2000 and remained relatively high in 2001.

The sea bass landings for the recreational fishery have generally been larger than those for the commercial fishery. Between 1936 and 1940, the DFG gathered landings data by weight for the CPFV fishery and the commercial fishery. During that time period, CPFV landings were on average almost three times larger than commercial landings. According to MRFSS estimates, the total annual recreational catch of sea

basses during the last two decades has ranged from a low of 1,153,000 lb in 1999 to a high of 4,103,000 lb in 1988 (Figure 11.3). Even the lowest recreational catch during the last two decades surpasses the highest commercial landings (852,000 lb in 1916) on record.

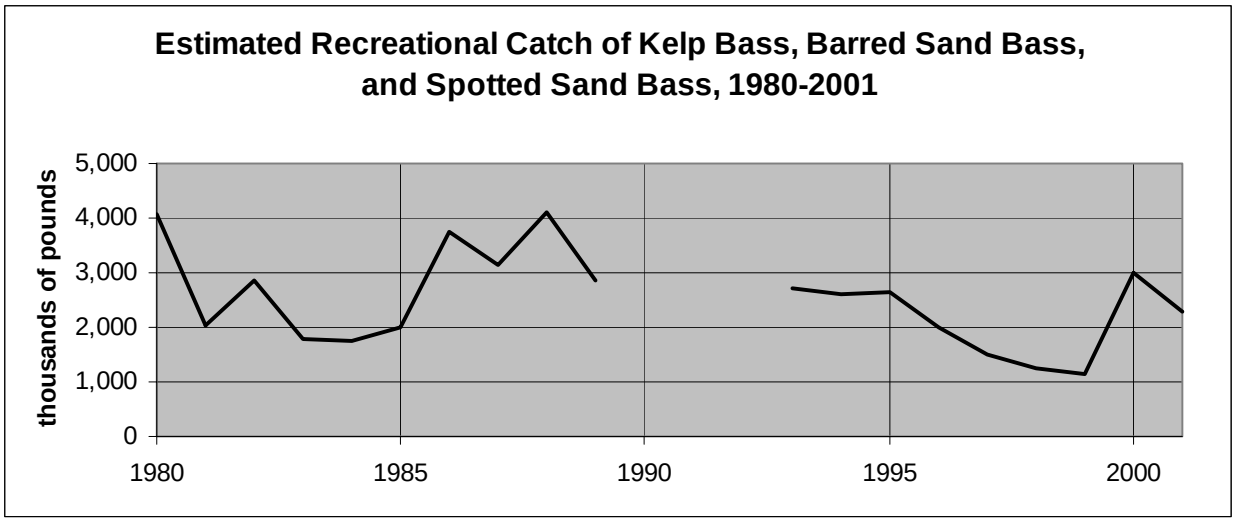

Figure 11.3. Estimated recreational catch (pounds) of kelp bass, barred sand bass, and spotted sand bass from 1980 to 1989 and 1993 to 2001. Catch estimates do not include fish that were caught and released alive. Data source is the MRFSS.

In the early 1950s sport fishermen and fishery managers became concerned about the sea basses resource. Data from life history studies conducted during the 1950s were used to formulate several conservation measures, including:

- Prohibiting the commercial take of all three sea bass species in California waters (established in 1953)
- Imposing a minimum size limit of 10.5 in. for all three species (established in 1953). The size limit was periodically increased between 1953 and 1959, when a 12-in. minimum size limit was adopted that remains in effect today
- Establishing a bag limit of 10 sea bass (any combination of barred sand bass, kelp bass and spotted sand bass) (established in 1959)

Barred Sand Bass

The barred sand bass is a relatively easy fish for marine anglers to catch. Although the sand bass was not considered a quality game fish during the 1930s and early 1940s, it became tremendously popular by the mid-1950s. Since the late 1970s, this species has consistently ranked among the top ten species in the southern California marine sport fish catch.

Barred sand bass are very susceptible to hook-and-line gear and are somewhat easier to catch than kelp bass. When CPFV skippers target schools of barred sand bass, they usually produce substantial catches for their passengers, even when the passengers are novice anglers possessing minimal fishing skills.

Most barred sand bass are caught from boats. Over the last two decades, a little more than half of the landings have been from CPFVs, a little less than half from private or rental boats, and less than 2% from shore (Table 11.3 and Table 11.4). MRFSS estimates of annual barred sand bass landings from all sport fishing modes (shore, pier, private boat, CPFVs, etc.) have averaged about 846,000 fish per year since 1980, with a peak landing of 2.1 million fish in 1988 (Table 11.3). CPFV logbook data indicates that the catch of barred sand bass generally increased from 1975 through 2001, expanding more than five-fold with a peak of 738,000 fish in 2000 (Table 11.2).

Barred sand bass landings now rival kelp bass landings in the nearshore recreational fishery off southern California. In 1985, barred sand bass became the leading bass species in the CPFV catch, exceeding kelp bass landings for the first time since landings for these two species were reported separately. Since 1985, the barred sand bass catch has exceeded the kelp bass catch 75% of the time (Table 11.2).

The major barred sand bass fishing sites include Silver Strand Beach, Del Mar, San Onofre, and the Huntington Flats area in Orange County, the inshore portion of northern Santa Monica Bay off Pacific Palisades and Santa Monica in Los Angeles County, and the Ventura Flats area in Ventura County.

Kelp Bass

Kelp bass, popularly referred to as calico bass, are one of the most important nearshore recreational species off southern California. This species has been targeted by southern California anglers since the early 1900s. Based on recent information, it is very likely that kelp bass comprised most of the "rock bass" category during the early years of the fishery. Sport anglers catch kelp bass using light hook-and-line tackle while fishing from piers, beaches, private boats, and CPFVs.

In the early 1900s, sport anglers considered small kelp bass to be a nuisance fish; only the largest “bull bass” were sought. Perceptions of kelp bass as a sport fish changed, and by the 1930s it had become a popular sport fish. In 1939, the first management attempt to prevent depletion of sport fishes limited the recreational catch to 15 total fish per day (multiple species). Intense fishing immediately after World War II may have caused a progressive decrease in the size of kelp bass, and deterioration of the popular kelp bass fishery. In 1950, DFG began comprehensive life history studies of kelp bass and sand bass. The resulting data were used to create new size and bag limits for sport-caught kelp bass and sand bass. The new size limit, 10.5 in., was increased several times over the years until 1959, when the current 12-in. limit was instated.

CPFV landings of kelp bass typically peak in the late spring and early fall. The catch of kelp bass, as reported in the CPFV logbooks, averaged approximately 328,000 fish per year between 1975 and 2001 (Table 11.2). The catch reached a record low of about 129,000 fish in 1999, but rebounded to previous average levels in 2000 and 2001.

The MRFSS data indicate that nearly all kelp bass are caught from CPFVs, private boats, and rental boats (Table 11.5 and Table 11.6). The MRFSS catch estimates show trends similar to those obtained from CPFV logbook data: declining catches through most of the 1990s with a low in 1999, and then a landings rebound in 2000 and 2001.

The most productive fishing areas for kelp bass in recent years have been off the Coronado Islands in Baja California, Mexico, Point Loma and La Jolla in San Diego County, Dana Point and Huntington Beach in Orange County, Horseshoe Kelp in Los Angeles County, and around the Channel Islands.

Spotted Sand Bass

The distribution of spotted sand bass is limited to a few bay, estuary and harbor habitats. Newport Bay (Orange County), and Mission and San Diego bays (San Diego County) are primary spotted sand bass fishing sites in southern California.

The annual catch of spotted sand bass over the last two decades has been considerably lower than the catches of kelp bass and barred sand bass (Table 11.7 and Table 11.8). During this time period, the average annual catch of spotted sand bass has been about 82,000 fish (Table 11.7), while the average annual catch of kelp bass was over nine times greater (753,000 fish) and the average annual catch of barred sand bass was over ten times greater (846,000 fish). However, the spotted sand bass has recently gained popularity with nearshore anglers for its aggressive behavior and fighting ability, and some angling tournaments exclusively target spotted sand bass. In addition, the accessibility to spotted sand bass habitat has increased dramatically with the introduction of float-tube technology and the increased popularity of fishing from ocean kayaks. This increased accessibility has generated interest in the spotted sand bass as a challenging sport fish.

Although spotted sand bass are not landed in great numbers, they are regionally important to anglers who fish from shore or from small boats. MRFSS estimates that most recreationally-caught spotted sand bass are caught from private or rental boats, while only 8% are caught from shore, and about 3% from CPFVs. The CPFV fleet does not target spotted sand bass since this species occurs in shallow areas where it is difficult to navigate large vessels.

DFG surveys between 1976 and 1981 indicate the annual catch of spotted sand bass in southern California waters by skiff fishermen ranged from about 13,000 to 24,000 fish. The MRFSS estimates of the total sport catch, including boat and shore fishing effort, ranged from 53,000 to 170,000 spotted sand bass per year from 1980 to 1989 and from 17,000 to 95,000 per year from 1994 to 1999 (Table 11.7).

Status of Biological Knowledge

Barred Sand Bass

Barred sand bass range from Santa Cruz (Santa Cruz County) south to Bahia Magdalena, Baja California, Mexico. They are rare north of Point Conception (Santa Barbara County). Barred sand bass chiefly inhabit shallow waters near the southern California mainland. They have been captured at depths of around 600 ft, but the greatest concentrations are found in less than 90 ft. Young barred sand bass are abundant in very shallow water (5 to 30 ft). The name “sand bass” is somewhat unfortunate since they are usually closely associated with sand/rock interfaces of deep reefs and artificial structures, and are rarely found over sandy expanses except when breeding.

Barred sand bass feed mainly on small fishes (including anchovies, sardines, and midshipman), and invertebrates such as crabs, clams, and squid. The largest barred sand bass on record measured 26 in. long, and the heaviest weighed 11.1 lb. Like kelp bass, barred sand bass are also relatively slow growing. A juvenile barred sand bass is approximately 6 in. long after 1 year, and reaches sexual maturity at 3 to 5 years at a length of 7 to 10.5 in. The oldest known barred sand bass was determined to be 24 years old.

Barred sand bass gather to breed over sandy bottoms at depths of 60 to 120 ft in the late spring and summer months. Spawning occurs from April through November, usually peaking in July. Male spawning colors are usually a gray-and-white, high-contrast pattern with large, golden-yellow crescents under the eyes. Barred sand bass produce numerous small, free-drifting eggs that enter the plankton in coastal waters. Young-of-the-year barred sand bass begin appearing in shallow, nearshore waters by early fall.

DFG tagging studies revealed that barred sand bass can move from 5 to 40 mi. from their tagging locations. In the early 1970s, evidence was presented that tumors, deformities, and other anomalies found in barred sand bass may have been linked to industrial and domestic wastes discharged into the nearshore environment. Reports of such abnormalities have decreased over the past two decades.

Kelp Bass

Kelp bass have historically ranged as far north as the mouth of the Columbia River in Washington and south to Bahia Magdalena, Baja California, Mexico; however, they are rare north of Point Conception (Santa Barbara County). Kelp bass are abundant in southern California waters including the Channel Islands, and are typically found in shallow water (surface to 150 ft) closely associated with high-relief structure and kelp. They range throughout the water column, but can be found in the greatest numbers between 8 and 70 ft. In general, kelp bass live solitary lives, assembling only to spawn and to feed on small, schooling fishes. Early tagging studies showed little movement for the majority of kelp bass and concluded that movement, if any, was to nearby rocky reefs or over short distances to gather for breeding. More recently, tagging studies in the northern portion of the Southern California Bight, from Point Conception south to the northern Channel Islands, have indicated that kelp bass are actually quite mobile in this area, with some fish traveling as far as 50 mi.

Kelp bass have the broad diet of a generalized carnivore. They eat small fishes (including anchovies, sardines, surfperch, and queenfish), squids, octopuses, crabs, shrimps, and amphipods. Kelp bass forage primarily in mid-water, but occasionally feed on the bottom. Young kelp bass feed on small crabs, copepods, and plankton. Kelp bass feed lightly in the winter and more heavily from May through September.

Kelp bass mature at about three to five years of age. When mature, they typically measure between 7 and 10.5 in. long. Mature individuals usually gather to breed in deeper water near kelp beds and rocky headlands, in depths of up to 150 ft. Several hundred adults may aggregate in a small area during spawning. Spawning males usually develop high-contrast, black-and-white breeding colors with yellow-orange snouts, while females exhibit golden hues with yellow chins and jaws.

Spawning occurs primarily around the full moon from April through November, peaking in the summer months.

Kelp bass produce free-drifting eggs which enter the plankton in coastal waters. Larvae remain in the plankton for 28 to 30 days, after which they settle into shallow water habitats that have attached algae and drift algae, including kelp. During the first 90 days of life, young kelp bass grow to a length of about 2 in. Juvenile kelp bass can grow to lengths of 5 or 6 in. by the end of their first year, and are about 12 in. (sport-legal size) at five years of age. The average 10-year-old kelp bass is about 18 in. long.

As with most fishes, growth is highly variable, with the largest fish not necessarily being the oldest. For example, the world-record kelp bass (14.5 lb) caught off Newport Beach in 1995 was 27 years old, while a 9.5 lb fish caught at San Clemente Island in 1993 was 34 years old. Kelp bass are known to grow to 28.5 in. and 14.5 lb; the oldest known kelp bass was 34 years old and 25 in. long.

Spotted Sand Bass

The spotted sand bass has a historic range from Monterey (Monterey County) to Mazatlan, Mexico. However, this species is rarely seen north of Santa Monica Bay (Los Angeles County). Included within that range are substantial populations in the Gulf of California. Southern California populations are typically restricted to sand or mud habitat within shallow bays, harbors, and coastal lagoons containing eelgrass, surfgrass and rock relief. These areas act as warm-water refuges for this generally sub-tropical species.

Spotted sand bass grow rapidly during their first two years. Some specimens may grow to 8.8 in. long by the end of their first year. There is no significant difference in growth rates between males and females.

Spotted sand bass spawn in the warm summer months, from late May to early September. The presence of multiple-sized, immature eggs in egg-bearing females indicates that this species may spawn multiple times during a season. During the spawning season, spotted sand bass gather to breed at or near the entrances of bays in southern California. Observations of spawning in the wild indicate that females initiate spawning by leaving the bottom and entering the water column to release eggs. At the time of release, multiple males may dart in to fertilize the eggs. The observed episodes were extremely brief and, once completed, the fish returned to the bottom.

Spotted sand bass eggs and larvae are free-floating and enter the plankton in coastal waters, settling out of the water column at 25 to 31 days. Juvenile spotted sand bass (greater than 2 in.) have several dark stripes running length-wise along their sides, making them similar in appearance to juvenile barred sand bass. Juvenile spotted sand bass occupy eelgrass beds and can share these nursery environments with juvenile barred sand bass and kelp bass. Adults usually occupy a depth of 2 to 30 ft; however, specimens have been taken from waters as deep as 200 ft in the Gulf of California.

The spotted sand bass appears to have a complex mating system. Individual populations within southern California display varied patterns of reproduction. In San Diego Bay, individual fish start their lives as females and after a period of time change into males (a reproductive strategy called “protogynous hermaphroditism”). In Anaheim and Newport Bays, spotted sand bass do not exhibit this reproductive strategy, and have an essentially equal distribution of males and females throughout the age and size

classes in the population. During the spawning season, male and female spotted sand bass exhibit different color patterns: males display a whitish chin color and overall high-contrast body coloration, while females display a yellow chin and a darker body. Male spotted sand bass mature at about 1.4 years and 7.8 in., and females mature at about 1 year and 6.7 in. The impact of potential sex change, if any, on these values is unknown.

In California waters, adult spotted sand bass diets consist primarily of crabs and clams, with fishes forming a relatively small component of their overall food complement. The crab component consists of brachyuran crabs, and the dominant bivalve in the diet is the jackknife clam.

While spotted sand bass can reach 14 years of age, most have a maximum life span of about 10 years. The current world record spotted sand bass is an individual caught in 1995, which was 10 years old, 23 in. long, and weighed 6.7 lb.

Significant physical and genetic differentiation has occurred among spotted sand bass populations throughout their geographic range. The Gulf of California populations appear to be distinct from those on the Pacific coast. Those populations in southern California also appear to be genetically distinct from those on the mid-Baja Pacific coast. This sub-population structure indicates that spotted sand bass do not travel far from their respective habitats.

Status of Populations

There are no current population estimates for any of the three sea bass species.

Barred Sand Bass

Several factors seem to account for the upward trend in CPFV landings of barred sand bass (Table 11.2). CPFVs and private boats have increasingly targeted summer spawning schools, with CPFVs taking most of the catch. Barred sand bass are easier to find during the summer spawning period when the fish are concentrated in well-defined areas along the coast. New barred sand bass spawning sites discovered over the last 20 years are now being exploited by CPFVs and private boats. As fishing effort targeting barred sand bass has increased, there has been concern that the stock may become over-exploited. More information must be collected before the effects of this intense fishing effort can be determined.

Kelp Bass

Low kelp bass landings in the mid-1970s and early 1980s may be attributed to El Niño events, which provide anglers with alternative species to catch. Peak landings of kelp bass have followed each El Niño event. DFG surveys of the CPFV industry in the 1970s and 1980s indicated that a stable spawning population was being maintained, because a large number of age-classes were being caught by anglers. Approximately 85% of the kelp bass kept by CPFV anglers measured between 11.4 and 15.9 in., which represented up to seven age-classes.

Spotted Sand Bass

Southern California populations of spotted sand bass are limited, and genetically distinct. The restrictive, limited environment inhabited by this species tends to amplify the adverse effects of environmental change and recreational fishing pressure.

Complicating matters further, recruitment (the point at which fishes attain sufficient size to enter the fishery) for this species is sporadic, and environmental conditions such as sea surface water temperatures may influence recruitment. Spotted sand bass have substantial recruitment success after El Niño episodes, when nearshore sea surface temperatures are elevated. In other years, recruitment has been poor. This sporadic recruitment pattern may have adverse effects on a population that is being subjected to increased angling pressure.

The effects of increased waterfront development on spotted sand bass populations are unknown. This development may permanently alter nursery habitat and water quality, and may cause downward trends in recruitment, resulting in negative impacts on certain populations.

Management Considerations

The Master Plan for the Marine Life Management Act identified barred sand bass and kelp bass as species in need of fishery management plans. The following management issues could be considered prior to the development of a fishery management plan for sea basses, however:

- Most barred sand bass are caught in the summer months when the fish are aggregated to spawn. Thus, this species may be a good candidate for the establishment of harvest refugia in some areas during peak spawning times.
- Under the current 12 in. minimum size restrictions, kelp bass populations appear to be self-sustaining. However, trophy-sized fish are rare. New conservation measures such as increasing the size limit, imposing minimum and maximum size limits (slot fishing), and/or promoting catch-and-release fishing could be explored.
- The available habitat for spotted sand bass is restricted in southern California. Studies indicate that most of the spotted sand bass caught by recreational anglers are released. Since they are not specifically targeted as a food fish and are mostly caught by recreational anglers for sport, adopting a catch-and-release policy might prove beneficial to this species.

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Further Reading

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Table 11.1. Commercial landings (pounds) of sea basses (kelp bass, barred sand bass, and spotted sand bass), 1916-1953

Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds
1916	852,059	**1926**	636,335	**1936**	416,145	**1946**	207,548
1917	607,734	**1927**	525,840	**1937**	325,000	**1947**	251,413
1918	783,864	**1928**	626,239	**1938**	286,087	**1948**	164,289
1919	450,229	**1929**	482,536	**1939**	266,153	**1949**	220,579
1920	210,380	**1930**	509,125	**1940**	245,559	**1950**	205,367
1921	363,856	**1931**	544,879	**1941**	141,977	**1951**	288,572
1922	316,051	**1932**	436,575	**1942**	122,812	**1952**	86,745
1923	357,269	**1933**	348,392	**1943**	198,132	**1953**	34,115
1924	466,208	**1934**	412,371	**1944**	229,032		
1925	330,285	**1935**	364,554	**1945**	163,846		

1. Data source: DFG Catch Bulletins where the combined landings of the three sea bass species are reported as rock bass.
2. Landings consist of fish caught in California or Mexican waters and landed in California, and fish caught in Mexican waters and shipped fresh to California.
3. Landings primarily consist of kelp bass and barred sand bass, with kelp bass comprising a larger proportion of the landings than barred sand bass.
4. Commercial take of sea basses (barred sand bass, kelp bass, and spotted sand bass) was prohibited in 1953.

Table 11.2. Recreational commercial passenger fishing vessel (CPFV) landings (number of fish) as reported on CPFV Logbooks for kelp bass, barred sand bass, and spotted sand bass, 1947-2001

Year	Unspecified kelp and sand basses	Kelp bass	Barred sand bass	Spotted sand bass	Total
1947	682,789	------	------	------	682,789
1948	630,223	------	------	------	630,223
1949	796,959	------	------	------	796,959
1950	619,397	------	------	------	619,397
1951	781,609	------	------	------	781,609
1952	536,075	------	------	------	536,075
1953	711,395	------	------	------	711,395
1954	876,667	------	------	------	876,667
1955	497,343	------	------	------	497,343
1956	470,362	------	------	------	470,362
1957	609,071	------	------	------	609,071
1958	653,671	------	------	------	653,671
1959	428,426	------	------	------	428,426
1960	478,656	------	------	------	478,656
1961	613,604	------	------	------	613,604
1962	789,149	------	------	------	789,149
1963	1,219,344	------	------	------	1,219,344
1964	1,103,394	------	------	------	1,103,394
1965	1,230,313	------	------	------	1,230,313
1966	1,278,939	------	------	------	1,278,939
1967	1,003,914	------	------	------	1,003,914
1968	1,317,963	------	------	------	1,317,963
1969	1,246,175	------	------	------	1,246,175
1970	922,260	------	------	------	922,260
1971	948,121	------	------	------	948,121
1972	842,681	------	------	------	842,681
1973	656,195	------	------	------	656,195
1974	618,034	------	------	------	618,034
1975	39,424	353,463	106,804	------	499,691
1976	14,485	485,280	156,056	------	655,821
1977	6,844	272,705	118,545	------	398,094
1978	6,328	360,277	110,377	------	476,982
1979	3,195	290,448	169,337	------	462,980
1980	375	355,950	229,107	------	585,432
1981	551	501,927	237,084	------	739,562
1982	630	312,891	273,828	------	587,349
1983	272	304,645	158,353	------	463,270
1984	530	222,771	136,612	------	359,913
1985	169	273,299	299,152	------	572,620
1986	72	435,516	265,014	------	700,602
1987	3	325,685	408,635	------	734,323
1988	26	319,629	451,125	------	770,780
1989	63	393,892	421,110	------	815,065

Table 11.2. Recreational commercial passenger fishing vessel (CPFV) landings (number of fish) as reported on CPFV Logbooks for kelp bass, barred sand bass, and spotted sand bass, 1947-2001

Year	Unspecified kelp and sand basses	Kelp bass	Barred sand bass	Spotted sand bass	Total
1990	56	439,701	423,885	------	863,642
1991	4	321,926	495,784	------	817,714
1992	153	463,673	363,304	------	827,130
1993	85	355,088	313,390	------	668,563
1994	------	276,087	286,444	------	562,531
1995	------	231,687	350,540	------	582,227
1996	------	282,673	604,132	------	886,805
1997	------	335,127	490,048	------	825,175
1998	------	233,591	377,890	------	611,481
1999	------	129,475	435,778	------	565,253
2000	------	277,191	737,950	------	1,015,141
2001	------	304,002	597,274	------	901,276

------ Landings data not available.

1. Data sources: DFG Catch Bulletins (1947-1978) and DFG Annual Reports of Statewide Fish Landings By The CPFV Fleet (1979-2001).
2. Logbooks have been required for southern California, including fish taken in Mexican waters and landed in California, for the entire time period reported here. Logbooks were required for central and northern California from 1957 to present.
3. The data are number of fish reported on logbooks submitted to DFG.
4. Spotted sand bass has never been listed as a separate reporting category on CPFV logbooks. From 1947 to 1974, an unspecified kelp and sand basses reporting category was used. By 1975, kelp bass and barred sand bass were being recorded separately. By 1994, only low numbers of fish were recorded under unspecified kelp and sand basses.

Table 11.3. Estimated catch (number of fish) by recreational anglers of barred sand bass by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	9,745	33,984	------	321,554	421,791	787,073
1981	5,163	------	------	162,653	206,774	374,591
1982	4,682	3,551	------	935,544	215,027	1,158,804
1983	4,155	2,572	------	232,914	187,377	427,018
1984	6,326	4,170	------	186,832	213,963	411,291
1985	6,893	3,183	------	532,639	251,785	794,499
1986	------	------	12,343	537,661	398,208	948,213
1987	------	------	17,258	500,371	718,514	1,236,142
1988	------	------	39,859	1,272,073	809,830	2,121,762
1989	------	------	5,090	769,884	520,799	1,295,773
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	2,591	835	------	411,951	315,808	731,185
1994	3,891	11,337	------	383,379	292,141	690,748
1995	9,627	4,854	------	511,364	275,668	801,513
1996	5,565	860	------	502,879	234,502	743,806
1997	6,640	3,680	------	189,799	262,854	462,972
1998	3,067	1,218	------	155,849	257,498	417,632
1999	2,403	749	------	214,208	271,382	488,742
2000	6,711	3,255	------	774,009	475,316	1,259,292
2001	3,549	885	------	355,628	567,245	927,308

------ Estimates not available.
1. Data source: MRFSS; data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California CPFVs were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

Table 11.4. Estimated catch (pounds) by recreational anglers of barred sand bass by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	11,339	28,842	------	775,866	896,530	1,712,577
1981	4,900	------	------	246,782	300,011	551,693
1982	1,507	3,753	------	1,340,897	312,977	1,659,134
1983	4,277	1,238	------	356,741	270,540	632,796
1984	4,586	3,704	------	294,782	321,242	624,314
1985	5,173	705	------	740,899	342,806	1,089,583
1986	------	------	12,236	781,410	615,016	1,408,662
1987	------	------	15,748	662,610	1,060,748	1,739,106
1988	------	------	26,144	1,568,702	1,174,013	2,768,859
1989	------	------	3,563	1,075,505	863,453	1,942,520
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	3,128	692	------	552,154	518,025	1,073,999
1994	2,303	12,459	------	565,696	512,602	1,093,060
1995	6,631	9,146	------	872,879	512,893	1,401,549
1996	4,808	969	------	789,970	378,872	1,174,620
1997	9,354	3,091	------	279,326	409,161	700,932
1998	4,165	1,505	------	243,874	448,885	698,429
1999	1,576	1,071	------	281,291	448,850	732,788
2000	6,386	3,255	------	1,059,986	784,980	1,854,607
2001	5,143	1,164	------	556,122	968,704	1,531,134

------ Estimates not available.

1. Data source: MRFSS; data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California CPFVs were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

Table 11.5. Estimated catch (number of fish) by recreational anglers of kelp bass by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	40,911	81,926	------	664,263	541,106	1,328,206
1981	9,671	16,482	------	588,060	313,161	927,374
1982	7,933	4,836	------	628,139	183,731	824,639
1983	11,700	10,950	------	476,843	247,929	747,421
1984	6,523	4,556	------	339,206	286,628	636,912
1985	5,155	2,796	------	542,308	166,575	716,835
1986	------	------	17,026	1,147,160	420,515	1,584,701
1987	------	------	20,924	261,035	548,399	830,359
1988	------	------	25,556	233,062	564,430	823,049
1989	------	------	15,197	389,964	237,517	642,679
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	10,794	5,370	------	556,579	357,651	930,393
1994	5,720	15,462	------	585,301	289,010	895,493
1995	2,989	9,590	------	456,298	218,510	687,388
1996	7,337	1,494	------	324,312	201,994	535,136
1997	2,692	2,573	------	250,744	211,718	467,727
1998	5,688	1,103	------	139,362	184,088	330,241
1999	3,051	614	------	95,722	149,447	248,833
2000	1,214	------	------	363,551	292,346	657,111
2001	1,736	------	------	187,795	301,019	490,550

------ Estimates not available.

1. Data source: MRFSS; data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California CPFVs were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

Table 11.6. Estimated catch (pounds) by recreational anglers of kelp bass by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	29,858	37,179	------	1,332,027	827,341	2,226,404
1981	11,216	14,737	------	849,176	496,125	1,371,255
1982	5,165	5,537	------	774,459	324,131	1,109,292
1983	7,046	10,994	------	628,547	400,025	1,046,612
1984	3,351	5,819	------	461,787	542,508	1,013,464
1985	3,204	3,569	------	605,223	230,601	842,597
1986	------	------	16,326	1,484,317	659,544	2,160,187
1987	------	------	48,303	346,158	856,723	1,251,184
1988	------	------	24,760	281,721	861,350	1,167,831
1989	------	------	11,355	456,606	377,594	845,555
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	15,899	7,076	------	767,946	747,238	1,538,158
1994	6,165	23,377	------	861,114	541,081	1,431,737
1995	3,510	17,021	------	658,132	445,843	1,124,506
1996	8,834	2,294	------	419,536	338,703	769,366
1997	2,590	5,084	------	376,780	350,237	734,690
1998	4,464	1,298	------	185,860	328,307	519,929
1999	2,323	931	------	125,184	247,207	375,646
2000	1,184	------	------	481,854	546,693	1,029,731
2001	1,357	------	------	234,972	452,779	689,109

------ Estimates not available.

1. Data source: the Marine Recreational Fisheries Statistics Survey (MRFSS); data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California CPFVs were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

Table 11.7. Estimated catch (number of fish) by recreational anglers of spotted sand bass by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	5,811	14,701	------	3,104	115,925	139,541
1981	749	6,513	------	------	84,168	91,429
1982	285	1,834	------	------	61,698	63,817
1983	1,507	141	------	987	72,418	75,053
1984	5,998	2,877	------	863	89,771	99,509
1985	791	1,501	------	------	66,615	68,906
1986	------	------	3,697	4,624	161,782	170,103
1987	------	------	2,567	673	137,637	140,877
1988	------	------	20,690	9,436	121,107	151,232
1989	------	------	4,509	926	48,059	53,494
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	1,866	5,323	------	4,636	82,880	94,705
1994	3,771	3,938	------	1,622	68,734	78,064
1995	3,489	2,093	------	10,818	37,526	53,927
1996	2,073	4,790	------	1,153	40,544	48,559
1997	1,019	2,257	------	1,525	45,334	50,134
1998	187	2,446	------	480	14,061	17,174
1999	------	527	------	195	34,867	35,589
2000	2,523	3,758	------	356	71,217	77,854
2001	------	2,232	------	------	48,071	50,303

------ Estimates not available.

1. Data source: the Marine Recreational Fisheries Statistics Survey (MRFSS); data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California CPFVs were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

Table 11.8. Estimated catch (pounds) by recreational anglers of spotted sand bass by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	4,907	15,007	------	7,645	121,522	149,082
1981	572	2,976	------	------	95,454	99,002
1982	126	1,573	------	------	75,195	76,894
1983	812	155	------	1,568	87,272	89,806
1984	3,591	2,827	------	951	98,282	105,651
1985	700	970	------	------	67,286	68,956
1986	------	------	3,295	5,765	177,556	186,616
1987	------	------	2,802	538	145,252	148,592
1988	------	------	21,910	9,016	135,865	166,791
1989	------	------	5,570	1,289	57,168	64,026
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	1,954	5,478	------	8,855	98,841	115,129
1994	4,607	5,012	------	1,301	85,729	96,649
1995	4,442	2,155	------	33,672	64,166	104,435
1996	2,456	5,490	------	1,460	51,702	61,108
1997	1,024	2,498	------	1,617	55,815	60,954
1998	173	3,075	------	616	19,013	22,877
1999	------	453	------	266	43,957	44,677
2000	2,701	4,820	------	449	89,905	97,875
2001	------	3,024	------	------	71,162	74,186

------ Estimates not available.

1. Data source: the Marine Recreational Fisheries Statistics Survey (MRFSS); data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California CPFVs were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

12. OCEAN WHITEFISH

Overview of the Fishery

Ocean whitefish, *Caulolatilus princeps*, belongs to the tilefish family, Malacanthidae, and is the only representative of this family found off California except for rare occurrences of Pacific golden-eyed tilefish, *C. affinis*. It is primarily a southern California species, frequently found in association with members of the rockfish family, Scorpaenidae, and California sheephead. Common names for ocean whitefish include blanquillo and pez blanco.

Ocean whitefish are found in loosely aggregated schools near high-relief seafloor structures such as shallow banks, rocky reefs, and kelp beds. They prefer offshore islands to the mainland coast and are abundant at Santa Rosa, Santa Barbara, Santa Catalina, and San Clemente Islands. Otoliths (earbones) of ocean whitefish found in kitchen middens at San Clemente Island indicate that this fish was an important food source for Native Americans.

Presently, peak landings occur during late winter and spring for both recreational and commercial fisheries. Estimated recreational landings have been significantly higher than commercial landings over the last two decades (Figure 12.1, Figure 12.3, Table 12.1, and Table 12.4). The Marine Recreational Fisheries Statistics Survey (MRFSS) estimates recreational catch from all modes of fishing: shore-based, commercial passenger fishing vessels (CPFVs), and private or rental boats. MRFSS catch estimates for 1980 through 1989 and 1993 through 2001 show average recreational landings of approximately 173,000 lb per year for all modes of fishing combined. In contrast, commercial landings from 1980 through 2001 ranged from a low of about 700 lb in 1985 to a high of nearly 51,000 lb in 1994, but have averaged about 11,000 lb per year.

Recreational landings peaked three times during the last two decades: approximately 297,000 lb in 1986, nearly 304,000 lb in 1995, and slightly over 249,000

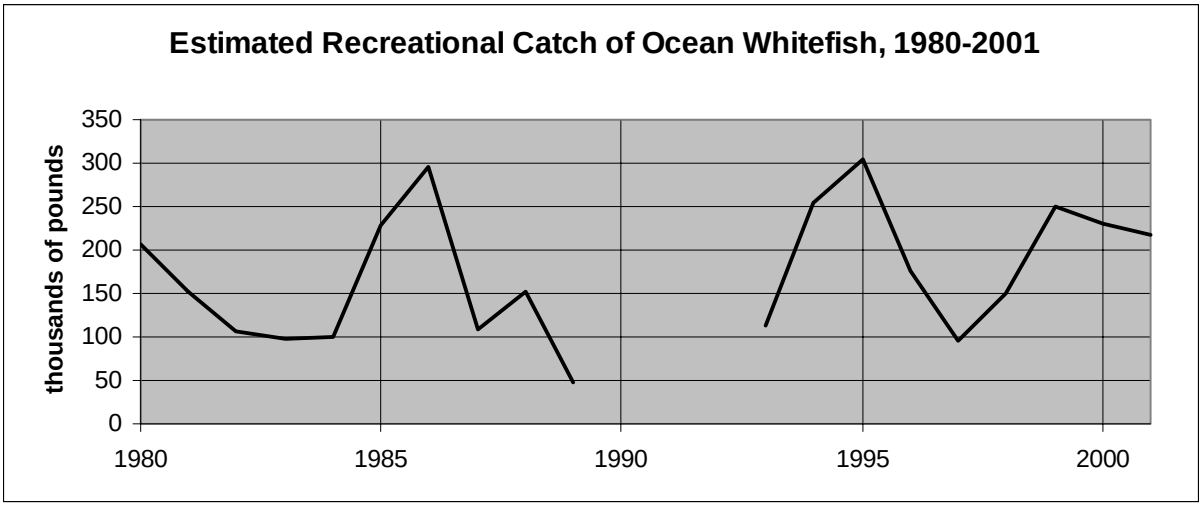

Figure 12.1. Estimated recreational catch (pounds) of ocean whitefish from 1980 to 1989 and 1993 to 2001. Catch estimates do not include fish that were caught and released alive. Data source is the Marine Recreational Fisheries Statistics Survey (MRFSS).

lb in 1999 (Figure 12.1). These peaks follow El Niño events in 1982-1984, 1992, and 1997, and may represent increased reproductive success off California due to warmer El Niño waters.

The recreational fishery uses baited hook-and-line gear, and the daily bag limit is 10 ocean whitefish per day, per angler. Ocean whitefish are relatively easy and enjoyable to catch, usually challenging anglers with an exciting fight.

MRFSS data indicate nearly all ocean whitefish are caught from boats, with CPFVs accounting for 66% of the recreational catch on average (Table 12.1 and Table 12.2). CPFV logbooks show an increase in landings since 1960 with a peak of over 144,000 fish in 2000 (Figure 12.2 and Table 12.3). The majority of ocean whitefish taken on CPFVs are caught at the Channel Islands and offshore banks near San Clemente Island. Most of these fish are between 1.5 to 3.5 years of age and are below the minimum size at maturity for both males and females.

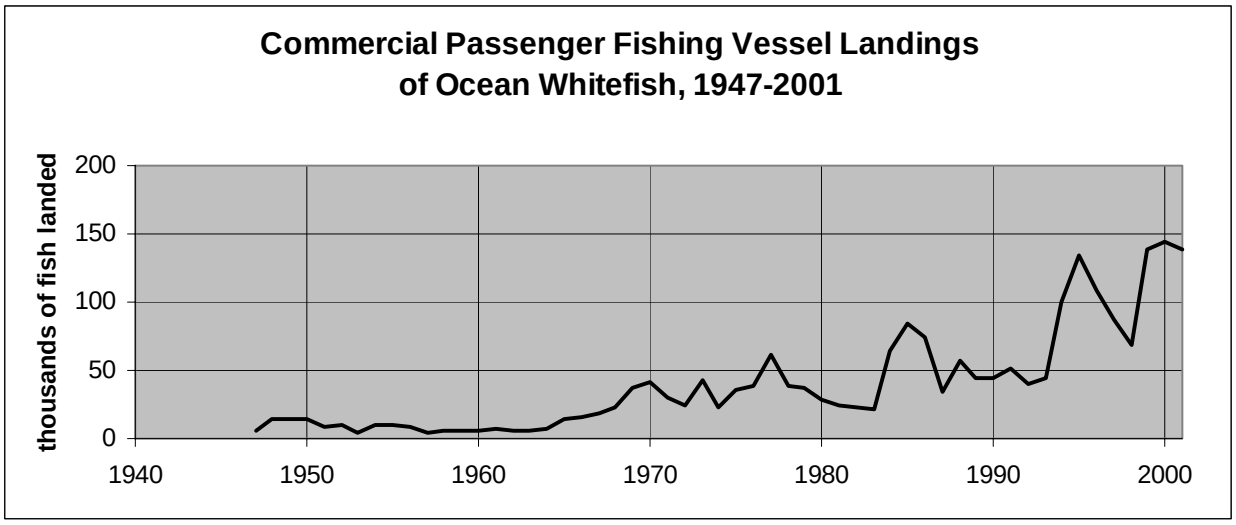

Figure 12.2. Recreational commercial passenger fishing vessel (CPFV) landings (number of fish) as reported on CPFV Logbooks for ocean whitefish from 1947 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1947-1978) and DFG Annual Reports of Statewide Fish Landings by the Commercial Passenger Fishing Vessels (CPFV) Fleet (1979-2001).

The texture and flavor of ocean whitefish is superb. The commercial catch is sold in fresh fish markets and makes excellent sashimi, comparable in flavor and texture to any of the most esteemed white-fleshed fish used for this purpose. In Japan, species of tilefish similar to ocean whitefish command premium prices in the fresh fish market. Off California, however, some ocean whitefish have an unpredictable bitterness which has made it a less profitable and less desirable species for commercial fishermen. The unpleasant taste remains regardless of the method used to clean, freeze, or cook them. The bitterness may be related to the fish's diet since the condition is apparently restricted to fish caught in and around kelp beds or shallow water.

Commercial landings of ocean whitefish peaked in 1926 with just over 368,000 lb landed (Figure 12.3 and Table 12.4). Commercial landings have not approached this level since, which may reflect low consumer demand rather than availability. A slight increase occurred in the 1940s, probably associated with the increased demand for all

fish during World War II. Landings at that time peaked at approximately 101,000 lb, followed by a significant decline. Annual commercial landings from 1950 through 2001 have remained low, averaging about 7,400 lb and only exceeding 50,000 lb once in 1994.

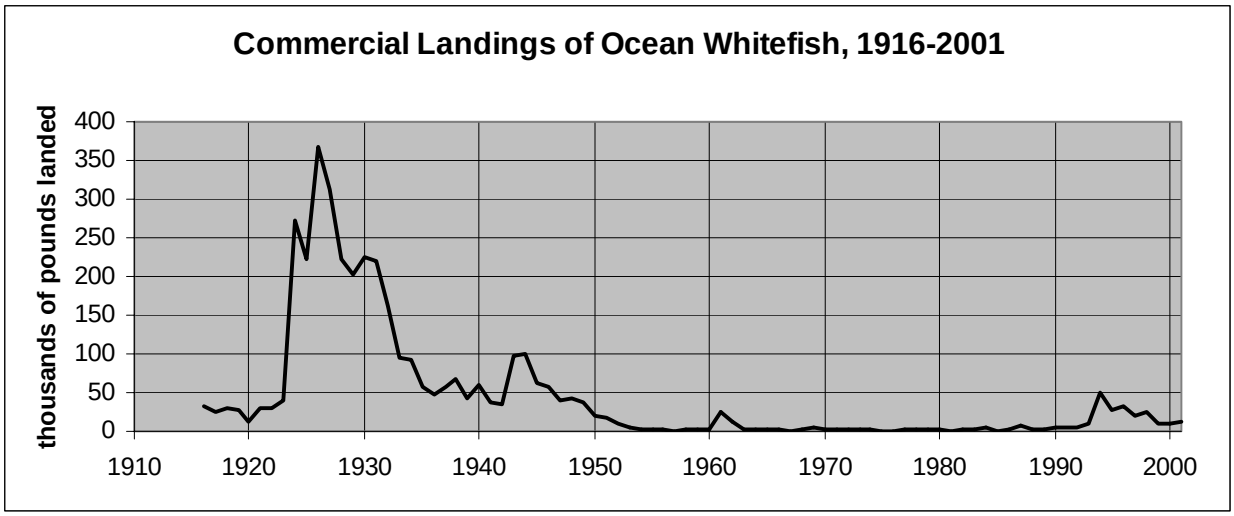

Figure 12.3. Annual commercial landings (pounds) of ocean whitefish from 1916 to 2001. Data sources are the California Department of Fish and Game (DFG) Catch Bulletins (1916-1949, 1951-1974, 1978), Draft Program Environmental Document Ocean Sportfishing Regulations, September 2001 (1950, 1975-1977, 1979-1983) and the DFG commercial landing receipt database (1984-2001).

The primary commercial gear used to take ocean whitefish is hook-and-line gear. Smaller quantities are taken incidentally with set longline, fish traps, and entangling nets (such as set gill nets).

The commercial premium live-fish fishery, which emerged in the late 1980s and early 1990s, has a high incidental catch rate for ocean whitefish in southern California. Although this hook-and-line fishery targets nearshore rockfish species, cabezon, and California sheephead, ocean whitefish are often unintentionally hooked. Increased consumer demand for quality fresh fish products and high market prices for nearshore species has caused increased fishing pressure in the nearshore, and coincidentally, higher landings of ocean whitefish. Live nearshore rockfish, cabezon and California sheephead commanded higher prices than live ocean whitefish, which are considered less desirable.

The first live ocean whitefish landing in the California Department of Fish and Game (DFG) commercial records occurred in 1993. The average price paid for live ocean whitefish from 1993 to 2001 was $1.72 per lb, $0.43 more per lb than the price paid for dead ocean whitefish landed during the same time period. Live landings peaked in 1998 at about 10,300 lb, which represented 43% of the commercial landings for that year. The following year, 71% of the catch was landed live; however, total landings for 1999 were approximately half of those in 1998. In 2000 and 2001, the average price per lb was the same for dead as for live ocean whitefish. The proportion of the catch landed live decreased to 59% in 2000 (5,300 lb) and down to 48% in 2001 (5,900 lb).

Status of Biological Knowledge

Ocean whitefish have elongated bodies covered with small scales, and relatively thick, fleshy lips. Overall coloration is yellowish-brown above and lighter below. The dorsal fin is continuous, beginning above the pectoral fin and ending near the broad, yellow tail. Right after capture, their coloration also includes a central light-blue band running the length of the dorsal and anal fins. The long, pointed, pectoral fins are bluish with a yellow streak near the center. This bright coloration fades as the fish dies.

The geographic range for ocean whitefish is from Vancouver Island, British Columbia, Canada to Peru, including the Galapagos Islands and the Gulf of California. It is most abundant south of Point Conception (Santa Barbara County) and occurrences north of Monterey (Monterey County) are rare.

Ocean whitefish prefer offshore rocky reefs and banks, which are abundant around the Channel Islands. They are found periodically in kelp beds, although they have no apparent relationship with giant kelp. Adults can be found from 4 to15 ft above the bottom anywhere from the shallow subtidal area to 450 ft, but are commonly caught at depths of 90 to 200 ft.

Ocean whitefish have relatively small mouths, and accordingly feed upon small organisms including crabs (such as the pelagic red crab) and other crustaceans, shrimps, euphausiids, small octopuses, squid, and various small fishes, especially anchovy and lanternfish. Pelagic juvenile ocean whitefish have been found in the stomachs of albacore, and adult ocean whitefish are preyed upon by giant sea bass, sharks, and other large fishes.

The maximum life span of ocean whitefish is thought to be about 13 years with a maximum length of 40 in. Maximum weight is thought to be about 12 lb; however, fish exceeding 10 lb are rarely seen. In one study, the oldest of several hundred ocean whitefish sampled was 13 years old, weighing 7.5 lb and measuring 25.5 in. Females are believed to mature slightly earlier than males. A 1980 study examining 485 ocean whitefish found that females seemed mature at 3 to 4 years (16 to 19 in. total length) whereas males appeared mature at 4 to 5 years (19 to 22 in. total length). No significant difference in growth rates has been found between the sexes.

Little is known about spawning and recruitment of ocean whitefish in California waters; however, a number of studies in California and Mexico have indicated that the spawning period is lengthy. A 1994 study examining developmental stages of gonads, conducted in the Bay of La Paz, Mexico, concluded that ocean whitefish spawn annually with a prolonged spawning period from November through March, with females spawning at least twice, possibly three times, during that period. Ocean whitefish eggs presumably drift with ocean currents. Plankton surveys have found that larval distributions of ocean whitefish are centered around Punta Eugenia in central Baja California, Mexico, and surveys have not found larvae off southern California.

Specific details about the northward migration of ocean whitefish remain unknown, particularly with respect to timing, age, and size of individuals. It is also not known if these same individuals return south to spawn again. Ocean current systems seem to play a critical role in the range of distribution and magnitude of ocean whitefish populations off California. One possibility is that northward currents may carry eggs, larvae, and juvenile fish long distances from their origin, perhaps providing an influx of

individuals to colonize cooler, northern waters. The reproductive success of ocean whitefish is likely inhibited in a cold water environment, which could explain observed variations in abundance off California. Indeed, abundance appears to increase following El Niño events.

Status of the Population

The current population level is unknown for ocean whitefish. It is thought that the fish off southern California are derived from the spawning population off central and southern Baja California, Mexico.

Management Considerations

No minimum size limit is required for ocean whitefish and any gear may be used to catch them. A large portion of recreationally caught ocean whitefish is immature. Recently, a size limit was considered as a management option; however, it is unclear whether this type of regulation would contribute to the reproductive success of fish caught in California waters. There is no direct evidence that ocean whitefish can successfully reproduce off California, and undersized fish may not survive once released because of problems readjusting buoyancy.

Much of the ocean whitefish catch comes from the Channel Islands. The new marine protected areas (MPAs) at the Channel Islands may affect the overall take of ocean whitefish. However, it is unknown if these MPAs will have an effect on ocean whitefish populations since ocean whitefish off California are not thought to contribute to the overall reproductive success of the population.

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Revised July 2002

Further Reading

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Table 12.1. Estimated catch (pounds) by recreational anglers of ocean whitefish by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	350	3,799	------	87,353	115,093	206,595
1981	------	------	------	96,616	55,160	151,776
1982	------	------	------	65,044	42,277	107,320
1983	------	------	------	76,187	20,932	97,118
1984	------	------	------	48,252	51,316	99,567
1985	------	------	------	184,853	43,728	228,581
1986	------	------	------	262,236	34,410	296,646
1987	------	------	------	62,099	46,044	108,143
1988	------	------	149	75,887	75,989	152,025
1989	------	------	------	39,405	9,334	48,739
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	------	------	------	90,991	21,260	112,251
1994	------	------	------	150,830	104,122	254,952
1995	------	256	------	233,727	69,682	303,665
1996	111	------	------	127,423	49,425	176,960
1997	------	------	------	62,810	32,731	95,540
1998	742	------	------	91,676	58,168	150,586
1999	------	------	------	205,301	43,904	249,205
2000	------	------	------	140,810	90,377	231,187
2001	------	------	------	97,939	120,087	218,026

------ Estimates not available.

1. Data source: the Marine Recreational Fisheries Statistics Survey (MRFSS); data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California CPFVs were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

Table 12.2. Estimated catch (number of fish) by recreational anglers of ocean whitefish by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	817	1,914	------	37,607	78,329	118,667
1981	------	------	------	35,248	22,158	57,406
1982	------	------	------	62,725	14,377	77,102
1983	161	------	------	36,293	16,115	52,569
1984	------	------	------	65,976	27,843	93,819
1985	------	------	------	243,053	44,514	287,566
1986	------	------	------	231,762	31,561	263,323
1987	------	------	------	85,191	39,636	124,828
1988	------	------	226	89,656	84,158	174,040
1989	------	------	------	34,592	8,413	43,006
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	------	------	------	48,001	19,741	67,742
1994	------	------	------	207,747	84,406	292,153
1995	------	241	------	260,234	74,034	334,510
1996	202	------	------	139,940	37,368	177,510
1997	------	------	------	63,028	27,542	90,570
1998	641	------	------	73,142	43,043	116,826
1999	------	------	------	174,139	38,240	212,379
2000	------	------	------	120,920	73,040	193,960
2001	------	------	------	95,109	104,205	199,315

------ Estimates not available.

1. Data source: the Marine Recreational Fisheries Statistics Survey (MRFSS); data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California CPFVs were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

Table 12.3. Recreational commercial passenger fishing vessel (CPFV) landings (number of fish) as reported on CPFV Logbooks for ocean whitefish, 1947-2001

Year	Number of fish	Year	Number of fish	Year	Number of fish	Year	Number of fish
1947	5,160	**1961**	6,647	**1975**	35,165	**1989**	44,777
1948	14,124	**1962**	6,157	**1976**	38,363	**1990**	44,789
1949	14,576	**1963**	6,231	**1977**	61,058	**1991**	51,605
1950	14,925	**1964**	6,949	**1978**	38,006	**1992**	40,702
1951	8,828	**1965**	13,810	**1979**	36,957	**1993**	44,355
1952	10,003	**1966**	15,587	**1980**	28,810	**1994**	100,599
1953	4,963	**1967**	18,184	**1981**	24,378	**1995**	133,666
1954	9,952	**1968**	22,155	**1982**	22,604	**1996**	108,370
1955	9,508	**1969**	36,474	**1983**	22,095	**1997**	87,655
1956	7,951	**1970**	40,990	**1984**	64,241	**1998**	69,266
1957	4,389	**1971**	29,800	**1985**	84,441	**1999**	139,285
1958	6,143	**1972**	24,632	**1986**	73,919	**2000**	144,060
1959	5,608	**1973**	42,362	**1987**	34,967	**2001**	138,011
1960	5,850	**1974**	23,301	**1988**	56,884		

------ Landings data not available.

1. Data sources: DFG Catch Bulletins (1947-1978) and DFG Annual Reports of Statewide Fish Landings by the Commercial Passenger Fishing Vessels (CPFV) Fleet (1979-2001).
2. Logbooks have been required for southern California, including fish taken in Mexican waters and landed in California, for the entire time period reported here. Logbooks were required for central and northern California from 1957 to present.
3. The data are number of fish reported on logbooks submitted to DFG.

Table 12.4. Commercial landings (pounds) of ocean whitefish, 1916-2001

Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds
1916	32,196	**1933**	95,053	**1950**	20,626	**1967**	1,059	**1984**	5,627
1917	25,976	**1934**	93,191	**1951**	18,198	**1968**	2,647	**1985**	722
1918	31,014	**1935**	57,771	**1952**	8,808	**1969**	4,490	**1986**	2,657
1919	28,016	**1936**	46,603	**1953**	5,839	**1970**	1,778	**1987**	7,036
1920	13,711	**1937**	57,198	**1954**	3,634	**1971**	3,706	**1988**	3,095
1921	29,439	**1938**	68,012	**1955**	2,312	**1972**	2,569	**1989**	3,174
1922	30,270	**1939**	43,688	**1956**	1,820	**1973**	1,584	**1990**	6,067
1923	39,908	**1940**	59,606	**1957**	834	**1974**	2,359	**1991**	5,014
1924	273,077	**1941**	36,970	**1958**	1,902	**1975**	975	**1992**	5,886
1925	222,112	**1942**	35,986	**1959**	1,319	**1976**	1,040	**1993**	10,380
1926	368,064	**1943**	97,434	**1960**	3,518	**1977**	1,651	**1994**	50,746
1927	313,102	**1944**	100,801	**1961**	25,191	**1978**	2,371	**1995**	27,807
1928	222,192	**1945**	61,988	**1962**	12,002	**1979**	2,278	**1996**	31,465
1929	201,725	**1946**	57,271	**1963**	3,254	**1980**	1,620	**1997**	21,232
1930	225,102	**1947**	40,946	**1964**	1,771	**1981**	885	**1998**	23,857
1931	221,200	**1948**	41,840	**1965**	1,982	**1982**	1,391	**1999**	11,168
1932	162,027	**1949**	37,821	**1966**	2,709	**1983**	1,974	**2000**	8,816
								2001	12,346

Data sources are the California Department of Fish and Game (DFG) Catch Bulletins (1916-1949, 1951-1974, 1978), Draft Program Environmental Document Ocean Sportfishing Regulations, September 2001 (1950, 1975-1977, 1979-1983) and the DFG commercial landing receipt database (1984-2001).

13. SURFPERCHES

Overview of the Fishery

The 22 species in the surfperch family, Embiotocidae, are commonly called surfperch, seaperch and perch. They are found predominantly in temperate, northeastern Pacific waters; however, three species are found in the Sea of Japan and one species (tule perch, *Hysterocarpus traski*) occupies freshwater and estuarine habitats in California. Eighteen species occur in California's coastal waters:

- barred surfperch *Amphistichus argenteus*
- black perch *Embiotoca jacksoni*
- calico surfperch *Amphistichus koelzi*
- dwarf perch *Micrometrus minimus*
- kelp perch *Brachyistius frenatus*
- pile perch *Rhacochilus vacca*
- pink seaperch *Zalembius rosaceus*
- rainbow seaperch *Hypsurus caryi*
- redtail surfperch *Amphistichus rhodoterus*
- reef perch *Micrometrus aurora*
- rubberlip seaperch *Rhacochilus toxotes*
- sharpnose seaperch *Phanerodon atripes*
- shiner perch *Cymatogaster aggregate*
- silver surfperch *Hyperprosopon ellipticum*
- spotfin surfperch *Hyperprosopon anale*
- striped seaperch *Embiotoca lateralis*
- walleye surfperch *Hyperprosopon argenteum*
- white seaperch *Phanerodon furcataus*

The island surfperch, *Cymatogaster gracilis,* was once thought to be a separate species, however it is now considered synonymous with shiner perch.

There are both recreational and commercial fisheries for surfperches in California. Surfperches are easy to catch and highly sought. They are caught using hook-and-line gear and a variety of baits such as clams, tubeworms, or sand crabs, as well as artificial lures. The recreational fishery is enjoyed by anglers of all ages who fish for surfperches from boats, piers, jetties, and sandy beaches. Flyfishing for surfperches has become popular in recent years. Commercially-caught surfperches are sold as food and as fishing bait. Commercial fishermen receive from $0.25 to $5.00 per pound for surfperches.

Currently, the recreational take of surfperches is far larger than the commercial take (Figure 13.1, Figure 13.2, Table 13.4 and Table 13.5). Recreational catch estimates and commercial landings from 1980 through 1989 and from 1993 through 2001 indicate that the recreational catch averages about 739,000 lb per year, while the commercial landings average about 127,000 lb per year, which is approximately 17% of the recreational catch.

Commercial Surfperch Fishery

Commercial landings data are available from 1916 to 2001; however, from 1916 through 1927, DFG reported as "perch" the combined landings of all surfperches and other perch-like species such as blacksmith, halfmoon, opaleye, and sargo. After 1927, DFG reported separately the landings of surfperches, blacksmith, halfmoon, opaleye, and sargo, but the surfperch landings reported by fish dealers on landing receipts may have included other perch-like species. In addition, individual landing receipts frequently do not specify the type of surfperch landed. For example, during the 1990s approximately 33% of the commercial landing receipts did not indicate which species of surfperch had been landed.

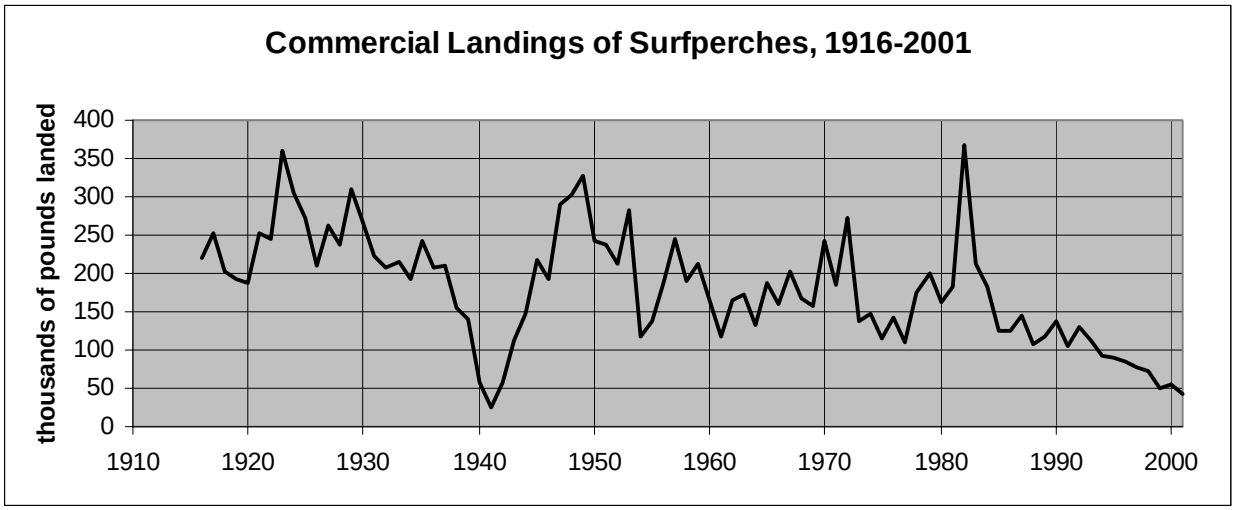

Figure 13.1. Annual commercial landings (pounds) of surfperches from 1916 to 2001. Data sources are the California Department of Fish and Game (DFG) Catch Bulletins (1916-1983) and the DFG commercial landing receipt database (1984-2001). Landings of surfperches, blacksmith, halfmoon, opaleye, and sargo were combined and reported as "perch" from 1916 to 1927. After 1927, surfperches, blacksmith, halfmoon, opaleye, and sargo were reported separately, but the reported surfperch landings may include some of the other perch-like species.

Annual commercial landings of surfperches have varied over time (Figure 13.1 and Table 13.4). Large drops in the landings occurred during two periods: from 1938 to 1941, and from 1983 to 2001. The drop in landings from 1938 to 1941 was due to decreased effort (because of the low prices offered to fishermen for surfperches) rather than a lack of fish, whereas the drop in landings from 1983 to 2001 appears to be due to declines in surfperch populations.

In addition to fluctuations in total surfperch landings, the composition and location of landings have changed as well. In the 1930s, an estimated 69% of the commercial surfperch landings came from waters north of Point Arguello (Santa Barbara County), and the catch was dominated by rubberlip seaperch, striped seaperch, walleye surfperch and white seaperch. In the 1990s, however, these species each comprised less than 1% of the identified species in commercial landings. Barred and redtail surfperches dominated the commercial landings in the 1990s, with 93% of landings coming from north of Point Arguello. The differences in fishing location and catch composition from the 1930s to the 1990s may be attributed to a variety of factors, such

as changes in the locations fished, in regulations, in the abundance of various species, and in the gear used to catch surfperches.

In the 1930s, fishing gear used to catch surfperches differed by area. Beach seines were used in bays and estuaries in northern California, lampara nets and drift gill nets[1] in Monterey Bay, and lampara nets and purse seines in southern California. In the 1990s, hook-and-line gear was the primary gear used to catch surfperch. The dominant species in the 1930s (rubberlip seaperch, striped seaperch, walleye surfperch and white seaperch) frequently occur in estuaries, while the dominant species in the 1990s (barred and redtail surfperch) are common along sandy beaches. The degradation and loss of estuarine habitats in California may have been a factor in the declines of surfperch populations, especially for those species that use estuaries.

In the 1990s, only about 67% of the commercial landing receipts indicated the species of surfperches landed. Redtail surfperch accounted for 54% of these landings, while barred surfperch accounted for 40%. Both redtail and barred surfperches are primarily caught from beaches with hook-and-line gear during the birthing season (spring to early fall for redtail surfperch, and spring to summer for barred surfperch). The commercial fishery for redtail surfperch is centered in the Crescent City/Eureka area, while the commercial fishery for barred surfperch is centered in the Morro Bay area.

Commercial restrictions include a closed season from May 1 through July 15 for all surfperches except shiner perch (which may be taken at any time). The closed season was first implemented in 1913, and was changed in 1963 to allow the take of shiner perch during the closed season. In 1953, the commercial take of surfperch was prohibited south of Point Arguello; however, the law was modified in 1959 to prohibit the commercial take of only three particular species south of Point Arguello: barred, calico, and redtail surfperches (however, redtail surfperch are not know to occur south of Point Arguello).

Recreational Surfperch Fishery

Catch estimates for the recreational fishery are available from 1980 to 1989 and from 1993 to 2001 through the Marine Recreational Fisheries Statistics Survey (MRFSS)[2]. During the last two decades, the size of the total recreational catch has fluctuated, but has generally declined (Figure 13.2, Table 13.5 and Table 13.6). The average annual catch from 1993 through 2001 is 40% smaller than the average annual catch from 1981 through 1989. The average annual catch and the catch-per-unit-of-effort for most surfperch species also declined from 1981 through 1989 and from 1993 through 2001 (Table 13.1).

The MRFSS estimates indicate that in the last two decades about 90% of surfperches were caught from shore, 9% from private or rental boats, and less than 1%

1 Surfperch were frightened into drift gill nets by setting the net close to shore and splashing the water between the shore and the net, or by setting in a circle around the fish and throwing a brick or stone into the center of the circle.

2 The catch estimates for 1980 are not used here to compare the catches from different time periods because the effort data used to calculate those estimates is of poor quality.

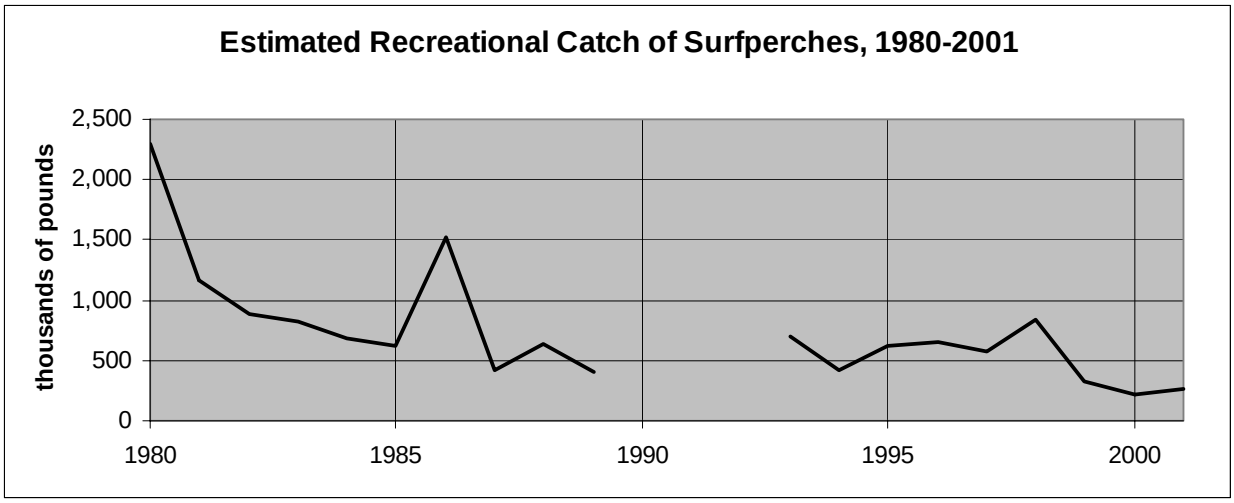

Figure 13.2. Estimated recreational catch (pounds) of surfperches from 1980 to 1989 and 1993 to 2001. Catch estimates do not include fish that were caught and released alive. Data source is the Marine Recreational Fisheries Statistics Survey (MRFSS).

from commercial passenger fishing vessels. Barred surfperch, black perch, redtail surfperch, shiner perch, silver surfperch, striped seaperch, and walleye surfperch are the most commonly caught species statewide. Barred surfperch comprise about one-half of the surfperch catch in southern California and one-third of the surfperch catch statewide.

During the last two decades, approximately 59% of the recreational surfperch catch has come from central and northern California, and 41% of the catch has come from southern California. The geographic distribution of the catch varies by species and by location (Table 13.1). Approximately 76% of the recreational surfperch catch comes from ocean waters and 24% from bays and estuaries

Until 2002, there was no recreational daily limit or possession limit on shiner perch, and the daily and possession limit for all other species of surfperch was 20, with not more than 10 of any one species. In an effort to reduce the recreational harvest of surfperches and stabilize population levels, the daily and possession limits were reduced in 2002 to an aggregate total of five surfperches for all species except shiner perch (limit of twenty). In addition, a minimum size limit was established for redtail surfperch of 10.5 inches, and a closed season (April 1 to July 31) was established in San Francisco Bay for all surfperch species except shiner perch.

Status of Biological Knowledge

Surfperches can be identified by their elliptical, compressed body form, single dorsal fin, large eyes, small mouth, and moderately- to deeply-forked tail fin. Some are silvery and many are marked with bars or stripes. Their most notable trait, however, is their mode of reproduction.

Surfperches bear live, highly developed young that swim at birth. Newborns are relatively large, ranging from about 1 to 2.5 in. depending upon the species. The number of young in a brood is relatively low, ranging from around a dozen to a little more than 100 (Table 13.2). For all species, brood size tends to increase with the size of the female. The age at sexual maturity varies by species and by sex. Males of a few

Table 13.1. Summary of recreational catches of marine surfperches from 1981 through 1989 and from 1993 through 2001 based on Marine Recreational Fisheries Statistics Survey data

Species	Geographic distribution of catch		Location of catch		Average annual catch		Trends in the catch: change between the periods 1981-1989 and 1993-2001		Primary fishing modes
	North/ Central	South	Ocean	Bays and estuaries	Number of fish	Weight (lb)	Average number of fish per year	Average catch per 1000 angler hours	
barred surfperch	40%	60%	98%	2%	374,000	255,000	13% decrease	45% increase	beach and bank (86%)
Black perch	38%	62%	57%	43%	68,000	43,000	21% decrease	44% increase	all shore modes (58%); private or rental boats (41%)
calico surfperch	66%	34%	96%	4%	28,000	15,000	67% decrease	50% decrease	beach and bank (89%)
dwarf perch	Rarely landed because of its small size								
kelp perch	Rarely landed because of its small size								
pile perch	70%	30%	47%	53%	45,000	57,000	80% decrease	73% decrease	all shore modes (71%); private or rental boats (29%)
pink seaperch	Rarely landed								
rainbow seaperch	85%	15%	50%	50%	12,000	6,000	23% decrease	78% increase	all shore modes (86%); private or rental boats (14%)
redtail surfperch	99%	1%	84%	16%	67,000	54,000	78% decrease	84% decrease	beach and bank (91%)
reef perch	Rarely landed because of its small size								
rubberlip seaperch	53%	47%	56%	44%	32,000	38,000	56% decrease	18% decrease	all shore modes (53%); private or rental boats (46%)
sharpnose seaperch	33%	67%	82%	18%	2,000	1,000	19% increase	29% decrease	man-made structures (25%); CPFV (57%)

Table 13.1. Summary of recreational catches of marine surfperches from 1981 through 1989 and from 1993 through 2001 based on Marine Recreational Fisheries Statistics Survey data

Species	Geographic distribution of catch		Location of catch		Average annual catch		Trends in the catch: change between the periods 1981-1989 and 1993-2001		Primary fishing modes
	North/ Central	South	Ocean	Bays and estuaries	Number of fish	Weight (lb)	Average number of fish per year	Average catch per 1000 angler hours	
shiner perch	74%	26%	54%	46%	109,000	10,000	42% decrease	25% decrease	man-made structures (84%);
silver surfperch	67%	33%	84%	16%	76,000	20,000	55% decrease	28% decrease	beach and bank (72%); man-made structures (26%)
spotfin surfperch	Rarely landed because of its small size								
striped seaperch	97%	3%	68%	32%	82,000	76,000	44% decrease	40% decrease	all shore modes (87%); private or rental boats (13%)
walleye surfperch	49%	51%	77%	23%	171,000	46,000	47% decrease	33% decrease	man-made structures (69%); beach and bank (25%)
white seaperch	71%	29%	44%	56%	45,000	18,000	67% decrease	62% decrease	all shore modes (82%); private or rental boats (17%)

1. No estimates are available from 1990 through 1992 or for January and February of 1995.
2. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
3. North/Central is the area north of Point Conception; South is the area south of Point Conception.

species are reproductively mature at birth, while, for example, female redtail surfperch do not reach maturity until they are 3 to 4 years old. Many surfperch species mate in the fall or winter (Table 13.2), and a number of species exhibit complicated courting behaviors. Fertilization is internal and the females of most species store sperm for several months after mating. Gestation lasts from 3 to 6 months. The birthing period varies by species and location, but most surfperches give birth in the spring and summer (Table 13.2).

Table 13.2. Summary of reproductive information for marine surfperch species in California			
Species	**Brood size (range)[1]**	**Mating Seasons**	**Release of young**
barred surfperch	4 to 113	fall and winter	spring and summer
black perch	5 to 31	most mating is in summer and fall, but have been reported mating year-round	most births are in the spring and summer, but young are reported year-round
calico surfperch	NA	NA	NA
dwarf perch	2 to 25	summer	spring and summer
kelp perch	insufficient data	fall and winter	spring and summer
pile perch	7 to 80	fall	spring and summer
pink seaperch	2 to 6	March to June	winter
rainbow seaperch	9 to 22	fall	summer and fall
redtail surfperch	1 to 45	winter	spring to early fall
reef perch	NA	summer	spring and summer
rubberlip seaperch	insufficient data	NA	spring, summer and fall - based on fish with embryos
sharpnose seaperch	Insufficient data (one specimen examined with 7 young)	NA	summer
shiner perch	2 to 36	spring and summer	spring and summer (about one year after mating)
silver surfperch	3 to 17	fall to early winter	spring and summer
spotfin surfperch	4 to 20	NA	summer - based on the number of small juveniles in coastal waters
striped seaperch	9 to 92	fall	summer
walleye surfperch	1 to 19	fall to early winter	spring and summer
white seaperch	8 to 33	NA	spring and summer

1. Minimum brood size is not well-known for most species.
2. NA = not available.

The maximum size and life span for surfperches varies by species. The maximum size ranges from 6.25 in. to 19.6 in. (Table 13.3), and the maximum life span ranges from 2 to 10 years.

Collectively, California's surfperch species range from southeastern Alaska to central Baja California, Mexico (Table 13.3). The center of most species' ranges is central California. The redtail surfperch is the only marine surfperch species in California whose range does not extend into Baja California. Seven of California's marine surfperch species are found only south of the California-Oregon border, while eleven have ranges that extend north of the border.

Surfperch species are found in a variety of habitats, including beaches, rocky substrate, and kelp beds. A few species, including the pile perch, rubberlip seaperch, shiner perch, walleye surfperch, and white seaperch, inhabit more than one habitat type. The majority of surfperches, however, occupy only one type of habitat. Species

most commonly found along beaches include the barred surfperch, calico surfperch, redtail surfperch, silver surfperch, and the spotfin surfperch. Black perch, dwarf perch, kelp perch, rainbow seaperch, reef perch, sharpnose seaperch, and striped seaperch tend to be associated with rocky substrate and kelp beds. The pink seaperch inhabits deep water. Many species move to different areas for mating and birthing; for example, female surfperches may move into shallow coastal waters, or bays and estuaries, to give birth.

The diets of surfperches are quite varied (Table 13.3), but most eat small crustaceans such as isopods (also known as rock lice), amphipods (also known as skeleton shrimp), small crabs (such as sand crabs), and copepods. Many eat mollusks and polychaete worms. Surfperches are usually bottom feeders, but may also feed mid-water when competitors are absent. Black perch, kelp perch, pile perch, rainbow seaperch, sharpnose seaperch, and white seaperch can act as "cleaners", removing external parasites from other fish.

Surfperches are prey for larger fish such as kelp bass, barred sand bass, California halibut, striped bass, sturgeon, rockfishes and salmon. They are also eaten by harbor seals and birds (including the great blue heron, least tern, Caspian tern, Forster's tern, cormorants, and various gulls).

Much information is lacking on this group. Life history and habitat requirements are areas in need of more research.

Table 13.3. Summary of biological information for marine surfperch species in California

Species	Range	Depth	Main habitat	Maximum size	Foods
barred surfperch	Bodega Bay (Sonoma County) to central Baja California, Mexico	surface to 240 ft	sandy beaches	17 in	sand crabs and other crustaceans, bivalves, echinoderms, and fish eggs
black perch	Fort Bragg (Mendocino County) to central Baja California, Mexico including Guadalupe Island	intertidal to 150 ft	rocky areas near kelp; kelp beds; occasionally around piers and pilings and in coastal bays	15.35 in	polychaete worms, bryozoans, mollusks, and small crustaceans
calico surfperch	northern Washington to northern Baja California, Mexico	surface to 30 ft	sandy beaches	12 in	small crustaceans
dwarf perch	Bodega Bay (Sonoma County) to central Baja California, Mexico	tidepools to 30 ft	shallow eelgrass and surfgrass beds, shallow rocky inshore areas such as reefs and jetties	6.25 in	small crustaceans, mollusks, polychaete worms and algae

Table 13.3. Summary of biological information for marine surfperch species in California					
Species	**Range**	**Depth**	**Main habitat**	**Maximum size**	**Foods**
kelp perch	southeastern Alaska to central Baja California, Mexico including Guadalupe Island	surface to 100 ft	kelp beds in coastal waters	8.5 in	small crustaceans
pile perch	Vancouver Island, British Columbia, Canada (*unconfirmed record - southeastern Alaska*) to central Baja California, Mexico including Guadalupe Island	surface to 240 ft	several habitats in coastal waters, bays and estuaries: piers and other underwater structures, rocky shores, and kelp beds	17.5 in	hard-shelled mollusks, crabs, barnacles, and other crustaceans
pink seaperch	Cape Vizcaino (Mendocino County) to central Baja California, Mexico, with an isolated population in the Gulf of California	30 to 750 ft	over soft bottoms; usually found in deeper water than other surfperches (upper to mid-shelf)	8 in	small crustaceans, snails, polychaete worms, and brittlestars
rainbow seaperch	Cape Mendocino (Humboldt County) to central Baja California, Mexico	surface to 130 ft	usually over rocky substrate, often at the edge of kelp beds and in kelp beds	12 in	small crustaceans, snails, and polychaete worms
redtail surfperch	Vancouver Island, British Columbia, Canada to Avila Beach (San Luis Obispo County)	surface to 60 ft	sandy beaches on the open coast; sometimes rocky shores and jetties, and estuaries and bays	16 in	worms, fishes, crabs and other small crustaceans
reef perch	Tomales Bay (Marin County) to northern Baja California, Mexico	intertidal to 20 ft	shallow rocky areas including tidepools	7.1 in	algae and small invertebrates
rubberlip seaperch	Russian Gulch State Beach (Mendocino County) to central Baja California, Mexico, including Guadalupe Island	surface to 150 ft	several habitats including rocky areas, kelp beds, near piers and jetties	19.6 in	small crustaceans, mollusks, and polychaete worms
sharpnose seaperch	central Oregon to central Baja California, Mexico	surface to 750 ft	kelp beds and inshore and offshore reefs; and around piers when spawning	11.5 in	small crustaceans, bryozoans, and kelp

Table 13.3. Summary of biological information for marine surfperch species in California					
Species	**Range**	**Depth**	**Main habitat**	**Maximum size**	**Foods**
shiner perch	southeastern Alaska to northern Baja California, Mexico	surface to 480 ft	common in bays and estuaries and in protected areas along the open coast; inhabits several habitats including eelgrass beds and piers	7 in	small crustaceans, algae, polychaete worms, snails and mussels
silver surfperch	Vancouver Island, British Columbia, Canada to northern Baja California, Mexico	surface to 360 ft	in the surf zone of sandy beaches, over sandy areas, and around rocks and piers	10.5 in	small crustaceans and algae
spotfin surfperch	central Oregon to central Baja California, Mexico	surface to 300 ft	in the surf zone of sandy beaches and over sand	7.8 in	young squid, polychaete worms, small crustaceans, algae and fish eggs
striped seaperch	southeastern Alaska to central Baja California, Mexico	surface to 95 ft	mostly coastal kelp beds and rocky areas, but also in bays and estuaries	15.3 in	small crustaceans, algae, polychaete worms, fish eggs, bryozoans, mussels and snails
walleye surfperch	Vancouver Island, British Columbia, Canada to central Baja California, Mexico including Guadalupe Island	surface to 60 ft	several habitats including sandy beaches, piers, jetties and kelp beds	12 in	small crustaceans, polychaete worms, and snails
white seaperch	Vancouver Island, British Columbia, Canada to central Baja California, Mexico	surface to 140 ft	several habitats including near piers and jetties, in deeper waters of bays and estuaries, and offshore near rocks	12.4 in	small crustaceans and polychaete worms

Status of the Populations

No estimates exist for the size of surfperch populations in California coastal waters. However, both fishery-dependent (catch, landings, and effort) and fishery-independent data suggest that populations of surfperches may be declining in California.

- The total commercial landings of surfperches show a long-term decline: annual commercial landing averaged 173,000 pounds during the 1970s and 1980s, but only 95,000 pounds during the 1990s. This represents a 45% decline in landings.
- The total commercial landings of surfperches declined precipitously from 1983 through 2001 (Table 13.4). Landings for 2001 are only 12% of the 1982 landings.
- Estimates of the recreational catch in central and northern California show a long-term decline: the annual average surfperch catch was 1,254,000 fish per year from 1958 through 1961, 831,000 fish per year from 1981 through 1989, and 524,000 fish per year from 1993 through 2001.
- The recreational catch of most species decreased, both in terms of average annual catch and catch-per-unit-of-effort, between the periods of 1981-1989 and 1993-2001 (Table 13.1).
- Since the mid-1980s, the abundance of surfperch species commonly caught in DFG trawl surveys in San Francisco has declined.

Fishery-dependent measures, such as catch, are not definitive measures of population abundance. The declines in recreational catch and commercial landings may be due to factors such as reduced fishing effort rather than a decline in the size of surfperch populations. However, catch-per-unit-of-effort can be indicative of declining populations (if catch rates are proportional to abundance). The catch-per-unit-of-effort (measured as average catch per 1000 angler hours) declined for most species in the recreational fishery.

Various life-history traits of surfperches make them susceptible to overfishing and vulnerable to habitat loss and degradation in estuaries and marine nearshore areas. Surfperches produce few young and are relatively short-lived, which makes it difficult for populations to rebound. Some species aggregate to mate and many species use bays and estuaries as birthing areas and nurseries.

Management Considerations

Surfperches are important commercial and recreational fishes. Most of the California coastal species are taken in the recreational fishery and the majority of the catch is taken when spawning aggregations are present. Female surfperches are intentionally targeted by recreational anglers because they are larger than males. Recreational anglers also grade their catch (discard smaller fish when larger ones are caught), which probably results in an even greater take of mature females with a resulting decline in the fishery. Recent research has indicated that some of the decline in surfperch populations is associated with increases in water temperature. The redtail and barred surfperches are the most notable in the commercial catch and may be important to local economies.

Human use of surfperch habitats will continue to negatively impact these populations, and cause conflict regarding the appropriate use of nearshore areas. As shoreline development increases, areas inhabited by surfperches may become polluted or destroyed. Although surfperches may adapt to structures such as jetties and piers, it

seems clear that they cannot be expected to successfully adapt to all the human-induced changes to which they are exposed.

In 2002, the regulations governing the recreational fishery were changed in an effort to reduce the recreational harvest to a sustainable level. In addition, the State Legislature gave the Fish and Game Commission authority to adopt regulations to manage the commercial surfperch fishery beginning in 2003.

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Further Reading

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Table 13.4. Commercial landings (pounds) of surfperches from 1916-2001

Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds	Year	Pounds
1916	221,186	**1933**	214,511	**1950**	242,354	**1967**	202,513	**1984**	182,082
1917	252,503	**1934**	192,596	**1951**	237,331	**1968**	168,040	**1985**	124,080
1918	203,420	**1935**	241,525	**1952**	213,357	**1969**	156,528	**1986**	124,858
1919	192,481	**1936**	207,280	**1953**	281,998	**1970**	241,409	**1987**	145,566
1920	186,381	**1937**	210,309	**1954**	118,499	**1971**	184,938	**1988**	107,071
1921	253,199	**1938**	155,815	**1955**	136,554	**1972**	272,913	**1989**	118,201
1922	243,776	**1939**	139,394	**1956**	187,681	**1973**	138,000	**1990**	137,648
1923	359,682	**1940**	57,977	**1957**	245,699	**1974**	148,086	**1991**	104,746
1924	305,726	**1941**	25,832	**1958**	189,679	**1975**	113,757	**1992**	129,662
1925	272,351	**1942**	58,018	**1959**	212,853	**1976**	142,037	**1993**	111,261
1926	208,910	**1943**	113,018	**1960**	164,273	**1977**	110,233	**1994**	93,672
1927	262,893	**1944**	146,546	**1961**	118,245	**1978**	174,064	**1995**	89,643
1928	236,974	**1945**	217,486	**1962**	165,115	**1979**	201,160	**1996**	85,279
1929	311,194	**1946**	192,430	**1963**	172,884	**1980**	162,952	**1997**	76,512
1930	267,972	**1947**	289,182	**1964**	133,115	**1981**	182,675	**1998**	73,731
1931	223,092	**1948**	302,087	**1965**	187,736	**1982**	367,704	**1999**	49,396
1932	207,222	**1949**	326,336	**1966**	160,381	**1983**	211,556	**2000**	56,235
								2001	43,225

1. Data sources: California Department of Fish and Game (DFG) Catch Bulletins (1916-1983) and DFG commercial landing receipt database (1984-2001).
2. Landings are the sum of all species of surfperch landed.

Table 13.5. Estimated recreational catch (pounds) of surfperches by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	1,124,270	958,401	------	8,913	200,246	2,291,830
1981	220,218	761,655	------	2,780	187,469	1,172,122
1982	152,845	636,565	------	585	91,705	881,700
1983	203,866	550,553	------	4,041	67,365	825,825
1984	172,904	393,711	------	1,281	114,282	682,177
1985	125,020	416,801	------	842	76,763	619,425
1986	------	------	1,268,683	2,083	244,721	1,515,486
1987	------	------	342,530	3,223	68,752	414,505
1988	------	------	558,522	625	73,233	632,380
1989	------	------	355,749	794	43,241	399,785
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	91,495	536,936	------	2,049	73,198	703,678
1994	61,193	302,025	------	815	56,501	420,534
1995	94,596	436,534	------	1,732	86,308	619,169
1996	124,499	429,036	------	1,838	96,446	651,818
1997	150,625	384,218	------	1,789	33,062	569,694
1998	104,979	695,122	------	777	44,268	845,144
1999	96,372	186,497	------	2,115	36,984	321,969
2000	40,203	151,907	------	585	30,868	223,563
2001	82,634	119,959	------	2,121	54,412	259,126

------ Estimates not available.

1. Data source: MRFSS; data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California commercial passenger fishing vessels were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

Table 13.6. Estimated recreational catch (number of fish) of surfperches by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	1,618,704	1,498,566	------	7,378	274,835	3,399,483
1981	619,572	1,358,110	------	2,825	286,755	2,267,262
1982	565,759	1,141,467	------	9,314	214,000	1,930,540
1983	588,267	903,514	------	5,823	126,884	1,624,488
1984	475,961	677,281	------	1,463	138,185	1,292,890
1985	390,128	838,492	------	2,425	87,417	1,318,463
1986	------	------	1,662,897	4,192	228,975	1,896,064
1987	------	------	848,870	4,206	108,276	961,353
1988	------	------	1,286,099	1,939	144,926	1,432,964
1989	------	------	803,015	1,784	139,980	944,779
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	364,576	784,474	------	5,474	95,348	1,249,872
1994	209,213	488,242	------	1,235	50,859	749,549
1995	323,988	703,923	------	1,846	131,173	1,160,929
1996	389,290	565,150	------	2,749	105,058	1,062,247
1997	361,776	554,633	------	2,557	36,569	955,534
1998	258,331	824,470	------	1,442	54,461	1,138,705
1999	205,260	259,718	------	4,019	37,244	506,242
2000	134,023	230,819	------	1,367	42,697	408,906
2001	404,646	197,774	------	3,798	66,444	672,662

------ Estimates not available.

1. Data source: the MRFSS; data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California commercial passenger fishing vessels were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

14. CALIFORNIA HALIBUT

Overview of the Fishery

Commercial Halibut Fishery

California halibut, *Paralichthys californicus*, is an important flatfish species in both the commercial and recreational fisheries of central and southern California. The highest recorded commercial landing of halibut was 4.7 million lb in 1919, which was followed by a decline to 950,000 lb in 1932 (Figure 14.1 and Table 14.1). Since 1932, an average of 913,000 lb has been landed annually with five notable peaks in landings: 1936 (1.6 million lb), 1946 (2.5 million lb), 1964 (1.3 million lb), 1981 (1.3 million lb), and 1997 (1.3 million lb).

The decline in commercial California halibut landings after 1919 is attributed to increased fishing pressure during World War I and to subsequent overfishing. Fishing restraints during World War II may have allowed halibut stocks to increase, resulting in peak landings in the late 1940s, followed by low catches in the 1950s. Warm waters during El Niño years in the late 1950s were followed by increased landings through the mid-1960s. Thereafter, annual landings decreased again to a historical low of 257,000 lb in 1970; after 1970 landings gradually increased. Since 1980, landings have averaged a little more than 1 million lb annually.

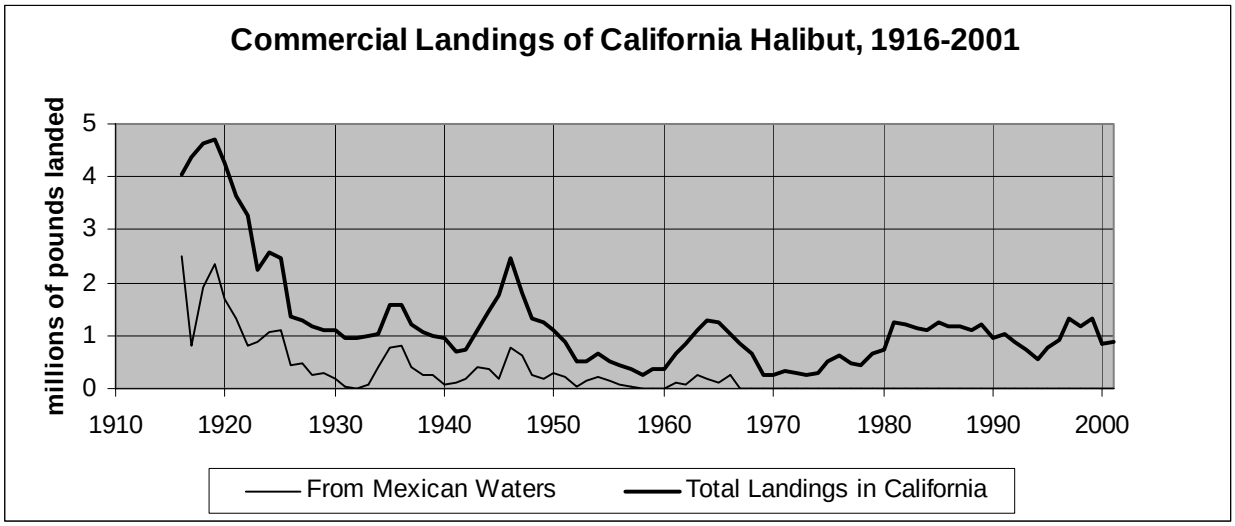

Figure 14.1. Annual commercial landings (pounds) of California halibut from 1916 to 2001. Data sources are the California Department of Fish and Game (DFG) Catch Bulletins (1916-1983) and the DFG commercial landing receipt database (1984-2001).

Although California halibut range from the Quillayute River, Washington to Almejas Bay, Baja California, Mexico, the commercial fishery is mostly concentrated from Bodega Bay in northern California to San Diego in southern California. The contribution of halibut from Mexican waters to California landings has varied but has generally been insignificant since 1967 (Figure 14.1 and Table 14.1). Historically, the fishery has been centered off southern California and Baja California, Mexico, but over the past twenty years, the greatest landings have oscillated between ports in southern

and central California. A majority of the halibut landings made in central California occurred in the San Francisco area. A limited amount of fishing occurs around the Channel Islands of southern California, which yields substantially larger halibut (average length 27 in.) than those caught in the nearshore mainland fishery (average length 24 in.).

Historically, California halibut have been commercially harvested by three principal gears: otter trawl, entangling nets (set gill net and set trammel net), and hook-and-line. The halibut trawl fishery evolved late in the nineteenth century in the San Francisco Bay area. Since then, the boats used to tow this gear across the ocean bottom have gone from sail-powered to steam-powered, to gasoline-powered, and finally to diesel-powered engines. Today, trawling for California halibut is permitted in federal waters (3 to 200 nautical miles (nm) offshore) using trawl nets with a minimum mesh size of 4.5 in. Trawling is prohibited within State waters (0 to 3 nm offshore), except in the designated "California halibut trawl grounds," which encompass the area between Point Arguello (Santa Barbara County) and Point Mugu (Ventura County) in waters beyond 1 nm from shore. Bottom trawls used in this area must have a minimum mesh size of 7.5 in., and trawling is closed from March 15 to June 15 to protect spawning adults.

A decade after the introduction of the trawl fishery to San Francisco Bay, set gill nets and trammel nets were used to fish for halibut coast-wide. Currently, the mesh size must be at least 8.5 in. to harvest California halibut. In southern California, gill and trammel nets are prohibited in State waters from Point Arguello to the U.S.-Mexico border, and in waters less than 70 fathoms (fm) or within 1 nm, whichever is less, around the Channel Islands.

North of Point Arguello, set gill nets and set trammel nets have been subject to many different area, depth, and seasonal closures over time. Beginning in September 2000, a series of closures were enacted to protect marine birds and mammals. Two emergency closures prohibited the use of gill and trammel nets in waters less than 60 fm between Point Reyes (Marin County) and Yankee Point (Monterey County), and between Point Sal (Santa Barbara County) and Point Arguello, then a third emergency closure prohibited use of the gear in waters less than 60 fm between Point Reyes and Point Arguello. Finally, in September 2002, the area covered by the third emergency closure was permanently closed.

Historically, commercial catches of California halibut by hook-and-line gear have been insignificant when compared to the total pounds landed annually by trawl and set net fisheries. However, over the last decade, hook-and-line catches of halibut have ranged from 11% to 23% of annual commercial landings, with the majority of those landings made in the San Francisco area.

Commercial fishing laws prohibit the sale of California halibut less than 22 in. long, unless the weight is at least 4 lb whole, 3.5 lb dressed with the head on, or 3 lb dressed with the head off. Four halibut less than the legal minimum size may be retained for personal use if taken incidentally with a gill, trammel or trawl net.

Recreational Halibut Fishery

California halibut are highly prized by recreational anglers and are primarily caught using hook-and-line. While California halibut can be caught from the shore, most are caught from boats.

The Marine Recreational Fisheries Statistics Survey (MRFSS), which has been conducted from 1980 to 1989 and 1993 to the present, estimates the recreational catch from shore, private or rental boats, and commercial passenger fishing vessels (CPFVs). The MRFSS estimates both the number and pounds of fish caught (Figure 14.2, Table 14.2 and Table 14.3). In the last two decades, about 90% of the recreational catch has been from boats, with most of that catch (77% to 79%) from private or rental boats (Table 14.2 and Table 14.3).

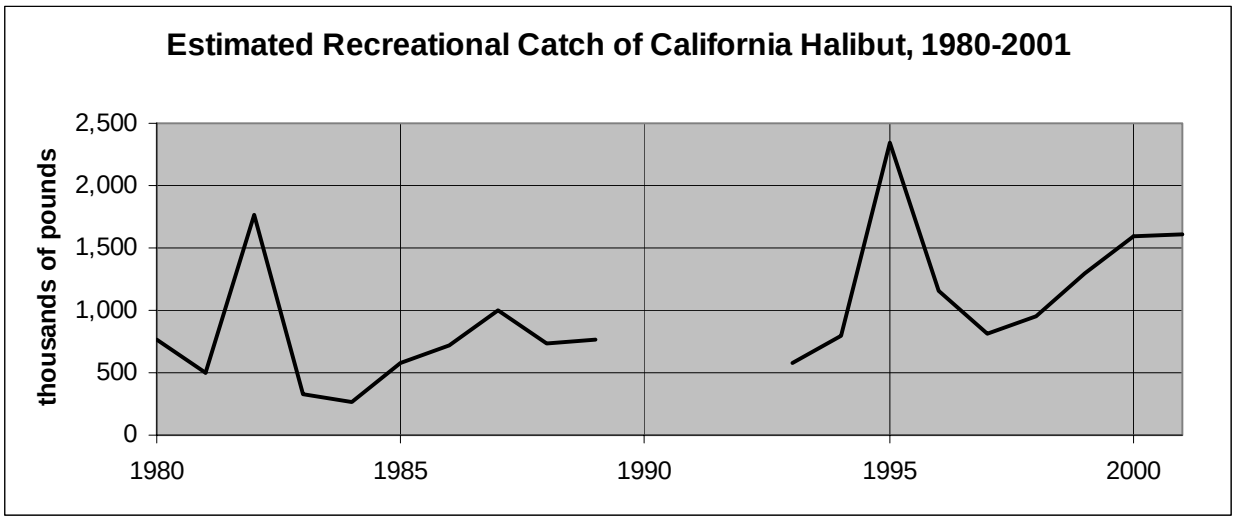

Figure 14.2. Estimated recreational catch (pounds) of California halibut from 1980 to 1989 and 1993 to 2001. Catch estimates do not include fish that were caught and released alive. Data source is the Marine Recreational Fisheries Statistics Survey (MRFSS).

The California Department of Fish and Game (DFG) did not keep records of recreational landings until 1936, when CPFV operators were required to submit logbooks reporting catches. No data were collected during World War II from 1941 to 1945. Although the CPFV catch was reported in pounds between 1936 and 1946, it was reported in pounds and number of fish in 1947, and only in number of fish after 1947 (Figure 14.3 and Table 14.4).

From 1947 through 1974, the catches reported by CPFV operators displayed trends similar to the commercial landings (Figure 14.3 and Table 14.4), with peaks in 1948 (143,000 halibut) and 1964 (141,000 halibut). While the commercial catch increased in the late 1970s and steadied in the 1980s, the CPFV catch remained low and variable with an average annual catch of 8,300 fish from 1971 to 1989. The CPFV catch rose to a 26-year high of 19,300 fish in 1995, and has averaged about 16,300 fish per year from 1995 to 2001. The CPFV catch, of course, represents only one component of the recreational fishery.

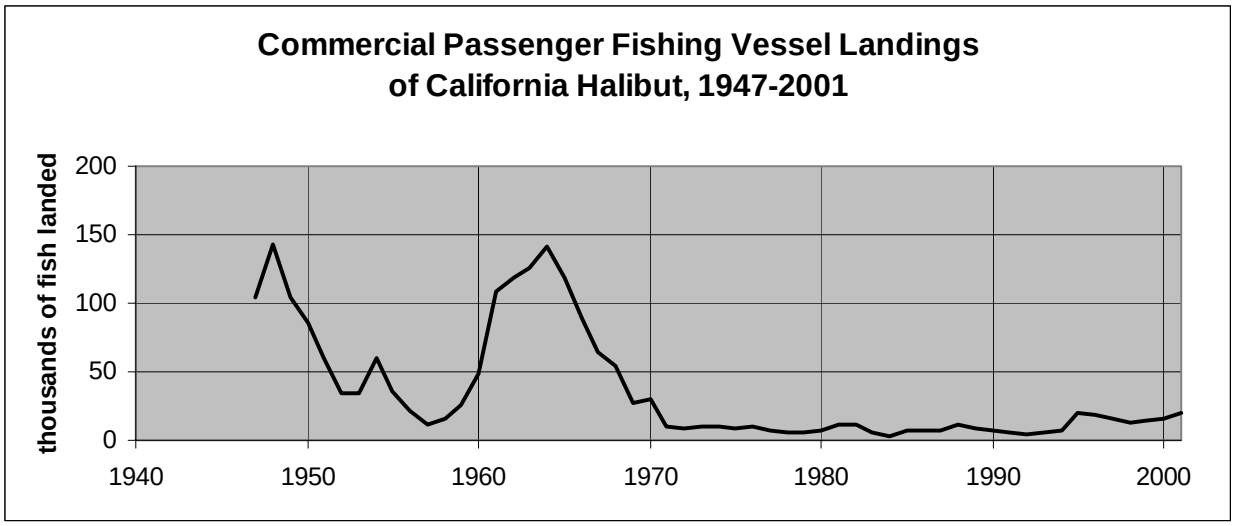

Figure 14.3. Recreational commercial passenger fishing vessel (CPFV) landings (number of fish) as reported on CPFV Logbooks for California halibut from 1947 to 2001. Data sources are California Department of Fish and Game (DFG) Catch Bulletins (1947-1978) and DFG Annual Reports of Statewide Fish Landings By The Commercial Passenger Fishing Vessels (CPFV) Fleet (1979-2001).

More recently, the MRFSS estimated that the annual recreational catch of California halibut ranged from 268,700 to 2.3 million lb between 1980 and 2001 for both shore and boat fishing; there are no catch estimates for 1990 to 1992 (Figure 14.2 and Table 14.3). The MRFSS also estimated that recreational anglers have taken, on average, 976,000 lb of halibut annually since 1980 (excluding 1990 to 1992), slightly below the average annual figure reported for the commercial component of the fishery for the same period.

Recreational regulations require a minimum size limit of 22 in., in addition to a daily bag limit of five California halibut per day when fishing south of Point Sur (Monterey County), and only three California halibut per day when fishing north of Point Sur. South of Point Arena (Mendocino County) fillets must be a minimum of 16.75 in. long and bear the entire skin intact. In the recreational fishery, halibut can be taken by hand, or by using hook-and-line or spear-fishing gear.

Status of Biological Knowledge

Adult California halibut inhabit soft-bottom habitats in coastal waters generally less than 300 ft deep, with greatest abundance at depths of less than 100 ft. Adults spawn throughout the year with peak spawning in winter and spring. Free-drifting eggs and larvae have been found over the continental shelf, with greatest densities in water less than 250 ft deep and within 4 mi of shore. Halibut larvae appear to move inshore as they begin to change from larval to adult form. Early larval stages (about 0.1 to 0.3 in.) occur in midwater more than 1 mi offshore, whereas transforming larvae occur within 0.6 mi of shore and occupy the surface zone at night and the bottom during the day. Halibut have a relatively short free-drifting larval stage (less than 30 days), transforming and settling to the bottom at a small size (about 0.3 to 0.5 in.). Newly-settled and larger juvenile halibut are frequently taken in un-vegetated shallow-water embayments and infrequently on the open coast, suggesting that embayments are

important nursery habitats. However, settlement either in bays or along the open coast varies yearly and may reflect variability in nearshore currents which influence the onshore transport of larvae. The advantages of bays as nursery areas probably include a decrease in the risk of mortality of newly-settled juveniles and an increase in the growth rate of larger juveniles that feed upon the abundant small fishes in the bays. Juveniles emigrate from the bays to the coast at about one year of age and 6.9 to 8.7 in. in length.

The DFG has conducted extensive tag-and-release studies on California halibut over the past four decades. Tagging effort has ranged geographically from Sebastian Vizcaino Bay, Baja California, Mexico north to Tomales Bay, California (Marin County), although the primary effort has been centered between Oceanside (San Diego County) and Point Conception (Santa Barbara County) in southern California. Results showed that halibut do not tend to move extensively. Most sub-legal (less than 22 in.) halibut were recaptured within 2 mi of their release sites, while larger halibut appear to travel greater distances. The average distance traveled by halibut during the study was 8 mi. The results also indicate that halibut movement is parallel to the coastline, with significantly greater northward movements than southward movements. Tagged halibut recaptures south of the international boundary with Mexico may not have been reported, limiting our knowledge of southward movements.

California halibut may live to 30 years and reach 60 in. long. The maximum recorded weight is 72 lb. Male halibut mature at 2 to 3 years and 8 to 9 in., whereas females mature at 4 to 5 years and 15 to 17 in. Female halibut attain larger sizes at a given age than males and represent a greater fraction of the commercial landings (60% to 80%). Female halibut reach legal size (22 in.) at 5 to 6 years of age, about 1 year before males.

California halibut are ambush predators. Small juvenile halibut in bays primarily eat crustaceans, including copepods and amphipods, until they reach about 2.5 in. At 2.5 in., they are large enough to eat fish such as the gobies that are commonly found in bays. The percentage of fish in juvenile halibut diets increases as the halibut grows. On the coast, adult halibut feed primarily on Pacific sardine, northern anchovy, squid, and other nearshore fish species that swim in the water column.

Status of the Population

Abundance of larval California halibut in plankton surveys is correlated with commercial landings of halibut. This species appears to have a cycle of abundance approximately 20 years in length. However, the size of the halibut population may be limited by the amount of available nursery habitat, as juvenile halibut appear to be dependent on shallow water embayments as nursery areas. The overall decline in halibut landings corresponds to a decline in shallow water habitats in southern California associated with dredging and filling of bays and wetlands.

Recreational and commercial fishermen have held conflicting views of how to best utilize and preserve the halibut resource in southern California. In 1988, a differential minimum size limit of 22 in. for the recreational fishery and 26 in. for the commercial fishery was investigated as a possible management tool. This strategy would allow recreational anglers to harvest halibut between 22 and 26 in. long before fish had grown large enough to recruit to the commercial fishery. Yield-per-recruit (Y/R)

analysis (that is, an analysis of how size limits, and natural and fishing mortality will affect production or yield) indicated that:

- Differential size limits would provide an increased Y/R for the recreational fishery, whereas the commercial fishery would experience a loss
- Overall fishing effort was about twice the optimum level
- Y/R would probably increase with decreased fishing effort

The Y/R analysis indicated that allocation conflicts between the recreational and commercial components of the halibut fishery are not likely to be resolved by a management strategy that increases the minimum commercial size limit.

A virtual population analysis (a mathematical modeling technique used to estimate the number of fish in and the weight of each year-class of fish) conducted in the late 1980s estimated that the total biomass (total weight) of California halibut in California was 5.7 to 13.2 million lb, with annual recruitment of fish at 1 year of age estimated to be between 450,000 and 1 million fish. The number of juvenile halibut emigrating from southern California bays to the open coast (at 1 year of age) estimated from beam trawl surveys ranged between 250,000 and 400,000 in the late 1980s.

In the early 1990s, a swept-area trawl survey was conducted by DFG to better understand California halibut population dynamics. This fishery-independent survey produced a preliminary biomass (total weight) and population estimate (number of fish) for halibut in southern and central California. The survey results indicated a halibut biomass of 6.9 million lb for southern California and 2.3 million lb for central California, while the population estimate was 3.9 million halibut for southern California and 700,000 halibut for central California.

Management Considerations

California halibut is an ecologically and economically important nearshore finfish species that supports both commercial and recreational fisheries. Over the past century abundance appears to have been cyclic, which may be due to a number of fishery-dependent and fishery-independent factors. However, protection of bay and estuarine habitats, upon which juvenile halibut depend, is important to insure the health of this resource. California has lost more than 80% of its estuarine habitats over the past century. Management actions that should be considered include:

- Maintaining the current California halibut commercial and recreational regulations.
- Protecting nursery grounds of California halibut by prohibiting modifications to southern California embayments and estuaries unless mitigating actions are taken.
- Prohibiting dredging operations in embayments and estuaries during periods of peak abundance (March-May) of larval and newly-settled California halibut in southern California.

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Table 14.1. Commercial landings (pounds) of California halibut, 1916-2001

Year	From California waters	From Mexican waters	Total California landings	Year	From California waters	From Mexican waters	Total California landings
1916 [1]	1,500,000	2,500,000	4,052,173	**1959**	345,286	8,956	354,242
1917 [1]	3,500,000	800,000	4,379,312	**1960**	366,191	10,072	376,263
1918	2,708,514	1,915,704	4,624,218	**1961**	545,472	109,082	654,554
1919	2,362,520	2,335,603	4,698,123	**1962**	776,077	87,009	863,086
1920	2,602,043	1,677,539	4,279,582	**1963**	855,092	265,277	1,120,369
1921	2,340,428	1,313,433	3,653,861	**1964**	1,092,068	184,037	1,276,105
1922	2,437,966	816,539	3,254,505	**1965**	1,128,348	115,370	1,243,718
1923	1,347,243	882,138	2,229,381	**1966**	749,555	261,857	1,011,412
1924	1,528,399	1,048,483	2,576,882	**1967**	824,919	13,139	838,058
1925	1,352,248	1,100,303	2,452,551	**1968**	659,425	12,229	671,654
1926	916,794	432,237	1,349,031	**1969**	272,331	1,946	274,277
1927	818,517	485,042	1,303,559	**1970**	256,898	546	257,444
1928	932,289	255,362	1,187,651	**1971**	336,416	455	336,871
1929	811,427	291,146	1,102,573	**1972**	309,003	242	309,245
1930	896,062	201,698	1,097,760	**1973**	272,466	1,060	273,526
1931	929,306	40,467	969,773	**1974**	306,290	189	306,479
1932	939,001	10,701	949,702	**1975**	507,785	1,128	508,913
1933	904,829	84,820	989,649	**1976**	627,574	796	628,400
1934	648,516	388,492	1,037,008	**1977**	463,760	4,102	467,862
1935	810,291	765,572	1,575,863	**1978**	432,884	8,244	441,440
1936	776,634	806,273	1,582,907	**1979**	658,892	6,399	665,546
1937	812,365	394,870	1,207,235	**1980**	724,590	2,120	726,852
1938	822,447	255,782	1,078,229	**1981**	1,259,029	3,236	1,262,265
1939	722,084	269,537	991,621	**1982**	1,211,232	1,324	1,214,375
1940	861,908	86,549	948,457	**1983**	1,130,543	38	1,130,581
1941	592,911	113,739	706,650	**1984**	1,105,273	------	1,107,019
1942	569,245	181,294	750,539	**1985**	1,255,599	204	1,255,966
1943	701,219	410,779	1,111,998	**1986**	1,183,482	205	1,184,296
1944	1,111,880	373,583	1,485,463	**1987**	1,185,139	2,609	1,188,596
1945	1,582,150	166,671	1,748,821	**1988**	1,106,877	------	1,107,207
1946	1,675,280	781,907	2,457,187	**1989**	1,217,868	76	1,219,321
1947	1,172,638	615,263	1,787,901	**1990**	938,572	------	938,572
1948	1,041,124	265,489	1,306,613	**1991**	1,040,855	------	1,040,864
1949	1,079,501	183,013	1,262,514	**1992**	885,073	57	885,130
1950	806,279	286,466	1,092,745	**1993**	725,535	980	726,525
1951	643,279	222,654	865,933	**1994**	533,917	780	535,018
1952	473,620	51,691	525,311	**1995**	770,065	94	771,628
1953	387,739	142,576	530,315	**1996**	914,034	60	914,236
1954	444,543	216,788	661,331	**1997**	1,324,987	106	1,325,175
1955	363,834	145,968	509,802	**1998**	1,187,115	351	1,187,549
1956	382,006	73,793	455,799	**1999**	1,313,286	------	1,313,495
1957	332,584	44,231	376,815	**2000**	847,946	------	847,949
1958	256,075	11,371	267,446	**2001**	891,475	------	894,002

------ Landings data not available.

1. Amounts caught from California and Mexican waters in 1916 and 1917 are estimates.
2. Data sources are DFG Catch Bulletins (1916-1983) and DFG commercial landing receipt database (1984-2001).
3. A small amount of the total commercial California halibut landings are from waters north of the State or from undesignated waters. These pounds are not reported separately in this table, but are included in the total.

Table 14.2. Estimated catch (number of fish) by recreational anglers of California halibut by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	17,959	2,558	------	12,064	94,071	126,652
1981	5,680	2,713	------	16,765	50,127	75,286
1982	6,519	176,969	------	16,683	72,301	272,473
1983	3,060	1,469	------	6,567	33,128	44,224
1984	3,936	2,281	------	2,960	30,745	39,922
1985	3,913	5,885	------	12,436	49,782	72,016
1986	------	------	8,132	11,410	106,173	125,715
1987	------	------	14,857	29,017	143,255	187,130
1988	------	------	23,567	18,665	63,284	105,517
1989	------	------	7,784	22,949	92,516	123,249
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	2,096	1,294	------	7,432	55,323	66,145
1994	1,618	2,046	------	13,833	86,072	103,569
1995	5,806	4,100	------	8,897	318,429	337,231
1996	9,315	986	------	13,645	122,975	146,921
1997	1,740	826	------	6,511	82,865	91,942
1998	2,155	------	------	7,445	96,620	106,220
1999	766	528	------	17,989	110,691	129,975
2000	1,768	5,822	------	22,709	136,116	166,415
2001	7,310	703	------	18,727	165,375	192,115

------ Estimates not available.

1. Data source: the Marine Recreational Fisheries Statistics Survey (MRFSS); data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California CPFVs were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

Table 14.3. Estimated catch (pounds) by recreational anglers of California halibut by fishing mode, 1980-2001

Year	Man-made structures	Beach and bank	Shore	Commercial passenger fishing vessels (CPFV)	Private or rental boats	Total
1980	57,447	7,487	------	107,828	598,290	771,052
1981	37,557	13,136	------	114,372	338,274	503,338
1982	16,336	1,230,207	------	87,060	429,499	1,763,103
1983	10,437	6,616	------	74,502	236,326	327,882
1984	10,506	11,330	------	45,026	201,923	268,786
1985	6,375	24,925	------	95,106	451,173	577,579
1986	------	------	26,263	72,251	615,017	713,531
1987	------	------	39,456	155,285	810,579	1,005,321
1988	------	------	169,234	98,551	463,378	731,163
1989	------	------	26,650	137,716	598,175	762,540
1990	------	------	------	------	------	------
1991	------	------	------	------	------	------
1992	------	------	------	------	------	------
1993	5,464	6,099	------	38,121	529,253	578,937
1994	5,362	14,139	------	101,669	669,912	791,083
1995	29,039	28,642	------	63,801	2,219,567	2,341,049
1996	56,641	5,466	------	109,940	984,657	1,156,703
1997	9,720	1,824	------	67,756	734,970	814,271
1998	14,495	------	------	68,122	863,242	945,859
1999	4,767	6,232	------	154,201	1,133,900	1,299,099
2000	10,351	63,032	------	241,398	1,276,052	1,590,833
2001	41,900	7,534	------	162,279	1,399,452	1,611,166

------ Estimates not available.

1. Data source: the Marine Recreational Fisheries Statistics Survey (MRFSS); data obtained from the Pacific States Marine Fisheries Commission website.
2. No estimates are available from 1990 through 1992 or for January and February of 1995. Estimates for 2001 are preliminary. Northern California CPFVs were not fully sampled because of refusals.
3. Catch estimates do not include fish that were caught and released alive; they only include fish that were harvested.
4. From 1986 to 1989, individual catch estimates were not made for the man-made structures mode or the beach and bank mode. Instead, a single estimate was made for these shore modes.

Table 14.4. Recreational commercial passenger fishing vessel (CPFV) landings (number of fish) as reported on CPFV Logbooks for California halibut, 1947-2001

Year	Number of fish	Year	Number of fish	Year	Number of fish	Year	Number of fish
1947	104,436	**1961**	108,011	**1975**	9,118	**1989**	9,116
1948	143,462	**1962**	118,966	**1976**	10,075	**1990**	6,658
1949	104,639	**1963**	125,669	**1977**	6,982	**1991**	5,984
1950	85,935	**1964**	141,465	**1978**	5,409	**1992**	4,341
1951	59,295	**1965**	118,213	**1979**	6,329	**1993**	5,335
1952	34,158	**1966**	88,726	**1980**	6,517	**1994**	7,549
1953	34,292	**1967**	63,582	**1981**	11,440	**1995**	19,345
1954	59,674	**1968**	54,663	**1982**	11,804	**1996**	19,092
1955	35,802	**1969**	27,634	**1983**	5,682	**1997**	15,846
1956	21,661	**1970**	29,968	**1984**	3,209	**1998**	12,191
1957	10,795	**1971**	10,598	**1985**	7,090	**1999**	14,339
1958	16,192	**1972**	8,140	**1986**	7,848	**2000**	15,865
1959	25,365	**1973**	9,622	**1987**	7,560	**2001**	20,637
1960	48,310	**1974**	10,292	**1988**	11,501		

------ Landings data not available.

1. Data sources: DFG Catch Bulletins (1947-1978) and DFG Annual Reports of Statewide Fish Landings By The Commercial Passenger Fishing Vessels (CPFV) Fleet (1979-2001).
2. Logbooks have been required for southern California, including fish taken in Mexican waters and landed in California, for the entire time period reported here. Logbooks were required for central and northern California from 1957 to present.
3. The data are number of fish reported on logbooks submitted to DFG.

Appendix A
Determining the Species List for the *Annual Status of the Fisheries Reports*

The *Annual Status of the Fisheries Report* (ASFR) editors used the list of state-managed marine life in the MLMA Master Plan (*The Master Plan: A Guide for the Development of Fishery Management Plans*, Appendix D, August 2001) as the starting point for determining the species of marine life to include in the ASFRs. The ASFR editors included species or groups of species that appear on the MLMA Master Plan list for review in the ASFRs unless:

1. The species or group is not the subject of a directed recreational or commercial fishery, or harvest of the species or group is relatively minor or periodic.
2. Harvest of the species or group is prohibited.
3. The species or group is included in a Pacific Fishery Management Council fishery management plan and is not the subject of a State recovery or fishery management plan.
4. The group is not well defined (i.e., not a single species, or a list of a number of species).
5. The species or group is primarily estuarine or freshwater, or resides primarily outside of state waters.

Some species on the ASFR list are taken incidentally as bycatch or were formerly the subject of a directed fishery; these species will be monitored and given limited reviews. All other species on the ASFR list will receive a detailed review (full review) every four years.

List of all marine algae, vascular plants, invertebrates, and fishes that are managed by the State of California[1]				
Common name	**Scientific name**	**FMP[2]**	**Reason(s) for exclusion[3] (notes)**	**Type of review[4] (review title for reviews covering multiple species)**
ALGAE				
kelp, bull	*Nereocystis luetkeana*			Full
kelp, giant	*Macrocystis pyrifera*			Full
sea palm	*Postelsia palmaeformis*			Full
	Chlorophyta		1,4	
	Fucus spp.		1,4	
	Gelidium		1,4	
	Gigartina		1,4	
	Gloiopeltis		1,4	
	Gracilaria		1,4	
	Laminaria		1,4	
	Mastocarpus		1,4	
	Mazaella (Iridaea)		1,4	

List of all marine algae, vascular plants, invertebrates, and fishes that are managed by the State of California[1]				
Common name	**Scientific name**	**FMP[2]**	**Reason(s) for exclusion[3] (notes)**	**Type of review[4] (review title for reviews covering multiple species)**
	Monostrema		1,4	
	Phaeophyta		1,4	
	Porphyra		1,4	
	Pterocladia		1,4	
	Rhodoglossum		1,4	
	Rhodophyta		1,4	
	Sarcodiotheca		1,4	
	Spermatophyta		1,4	
VASCULAR PLANTS				
eelgrass	*Zostera marina*		2	
surfgrass	*Phyllospadix* spp.		2	
INVERTEBRATES				
abalone, black	*Haliotis cracherodii*	AB		Full (abalones)
abalone, flat	*Haliotis walallensis*	AB		Full (abalones)
abalone, green	*Haliotis fulgens*	AB		Full (abalones)
abalone, pink	*Haliotis corrugata*	AB		Full (abalones)
abalone, pinto	*Haliotis kamtschatkana*	AB		Full (abalones)
abalone, red	*Haliotis rufescens*	AB		Full (abalones)
abalone, threaded	*Haliotis assimilis*	AB	No longer considered a separate species; synonymous with pinto abalone	
abalone, white	*Haliotis sorenseni*	AB		Full (abalones)
amphipod	Amphipoda		1,4	
anemone	Coelenterata		1,4 (commercial take prohibited)	
barnacle, acorn	*Balanus nubilus, B. aquila*		1 (commercial take prohibited)	

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barnacle, gooseneck	*Pollicipes polymerus*		1 (commercial take prohibited)	
barnacle, stalked	*Pollicipes* spp.		1 (commercial take prohibited)	
chione, banded	*Chione californiensis*			Full (littleneck clams)
chione, smooth	*Chione fluctifraga*			Full (littleneck clams)
chione, wavy	*Chione undatella*			Full
chiton	Polyplacophora		1,4	
clam, butter	*Saxidomus giganteus*		Minor fishery in Humboldt Bay	Limited
clam, California jackknife	*Tagelus californianus*			Limited
clam, common littleneck	*Protothaca staminea*			Full (littleneck clams)
clam, common Washington	*Saxidomus nuttalli*			Full (Washington clams)
clam, Pacific gaper	*Tresus nuttalli*			Full (gaper clams)
clam, fat gaper	*Tresus capax*			Full (gaper clams)
clam, geoduck	*Panopea genersoa*			Full
clam, Japanese littleneck	*Tapes japonica, T. philippinarum*			Full (littleneck clams)
clam, northern quahog	*Mercenaria mercenaria*			Limited
clam, northern razor	*Siliqua patula*		commercial take prohibited	Limited
clam, Pismo	*Tivela stultorum*		commercial take prohibited	Full
clam, rosy razor	*Solen sicarius*		1	
clam, rough-sided littleneck	*Protothaca laciniata*			Full (little-neck clams)

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clam, softshell	*Mya arenaria*			Limited
clam, thin-shelled littleneck	*Protothaca tenerrima*			Full (littleneck clams)
cockle, basket	*Clinocardium nuttallii*		1	
coral	Coelenterata		1,4 (commercial take prohibited)	
cowrie, chestnut	*Cypraea spadicea*		1	
crab, box	*Lopholithodes foraminatus*			Limited
crab, brown rock	*Cancer antennarius*			Full (rock crabs)
crab, Californa king	*Paralithodes californiensis*		1	
crab, California hermit	*Pagurus spp., Isochelis sp.*		1	
crab, claws	*Cancer spp., Loxorhynchus grandis*		4	
crab, Dungeness	*Cancer magister*			Full
crab, fiddler	*Uca crenulata*		1 (commercial take prohibited)	
crab, forknose king	*Paralithodes rathbuni*		1	
crab, king	*Paralithodes spp.*		1	
crab, pelagic red	*Pleuroncodes planipes*		1	
crab, red rock	*Cancer productus*			Full (rock crabs)
crab, sand (mole crab)	*Emerita analoga*			Limited
crab, sheep	*Loxorhynchus grandis*			Full
crab, shore	*Pachygrapsus crassipes*		1	
crab, slender	*Cancer gracilis*			Limited
crab, tanner	*Chionoecetes tanneri*			Limited
crab, umbrella	*Cryptolithodes stichensis*		1 (commercial take prohibited)	
crab, yellow rock	*Cancer anthonyi*			Full (rock crabs)
cucumber, California sea	*Parastichopus californicus*			Full (sea cucumbers)
cucumber, sea	Holothuroidea		4	
cucumber, warty sea	*Parastichopus parvimensis*			Full (sea cucumbers)

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gorgonians	Gorgonacea		1,4 (commercial take prohibited)	
invertebrate, colonial	Cnidaria, Porifera		1,4 (commercial take prohibited)	
jellyfish	*Pelagia* spp.		1,4 (commercial take prohibited)	
limpet, owl	*Lottia gigantea*		commercial take prohibited	Full (intertidal invert-ebrates)
limpet, unspecified	Archaeogastropoda		1,4	
lobster, California spiny	*Panulirus interruptus*			Full
mantis shrimp, blueleg	*Hemisquilla ensigera*		1	
mussel	*Mytilus galloprovincialis, M. trossulus, M. californianus*			Limited
nudibranch, hermissenda	*Hermissenda crassicornis*			Limited
nudibranch, lion's mouth	Melibe leonina		1	
nudibranch, shagg rug	*Aeolidia papillosa*		1	
nudibranch, spanish shawl	*Flabellinopsis iodinea*		1	
octopus, two-spot	*Octopus bimaculoides, O. bimaculatus*			Limited
octopus, unspecified	*Octopus* spp.		4	
ophistobranch	Ophistobranchia		1,4	
oyster, unspecified	Ostreidae		1,4	
polychaete	Polychaeta		1,4	
prawn, golden	*Penaeus californiensis*			Full (prawns)
prawn, ridgeback	*Sicyonia ingentis*			Full (prawns)
prawn, spot	*Pandalus platyceros*			Full (prawns)
rock, live	Invertebrata		1,4 (commercial take prohibited)	
sand dollar	*Dendraster* spp.		1,4	
scallop, rock	*Crassadoma gigantea*		commercial take prohibited	Limited

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scallop, speckled (bay)	*Argopecten aequisulcatus*		1 (commercial take prohibited)	
sea hare, black	*Aplysia vaccaria*		1	
sea hare, California	*Aplysia californica*		1	
sea pansy	*Renilla kollikeri*		1	
sea pen	Pennatulacea		1,4	
sea slug	Opisthobranchia		1,4	
shrimp, bay	*Crangon franciscorum, C. nigricauda, C. nigromaculata, Palaemon macrodactylus*			Full (bay shrimp)
shrimp, blue mud	*Upogebia pugettensis*			Limited
shrimp, brine	*Artemia salina*		5	
shrimp, coonstriped	*Pandalus danae*			Full
shrimp, ghost	*Callianassa californiensis, Callianassa affinis, C. gigas*			Limited
shrimp, Pacific ocean (pink shrimp)	*Pandalus jordani*			Full
shrimp, red rock	*Lysmata californica*			Full
snail, moon	*Polinices* spp.			Limited
snail, sea	Gastropoda		1,4	
snail, three-winged murex	*Pteropurpura trialata*		1 (commercial take prohibited)	
snail, trivia	*Trivia solandri, T. californiana*		1 (commercial take prohibited)	
shell, top	Trochidae, Turbinidae, *Tegula* spp.			Full (intertidal invertebrates)
shell, wavy top	*Astraea undosa*			Full (subtidal snails)
spider, sea	Pycnogonida		1,4	
sponge	Porifera		1,4 (commercial take prohibited)	
squid, Humboldt (jumbo squid)	*Doscidicus gigas*		1,4	
squid, market	*Loligo opalescens*	CP**		Full
star, brittle	Ophiuroidea		1,4	
star, sea	Asteroidea		4	
tunicate	Urochordata		1,4	

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urchin, purple sea	*Strongylocentrotus purpuratus*			Full
urchin, red sea	*Strongylocentrotus franciscanus*			Full
urchin, white sea	*Lytechinus anamesus*		1	
whelk, kellet's	*Kelletia kelletii*			Full (subtidal snails)
worm, feather-duster	*Eudistylia polymorpha*		1 (commercial take prohibited)	
worm, marine	Polychaeta		1,4	
FISHES				
anchovy, northern	*Engraulis mordax*	CP	3	
barracuda, Pacific	*Sphyraena argentea*			Full
bass, barred sand	*Paralabrax nebulifer*			Full (sea basses)
bass, giant sea	*Stereolepis gigas*		2	
bass, kelp	*Paralabrax clathratus*			Full (sea basses)
bass, spotted sand	*Paralabrax maculatofasciatus*			Full (sea basses)
bass, striped	*Morone saxatilis*		5	
blacksmith	*Chromis punctipinnis*			Limited
bonito, Pacific	*Sarda chiliensis*			Full
butterfish (Pacific pompano)	*Peprilus simillimus*			Full
cabezon	*Scorpaenichthys marmoratus*	GF, NS		Full
cod, Pacific	*Gadus macrocephalus*	GF	3	
corbina, California	*Menticirrhus undulatus*		commercial take prohibited	Full (drums)
croaker, black	*Cheilotrema saturnum*		1 (covered in review of drums)	
croaker, spotfin	*Roncador stearnsi*		commercial take prohibited	Full (drums)
croaker, white	*Genyonemus lineatus*			Full (drums)
croaker, yellowfin	*Umbrina roncador*		commercial take prohibited	Full (drums)
dolphin (fish)	*Coryphaena hippurus*	HM	3	
eel, California moray	*Gymnothorax mordax*		1	

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eel, monkeyface- (prickleback)	*Cebidichthys violaceus*	NS		Full
eel, wolf-	*Anarrhichthys ocellatus*		commercial take prohibited	Limited
escolar	*Lepidocybium flavobrunneum*	HM*	3	
eulachon	*Thaleichthys pacificus*		1 (covered in review of true smelts)	
flatnose, Pacific (finescale codling)	*Antimora microlepis*	GF	3	
flounder, arrowtooth	*Atheresthes stomias*	GF	3	
flounder, starry	*Platichthys stellatus*	GF	3	
flyingfish	*Exocoetidae spp.*		1	
garibaldi	*Hypsypops rubicundus*		2	
goby, blackeye	*Coryphopterus nicholsi*		1	
goby, bluebanded	*Lythrypnus dalli*		1	
goby, chameleon (oriental goby)	*Tridentiger trigonocephalus*		1	
goby, yellowfin (oriental goby)	*Acanthogobius flavimanus*		1	
greenling, kelp	*Hexagrammos decagrammus*	NS		Full (greenlings)
greenling, painted	*Oxylebius pictus*		1 (covered in review of greenlings)	
greenling, rock	*Hexagrammos lagocephalus*	NS		Full (greenlings)
grenadier, Pacific rattail	*Coryphaenoides acrolepis*	GF	3	
grouper, broomtail	*Mycteroperca xenarcha*		5	
grouper, gulf	*Mycteroperca jordani*		5	
grunion, California	*Leuresthes tenuis*			Full (silversides)
guitarfish, shovelnose	*Rhinobatos productus*			Full (nearshore sharks and rays)
hagfish	*Eptatretus* spp.			Limited
halfmoon	*Medialuna californiensis*			Full (sea chubs)
halibut, California	*Paralichthys californicus*			Full
halibut, Greenland	*Reinhardtius hippoglossoides*		5	
halibut, Pacific	*Hippoglossus stenolepis*	GF	3	
herring roe on algae (sport)	*Clupea pallasi/ Algae*		4	
herring roe on kelp	*Clupea pallasi/ Macrocystis*		4	
herring, Pacific	*Clupea pallasi*			Full

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jacksmelt	*Atherinopsis californiensis*			Full (silversides)
kelpfish, giant	*Heterostichus rostratus*		1	
kelpfish, island	*Alloclinus holderi*		1	
killifish, California	*Fundulus parvipinnis*		1	
lamprey, Pacific	*Lampetra tridentata*		1	
lamprey, western river	*Lampetra ayresii*		1	
lingcod	*Ophiodon elongatus*	GF	3	
lizardfish, California	*Synodus lucioceps*		1 (bycatch)	Limited
louvar	*Luvarus imperialis*	HM*	3	
mackerel, bullet	*Auxis rochei*	HM*	3	
mackerel, chub (Pacific mackerel)	*Scomber japonicus*	CP	3	
mackerel, jack	*Trachurus symmetricus*	CP	3	
marlin, striped	*Tetrapturus audax*	HM	3	
midshipman, plainfin	*Porichthys notatus*		1	
mudsucker, longjaw	*Gillichthys mirabilis*		1	
mullet, striped	*Mugil cephalus*			Limited
needlefish, California	*Strongylura exilis*		1	
oilfish	*Ruvettus pretiosus*		1	
opah	*Lampris guttatus*	HM*	3	
opaleye	*Girella nigricans*			Full (sea chubs)
poacher	Agonidae		4 (commercial take prohibited)	
queenfish	*Seriphus politus*			Full (drums)
ratfish, spotted	*Hydrolagus colliei*	GF	3	
ray, bat	*Myliobatis californica*			Full (nearshore sharks and rays)
ray, Pacific electric	*Torpedo californica*			Limited
rockfish, aurora	*Sebastes aurora*	GF	3	
rockfish, bank	*Sebastes rufus*	GF	3	
rockfish, black	*Sebastes melanops*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)

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rockfish, black-and-yellow	*Sebastes chrysomelas*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, blackgill	*Sebastes melanostomus*	GF	3	
rockfish, blue	*Sebastes mystinus*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, bocaccio	*Sebastes paucispinis*	GF	3	
rockfish, bronzespotted	*Sebastes gilli*	GF	3	
rockfish, brown	*Sebastes auriculatus*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, calico	*Sebastes dalli*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, canary	*Sebastes pinniger*	GF	3	
rockfish, chameleon	*Sebastes phillipsi*	GF	3	
rockfish, chilipepper	*Sebastes goodei*	GF	3	
rockfish, China	*Sebastes nebulosus*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, copper	*Sebastes caurinus*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, cowcod	*Sebastes levis*	GF	3	
rockfish, darkblotched	*Sebastes crameri*	GF	3	

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rockfish, dusky	*Sebastes ciliatus*	GF	3	
rockfish, dwarf-red	*Sebastes rufinanus*	GF	3	
rockfish, flag	*Sebastes rubrivinctus*	GF	3	
rockfish, freckled	*Sebastes lentiginosus*	GF	3	
rockfish, gopher	*Sebastes carnatus*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, grass	*Sebastes rastrelliger*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, greenblotched	*Sebastes rosenblatti*	GF	3	
rockfish, greenspotted	*Sebastes chlorostictus*	GF	3	
rockfish, greenstriped	*Sebastes elongatus*	GF	3	
rockfish, halfbanded	*Sebastes semicinctus*	GF	3	
rockfish, harlequin	*Sebastes variegatus*	GF	3	
rockfish, honeycomb	*Sebastes umbrosus*	GF	3	
rockfish, kelp	*Sebastes atrovirens*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, Mexican	*Sebastes macdonaldi*	GF	3	
rockfish, olive	*Sebastes serranoides*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, Pacific ocean perch	*Sebastes alutus*	GF	3	
rockfish, pink	*Sebastes eos*	GF	3	
rockfish, pinkrose	*Sebastes simulator*	GF	3	
rockfish, pygmy	*Sebastes wilsoni*	GF	3	

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rockfish, quillback	*Sebastes maliger*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, redbanded	*Sebastes babcocki*	GF	3	
rockfish, redstriped	*Sebastes proriger*	GF	3	
rockfish, rosethorn	*Sebastes helvomaculatus*	GF	3	
rockfish, rosy	*Sebastes rosaceus*	GF	3	
rockfish, rougheye	*Sebastes aleutianus*	GF	3	
rockfish, sharpchin	*Sebastes zacentrus*	GF	3	
rockfish, shortbelly	*Sebastes jordani*	GF	3	
rockfish, shortraker	*Sebastes borealis*	GF	3	
rockfish, silvergray	*Sebastes brevispinis*	GF	3	
rockfish, speckled	*Sebastes ovalis*	GF	3	
rockfish, splitnose	*Sebastes diploproa*	GF	3	
rockfish, squarespot	*Sebastes hopkinsi*	GF	3	
rockfish, starry	*Sebastes constellatus*	GF	3	
rockfish, stripetail	*Sebastes saxicola*	GF	3	
rockfish, swordspine	*Sebastes ensifer*	GF	3	
rockfish, tiger	*Sebastes nigrocinctus*	GF	3	
rockfish, treefish	*Sebastes serriceps*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
rockfish, vermilion	*Sebastes miniatus*	GF	3	
rockfish, widow	*Sebastes entomelas*	GF	3	
rockfish, yelloweye	*Sebastes ruberrimus*	GF	3	
rockfish, yellowmouth	*Sebastes reedi*	GF	3	
rockfish, yellowtail	*Sebastes flavidus*	GF	3	
sablefish	*Anoplopoma fimbria*	GF	3	
salema	*Xenistius californiensis*		1	
salmon, chinook	*Oncorhynchus tshawytscha*	S	3	
salmon, coho	*Oncorhynchus kisutch*	S	2, 3	
salmon, pink	*Oncorhynchus gorbuscha*	S	3	
salmon, roe	*Oncorhynchus* spp.	S	3	
sanddab, longfin	*Citharichthys xanthostigma*			Full (sanddabs)
sanddab, Pacific	*Citharichthys sordidus*	GF	3	
sanddab, speckled	*Citharichthys stigmaeus*			Full (sanddabs)

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sardine, Pacific	*Sardinops sagax caeruleus*	CP	3	
sargo	*Anisotremus davidsoni*			Full
saury, Pacific	*Cololabis saira*		1	
scad, Mexican	*Decapterus scombrinus*		1	
scorpionfish, California	*Scorpaena guttata*	GF, NS		Full (nearshore rockfishes and scorpion-fishes)
sculpin, buffalo	*Enophrys bison*		1	
sculpin, Pacific staghorn	*Leptocottus armatus*			Full
sculpin, prickly	*Cottus asper*		1	
sculpin, unspecified	Cottidae		1,4	
seabass, white	*Atractoscion nobilis*	WS		Full
senorita	*Oxyjulis californica*		1	
shad, American	*Alosa sapidissima*		5-fishery primarily in freshwater	
shark, basking	*Cetorhinus maximus*	HM*	3	
shark, blue	*Prionace glauca*	HM	3	
shark, brown smoothhound	*Mustelus henlei*			Full (nearshore sharks and rays)
shark, gray smoothhound	*Mustelus californicus*			Full (nearshore sharks and rays)
shark, horn	*Heterodontus francisci*		1	
shark, leopard	*Triakis semifasciata*	GF	3	
shark, Pacific angel	*Squatina californica*			Full (nearshore sharks and rays)
shark, salmon	*Lamna ditropis*	HM*	3	
shark, sevengill	*Notorynchus cepedianus*			Full (cow sharks)
shark, shortfin mako	*Isurus oxyrinchus*	HM	3	
shark, sixgill	*Hexanchus griseus*			Full (cow sharks)
shark, soupfin	*Galeorhinus zyopterus*	GF	3	
shark, spiny dogfish	*Squalus acanthias*	GF	3	
shark, swell	*Cephaloscyllium ventriosum*		1	

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shark, thresher	*Alopias vulpinus*	HM	3	
shark, thresher bigeye	*Alopias superciliosus*	HM*	3	
shark, thresher pelagic	*Alopias pelagicus*	HM*	3	
shark, white	*Carcharodon carcharias*	HM	2, 3	
shark/ray egg cases	Elasmobranch		4 (commercial take prohibited)	
sheephead, California	*Semicossyphus pulcher*	NS		Full
skate, big	*Raja binoculata*	GF	3	
skate, California	*Raja inornata*	GF	3	
skate, longnose	*Raja rhina*	GF	3	
skate, sandpaper	*Bathyraja interruptus (Raja kincaidii)*		1	
skate, starry	*Raja stellulata*		1	
smelt, delta	*Hypomesus transpacificus*		5	
smelt, longfin	*Spirinchus thaleichthys*		1 (covered in review of true smelts)	
smelt, night	*Spirinchus starksi*			Full (true smelts)
smelt, surf	*Hypomesus pretiosus*			Full (true smelts)
smelt, whitebait	*Allosmerus elongatus*			Full (true smelts)
sole, bigmouth	*Hippoglossina stomata*		1	
sole, butter	*Pleuronectes isolepis*	GF	3	
sole, C-O	*Pleuronichthys coenosus*		1	
sole, curlfin	*Pleuronichthys decurrens*	GF	3	
sole, dover	*Microstomus pacificus*	GF	3	
sole, English	*Pleuronectes vetulus*	GF	3	
sole, fantail	*Xystreurys liolepis*			Limited
sole, flathead	*Hippoglossoides elassodon*	GF	3	
sole, petrale	*Eopsetta jordani*	GF	3	
sole, rex	*Errex zachirus*	GF	3	
sole, rock	*Pleuronectes bilineatus*	GF	3	
sole, sand	*Psettichthys melanostictus*	GF	3	
sole, slender	*Lyopsetta exilis (Eopsetta exilis)*		1	
sole, unspecified	Pleuronectiformes		4	
steelhead (rainbow trout)	*Oncorhynchus mykiss*	S	3	
stickleback, threespine	*Gasterosteus aculeatus*		5	
stingray	Dasyatidae		4	
stingray, round	*Urolophus halleri*		1	

List of all marine algae, vascular plants, invertebrates, and fishes that are managed by the State of California[1]				
Common name	**Scientific name**	**FMP[2]**	**Reason(s) for exclusion[3] (notes)**	**Type of review[4] (review title for reviews covering multiple species)**
sturgeon, green	*Acipenser medirostris*		5 (commercial take prohibited)	
sturgeon, white	*Acipenser transmontanus*		5 (commercial take prohibited)	
sunfish, ocean	*Mola mola*	HM*	3	
surfperch, barred	*Amphistichus argenteus*			Full (surfperches)
surfperch, black (perch)	*Embiotoca jacksoni*			Full (surfperches)
surfperch, calico	*Amphistichus koelzi*			Full (surfperches)
surfperch, dwarf (perch)	*Micrometrus minimus*			Full (surfperches)
surfperch, island	*Cymatogaster gracilis*		No longer considered a separate species; synonymous with shiner perch	
surfperch, kelp (perch)	*Brachyistius frenatus*			Full (surfperches)
surfperch, pile (perch)	*Rhacochilus vacca*			Full (surfperches)
surfperch, pink (seaperch)	*Zalembius rosaceus*			Full (surfperches)
surfperch, rainbow (seaperch)	*Hypsurus caryi*			Full (surfperches)
surfperch, redtail	*Amphistichus rhodoterus*			Full (surfperches)
surfperch, reef (perch)	*Micrometrus aurora*			Full (surfperches)
surfperch, rubberlip (seaperch)	*Rhacochilus toxotes*			Full (surfperches)
surfperch, sharpnose (seaperch)	*Phanerodon atripes*			Full (surfperches)
surfperch, shiner (perch)	*Cymatogaster aggregata*			Full (surfperches)
surfperch, silver	*Hyperprosopon ellipticum*			Full (surfperches)

List of all marine algae, vascular plants, invertebrates, and fishes that are managed by the State of California[1]				
Common name	**Scientific name**	**FMP[2]**	**Reason(s) for exclusion[3] (notes)**	**Type of review[4] (review title for reviews covering multiple species)**
surfperch, spotfin	*Hyperprosopon anale*			Full (surfperches)
surfperch, striped (seaperch)	*Embiotoca lateralis*			Full (surfperches)
surfperch, walleye	*Hyperprosopon argenteum*			Full (surfperches)
surfperch, white (seaperch)	*Phanerodon furcatus*			Full (surfperches)
swordfish	*Xiphias gladius*	HM	3	
thornback	*Platyrhinoidis triseriata*			Full (nearshore sharks and rays)
thornyhead, longspine	*Sebastolobus altivelis*	GF	3	
thornyhead, shortspine	*Sebastolobus alascanus*	GF	3	
tilapia, Mozambique	*Tilapia mossambica*		5	
tomcod, Pacific	*Microgadus proximus*			Limited
tonguefish, California (tongue sole)	*Symphurus atricauda*		1	
topsmelt	*Atherinops affinis*			Full (silversides)
tuna, albacore	*Thunnus alalunga*	HM	3	
tuna, bigeye	*Thunnus obesus*	HM	3	
tuna, bluefin	*Thunnus thynnus*	HM	3	
tuna, skipjack	*Katsuwonus pelamis*	HM	3	
tuna, skipjack black	*Euthynnus lineatus*	HM*	3	
tuna, yellowfin	*Thunnus albacares*	HM	3	
turbot, diamond	*Hypsopsetta guttulata*			Limited
turbot, hornyhead	*Pleuronichthys verticalis*		1	
turbot, spotted	*Pleuronichthys ritteri*		1	
whitefish, ocean	*Caulolatilus princeps*			Full
whiting, Pacific (Pacific hake)	*Merluccius productus*	GF	3	
wrasse, rock	*Halichoeres semicinctus*		1	
yellowtail	*Seriola lalandi*			Full
zebraperch	*Hermosilla azurea*		1 (covered in review of true smelts)	

1. List from Appendix D of *The Master Plan: A Guide for the Development of Fishery Management Plans*, August 2001.
2. FMP = Fishery Management Plan. Abbreviations for various FMPs:
   AB =Abalone Recovery and Management Plan (DFG)
   CP =Coastal Pelagic Species (PFMC), and CP* *=Monitored species only for the Coastal Pelagic Species Fishery Management Plan. Pacific Fishery Management Council has deferred management of squid to the State as long as management is consistent with federal

List of all marine algae, vascular plants, invertebrates, and fishes that are managed by the State of California[1]				
Common name	**Scientific name**	**FMP[2]**	**Reason(s) for exclusion[3] (notes)**	**Type of review[4] (review title for reviews covering multiple species)**
regulations. GF=Groundfish (PFMC) HM=Highly Migratory Species (PFMC), and HM*=Species included in the plan if it becomes targeted or significant bycatch, discard, or incidental catch. NS=Nearshore Fishery (DFG) S=Salmon (PFMC) WS=White Seabass (DFG) (Agencies responsible for drafting the plan: California Department of Fish and Game (DFG) and Pacific Fishery Management Council (PFMC)) 3. The reasons for excluding species or species groups from the *Status of the Fisheries Reports*: 1. Not the subject of a directed fishery, harvest is relatively minor or harvest is periodic 2. Harvest is prohibited 3. Included in a Pacific Fishery Management Council fishery management plan and not the subject of a State recovery of fishery management plan 4. Not specific (that is, not a single species or a group of species) 5. Estuarine or freshwater species, or species that resides primarily outside of state waters 4. Type of review: Full or Limited				

Appendix B
Data Sources for this *Annual Status of the Fisheries Report*

Three primary types of fishery-dependent data (that is, data collected directly from the fishery) were used in this *Annual Status of the Fisheries Report* (ASFR):

- Commercial landing receipts for commercial landings
- Marine Recreational Fisheries Statistics Survey (MRFSS) for estimates of recreational catch
- Commercial passenger fishing vessel (CPFV) logbooks for landings of recreational catch from CPFVs

Some reviews used other fishery-dependent and fishery-independent data sources; these sources are described in the individual reviews.

Commercial Landing Receipts

Landing records for California's commercial fisheries have been collected and compiled since 1916. The landing records are in the form of landing receipts, also commonly called market receipts, dealer receipts, fish tickets or pink tickets. Each landing receipt contains the following information:

- Weight of the finfish or shellfish landed by market category (general groupings of fish that are not species-specific)
- Price paid to the fisherman by market category
- Date the fish was landed
- Type of gear used to harvest the fish
- Port of landing
- General location where the fish was harvested

By law, a fish buyer must complete a landing receipt when the fishermen delivers the fish, and must submit the landing receipts to the DFG on a semi-monthly basis.

Fish buyers sort finfish and shellfish into market categories that often contain more than one species. Commonly, buyers group fish by value (price per pound) or some other criteria.

Marine Recreational Fisheries Statistics Survey

MRFSS has collected data on recreational catch of finfish (not on shellfish) in California since 1979. Data are available from 1980 through 1989 and from 1993 through the present. Field survey and telephone survey data are combined to produce estimates of fishing effort and catch. In the field survey, fishery technicians interview anglers at the end of the angler's fishing day and sample the anglers' catch. The information collected in the field survey includes:

- Number of fish caught by species
- Length, weight and sex of each fish (when possible)
- General catch location

- Amount of time spent fishing
- Mode of fishing

The randomized phone survey of households in coastal counties collects data on fishing effort such as:

- Number of anglers per household
- Number of fishing trips per two-month period
- Fishing mode and location of each trip

MRFSS estimates catch and effort by species, area, and fishing mode, and can provide separate estimates for the area north of Point Conception (Santa Barbara County) and for the area south of Point Conception. It can also provide separate estimates for each mode: fishing from beaches or banks, from man-made structures such as piers and jetties, from private of rental vessels, and from CPFVs. MRFSS estimates the total number and weight of the fish that were:

- Caught, landed whole and available for identification by fishery technicians
- Caught but not available for identification by fishery technicians because they were released dead, given away or filleted
- Caught and released alive

In the ASFR, the total number and weight of the fish removed from the fishery resource (the sum of the fish that were caught, landed whole and available for identification by the fishery technicians and the fish that were caught but not available for identification) is used.

Commercial Passenger Fishing Vessel Logbooks

Since 1936, operators of CPFVs in southern California have been required to record data on individual fishing trips in a logbook and then submit the logbook to DFG. The CPFV logbook program was suspended for a six-year period during World War II (1941 to 1946), but resumed again in 1947. In 1957, CPFV operators in northern California were also required to submit logbooks. The data collected includes:

- Number of anglers
- Number of hours fished
- General fishing location
- Port of departure
- Type and number of fish caught and number of discards

The CPFV logbooks provide the landings reported by CPFV operators and submitted to DFG, while MRFSS provides an estimate of catch by CPFVs.