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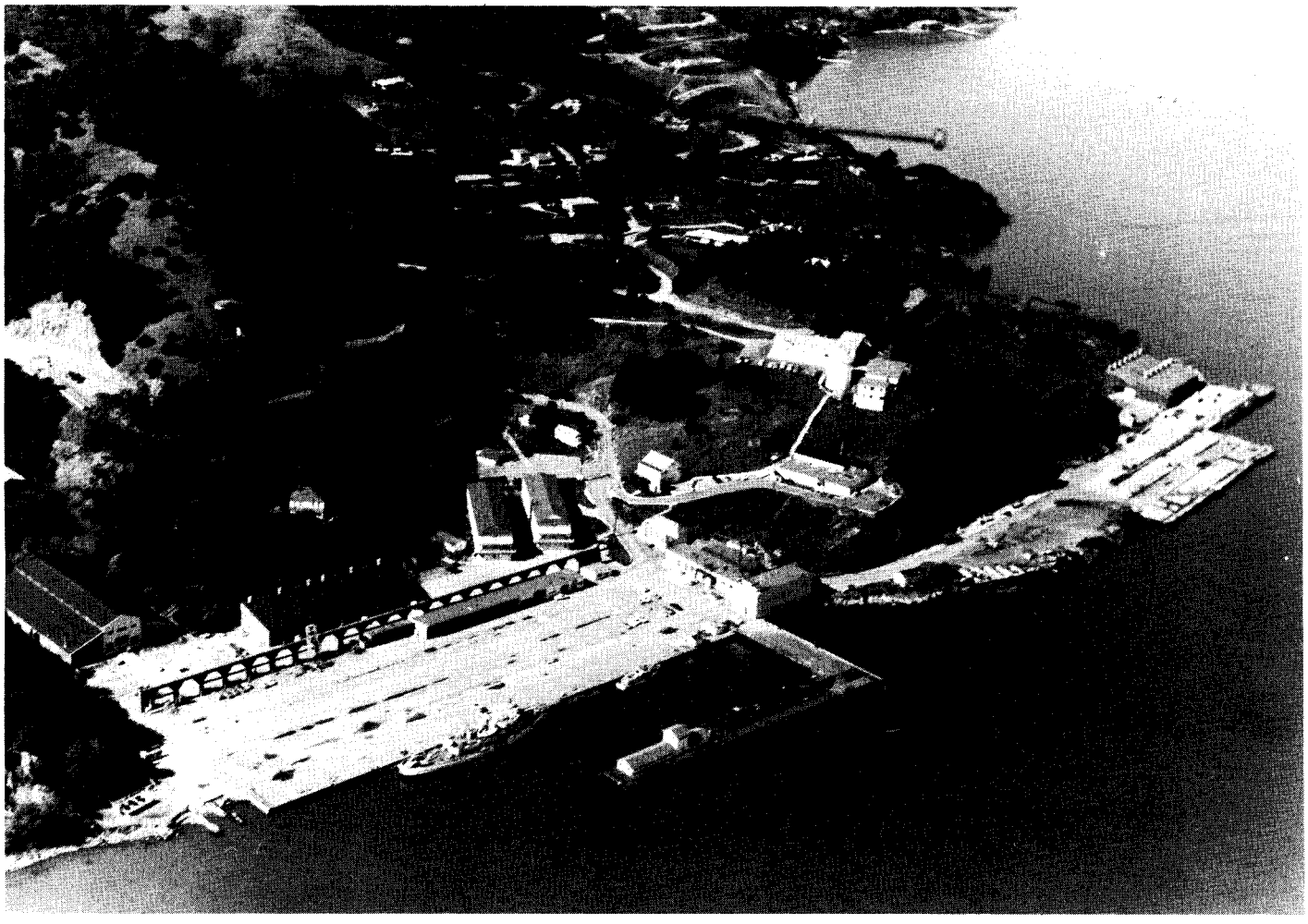
GUIDE TO UNDERUTILIZED SPECIES OF CALIFORNIA

by the staff,

Underutilized Fishery Resources Task



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INTRODUCTION

This guide was prepared by the Underutilized Fisheries Resources staff of the Tiburon Laboratory, National Marine Fisheries Service. The Laboratory is part of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), Southwest Fisheries Center. Staff members are: Susumu Kato, William Leet, Sennen Salapare and Patrick Rutten. Susan Pollock and Frank Jacques, formerly of the Tiburon Laboratory, also helped prepare material for this publication. Much information was supplied by the Statistics Division of California Fish and Game, while most drawings were drafted by Ken Raymond of Southwest Fisheries Center, La Jolla.

The chief purpose of this guide is to provide information to foreign buyers about the seafood products available in California. Most of the species described here are considered "underutilized"; that is, we feel that production could be increased if a favorable market existed. Also included are some fishes that are presently being used to near capacity, but which may have certain by-products or size groups which are not presently fully utilized. Examples are small individuals of certain flatfishes and rockfishes, and by-products such as fish eggs.

For each species, we give a brief description of the life history, distribution, abundance, and present fishery. We also point out some new processing or marketing ideas which may be of commercial significance. The descriptions will be updated from time to time, and new species descriptions will be added periodically. We have the names and addresses of everyone who has a guide, and plan to periodically send each person additional information. An open Table of Contents is provided so users can index the new material in proper sequence.

The introductory section is numbered consecutively with Roman numerals. Beginning on Page 1, Arabic numerals are used to number the pages containing species descriptions. At the end of the guide are a number of Plates, numbered consecutively; these contain photographs of the species described.

We hope that this booklet is useful both to potential buyers and suppliers. Any comments for improving the guide would be appreciated. Please direct all such comments to:

Director, Tiburon Laboratory
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3150 Paradise Drive
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BRIEF DESCRIPTION OF THE CALIFORNIA FISHERIES

In 1981, about 8500 vessels and 19,000 persons were engaged in commercial fishing in California. Most of the vessels were under five net tons, but many larger vessels such as the huge "superseiners" are also based in California. Recently a number of large trawling vessels capable of midwater trawling have appeared on the scene.

The principal fishing ports are shown in Figure 1. In general, many of the bottom-dwelling food fishes are caught off central and northern California by approximately 180 trawlers, while industrial fishes (mackerels, anchovy) are caught mainly off Southern California, by purse seiners.

Well over a hundred species are caught by California commercial fishermen. Of these, the following were the principal fish landed (tunas excluded) by California fishermen in 1981:

SPECIES	AMOUNT LANDED
Northern anchovy	52,000 mt
Pacific mackerel	42,000
Market squid	22,500
Jack mackerel	15,500
Rockfish (several species)	17,100
Sea urchin	10,900
Pacific bonito	7,500

Many other species landed in lesser amounts are highly valued, such as chinook and coho salmon, dungeness crab, abalone, herring, and ocean shrimp.

Figure 1. Major landing ports in California.

FISHING GEAR AND METHODS

A variety of gear and methods is necessary for catching the different species of fish. The following account outlines the major fishing methods used by California fishermen.

1. Purse seine (Fig. 2)

This is essentially a large roundhaul or surround net which can be closed (pursed) at the bottom to trap fish that are encircled. In California, this is a one-boat operation, although a small powered skiff is usually used to help in setting and brailing operations, as well as in towing the vessel while the net is being hauled, to keep the vessel from drifting over the net. Species caught by purse seine are the tunas (except albacore), bonito, anchovy, mackerels, squid and herring. Nearly all seiners work out of southern California and land their catches at San Diego, San Pedro, or Port Hueneme. A few seiners work out of Monterey and San Francisco, catching anchovy and herring. Purse seining is an efficient fishing method and is cost-effective for catching the cheap "industrial fish" like anchovy and mackerels, which are used in making fish meal and pet food. The method is quite selective, and by-catch is minimal.

California state laws govern the use of purse seines, specifying the species that can be taken, as well as areas where they can be used.

Most "local" seiners (i.e., other than tuna vessels) carry a crew of about 10 persons. Around 30 seiners are based at San Pedro and Port Hueneme, while two or three seiners fish out of Monterey. During winter, a number of out-of-state seiners fish in San Francisco Bay for herring.

2. Otter Trawl (Fig. 3)

Otter trawls are towed nets whose horizontal opening is maintained by hydrodynamic forces acting on otter boards or "doors". The nets are funnel shaped and can be dragged on the bottom to catch groundfish, or towed in midwater to catch pelagic fish. The trawl warps (cables running from boat to doors), the bridles (cables running from doors to net) and net wings (side panels) all serve to herd fish inward toward the net opening where, as they gradually become fatigued, they fall back into the cod end. Regulations on trawl nets include mesh size, areas in which they can and cannot be used, as well as species limitations. The trawl fishing in California is confined mostly to waters north of Santa Barbara, where the continental shelf is several times wider than in the south. Trawling is restricted in most areas to outside of three miles from shore.

3. Gill Net (Fig. 4)

Gill nets are rectangular nets which entangle fish that swim into them. The net can be set adrift with ocean currents or anchored in a stationary set. In addition, the net can be set to fish at any depth by varying the length of anchor and float lines. Regardless of how the net is set, the catch is a result of the fish swimming into the net and becoming entangled in the meshes of the netting. Thus the net must be placed in a location

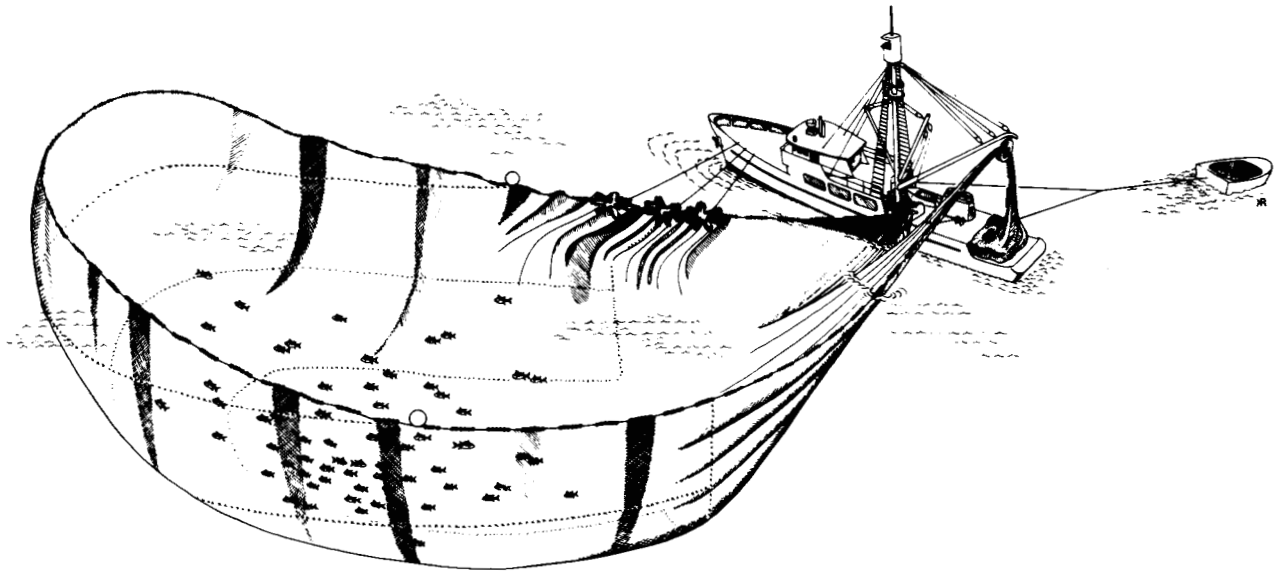


Figure 2. Purse seine

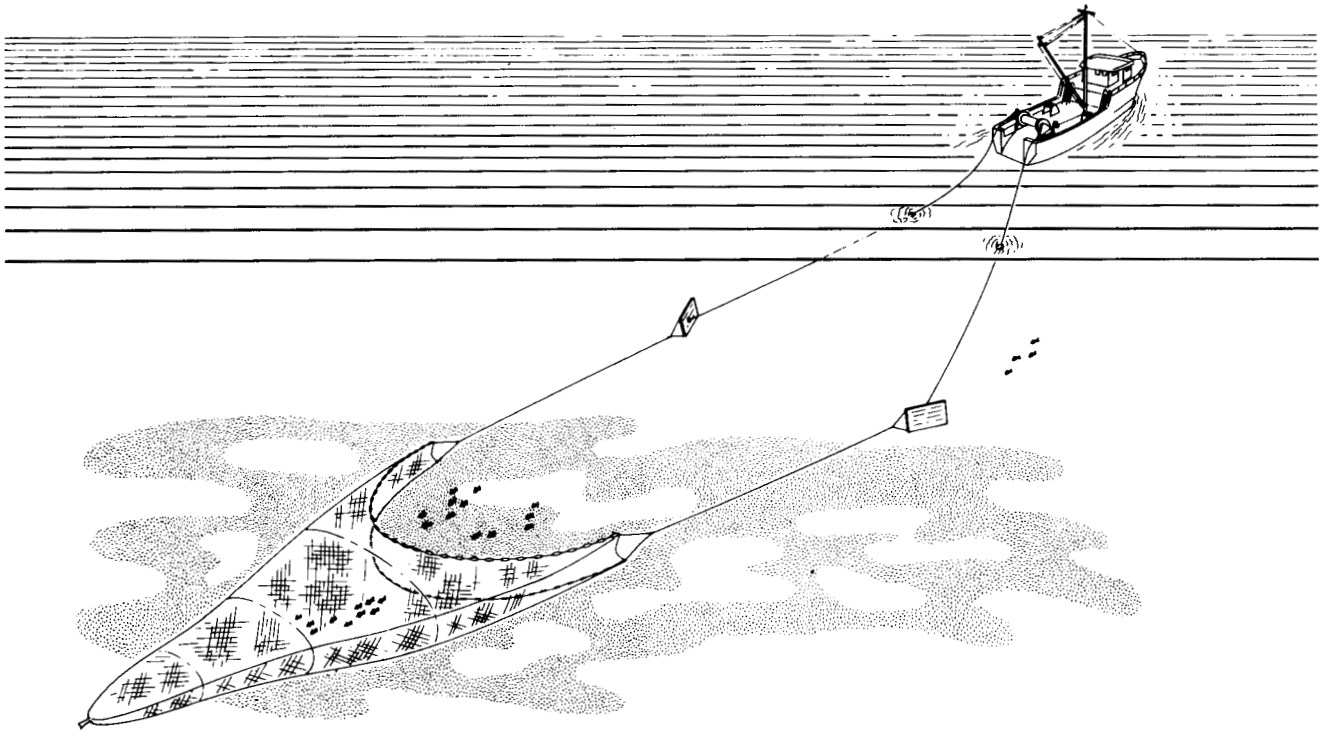


Figure 3. Otter trawl.

where fish are suspected to be on the move. Trammel nets are similar, but have three walls of webbing instead of a single one. Regulations on gill nets include mesh size, area and species limitations.

4. Trolling (Fig. 5)

Trolling is a fishing technique wherein hooks affixed to a fishing line are towed through the water behind a boat. Fish are attracted to the hooks by artificial lures or natural bait. The species which most commonly are caught commercially by trolling are albacore tuna and salmon. In the albacore troll fishery feathered jigs towed near the surface are often used as lures. Salmon trollers (depicted in the figure) are rigged to tow bait or lures at varying depths. Many salmon trollers stay at sea for several days, the catch being gilled and gutted and then stored on ice. Most albacore trollers are capable of freezing the catch and may stay at sea for several weeks. Trolling is a legal fishing method in nearly all areas.

5. Longline (Fig. 6)

Another hook and line technique is longlining. The method involves setting a long length of line (ground line) to which short lines (gangions) with baited hooks are attached at varying intervals. With bottom longlines, the ground line, which is anchored, is left unattended for a period of time and then hauled aboard the attending vessel, usually with a specially designed longline puller. Floating or drifting longlines are similar in makeup. Dimensions of the gear vary widely, depending on target species and depth of the set. When fishing for demersal species such as halibut and sablefish, the ground line is fished at the bottom. Pelagic species such as tuna are caught with drifting longlines with hooks placed at desired depths below the surface. In such an arrangement, surface buoys are used to keep the line at the desired depth. Some restrictions apply to the use of longlines.

6. Traps (Fig. 7)

Traps are used in a variety of fisheries but are especially adapted to crustaceans, such as crab and lobster, which walk about on the bottom looking for food. They may be constructed in a variety of shapes and materials. Usually they are baited to attract the target species, and they normally have one or more funnel shaped openings that make entry easy and escape difficult. Such is not the case with octopus traps, which have an open side and are usually not baited. Octopus use them as lairs. Traps are also used off California for sablefish, certain prawns, and are suggested for Kelletia, a marine snail. A special permit is usually required from California Department of Fish and Game to use traps.

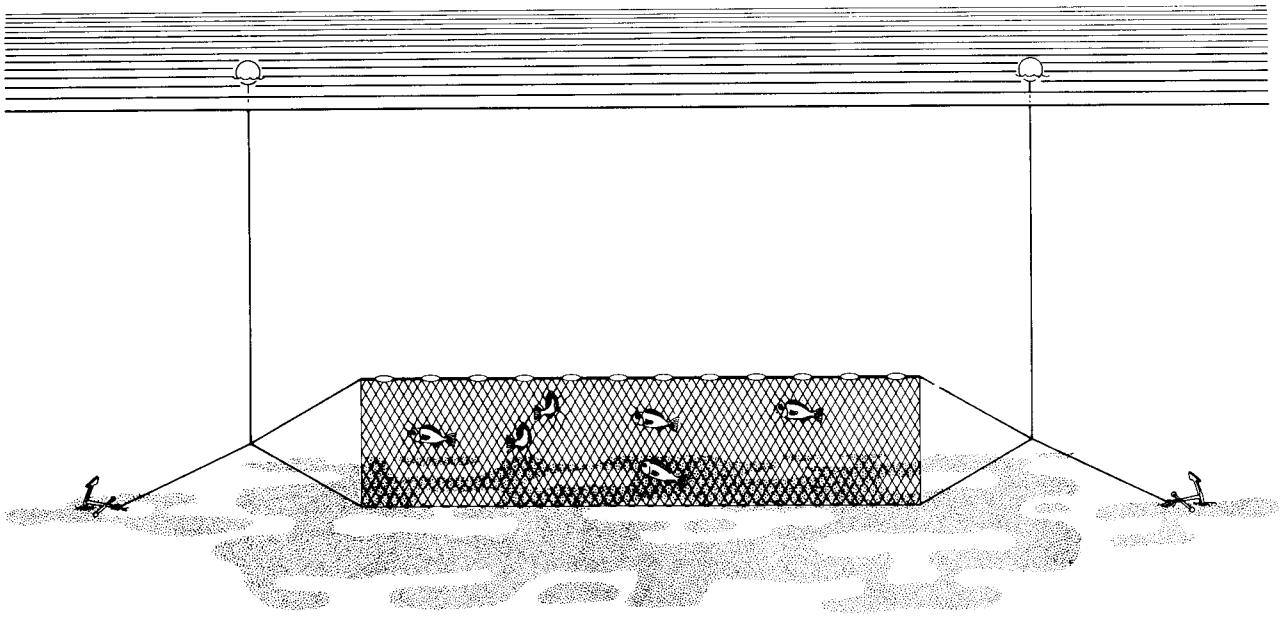


Figure 4. Gill net.

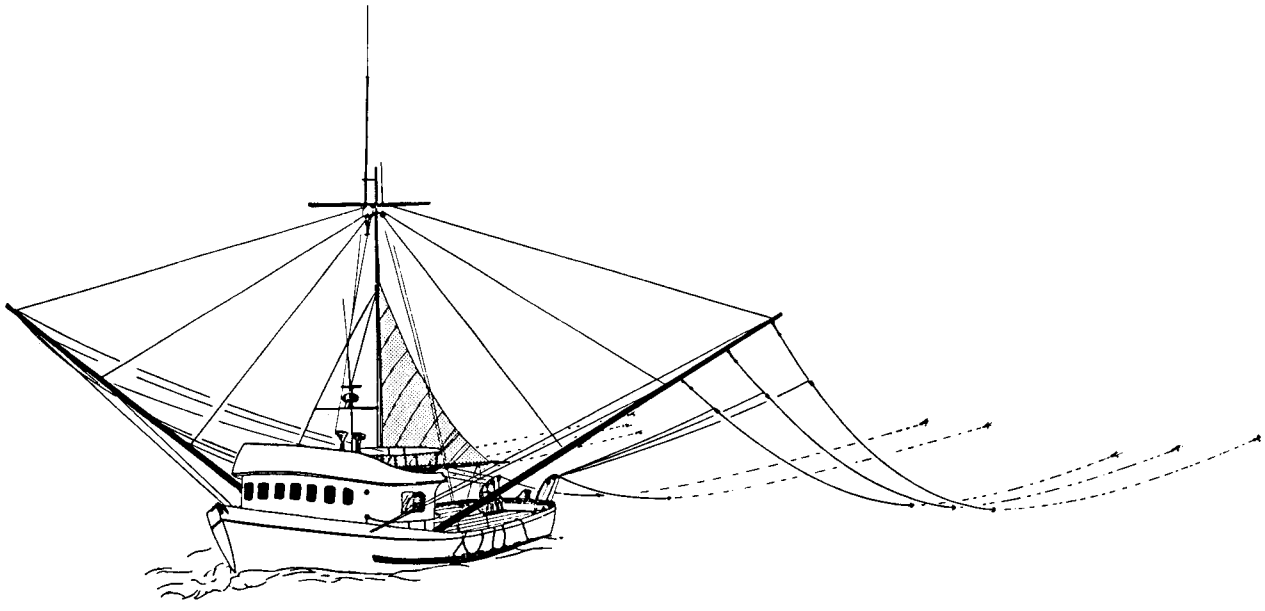


Figure 5. Troller.

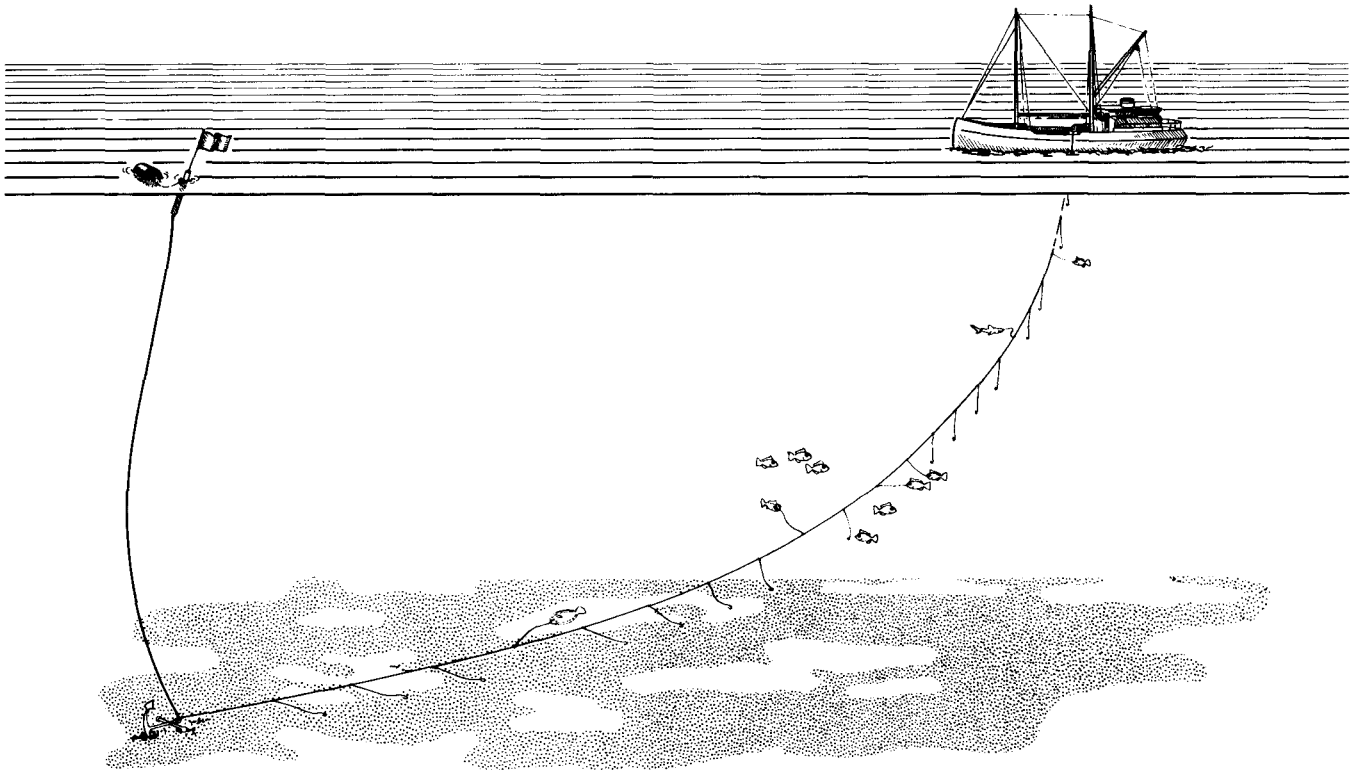


Figure 6. Longline.

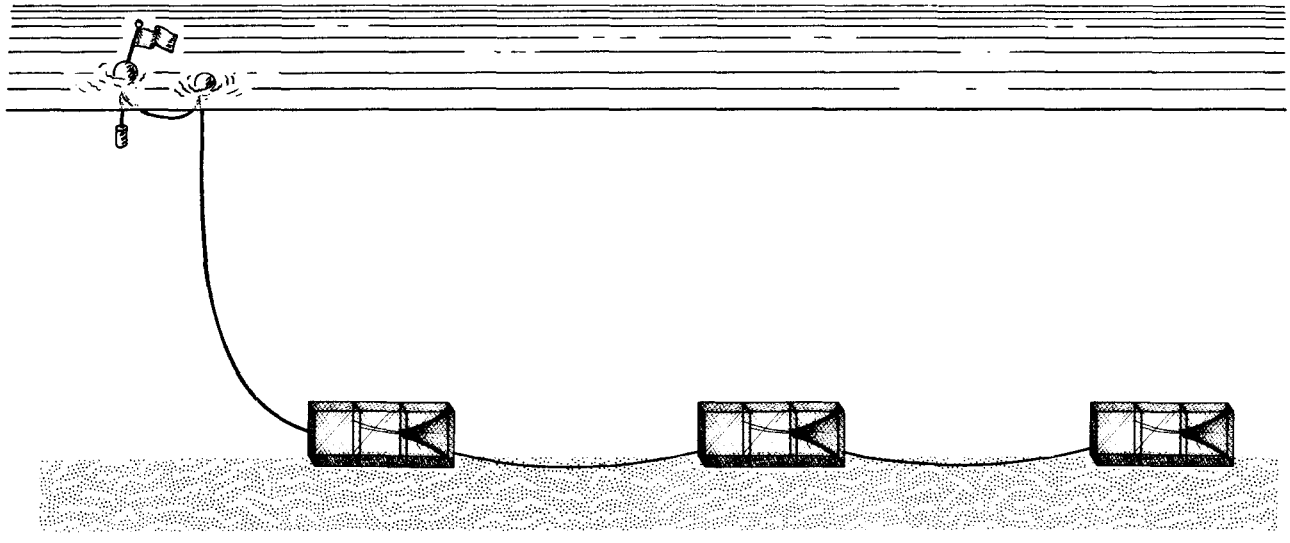


Figure 7. Trap.

SHORTBELLY ROCKFISH, Sebastes jordani (Plate I, Nos. 1 and 2)

Japanese name: Hime-mebaru
Similar fish in Japan: Yanagi-mebaru (Sebastes itinus); Hatsume (S. owstoni)

1. Introduction: Shortbelly rockfish is the most abundant rockfish (family Scorpaenidae) in the California Current. Commercial fishing for this species has not yet begun (June 1983), but extensive biological and market research have been conducted. A Russian-American joint venture project harvested 650 tons in two weeks, with two American trawlers catching all the fish.

2. Description: A small rockfish species, averaging about 25 cm and 180 g; maximum length about 32 cm. Pink-red color, darker above and whitish near belly; other characteristics include a vent well forward of anal fin and strongly forked tail.

Proximate analysis:

	November	March
Crude protein	17.5	17.4%
Total fat	6.4	0.9
Total moisture	74.1	80.0
Ash	1.8	1.4
Crude fiber	0.2	0.3

3. Life history notes:

Distribution: Geographical--Oregon to Baja California; concentrated primarily between San Francisco and Point Sur, California. Depth--mostly in 150-250 m, but can be found in considerably greater depths; often found off bottom. Seasonal--found throughout the year, but may be most common near San Francisco in summer.

Migration: Spawning migrations may occur in winter, when some mature shortbelly may possibly move to southern California waters.

Food and feeding: Diet consists primarily of euphausiid shrimps; shortbelly rockfish probably feed mostly at night, well off the bottom.

Behavior: Forms compact schools near bottom during the day; more dispersed at night, and generally found higher up in the water column, but still concentrated in fishable groups.

Reproduction: Spawning season starts around January and ends in late April; fecundity rather low, about 16,000 eggs per adult of 240 mm; viviparous; age at maturity about 2 years.

Age and growth: Grows rather fast for a rockfish, reaching 240 mm by age four.

4. Population dynamics and management:

Population size: At least 300,000 tons of mature fish off California in 1977.

MSY: About 40,000 tons.

OY: 10,000 tons in 1982, with increase of 20 percent each year thereafter until MSY is reached, unless the population shows signs of stress.

Management: By the Pacific Fisheries Management Council, Groundfish Management Plan.

5. Fishing methods: Midwater trawls are effective, but the fish can be also caught with bottom trawls. Catch rate of about 15-20 tons per day is feasible. No commercial fishery at present.

6. Product forms: Frozen whole fish is most feasible, but could also be headed and gutted. Machine-filleting is possible, but likely to be expensive.

7. Reference: Lenarz, W. H. 1980. Shortbelly rockfish, Sebastes jordani: a large unfished resource in waters off California. Marine Fisheries Review, March-April 1980:34-40.

PACIFIC SANDDAB, Citharichthys sordidus (Plate I, Nos. 3 and 4)

Japanese common name: Medama birame

1. Introduction: The Pacific sanddab is a small flatfish belonging to the family Bothidae (left-eyed flounders). Sanddabs are considered a delicacy and are abundant, but the catch has remained low because the fish has traditionally been marketed fresh only, mainly to restaurants.

2. Description: Average size 225 mm, 135 g; maximum length 400 mm; color light brown; scales rather large for flatfish, eyes on left side.

3. Life history notes:
Distribution: Geographical--entire California coast. Depth--mostly 35-110 m.

Seasonal--available throughout year, but scarce in some areas during late fall and winter.

Migrations: Not known, but apparently leaves traditional fishing grounds at times.

Food and feeding: Diet consists primarily of crustaceans, polychaete worms, and molluscs.

Behavior: Inhabits sandy bottom, but often swims off bottom to feed, especially at night.

Reproduction: Spawning season from July to early September; individuals spawn more than once during a season.

Age and growth: Growth rapid through fourth year (225 mm), then slows; average 10-year-old fish measures around 300 mm.

4. Population dynamics and management:
Population size: Unknown.

MSY and OY: Unknown.

Management: Pacific Fishery Management Council, through Pacific Coast Groundfish plan.

5. Fishing methods: Caught primarily by bottom trawling with otter trawls; most of the catch comes from central and northern California; annual California catch around 450 mt, can be increased considerably.

6. Product forms: Now mostly sold fresh, gilled and gutted, or headed and gutted, and sometimes with the fins trimmed; can be partially dried.

7. Reference: Arora, H. L. 1951. An investigation of the California sanddab, Citharichthys sordidus (Girard). Calif. Fish and Game 37(1):3-52.

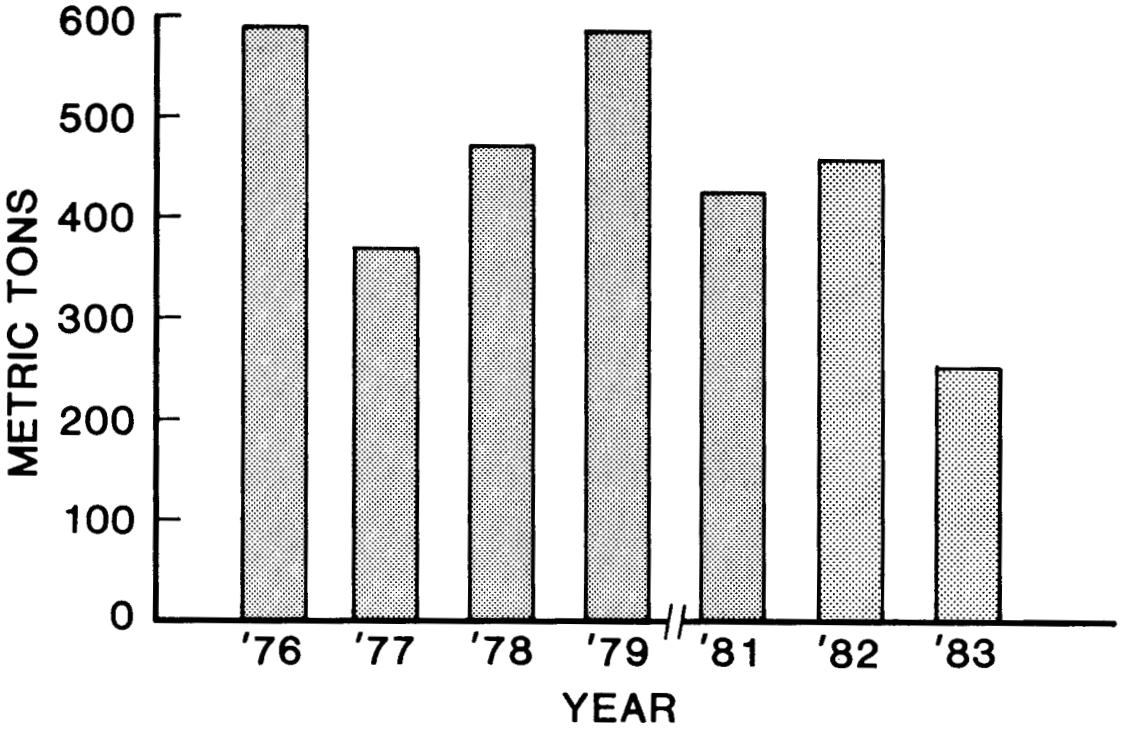


Figure 8. Annual landings of Pacific sanddab in California.

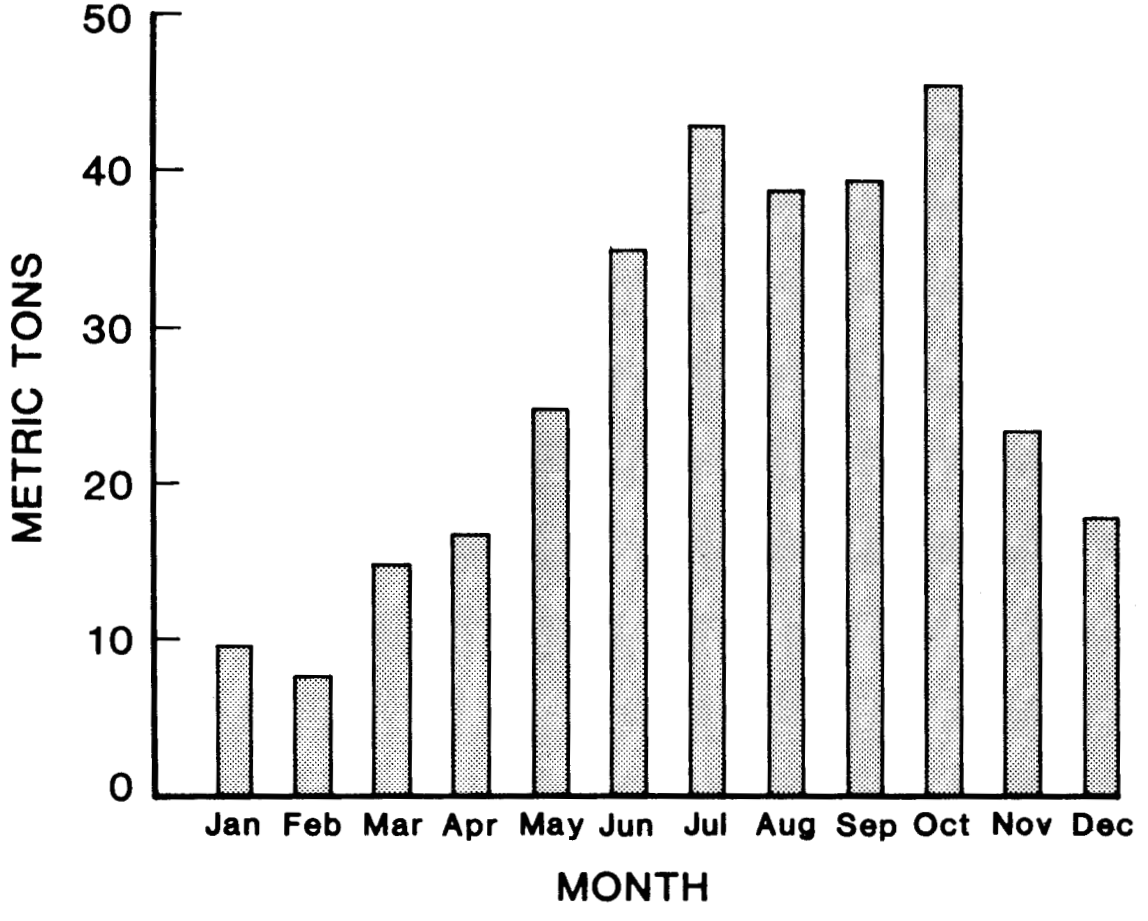


Figure 9. Average monthly landings of Pacific sanddab in California, 1974-81 (excluding 1979 and 1981).

JACK MACKEREL, Trachurus symmetricus (Plate 2, No. 1)

Japanese name: America Aji

Similar Japanese species: Trachurus japonicus (Ma-aji)

1. Introduction: Jack Mackerel (family Carangidae) has been landed commercially in California since 1888, but was of minor commercial value before 1947, when a change in the name from horse mackerel to jack mackerel improved consumer acceptance of the species. The canned product is used for human consumption and pet food.

2. Description: Average commercial size 20-30 cm; larger fish available, but not harvested; color metallic blue to olive green above, silvery below.

Proximate analysis:	May 1981	June 1981
Total protein	19.0%	20.3%
Total fat	4.4	0.7
Moisture	74.0	77.3
Crude fiber	0.3	0.1
Ash	2.2	1.4

3. Life history notes:
Distribution: Geographical--entire California coast, with smaller jack mackerel concentrated in southern California and larger ones found further offshore in deeper water along central and northern California. Depth--usually in shallow waters, or near surface; can also be found in depths over 200 m or more. Seasonal--found throughout year in southern California.
Migrations: Inshore-offshore as well as coastal migrations.
Food and feeding: Feeds primarily on euphausiids, copepods, pteropods, juvenile squid and anchovy.
Behavior: Tends to inhabit rocky offshore bank areas, islands with rocky perimeters, and shallow rocky coastal areas; moves to deeper water during the night; large jack mackerel are either solitary or form small, loose schools, but sometimes aggregate in large numbers.
Reproduction: Females mature between ages 1 and 3. Spawning occurs from March through September, mostly south of Pt. Conception. Large females normally spawn more than once during a season; eggs epipelagic, hatch into larvae in 4-5 days.
Age and growth: Weight gain is most rapid through the 5th year; maximum length 560 mm and 1900 gm at age 25.

4. Population dynamics and management:
Population size: Total spawning biomass probably around 1-2 million tons; mortality rate relatively low; potential yield of small fish probably around 50,000 tons; larger fish have considerably less potential yield.
MSY: Unknown, probably within 50-250 mt; OY - not established.
Management: State of California; no season, size limits, or quotas.

5. Fishing methods: Primarily purse seine, landed in San Pedro, Terminal Island or Port Hueneme; large fish caught with otter trawls.

6. Product forms: Primarily canned, headed and gutted, for human consumption and pet foods; offal reduced for fish meal; some fish sold fresh or frozen.

7. Reference: MacCall, A.D., H.W. Frey, D.D. Huppert, E.H. Knaggs, J.A. McMillan, and G.D. Stauffer. 1980. Biology and economics of the fishery for jack mackerel in the Northeastern Pacific. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFC-4

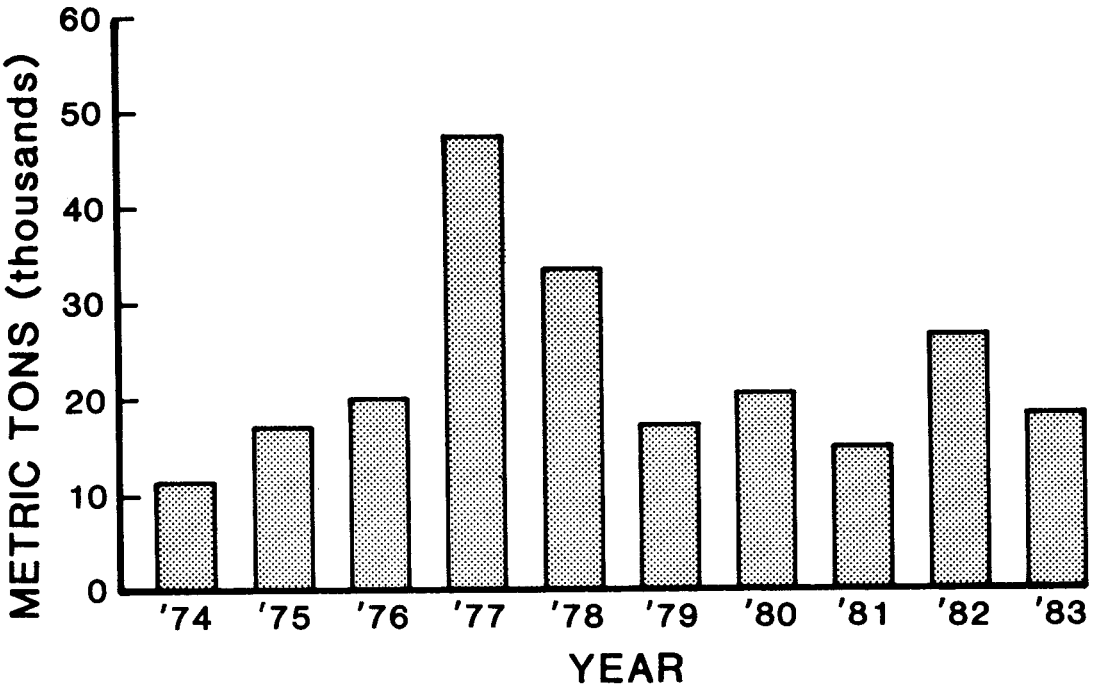


Figure 10. Annual landings of jack mackerel in California.

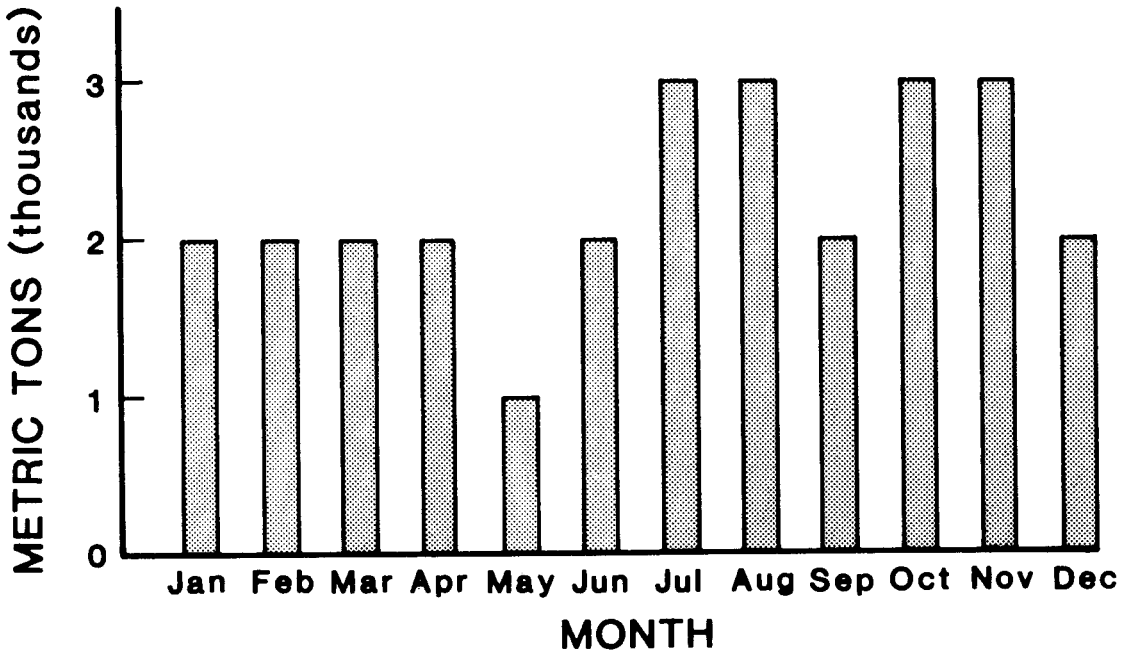


Figure 11. Average monthly landings of jack mackerel in California, 1974-81.

OCEAN SUNFISH, Mola mola (Plate 2, No. 2)

Japanese name: Mambō

Japanese species: Same

1. Introduction: Mola mola is an epipelagic fish that is found in all temperate and tropical seas of the world. It is relished by a few fishermen in many countries, but is not often seen in the market.

2. Description: A large species, up to 3-4 m long by 2 m high, and weighing more than 680 kg. Average fish weight around 10-45 kg. Shape oval, with silver sides; no tail fin or pelvic fins; high dorsal and anal fins, located well torwards the posterior section of the body; small terminal mouth; no scales; thick layer of cartilage beneath skin.

3. Life history notes: Geographical--entire California coast. Depth--epipelagic, often seen on the surface.

   Migrations: Commonly present south of Pt. Conception during winter and spring, and north of Pt. Conception during summer.

   Food and feeding: Sunfish are known to feed on medusae, salps, crustaceans, molluscs, hydroids and algae. When a jellyfish is eaten, it is consumed with a loud sucking noise which can be heard some distance away.

   Behavior: Sunfish are often seen on the surface lying on their sides, moving their dorsal and anal fins slowly.

   Reproduction: Spawning grounds located near 30^{o}N latitude and 130^{o} E longitude, northwestern Pacific Ocean. One female (1.37 m) was found to contain 300 million eggs. The eggs and larvae are free-floating.

4. Population dynamics and management:
   Population size: Unknown.

   MSY and OY: Unknown.

   Management: California Department of Fish and Game, no specific regulations apply.

5. Fishing methods: Incidentally caught in mid-water trawls and purse seines, and shark gill nets. Harpoons should be effective.

6. Product form: Not generally utilized for either sport or commercial use. A few people consider them a delicacy. The texture and taste of the flesh is reminiscent of shellfish.

7. Reference: Fitch, J. E. and R.J. Lavenberg,1971. Marine Food and Game Fishes. Univ. of Calif. Press, Berkeley, California.

OCEAN WHITEFISH, Caulolatilus princeps (Plate 2, No. 3)

Japanese name: Uguisu amadai

Similar Japanese fish: Amadai (Branchiostegus spp.)

1. Introduction: This species is not held in high regard presently, but is perhaps one of the best "sashimi" fish on the west coast. It will no doubt be "discovered" soon by the growing numbers of "sushi" enthusiasts. Some fish caught in shallow water are reported to be bitter.

2. Description: A handsome fish, with long dorsal and anal fins and small scales. Color is brownish-green above, lighter below, with yellowish tail. Adults commonly are around 50 cm and 1.5 kg.

3. Life history notes:
Distribution: Geographical--British Columbia to Gulf of California, and from South America; in California, rare north of Pt. Conception. Depth--10-130 m, over rocky grounds. Seasonal--probably present all year.

Migration: Unknown; possibly moves north from Mexican waters.

Food and feeding: Diet consists of various small organisms, including shrimps, pelagic red crab, euphausiids, squid, anchovy and lanternfish.

Behavior: Occurs in shallow water as well as fairly deep, and juveniles may be found well off-shore.

Reproduction: Mature fish found from October through April.

Age and growth: Somewhat slow-growing; thirteen-year-old fish measured 64 cm and weighed 3.4 kg; maximum size around 100 cm and over 5 kg.

4. Population dynamics and management:
Population size: Unknown.

MSY and OY: Unknown.

Management: California Department of Fish and Game; no specific regulations apply.

5. Fishing methods: Taken incidentally in commercial hook-and-line fishery; annual catches usually under a ton; commonly caught by recreational anglers.

6. Product forms: Normally sold fresh, but could be processed and frozen.

7. Reference: Fitch, J.E. and R.J. Lavenberg, 1971. Marine Food and Game Fishes of California. Univ. of Calif. Press, Berkeley. 179 p.

NIGHT SMELT, Spirinchus starksi (Plate 2, No. 4)

Japanese name: Shishamo

Similar fish in Japan: Spirinchus lanceolatus (Shishamo)

1. Introduction: Night smelt fishing is a popular recreational pastime; a small commercial fishery has also existed for many years. The fish is mild-flavored and delicious, but the mouth and gills may contain sand grains of various size.

2. Description: A small species, average adult size around 125 mm; sides silver, brownish-green on back.

3. Life history notes:
Distribution: Geographical--Pt. Arguello to Shelikof Bay, Alaska; occurs in bays, estuaries and inshore areas along the outer coast. Depth--surface to 125 m.

Migrations: Spawning migrations occur in late spring and summer.

Food and feeding: Feed on small shrimplike crustaceans.

Behavior: Prefer coarse sand; spawning runs are erratic, apparently not correlated with tides; males congregate in dense schools in shallow waters, where they outnumber females eight to one at the height of a run and 100 to one at the end; offshore catch has shown equal numbers of males and females.

Reproduction: Spawning takes place at night from mid-March to fall months.

Age and growth: No information available.

4. Population dynamics and management:
Population size: Not known, catches have exceeded around 45 t in a year.

MSY and OY: Unknown.

Management: California Department of Fish and Game.

5. Fishing methods: Taken in the surf with A-frame dip nets, or small hand seines. Can also be caught from piers with hook and line.

6. Product forms: A delicious food fish, sold entirely in fresh fish markets, often for bait.

7. Reference: Frey, H.W. (Ed.), 1971. California's Living Marine Resources and Their Utilization. State of California, Resource Agency, 148 p.

BASKING SHARK, Cetorhinus maximus (Plate 3, No. 1)

Japanese common name: Ubazame

Japanese species: Same

1. Introduction: Basking sharks are huge, second only to whale sharks in size. A fishery existed for this species in California in the 1940's and early 1950's, and again around 1969. The object of the fishery was the liver, which weighs up to 20 percent of the total weight. Renewed interest in this shark stems from new uses for the flesh. Also, they are a nuisance in the developing gill net fishery in southern California.

2. Description: Average size around 7 m and 2500 kg, with liver weighing over 500 kg. The meat is used in northern Japan.

3. Life history notes:
Distribution: Geographical--from San Diego, California to British Columbia; plentiful at times near Santa Barbara, Morro Bay, Monterey Bay, and Humboldt Bay. Depth--often seen on the surface, but apparently also spends time on the bottom. Seasonal--generally common in southern California around February, and in the summer off Morro Bay.

   Migration: Seems to undergo annual migration, moving from southern to northern California from February to August.

   Food and feeding: Diet consists primarily of plankton, mostly copepods; feeds right at the surface, usually during early morning and late afternoon.

   Behavior: Thought by some to hibernate during certain seasons.

   Reproduction: Little known; very few embryos have been found, and they seem to occur singly or at most, two per female.

   Age and growth: Not known.

4. Population dynamics and management:
Population size: Unknown; hundreds have been seen in schools by airplane pilots.

   MSY and OY: Unknown, but low fecundity suggests that overfishing may easily occur.

   Management: California State regulations; no quotas or seasons apply.

5. Fishing methods: Caught principally with heavy hand-thrown harpoons; many are caught accidentally in gill nets.

6. Product forms: Earlier fisheries used only the liver oil, which is valuable for its squalene content (about 50 percent squalene); flesh can be used, as well as the skin, and perhaps the fins.

7. Reference: Kato, S., S. Springer and M. H. Wagner. 1967. Field Guide to Eastern Pacific and Hawaiian Sharks. Fish and Wildlife Serv., Circular 271, 47 p.

RATFISH, Hydrolagus colliei (Plate 3, No. 2)

Japanese name: Zōginzame

Similar fish in Japan: Callorhynchus millii (Zōginzame)

1. Introduction: Ratfish is the only member of the family Chimaeridae found off California. It is an important food for soupfin shark and Pacific halibut.

2. Description: A cartilaginous species, length almost reaching one meter. Body with bronze metallic hue, silvery below with numerous white spots. The spine is venomous and reproductive organs toxic.

3. Life history notes:
Distribution: Geographical--northwest Alaska to northern Baja California. Depth--shallow water to 365 m; most abundant in about 75 m; large individuals predominate in shallow water, and smaller ones in deeper water.

Migration: Tends to be in slightly shallower water in spring and deeper water in fall.

Food and feeding: Diet consists of small fishes and invertebrates; shrimp (Pandalus and Crago), mollusks (Musculus and Amphissa), and echinoderms (Brisaster) are the most important food.

Behavior: Smaller ratfish tend to move onshore at night.

Reproduction: Peak reproductive period is summer, although one-third of females and all of males exhibit reproductive activity throughout the year. Sexual maturity is reached at 24-25 cm for females and 18.5-20 cm for males.

Age and growth: Attempts to age fish on the basis of length-frequency distributions have not been completed.

4. Population dynamics and management:
Population size: Unknown.

MSY and OY: Unknown.

Management: California Department of Fish and Game; no specific rules apply.

5. Fishing methods: Usually caught by otter trawls, as a by-catch. No commercial fishery at present.

6. Product forms: Liver oil of fish is an excellent lubricant and could be used commercially. Flesh has little economic value, but apparently is edible.

7. Reference: Johnson, A.G. and H.F. Horton. 1972. Length-weight relationship, food habits, parasites, and sex and age determination of the ratfish, Hydrolagus colliei (Lay and Bennett). Fish. Bull. 70(2): 421-429.

FISH EGGS FROM GROUNDFISH

1. Introduction: Besides the more popular fish egg products used in Japan (herring, salmon, sea urchin, etc.), roe from other species is available during certain seasons. These can be taken primarily from groundfish, except flatfish, which are caught by trawls and traps.

2. Description: The groundfish catch is made up mainly of sablefish (gindara) and the many species of rockfish (mebaru-rui). Groundfish generally spawn in winter in northern California, where most of the catch is taken. Thus developing roe can be expected from around summer to the end of the year. Ovaries are of varied size and color, depending on season and species, and the size of the individual eggs is also variable.

3. Amount available: About 20-30,000 tons of rockfish and sablefish are taken annually in California. If the roe make up 10 percent of the total weight of the females, perhaps 500 tons of fish roe may be available in California.

4. Product forms: Roe can be processed and packed according to the buyers' requirements. Since the ovaries will be collected after the filleting process, many of the ovaries are likely to be damaged.

MARKET SQUID, Loligo opalescens (Plate 3, Nos. 3 and 4)

Japanese name: America (California) yari-ika; Monterey ika

Similar Japanese species: Loligo bleekeri (yari-ika)

1. Introduction: The market squid is unique in that the fishery is conducted only at the height of the spawning season. Thus practically all female squid are full of eggs, which are highly regarded in the market.

2. Description: A small species, average size for males 150 mm and 70 g; females 140 mm and 50 g; maximum length for males 190 mm, females 180 mm.

3. Life history notes:
Distribution: Geographical--British Columbia to central Baja California, but most abundant off southern and central California. Depth--common in shallow water, but also found as deep as 200 m. Seasonal--spawning aggregations occur primarily in winter and spring in southern California, and spring to summer near Monterey, California; spawning squid can also be found during other seasons at both areas.

Migration: Not known; spawning aggregations during reproductive season.

Food and feeding: Feeds primarily on fish and small crustaceans; sometimes feed on euphausiid shrimps near the surface.

Behavior: Can be found in schools from an early age, but are seldom caught in large numbers before the spawning season. Both sexes apparently die after spawning; overall sex ratio is about equal, but either sex may predominate in particular schools.

Reproduction: Mature squid congregate in shallow waters to spawn, usually in 12-35 m, but sometimes as deep as 185 m; eggs are laid in clusters of capsules, each holding around 250 eggs.

Age and growth: Life span is unknown, but thought to be one to two years; in captivity market squid grew to maturity in less than eight months. Early growth is probably rapid, but mature squid may grow at a rate of around 4 mm/month.

4. Population dynamics and management:
Population size: Not determined, but probably varies considerably each year; estimates range from 100,000 to 1,000,000 tons.

MSY and OY: Not determined, but possibly around 35-50,000 tons.

Management: California Department of Fish and Game: some gear restrictions at Monterey (no lights or purse seines allowed).

5. Fishing methods: In southern California, caught by light-attraction and power-assisted brails, and also by purse seine; at Monterey, lampara nets (a kind of roundhaul net) are used, without light-attraction.

6. Product forms: Presently canned or frozen whole; a small amount of cleaned and skinned mantles are also sold; it is possible to segregate large males, egg-bearing females, and smaller squid.

7. Reference: Kato, S. and J.E. Hardwick. 1975. The California squid fishery. FAO Fish. Rep., (170) Suppl. 1, p. 107-127.

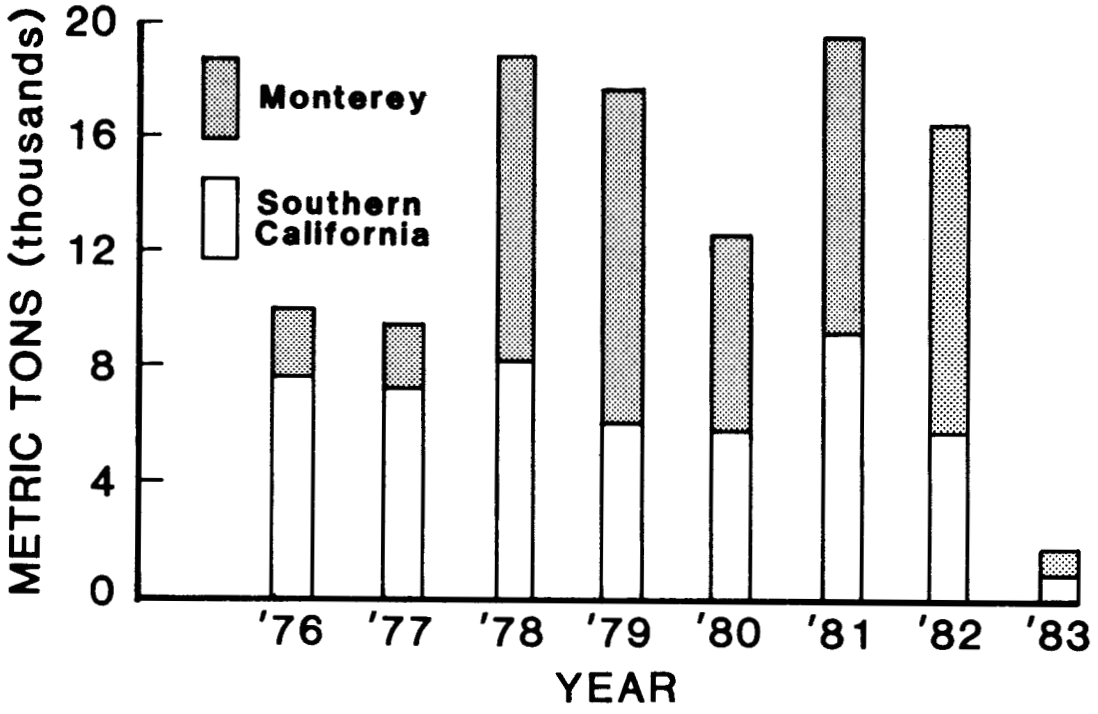


Figure 12. Annual landings of market squid at Monterey and southern California.

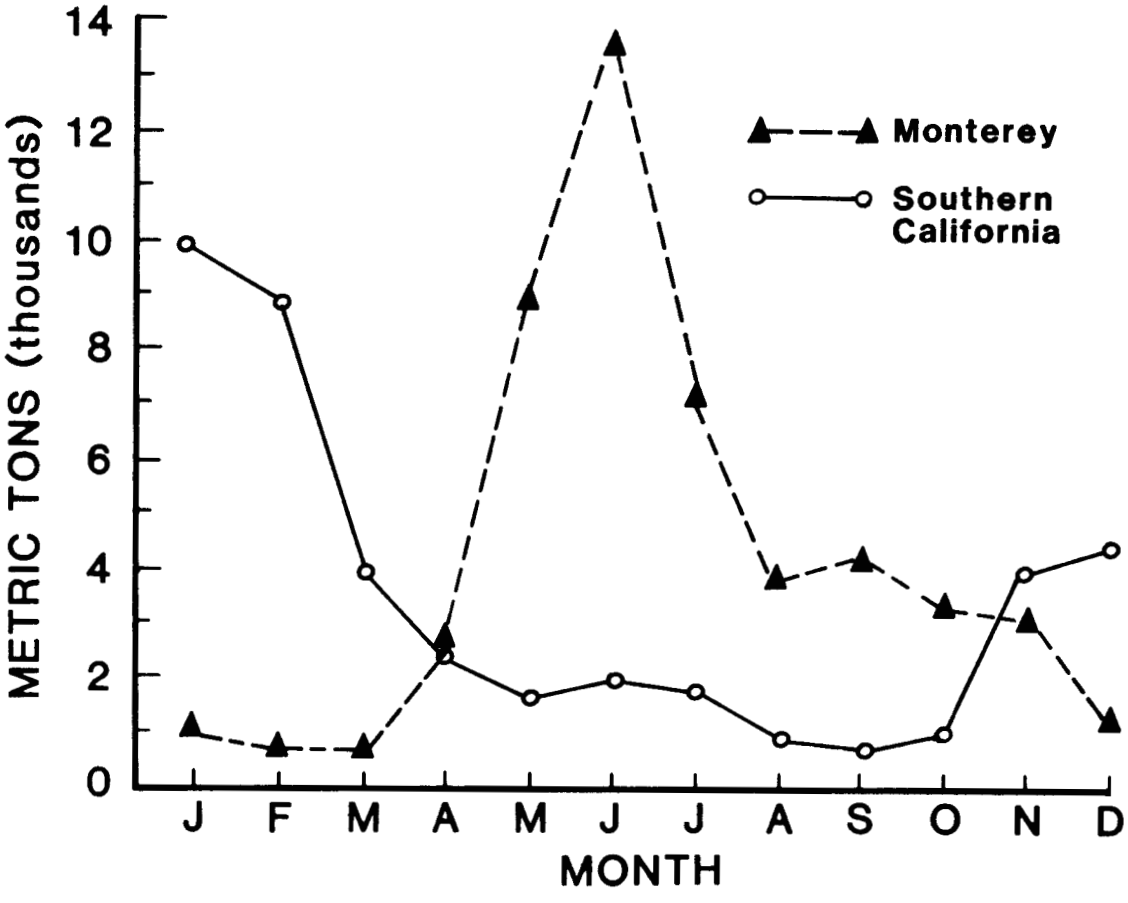


Figure 13. Average monthly landings of market squid in California, 1955-78.

KING CRAB, Paralithodes californiensis amd TANNER CRAB,
Chionocetes tanneri (Plate 4, Nos. 1 and 2)

Japanese common names: Taraba-gani (king crab); zuwai-gani (tanner crab)

Similar Japanese species: Paralithodes sp.; Lithodes sp., beni-zuwaigani, Chionocetes sp.

1. Introduction: King and tanner crabs are fished extensively off Alaska, but California species are smaller and not commonly caught. No landings of either species were recorded in 1981, but several California king crab are known to have been caught and sold.

2. Description: The shell of both species is heavy, hard and rough. King crabs are larger, probably reaching 1.5 kg. The pair of legs behind the pincers is small, making king crabs appear to have only four pairs of legs. Tanner crabs are smaller, with an average weight of 700 g. (females). All five pairs of legs are well-developed, long and slender.

3. Life history notes:
Distribution: Both species occur throughout California, mainly from 200 m and greater depths.

Migrations: Not known for California species, but others migrate during spawning and molting seasons.

Food and feeding: King crabs feed mainly on molluscs and echinoderms; tanner crabs mainly on polychaete worms. Both also eat some planktonic organisms.

Behavior: Both species are bottom dwellers.

Reproduction: Females probably mature at age two or three. Spawning occurs once a year, immediately or soon after the female has molted.

Age and growth: Growth rate depends on molting frequency, which is affected by water temperature and other factors. Both species may live over twenty years.

4. Population dynamics: No information is available for California populations of king or tanner crab.

MSY and OY: Unknown.

Management: California Department of Fish and Game; special permit required for traps; no catch limits or seasons have been established.

5. Fishing methods: Caught incidentally in large traps and bottom trawls. No directed fishery at present (May, 1983).

6. Product forms: Fresh as well as cooked and frozen crabs can be provided.

7. Reference: Schmitt, W. 1921. The Marine Decapod Crustacea of California. Univ. of Calif. Press, Berkeley, California. 470 p.

ROCK CRAB, Cancer productus, C. antennarius, C. antonyi (Plate 4, Nos. 3 and 4)

Japanese name: Ichogani

Similar crab in Japan: Cancer japonicus (Ichogani)

1. Introduction: Four species of Cancer crabs in California are fished commercially, of which the Dungeness crab (C. magister) is the most important. However, rock crabs have been fished extensively in central and southern California and evidence exists that northern California may also have the potential to support a fishery.

2. Description: Rock crab is the common name given collectively to three species of crab. These crabs can be differentiated by color. The species termed "rock crab" (C. antennarius) has a dark-red to purple carapace with red spots on the underside. The "red crab" (C. productus) has a dark-red carapace with orange-red blotches on the underside, and the "yellow crab" (C. antonyi) is yellow-brown in color. All three have black-tipped claws. These hard-shelled crabs weigh from 200-454 gm and have a carapace width of 125-175 mm.

3. Life history notes:
Distribution: Geographical--Oregon to Baja California; concentrated primarily between Santa Barbara and San Diego, California. Depth--mostly in 10-70 m, but can be found deeper. Seasonal--found throughout the year.

Migration: Does not appear to have large seasonal movements, but is more abundant in the fall and winter near shore.

Food and feeding: Diet consists mainly of bivalves, but also consumes snails, worms and other invertebrates.

Behavior: Inhabits sandy and semi-hard mud areas, but may occur on gravel or rocky substrates.

Reproduction: Spawning season begins in June and peaks in August.

Age and growth: Both male and female tend to have the same growth rate till carapace widths measure 60 mm. Beyond that size, changes due to sexual maturity complicate growth relationship.

4. Population dynamics and management:
Population size: Unknown. Northern stocks are unfished (1982).

MSY and OY: Unknown.

Management: No restrictions; females as well as males may be harvested.

5. Fishing methods: Fished with traps, principally over hard mud-sand bottom. Currently the fishery produces 500 tons annually.

6. Product forms: Sold freshly cooked in the whole form. The potential for a "cocktail claw" product exists, since 50% of the crab meat is in the claws. Machine processing and hand picking may be possible.

7. Reference: Phillips, J.B. 1973. California Market Crab and Its Close Relatives. California Fish and Game, 25(1):18-29 (updated).

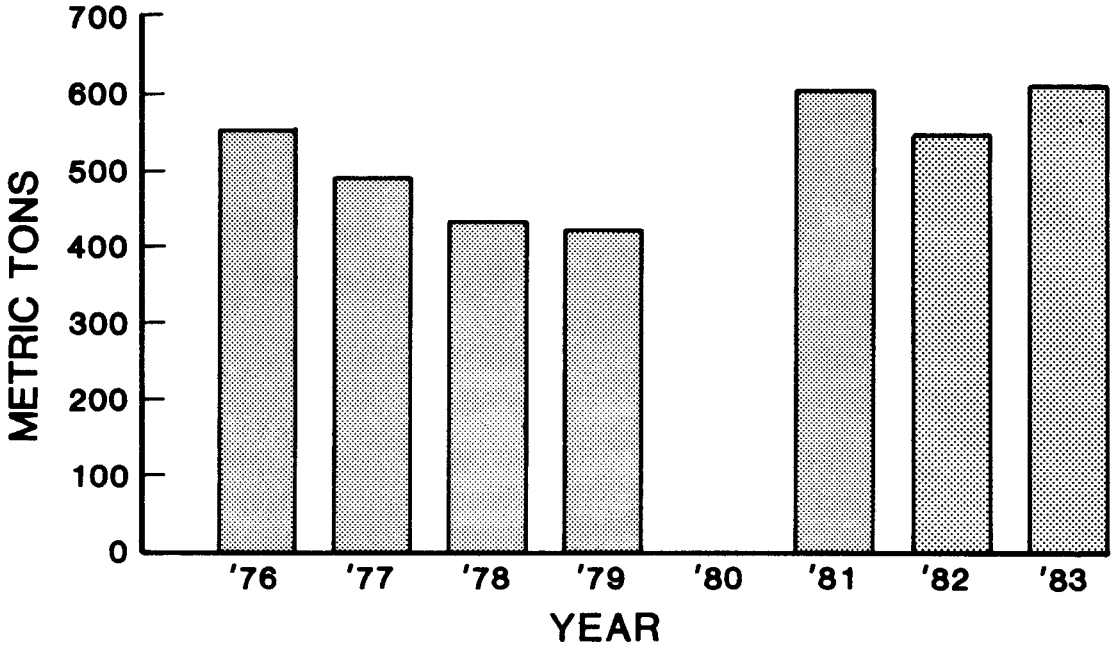


Figure 14. Annual landings of rock crabs in California.

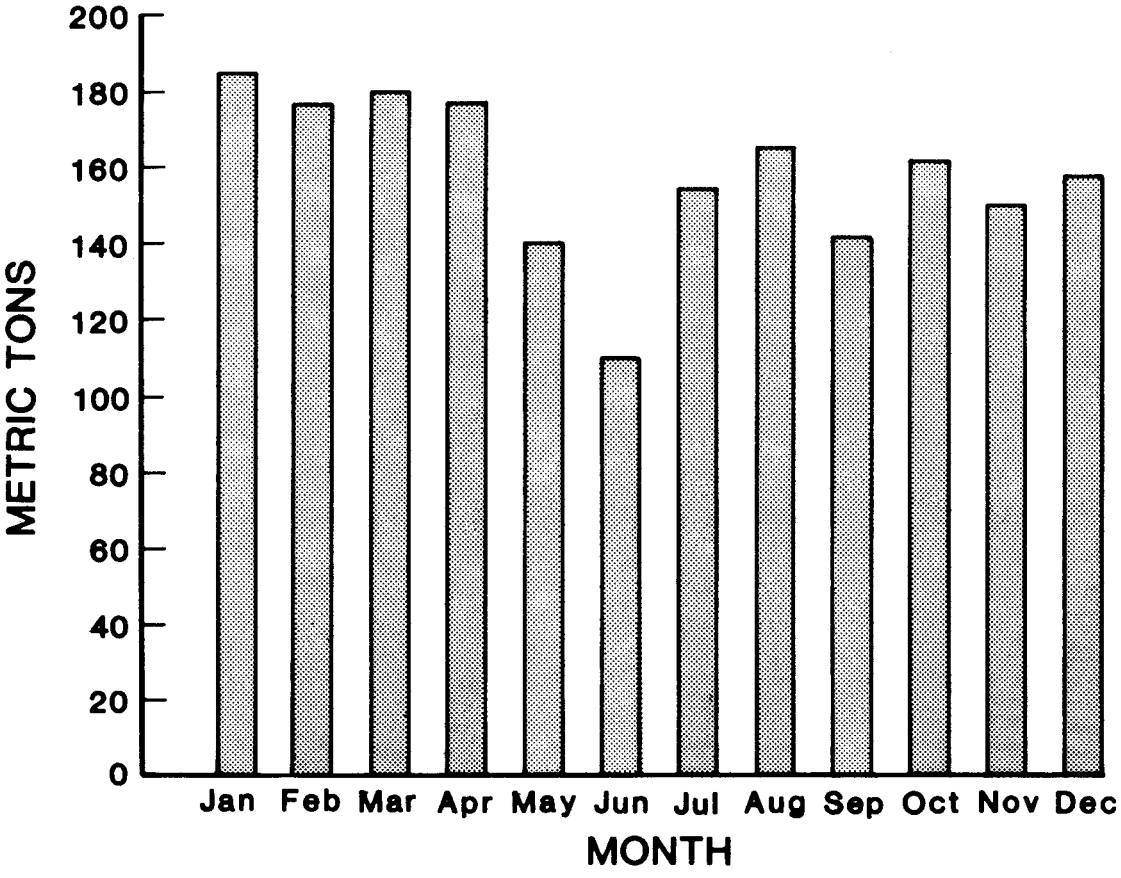


Figure 15. Average monthly landings of rock crabs in California, 1976-81 (excluding 1980).

EUPHAUSIID SHRIMP OR KRILL, Euphausia pacifica (Plate 5, Nos. 1 and 2)

Japanese name: Oki ami; Sanriku ami.

Japanese species: Same.

1. Introduction: Euphausiid shrimp (krill) are small shrimp-like crustaceans. They are primarily deep living, but many migrate toward the surface at night. There is no domestic commercial fishing for krill, but there is a market which at present is supplied by imports from Japan and Canada. Freeze-dried euphausiids, as well as frozen euphausiids, are sold as aquarium fish food. Of several species inhabiting California waters, Euphausia pacifica appears to hold the greatest potential for commercial fishery development. Thysanoessa spinifera is slightly larger and is common near the surface during spring and summer.

2. Description:(E. pacifica): A small species, average about 12 mm. in total length; color is brownish-pink.

Proximate analysis:

Protein	13%	Moisture	78%
Fat	3%	Ash	2%

3. Life history notes:
Distribution: Geographical--found throughout the California current; may be associated with submarine canyons, such as the one off Monterey. Depth--euphausiids form a part of the sonic scattering layer. During darkness they are located within 50 m of the surface. In daylight they migrate vertically to a depth of 200 m to 400 m. Seasonal--minor changes in seasonal distribution correspond to the position of the California current. Seasonal increases in abundance may correlate with periods of intense upwelling, particularly in April.
Migration: The only significant migration is the daily vertical movement described above.
Food and feeding: Euphausiids graze on microscopic plants and animals. It is likely that they feed actively at night when they are amassed near the surface.
Behavior: Migration toward the surface at night should result in concentrations sufficiently dense for acoustical targeting and harvesting with fine mesh netting.
Reproduction: Spawning is more or less continuous. Under ideal conditions. a female could spawn every two months. Females carry 20-250 eggs which hatch into larvae.
Age and growth: E. pacifica usually reaches its maximum length of 22 mm in about 12 or 13 months. Individuals from 10 to 15 mm length predominate in the population.

4. Population dynamics and management:
Population size: Probably over 100 million tons off California.
MSY and OY: Unknown.
Management: The California Department of Fish and Game requires a special permit to harvest euphausiids.

5. Fishing methods: Efficient fishing off California has not yet been demonstrated, but mid-water trawl with 1/16 inch mesh liner appears well suited to catching krill.

6. Product forms: There presently is a market for krill as food for aquarium fish. It is most often frozen, then freeze-dried for ease in handling and distribution to retail markets. Potentially marketable as feed in fish culture operations.

7. Reference: Brinton, Edward. 1976. Population biology of Euphausia pacifica off Southern California. Fishery Bulletin 74(4):733-762.

KELLET'S WHELK, Kelletia kelletii (Plate 5, No. 3)

Japanese common name: America migakibora, or baigai
Similar species in Japan: Kelletia lischkei (migakibora)

1. Introduction: Kellet's whelk is a gastropod of the family Neptunidae. It is a fairly large gastropod, located in and near kelp beds and nearshore reefs.

2. Description: Average shell length of adult female around 85 mm; males somewhat smaller; average total weight around 105 gm, meat yield about 7-10 percent; color of shell gray and white, often with greenish tinge.

3. Life history notes:

Distribution: Geographical -- Pt. Conception, California, south to central Baja California. Depth -- commonly between 3-40 m. Seasonal -- found year-round.

Migration: Forms spawning aggregations, usually in April and May.

Food and feeding: Classified as a carnivorous scavenger, but has been observed consuming live polychaete worms; appears to be attracted to maimed or moribund animals; its long proboscis enables it to probe for food within rocks.

Behavior: Found singly or aggregated in feeding groups; can be caught in baited traps.

Reproduction: Sexes are separate. Females sexually mature at 80-90 mm shell length, males a little smaller; spawning usually occurs in April and May; egg capsules are deposited on hard substrate, each capsule with 400-1000 eggs; larvae emerge after about one month.

Age and growth: Unknown; females apparently grow slightly larger than males.

4. Population dynamics and management:

Population size: Unknown.

MSY and OY: Unknown.

Management: California Department of Fish and Game; special permit required; no catch limits or seasons apply.

5. Fishing methods: Presently caught incidentally in rock crab traps and trammel nets.

6. Product forms: Whole, live or frozen; meat only, raw or cooked.

7. Reference: Rosenthal, R. J. 1970. Observation on the reproductive biology of the Kellet's whelk, Kelletia kelletii. (Gastropoda: Neptunidae). Veliger 12(3): 319-324.

GIANT PACIFIC OCTOPUS, Octopus dofleini (Plate 5, No. 4)

Japanese name: Mizudako
Japanese species: Same

1. Introduction: The giant Pacific octopus is the largest species of octopus known. It has been landed in California for many years as an incidental catch in the bottom trawl and Dungeness crab fisheries. A directed fishery for octopus has not yet begun (June, 1982), but the resource appears to be capable of supporting a fishery.

2. Description: This species may attain a weight of over 50 kg, but mature octopus usually weigh less than 32 kg; total arm spread of a mature octopus is about 3-4 m. Color is dark brown to reddish.

Proximate analysis: (100 g flesh)

Calories	69.0	Phosphorus	140.0 mg
Total fat	0.6 g	Iron	0.3 mg
Total moisture	82.9 g	Vitamin A	10.0 I.U.
Ash	1.6 g	Vitamin B_1	0.02 mg
Protein	14.6 g	Vitamin B_2	2.50 mg
Sugar	0.3 g		
Calcium	13.0 mg	Nicotinic acid	2.50 mg

3. Life history notes:
Distribution: Geographical--Entire California coast. Depth--Subtidal to 350 m, usually less than 180 m. Seasonal--Found throughout the year, frequency of occurrence is probably higher during spring and fall in 25-45 m.

Migration: Immature individuals (1-15 kg) migrate inshore and offshore with changes in salinity and temperature. These movements occur from November-January and from April-July. Mature octopus move inshore to spawn.

Food and feeding: Opportunistic predators, feeding on crustaceans, molluscs, and fish.

Behavior: Solitary animals, occupying rocky dens or dark protective shelters. They are territorial and will defend against other octopus entering their area.

Reproduction: Spawning probably occurs all year, but the peak season is unknown; probably reproduces mainly during the shoreward migration. Mature males mate with nearly mature females; the female may then hold the sperm packets up to 4 months before fertilization occurs. Females deposit eggs in string-like clusters on the roof of a den and stop feeding while they tend the eggs. A mature female produces 30-40,000 eggs, which hatch in 5-6 months. Male octopus die 7-9 months after mating; females die soon after the eggs hatch.

Age and growth: After age one, growth is rapid, with weight increasing from 1 kg at age one to 10 kg by the end of age two; life span is probably three to five years.

4. Population dynamics and management:
Population size: Unknown

MSY and OY: Unknown.

Management: No closed season or limits; can be trapped or taken by other means with an experimental gear permit from the California Fish and Game Commission.

5. Fishing methods: Octopus are presently caught in crab pots and bottom trawls. Catch rate is unknown. Wooden and plastic boxes which simulate natural (octopus) dens are being used experimentally, as are baited drift hooks.

6. Product forms: Most O. dofleini are eviscerated and frozen for halibut bait. A small amount is skinned and sectioned before packing in a vacuum-sealed package. Sauteed or marinated products can be produced as well. Other species similar to the Japanese "madako" may be available in southern California.

7. Reference: Mottet, M.G. 1975. The Fishery Biology of Octopus dofleini (Wuelker). Washington Dept. of Fisheries Technical Report No. 16. 39 pp.

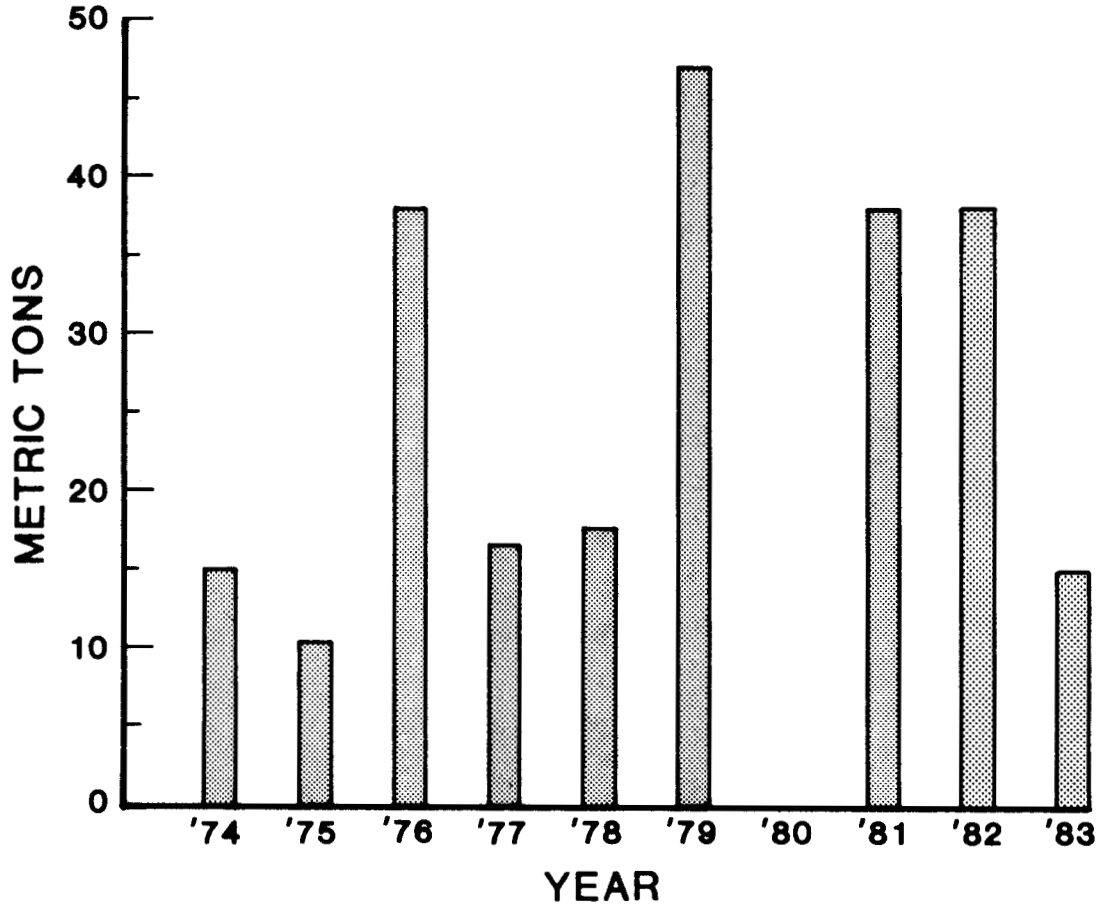


Figure 16. Annual landings of giant Pacific octopus in California

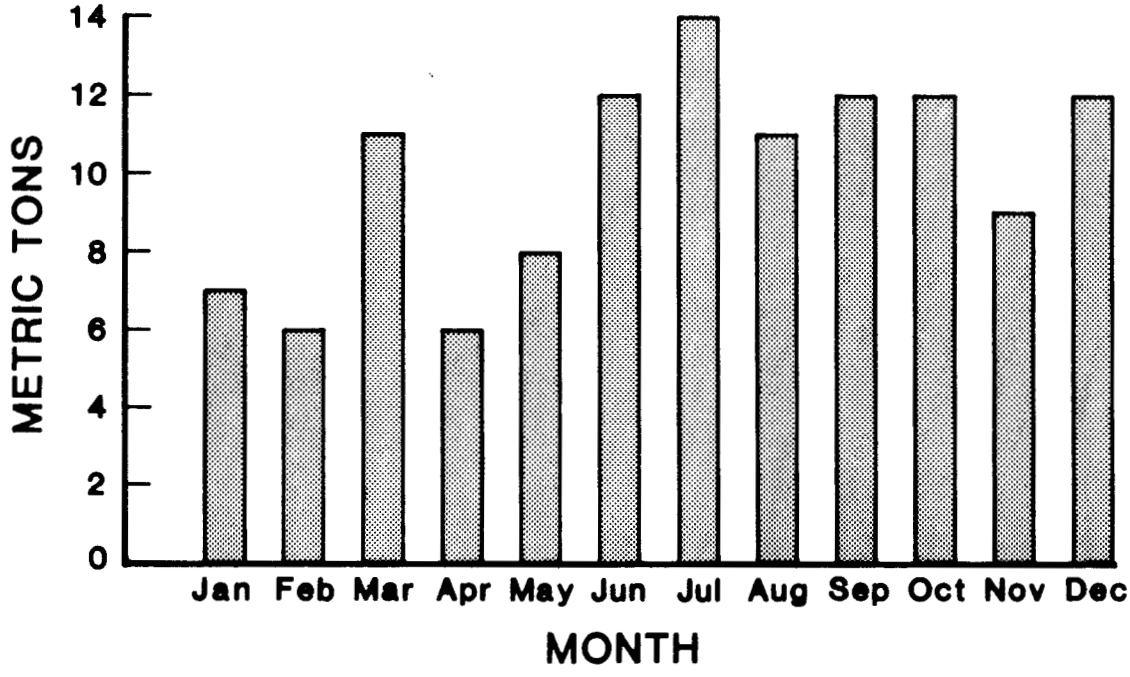


Figure 17. Average monthly landings of giant Pacific octopus in California, 1974-81 (excluding 1980).

SPINY DOGFISH, Squalus acanthias (Plate 6, No. 1)

Japanese common name: Abura tsunozame

Japanese species: Same

1. Introduction: This species was fished for its liver oil, which has a relatively high vitamin A content; on the West Coast, the U.S. fishery is now conducted in the state of Washington for the shark's flesh, which is exported to Europe. The fin is also sold in the Orient.

2. Description: Body usually with white spots; no anal fin; sharp spine in front of both dorsal fins. Grows to around 150 cm, but adult males are commonly around 90 cm and adult females around 110 cm and 3.5 kg.

3. Life history notes:
Distribution: Found in temperate coastal waters, from central Baja California to Alaska, and westward to Japan. Usually occurs near bottom, from 20-350 m, most often in 50-175 m.

Migration: Generally abundant in winter in northern and central California, moving southward in spring and summer.

Food and feeding: Feeds primarily on fish and crustaceans, and also on squid; adept at feeding on pelagic prey.

Behavior: Sometimes occur in large schools.

Reproduction: Females carry an average of seven progeny. Gestation period is nearly two years.

Age and growth: Dogfish are slow-growing and may live as long as 60 years; females mature at around age 25 (about 90 cm).

4. Population dynamics and management:
Population size: Not known but apparently abundant at times over the entire California coast.

MSY and OY: MSY unknown; no harvest quotas when using 11.4 mm stretched-mesh bottom trawl or other legal gear. Because of low reproduction potential, dogfish shark populations are vulnerable to intensive fishing.

Management: Pacific Fishery Management Council. Some California state regulations, especially those pertaining to use of gill nets, may affect fishing for spiny dogfish.

5. Fishing Methods: Commonly taken incidentally in bottom trawls, and gill and trammel nets set on the bottom, but usually discarded; also can be caught with hook and line.

6. Product forms: Dogfish sharks are usually landed whole. They can be marketed headed and gutted, or filleted. Fins, though small, are also utilized.

7. Reference: Roedel, P.M. and W.E. Ripley. 1950. California Sharks and Rays. California Division of Fish and Game, Fish Bull. No. 75, 88 p.

SEA CUCUMBER, Parastichopus californicus and P. parvimensis (Plate 6, No. 2)

Japanese common name: Namako; Mandarin Chinese name: Hai Shen

1. Introduction: Two species of sea cucumber are common off California: the California sea cucumber (P. californicus) and the warty sea cucumber (P. parvimensis). There is a small fishery for both off Santa Barbara.

2. Description: Cucumber-shaped, up to 45 cm long; color ranges from golden brown to reddish brown. California sea cucumbers possess few large pointed papillae (projections), while warty sea cucumbers possess numerous short, black-tipped projections; both have tube feet only on the underside of the body.

3. Life History Notes:
Distribution: Geographical--P. californicus from Gulf of Alaska to San Diego. P. parvimensis from Carmel Bay, CA, to Baja California. Depth--intertidal to 30 m for P. parvimensis, usually 50-130 m for P. californicus, but this species replaces P. parvimensis in shallow water in northern latitudes. Most individuals are found below the depth of the seasonal thermocline (15 m) from August through November. Both are found on sand, mud and rock substrates.

Migration: Both species are known to suddenly disappear or reappear in known fishing grounds.

Food and Feeding: Surface deposit feeders, using tentacles to pass sediments into gut. Feeding rates vary seasonally with highest rate in late winter and spring and lowest in fall when some animals eject their viscera and regenerate a new set for fall.

Behavior: Adults tend to clump on rock surfaces, but the largest individuals are found on sand. Both species have well-developed locomotion capabilities, utilizing their tube feet. Neither possesses the toxicity frequently found in other sea cucumbers, and the ability to move probably aids in avoiding predators such as starfish.

Reproduction: Spawning in both species occurs in May and June and extends into August for P. californicus. Sexes are separate and fertilization external.

Age and Growth: Length-frequency data suggest that growth is slow. Large individuals on sand are at least five years old.

4. Population Dynamics and Management:
Population Size: Unknown MSY and OY: Unknown

Management: Calif. Dept. of Fish and Game; no limits apply.

5. Fishing Methods: P. californicus is caught mostly by bottom trawl; P. parvimensis is hand-harvested by divers.

6. Product Forms: Most common product is dried sea cucumber. Animals are gutted, boiled and dried. The longitudinal muscles can also be removed. P. parvimensis yields a more desirable product and brings a higher price. Fresh and boiled products can be made, as well as salted intestines ("konowata").

7. References: Mottet, M.G. 1976. The fishery biology and market preparation of sea cucumbers. Washington Dept. of Fisheries, Tech. Rep. No. 22, 44 pp.

SHEEP CRAB, Loxorhynchus grandis (Plate 6, No. 3)

Japanese name: Kumogani (family)

1. Introduction: The sheep crab belongs to a group known as decorator crabs because they disguise their own carapace and appendages with bits of seaweed, sponge and barnacles. Sheep crab lose this instinct upon reaching a size of 7 or 8 cm, at which time they are well able to defend against or escape from predators.

2. Description: Carapace arched with spines around head region. Walking legs progressively longer toward front. Large claw may reach a length of 17 cm. Adult males weigh up to 6.4 kg and females about half as much.

3. Life history notes:
   Distribution: Geographical--California coast from Farallon Islands south to Baja, California; abundant off Southern California and at the Channel Island. Depth--commonly found in 20-60 m, but range in both shallower and deeper depths. Season--apparently abundant during certain periods and rare at other times, but can be caught throughout the year.
   Migration: Have been reported to move in and out of local areas, perhaps twice in a year.
   Behavior: Sometimes found in large numbers piled on top of each other on the ocean floor. As many as 40 large crabs have been caught in a baited trap around 0.4 m^3 in volume; these were usually females.
   Reproduction: Largely unknown. Some berried females can be found throughout the year.
   Age and growth: Unknown; small animals may double their size during early moults.

4. Population dynamics and management:
   Population size: Unknown; the 1983 catch, all from Santa Barbara, was around 20 tons.
   MSY and OY: Unknown.
   Management: State of California; a permit is required when traps are used.

5. Fishing methods: Primarily caught in baited traps, often as a by-catch of the rock crab (Cancer spp) fishery in Southern California. Commonly caught in gill nets and trammel nets used to catch California halibut and sharks.

6. Product forms: Usually sold live. Average weight around 1 kg in spring and summer, and around 2.3 kg in fall and winter. Some fishermen bring in only the claws, usually from crabs caught in nets.

7. Reference: Gilbert Crabbe, commercial fisherman, P.O. Box 1451, Santa Barbara, CA 93102.

RIDGEBACK PRAWN, Sicyonia ingentis (Plate 6, No. 4)

Japanese name: Ishiebi

Similar Japanese species: Sicyonia inflexa, (Shinkai ishiebi)

1. Introduction: The ridgeback (Family Peneidae) is a small prawn found in fair concentrations near Santa Barbara and the northern Channel Islands. They are rather heavily fished in that area, and are only considered "underutilized" because of the low ex-vessel price, which is commonly around $1.10-1.65/kg.

2. Description: Color light orange to pink below, tinged with olive dorsally. Carapace ridged along the mid-line of back from head to tail. Average size of prawns in the commercial catch is around 140-165 whole shrimp per kg.

3. Life history notes:

   Distribution: Geographical--Monterey, California to Cedros Island, Baja California; abundant between Ventura and Pt. Conception, and near the northern Channel Islands; also recently found further south, near San Pedro. Depth--ranges from 10-240 m, most common in 100-150 m; seasonal--found throughout the year.

   Migration: Gradual offshore migration accompanies growth, with larger individuals found deeper than 120 m.

   Behavior: Generally occurs on mud and fine sand substrates.

   Reproduction: Spawning season lasts from June to October, with a peak in late August and early September. Females spawn several times, in deep water (145 m); the eggs are demersal.

   Age and growth: Maximum age probably four years. Females reach 45 mm carapace length, and males 37 mm.

4. Population dynamics and management:

   Population size: Unknown; peak catch 162 mt in 1979; catch has declined to 64 mt in 1982, indicating a distressed population near Santa Barbara.

   MSY and OY: Unknown.

   Management: Calif. Dept. of Fish & Game. Seasonal closure from June 1-September 30.

5. Fishing methods: Bottom trawl (Gulf shrimp trawl or semi-ballon trawl); some vessels use "double-rig" trawls. Mesh size restricted by law to a minimum of 3.8 cm for standard trawls, or 7.6 cm for nets with double-wall codends.

6. Product forms: Landed whole; frozen tails or whole shrimp are available, as is a heads-off, split and deveined tails pack; smoked product is quite good. Yield: tails with shell on 49%; peeled and deveined tails, 25%. During summer females carry greenish roe, which turns to an attractive orange color upon cooking.

7. Reference: Sunada, John. 1984. Spot prawn, Pandalus platyceros, and ridgeback prawn, Sicyonia ingentis, fisheries in the Santa Barbara Channel. CalCOFI Reports, Vol 25, p. 100-104.

PACIFIC GRENADIER, Coryphaenoides acrolepis (Plate 7, Nos. 1 and 2)

Japanese name: Ibara-hige

1. Introduction: Pacific grenadier is one of the most abundant deep-water species found off California. It is often taken in trawl tows directed at Dover sole (Microstomus pacificus), in depths greater than 1,000 m. Only a small amount of incidentally-caught Pacific grenadier is presently being sold, though its flesh is white and firm and has a long shelf life. A major impediment to its sale is its low fillet yield, which is around 25 percent.

2. Description: Skin dark, with rough scales. Long, tapering tail is characteristic of grenadiers. Maximum size of females around 90 cm and 3.4 kg; males are smaller. Average size of fish caught on hook and line around 1.5 kg (females) and 1.0 kg (males).

Proximate Analysis

	October	December
Crude protein	15.8%	15.9%
Total fat	0.1	0.2
Total moisture	83.0	83.1
Ash	1.2	1.1

3. Life history notes:

Distribution: Geographical--found off entire California coast, northward to Alaska and across the Pacific to Japan. Depth--range around 450 to 2,800 m; larger individuals commonly found between 1,200 and 1,600 m; caught with bottom trawls as well as with vertical longlines; juveniles seem to inhabit shallower waters. Seasonal--no indication of seasonal differences in availability.

Migration: No data regarding regular movements, though males and females are often caught in different areas.

Food and feeding: Probably feeds primarily on bottom-dwelling invertebrates and small midwater animals.

Behavior: Can be caught 100 m off the bottom with baited hooks, on vertical longline gear; common in deep water on the bottom, as evidenced by catches with bottom trawls.

Reproduction: Ripe males and females have been found in winter off southern and south-central California. Fecundity averaged about 70,000 eggs in seven females.

Age and growth: No validated age data available; probably a slow-growing, long-lived species.

4. Population dynamics and management:

Population size: Unknown, but apparently large, judging from the wide distribution of the species and extensive catches made by both research and commercial vessels along the continental slope.

MSY and OY: Unknown.

Management: Pacific Fisheries Management Council, Groundfish Management Plan; no quotas or seasons apply.

5. Fishing methods: Now taken incidentally in deep-water trawl fishery off California; can be caught with hook and line.

6. Product forms: Fresh fillets have a long shelf life, probably around two weeks or more; freezing is also suitable because of the low oil content; smoked product is also good.

7. Reference: Stein, D. L., and W. G. Pearcy. 1981. Aspects of reproduction, early life history, and biology of macrourid fishes off Oregon, U.S.A. Deep-Sea Research 29 (11A):1313-1329.

BOX CRAB, Lopholithodes foraminatus (Plate 7, Nos. 3 and 4)

Japanese name: Calappa gani

Similar species in Japan: Sode-calappa, Calappa hepatica

1. Introduction: Box crabs are taken incidentally in trawls, gill nets and traps. They are usually discarded because of the lack of a market, but a fishery is now (1986) being developed in southern California. The meat is tasty, with good texture, and has been marketed in Oregon.

2. Description: Unique hole formed by claw and first walking leg. Shell oval, with short spines along margin, maximum width around 18 cm; attains a weight of over 1 kg; mature males commonly weigh around 600 gm, while females are smaller. Meat yield around 25 percent.

3. Life history notes:

   Distribution: Geographical--along entire California coast. Depth--mainly between 100 and 300 m, but found as deep as 550 m. Seasonal--no information.

   Migration: No information available.

   Food and feeding: Like other crabs, probably feeds on a variety of invertebrates; readily attracted to bait in the form of uncooked or canned fish, as well as frozen squid.

   Behavior: Found on sandy and muddy bottom, as well as on rocky grounds.

   Reproduction: Egg-bearing females are common off southern California in February. Hatching probably occurs sometime in spring.

   Age and growth: No information.

4. Population dynamics and management:

   Population size: Unknown.

   MSY and OY: Unknown.

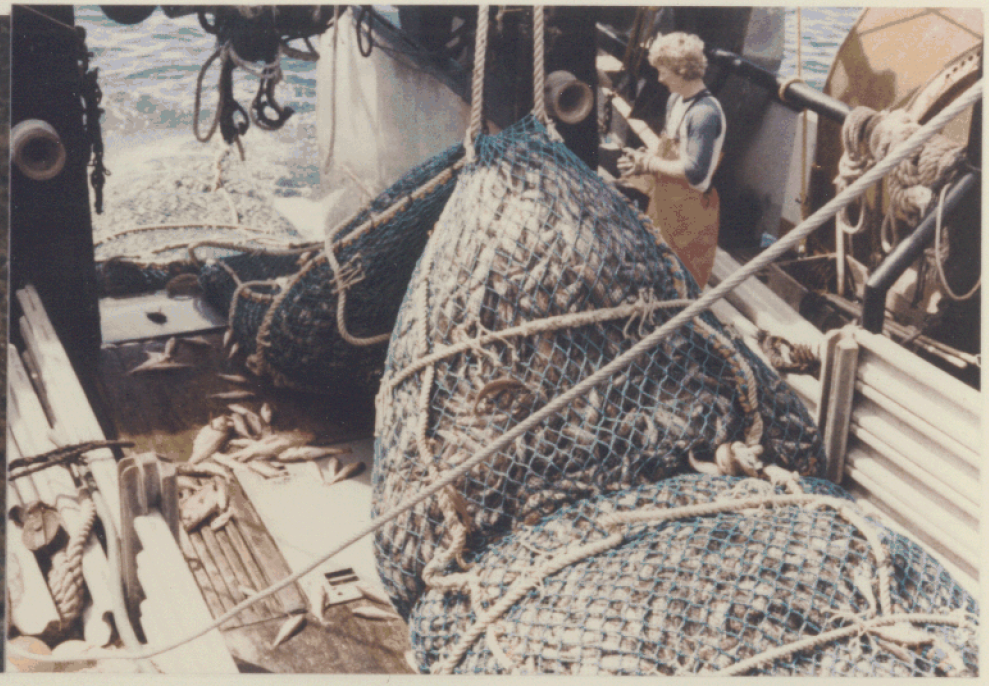
   Management: California Department of Fish and Game; a general trap permit is required.

5. Fishing methods: Caught incidentally in bottom trawl tows in northern California, in rockfish gill nets in central and southern California, and in shrimp traps in southern California. Box crabs can be readily caught in baited traps set at appropriate depths.

6. Product forms: Can be delivered alive, or meat can be extracted.

7. Reference: Schmitt, W. L. 1921. The marine decapod crustacea of California. Univ. of Calif. Publ. in Zool., Vol. XXIII, Berkeley, CA. 470 p.

No. 1. Shortbelly rockfish, p. 1.



No. 2. Catch of shortbelly by trawl.

No. 3. Pacific sanddab, p. 2.

No. 4. Pacific sanddab, p. 2.

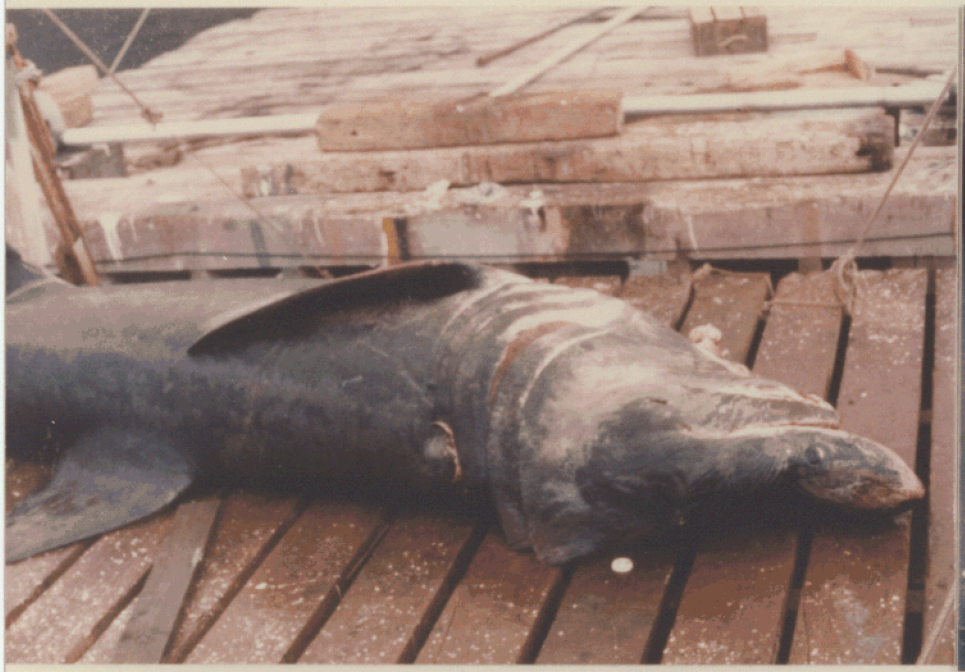
No. 1. Jack mackerel, p. 5.

No. 2. Ocean sunfish, p. 7.

No. 3. Ocean whitefish, p. 8.

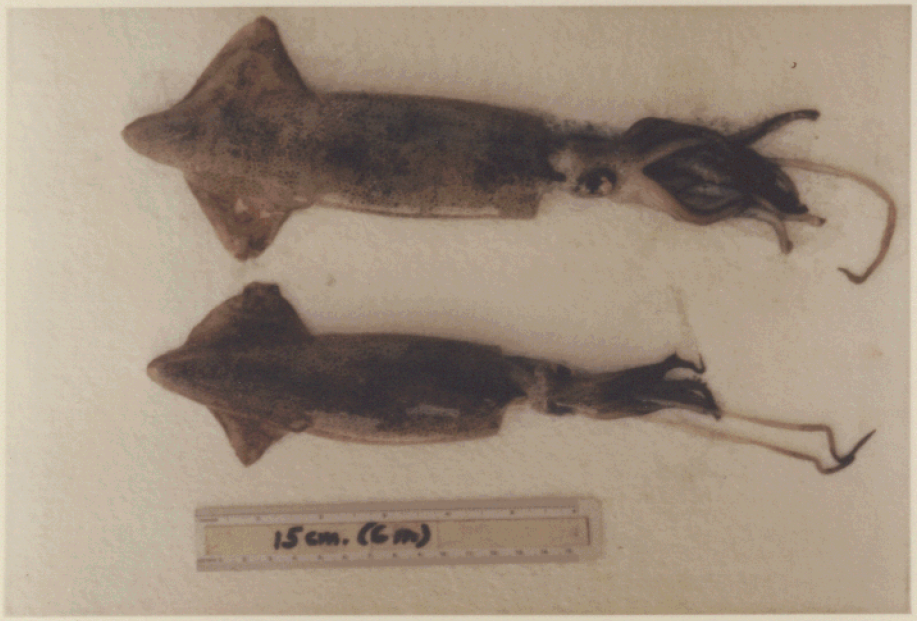
No. 4. Night smelt, p. 9.

PLATE 2



No. 1. Basking shark, p. 10.

No. 2. Ratfish, p. 11.



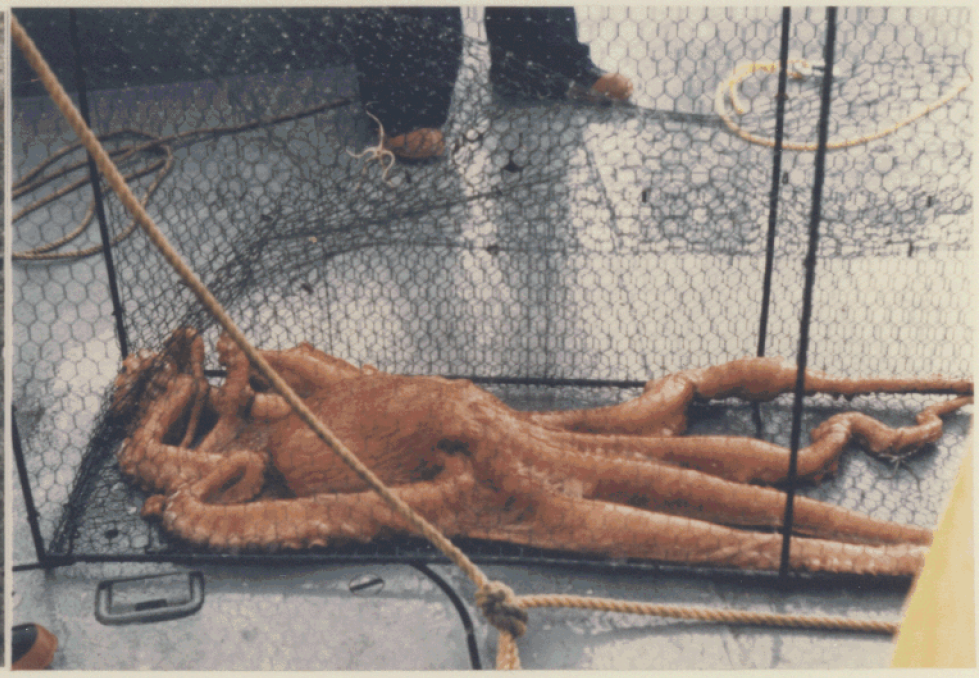
No. 1. King crab, p. 15.

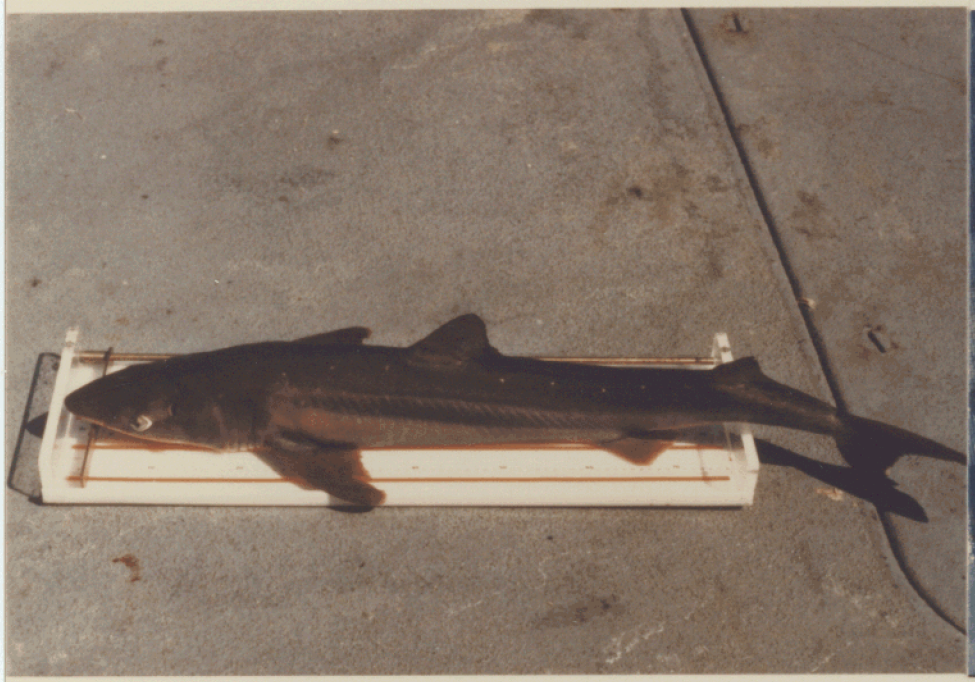
No. 2. Tanner crab, p. 15.

PLATE 4

No. 1. Krill, Euphausia, p. 18.

No. 2. Krill, Thysanoessa spinifera.





No. 1. Spiny dogfish, Squalus acanthias p. 23

No. 2. Sea Cucumber, Parastichopus californicus p. 24

PLATE 6

No. 1. Pacific grenadier, p. 27.

No. 2. Pacific grenadiers caught with longline.

No. 3. Box crab, cooked, p. 29.

No. 4. Box crab meat.