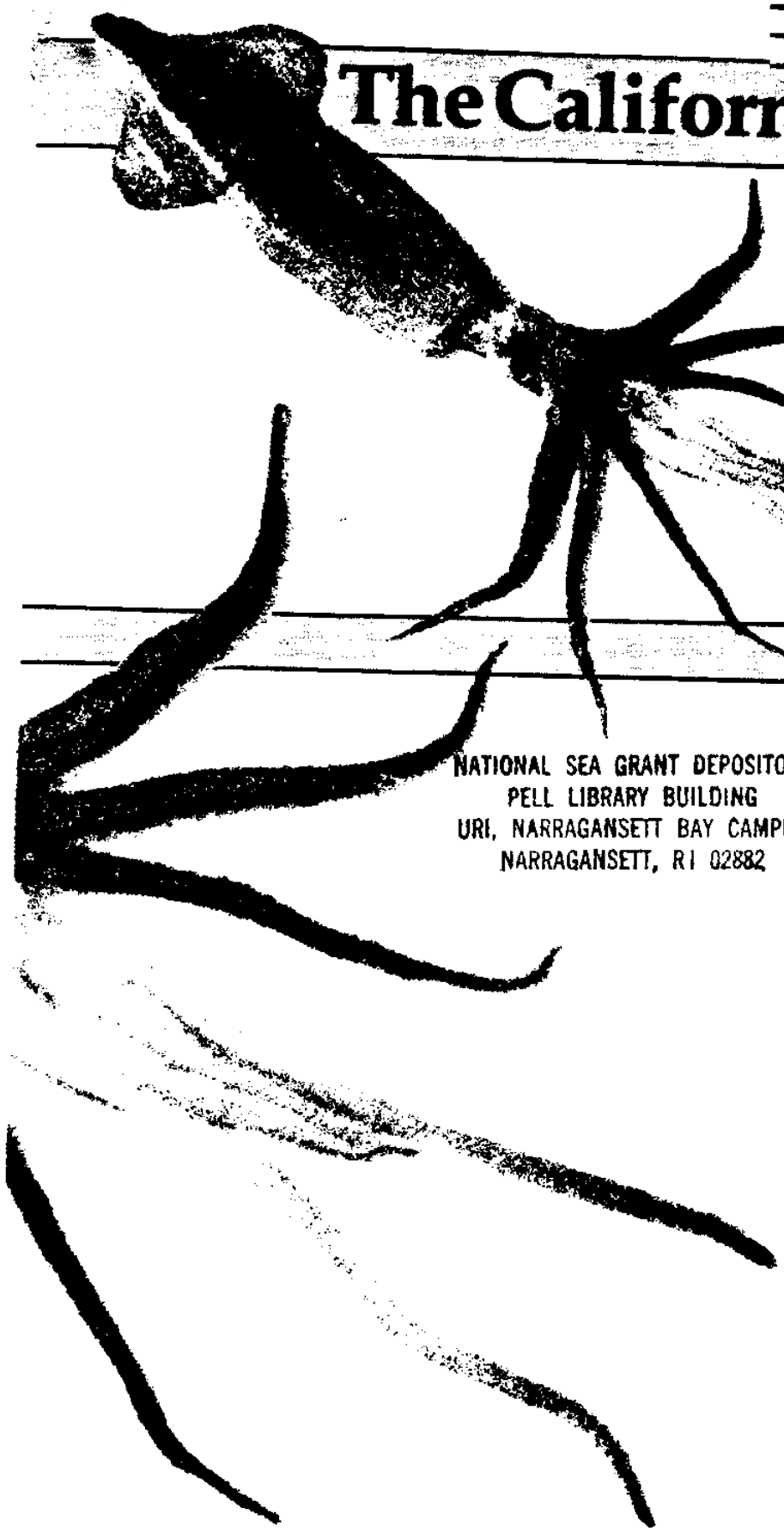
The California Squid Fishery



Introduction

Since the 1860s, the California coastal squid fishery has primarily been directed at the market squid, *Loligo opalescens*. Market squid are small, with a maximum total length of about 30.5 centimeters, including the arms and tentacles. In 1965, samples of Monterey Bay commercial landings showed that the mantle length of males averaged 15 centimeters in length and 70 grams in weight, and females averaged 14 centimeters in length and 50 grams in weight. National Marine Fisheries Service statistics reveal that recent landings have ranged between 10,000 and 20,000 tons annually, while estimates of the *potential* annual yield have varied from 100,000 to 300,000 tons. These estimates indicate that there is great potential for expansion of the fishery. Market squid occur from at least the southern tip of Baja California (22°N) up to British Columbia (50°N). Despite this wide distribution, almost all of the landings are in California.

This publication, based on a review of the existing literature and interviews with squid processors, provides a general overview of California's fishery for the market squid. The biology of squid, history of the fishery, fishing gear and methods, processing methods, sportfishing, and consumer information are included. More in-depth information is contained in the references listed in the annotated bibliography at the end of this publication.

Cooperative Extension
Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

LEAFLET 21330

Life History of Market Squid

Squid usually migrate into shallow waters of 15 to 35 meters in depth to spawn, although some trawlers claim to have captured squid egg capsules at depths exceeding 100 meters. Spawning aggregations occur most frequently during winter in southern California and progressively later in the season further northward.

Major spawning areas have been documented for years in Monterey Bay, near La Jolla, and near the Channel Islands. These spawning aggregations support the bulk of the existing fishery. Several large, unexploited concentrations of squid have also been reported along the central California coast. Squid tend to spawn on a sandy bottom with rocky outcroppings. Each female extrudes twenty to thirty egg capsules, each containing one hundred eighty to three hundred eggs. Recent studies support the general belief that both sexes of market squid spawn only once.

Larval squid hatch after 3 weeks, depending on water temperature. Little is known about the life history of the market squid between hatching and maturity. Squid are important predators; research has shown that squid feed most heavily during daylight hours, primarily on euphausiids, copepods, megalops larvae, mysids, amphipods, fish, and other cephalopods. Market squid are themselves an important prey of sharks, fishes, seabirds, and marine mammals.

Age and growth information is important for management of the fishery, but studies have been difficult to carry out on market squid. Most authors state that market squid live approximately 3 years; however, recent work suggests that the market squid's longevity is only about 12 to 18 months. Most authors do agree that squid die soon after spawning.

Some investigators have suggested that there might be several stocks or subpopulations of market squid. Subsequent research has not been able to support this hypothesis conclusively, however. Future research should more closely examine market squid population structure and biomass. Some interesting preliminary work indicates that the abundance of spawning squid may be related to water temperatures 18 months earlier.

The Fishery

The California fishery started in 1863 when Chinese fishermen in Monterey Bay began fishing with small purse seines, using torches to attract the squid to the surface at night. By 1905 lampara nets had been introduced by Italian fishermen, increasing yields to several hundred tons annually until 1923. Between 1923 and 1932, average landings were 2,100 tons per year. By the end of World War II, landings had reached a record high of 19,000 tons. Since World War II, landings in Monterey have fluctuated between 1,000 and 11,500 tons annually (table 1). Squid landings vary widely from year to year due to changes in abundance as well as in market conditions. The exact reasons for the fluctuations in abundance are not known. Water temperature, upwelling, food supply, and other oceanographic conditions probably affect abundance. Changes in market demand affect landings in that when prices paid for squid are low, fishermen pursue other fish species.

An additional squid fishery in southern California developed in the 1950s. In contrast to the lampara net fishery of Monterey Bay, the southern California fishery depends primarily on the

Table 1. **California market squid landings in tons 1920–1980**

Year	Monterey	Southern California	Total
1920	—	—	254
1925	—	—	946
1930	—	—	5,485
1935	—	—	408
1940	—	—	901
1945	7,586	26	7,612
1950	2,996	1	2,997
1955	7,059	69	7,128
1960	1,118	163	1,281
1965	4,433	4,877	9,310
1970	7,982	4,314	12,296
1971	8,323	7,435	15,758
1972	6,129	3,950	10,079
1973	5,412	621	6,033
1974	7,205	7,247	14,452
1975	2,495	9,317	11,812
1976	2,519	7,660	10,179
1977	2,456	7,249	9,705
1978	10,406	8,295	18,701
1979	11,598	6,051	17,649
1980	6,786	5,815	12,601

Source: California Department of Fish and Game

technique of attracting squid to lights and on the use of a power-assisted brail. Fishing takes place primarily near the Channel Islands, several hours offshore. In some recent years the southern California catch has exceeded that of Monterey (table 1). Landings in southern California tend to peak during the winter months, as opposed to early summer peaking in Monterey Bay (figure 1).

Fishing Methods and Gear

The gear and methods used in Monterey and in southern California are quite different. The major difference is in the use of lights by southern California squid fishermen. Lights attract squid to the vessel at night, and they are scooped directly on board. Monterey fishermen rely on locating spawning aggregations of squid, which they then encircle with large lampara nets. The following fishery descriptions are adapted from Kato and Hardwick (1975).

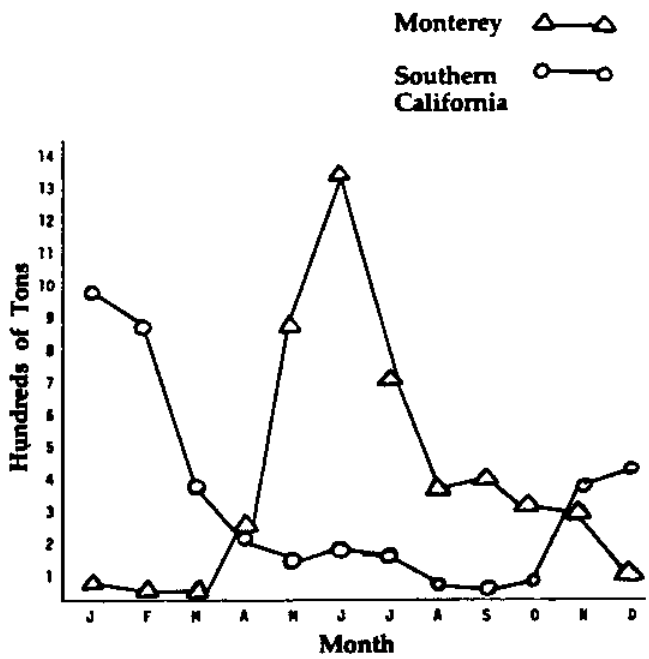
The Southern California Fishery

Scouting usually commences before dark and continues into the night until squid are found. Most searching is concentrated near the shore in depths of 20 to 70 meters. No searching is done in deeper waters, where squid are undoubtedly present, because fishing operations are limited to depths in which the vessels can anchor. Further, when squid are too deep, they will not respond to the attraction system employed by the southern California fishery.

Several methods are used to locate schools. Depth sounders (38 to 125 kHz) and sonar (160 kHz) are used. To confirm that the school is of squid rather than of anchovy or jack mackerel, fishermen often use bare hooks to snag animals located with the echo sounders. At night, bioluminescence also aids in the detection of squid schools. Another indication of squid schools is the presence of predators such as pilot whales, sea birds, and sea lions.

Once a promising school is found, the vessel is anchored in the area of heaviest concentration (except when purse seining, which will be discussed later). At dark, attracting lamps are turned on. The lamps consist of two or more 1,500-watt, incandescent lamps placed high on the mast. Other types of lamps such as quartz-

Figure 1. **Average monthly landings of squid in Monterey Bay and Southern California, 1955–1978**



Source: California Department of Fish and Game

Figure 2. **Typical Southern California squid vessel with lights**

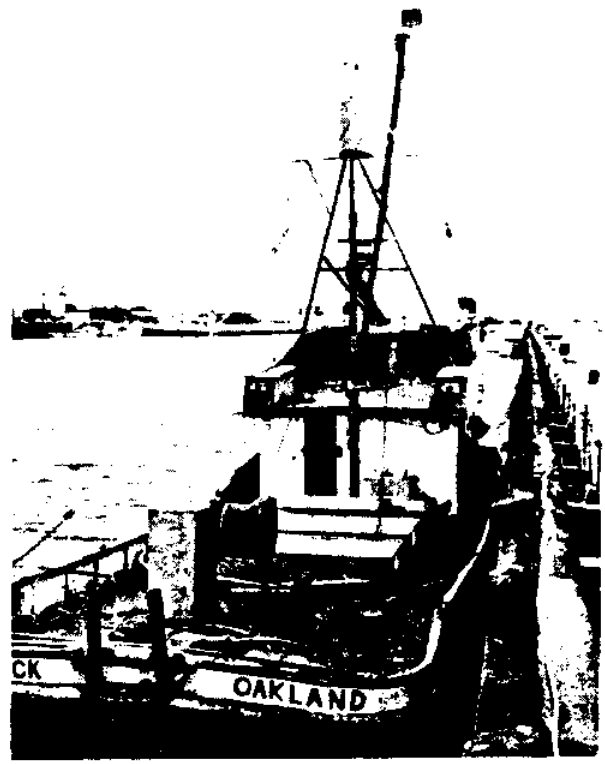


Photo by S. Kato

halogen and mercury vapor have occasionally been used, but most fishermen prefer the incandescent lamp. Concentrating lamps, usually of a similar intensity, are situated about 2 meters above the water and turned on simultaneously with the higher ones.

After a period of time that varies with the behavior of the school, the squid come to the surface. School size varies from a few tons to over 100 tons. The squid swim in a circle, usually heading aft outboard, turning at the edge of the lighted area, and passing alongside the ship on both sides directly under the concentrating lamps. Squid normally swim heading into the current toward the lamp. Thus, when current and wind directions are markedly different, the vessel is placed under power to maintain the bow headed into the current.

A power-assisted brail is the principal fishing gear used in southern California. The hoop of a typical brail is about 1.1 to 1.5 meters in diameter, and the netting, constructed of 2.5-centimeter stretched mesh, is about 150 to 200 meshes deep. Small purse rings are sewn in at the bottom of the net to facilitate quick opening and closing of the brail. During operation, one man guides the brail into the water holding a handle 3 meters long. The same man holds onto the chain purse line. The brail is lowered and raised by a second man with a hydraulic or mechanical winch. As the brail is maneuvered into the water ahead of the swimming squid, a third man pulls the brail toward the stern of the vessel, through the concentration of squid. At the end of a sweep, the winch man lifts the brail out of the water and lets the net rest on the gunwale until it is poised over the fish hold, and the bottom is opened. The brails hold about 250 to 500 kilograms of squid.

A variation called the "Canadian" or "sock" brail is sometimes used. This brail has a net depth of about 6 meters and does not have purse rings. During operation, the brail is passed several times through the school of squid. To bring the catch aboard, the hoop is placed on the opening of the fish hold, and the end of the brail is lifted upward by means of a line passing through a block on the mast. Although most vessels carry three crew members, two-person operations are not uncommon, and in one case a single man uses a power-assisted brail effectively, although the amount he can catch is limited.

Photo by S. Kato

Figure 3. **Squid concentrated under the lights**

Figure 4. **Typical power-assisted brail used in the squid fishery**

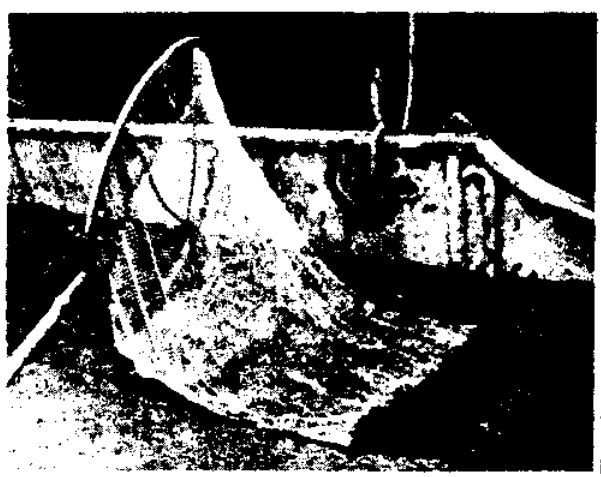


Photo by S. Kato

Photo by S. Kato

Figure 5. **Brailing the squid attracted by lights**

Photo by S. Kato

Figure 6. **Brailed squid is loaded into the hold and on deck**

Squid are usually oblivious to brailing activity; thus, operations often continue until the hold or the market order is filled. Occasionally commotion at the surface will cause squid to dive, halting fishing operations. Active predators such as dogfish sharks, pilot whales, sea lions, and diving birds can cause the squid to sound, though slow-moving blue sharks cause little alarm to the school unless they appear in large numbers. In general, fishermen are obliged to continuously chase predators away from the immediate area.

When a school of squid behaves erratically, it becomes impossible to use a large brail, because the disturbance causes the squid to sound. In such cases, fishermen often resort to the use of hand-operated brails, gently dipping a few kilograms per scoop.

A unique pumping system has been developed in an effort to reduce the amount of physical labor required. The pump has worked well and been particularly advantageous where squid occur in low concentrations. However, 2 to 5 percent of the heads of the squid are torn loose from the mantles with this technique.

Southern California has yet another method for catching squid: purse seining. No special seines are used for catching squid; anchovy and jack mackerel seines may be used when the opportunity arises. Typically, the seines are 460 to 550 meters long and 64 to 73 meters deep. The anchovy net has a stretched mesh of 17 millimeters and the mackerel net one of 35 millimeters. Like brail fishermen, purse seiners use bioluminescence, presence of predators, depth sounders, and sonars to locate squid.

Most fishing is done at night, although day fishing is not uncommon. Fishing operations follow the same procedure used in other single-boat purse seining operations. Sometimes squid are attracted to the surface with lights from the vessel. Then a skiff bearing a small portable lamp is used to hold the squid while the vessel extinguishes other lights and makes a set around the skiff. This method is not preferred because of the large number of predators, particularly sharks, attracted to the scene. When these animals are caught in the seine, it is difficult to transfer the catch into the hold—a task often accomplished with a 300 millimeter Marco Capsulpump. Further, sharks outside the net often bite and tear the bag of the net during the transferring operation. During most years, low market demand and small shoreside handling and processing capacity discourage the use of purse seines, which are capable of catching large quantities of squid.

Monterey Fishery

The different squid-fishing method in Monterey Bay is primarily a result of California state fishing regulations, one of which outlawed purse seining in 1953 because of its possible effects on squid eggs. Spawning squid occur in shallow waters in the fishing grounds in Monterey Bay, and the lead line of purse seines would drag across the ocean floor, uprooting the sessile egg masses. Another limiting law, introduced in 1959, is a ban on the use of lights in Monterey Bay to attract squid.

Squid at Monterey are caught with a roundhaul net called a *lampara*. Lamparas have a large central bunt of small mesh and short wings of larger mesh. These nets have been used to catch squid in Monterey Bay since 1905, when they replaced the purse seine that had been used by Chinese fishermen since at least 1863. The bunt of the present-day lampara has a mesh size of 32 millimeters, stretched. The cork line is usually 55 to 73 meters long over the bunt. The lead line is usually less than 36 meters long (sometimes as short as 12 meters) below the bunt. The cork line of each wing is 145 to 190 meters long. The lead

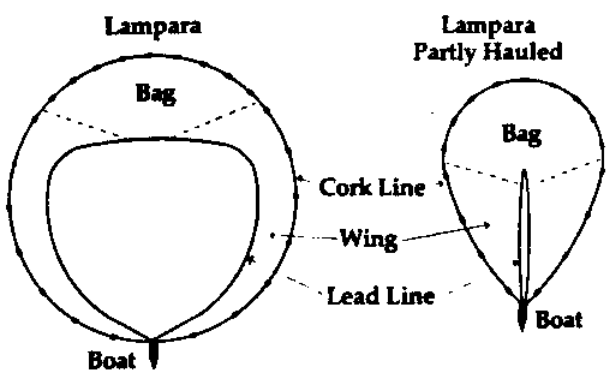


Figure 7. **Lampara net set and partially hauled (from Scofield, 1951)**

line is usually 10 percent shorter so that it precedes the cork line as the net is hauled, minimizing the chance of squid escaping downward. Adjacent to the bunt, the mesh size in the wings is 100 millimeters, stretched, and increases toward the wingtips to 150 to 230 millimeters. The wings of some nets taper to a point; others are cut nearly square. They are usually about 55 meters deep where they join the bunt.

Fishermen began replacing and repairing their cotton nets with Marlon (mixed polymeric) in the early fifties. In spite of its greater bulk, this Japanese synthetic netting material was favored over nylon (polyamide) because of its softness, superior knot-holding qualities, and lower cost. At present, however, fishermen use nylon, because its price has come down.

Most depth sounders used to locate squid in the Monterey area are of the flasher type. Frequencies are similar to those used in southern California. Attempts to use sonar have been ineffective due to the wakes created by, for example, ten to twenty boats scouting an area of less than one square mile. Squid are also commonly located by searching for the bioluminescence created by plankton when disturbed by schools of moving animals. However, as the top of a school of squid tends to remain deeper than that of many other species located by luminescence, they can be difficult to locate by this method.

As in southern California, predators indicate the presence of squid. Predators used to locate squid schools at Monterey include marine birds, California sea lions, and, since about 1970, sea otters.

In most years extensive scouting is normally not required during the height of the season. The fleet simply proceeds to the end of the breakwater of the Monterey boat harbor, and vessels maneuver for positions within the few hundred square meters in which squid are densest. The fishing area is often crowded with vessels, and the question of where to set the net is often decided on the basis of where the safety of the crew, vessel, and net is most secure. When the species composition of schools is questionable, it is common practice to allow the first vessel to complete a set before the other vessels begin theirs. Vessels usually leave port around midnight except in periods of low availability, when they embark shortly after dusk. Scouting is conducted outside the edge of an existing kelp bed in 20 meters of water. The greatest depth scouted is around 60 meters, and lampara nets generally fish to a depth of 35 to 55 meters.

When a school of squid has been located, a small skiff carrying the end of one towline attached to a wing is released from the stern of the vessel. The remainder of the net, along with a length of towline, is pulled over the stern as the vessel makes a counterclockwise encircling maneuver, returning to the skiff. Sections of the bunt are usually thrown overboard manually to allow them to sink deeper. In a few cases, a skiff is not used; in its place a large, lighted buoy with the end of one towline tied on is used.

Photo by J. Hardwick

Figure 8. **Monterey squid vessel setting a lampara net**

After the towline is retrieved from the skiff or float, both ends of the net are hauled simultaneously with the aid of powered net haulers or gurdies. Most gurdies are made from automobile differentials and the net rollers constructed of automobile tires. Although a few gurdies are powered mechanically by the main engine, most are powered hydraulically. The lead lines close as the wings are drawn together, and the squid are thus trapped.

While the wings are being hauled, a submerged flashing light is often hung from the vessel to attract squid and keep them from escaping between the wings. Loud hammering on the deck or gunwale also serves the same purpose. The boom is used to bring in the bunt of the net by strapping. A winch aids in cinching up the strapping slings. If the skiff is powered, it is sometimes used to tow the fishing vessel away from the net during hauling operations. In most cases, however, the captain sets the net so that the vessel is downwind during retrieval, and towing is unnecessary.

The bag of the net is held open with a wooden or metal boom and by the skiff. Brailing squid from the net into the fish hold requires at least five men. Two men in the skiff dip the brail into the bag to fill it with squid. A man on the winch hoists the brail, and two men pull it toward the vessel while the men in the skiff push the handle. After excess water is drained off, the net is poised over the fish hold and the purse line slackened to allow the squid to fall into the hold. Loose netting is hauled by hand during the brailing operation as the weight in the bag diminishes. When transferring the catch from the net into a barge or lighter, the brail is handled from the main vessel and pushed over the net to the lighter. Most brailing is done with the sock brail, which is operated from the main vessel, as with the method used in southern California.

In a typical set, about 1.5 minutes are required to set the net around a school of squid. The towlines and wings are hauled aboard in about 5 minutes. The net is dried up by strapping in 40 minutes. Brailing requires about 2.5 minutes per ton of squid.

In 1981 about thirty vessels ranging from 8 to 20 meters in length participated in the Monterey squid fishery. The crew complement varied from six to ten men. Almost all of the vessels are now using powered net reels to haul in the nets and to save labor.

Photo by J. Hardwick

Figure 9. **Brailing squid; note the large crew size**

Handling and Processing

Handling Catch at Sea

The squid fishing grounds are very close to the unloading docks and processors. In Monterey the fishing grounds are less than one hour away, while southern California fishermen fish within six hours of port. Therefore, the catch is not refrigerated or iced on board the vessels. The catch is pumped or brailed directly into the hold. Most fishing is done at night and the catch is landed and processed the following morning.

Prices

Squid command several different price ranges. Usually squid sold for freezing whole obtain a higher price than squid destined for canning. Some canners process the squid in excess of what the freezers can handle. In years of high squid abundance, a larger amount is canned and the average value of squid is lowered. There is also a price differential between Monterey and southern California. Processors perceive Monterey squid as being of higher quality, and currently pay a much higher price for it. In addition, union activity and market conditions are apparently related to the higher price. Prices in 1981–1982 ranged from $115 to $285 per ton.

Processing Market Squid

Processing of California market squid began in 1863 with the production of sun-dried squid for export, chiefly to China. This industry continued until 1933 when, due to financial conditions, the Oriental market was closed. Canning and freezing were introduced in about 1920 and 1926, respectively, and these processes remain the principal methods for preserving California market squid today. From the late 1940s until the early 1970s, the majority of the catch was processed into canned squid for export to countries such as the Philippines and Greece. Since that time, changes in processing economics and in world markets have resulted in a shift toward frozen squid products.

Currently, California market squid are processed into fresh, frozen, canned, and specialty products. Processing plants are located near the coast within a few miles of the unloading docks. Since squid are highly perishable, they are transferred to slush-ice holding tanks upon delivery at the processing plant. The slush ice chills the squid,

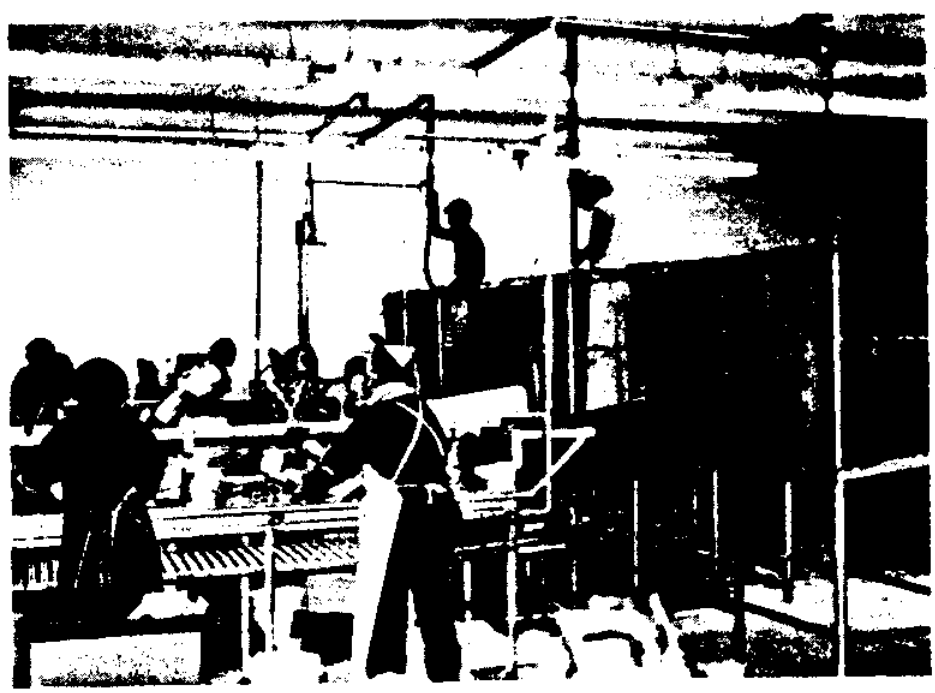


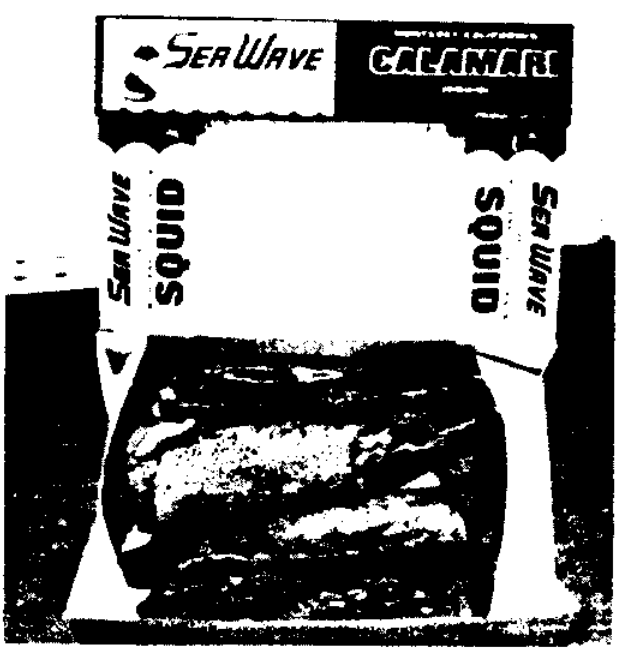
Figure 10. **Squid processing line**

bleaches them to a whitish color, and rinses off extraneous material.

Fresh squid. Squid for fresh markets are washed, sorted into uniform sizes, and packed whole in ice for immediate distribution. Small squid and squid with cuts, torn skin, or missing parts are culled for later processing into bait. Due to their perishability, fresh squid are only marketed along the California coast near the squid grounds and processing facilities. Most of the fresh squid are marketed through retail and food service establishments. This market is relatively small, accounting for 2 to 3 percent of the catch.

Frozen squid. Squid for frozen markets are washed, sorted by size and quality, and hand packed whole into 1-, 2-, 3-, 5-, 10-, and 25-pound, and 10-kilogram containers. The packaged squid are frozen and then ice-glazed or overwrapped to minimize oxidation during frozen storage. Frozen squid are stored at −15° C to −20° C. High temperature storage or temperature fluctuation during frozen storage causes damage to skin pigment cells, reddening the meat and reducing the commercial value of the product. During the last five years about three quarters of the annual squid catch has been marketed as frozen, whole squid. About 80 percent of that amount is exported, primarily to Japan and southern Europe, where prices are generally higher than on the domestic market. A small but slowly expanding domestic market for frozen whole squid exists in California and on the East Coast. This domestic market is made up chiefly of food service establishments, due to a general consumer resistance to buying whole squid in retail markets. The remaining 15 to 20 percent of the frozen, whole squid is marketed as a recreational and commercial fish bait. That market has declined somewhat in recent years due to increases in the price of squid.

Figure 11. **A one-pound box of squid ready for freezing**



Canned squid. Squid for canning are washed, sorted, and hand packed whole into 1-pound cans. During the last five years, between 85,000 and 162,000 cases have been packed annually. Canned squid commands a lower price than frozen squid on the world market, and often squid are canned only when the daily landings exceed the capacity of the freezing plants. Almost all canned squid are packed for export, but a small amount is marketed domestically.

Processed squid. Although almost all market squid landed in California are sold whole, there is an expanding market for further processed specialty products. Processed market squid products currently produced in California include cleaned and skinned mantles (either split or whole), tentacles, breaded mantles and tentacles, stuffed squid, squid burgers, dried squid, and smoked squid. Both fresh and frozen squid are used as raw material for specialty products. The squid are cleaned and skinned by hand. Experienced workers can process 45 to 60 pounds of whole, large squid (2 ounces each) into 15 to 20 pounds of cleaned squid mantles per hour. Cleaned squid mantles are generally run through an electric tenderizer before being further processed. Breaded or unbreaded tentacles are packed along with the mantles, sold separately, or sold as fish bait. Cleaned, breaded, and stuffed squid products and squid burgers are usually marketed frozen.

Dried squid and smoked squid are processed in small amounts for export to Asian markets and for small, ethnic, domestic markets. Fresh and frozen processed squid products are marketed primarily to food service operations, and to a small extent to retail outlets. The demand for processed squid products is increasing, but prod-

uct costs are high due to the hand labor involved. Hand cleaning of squid adds from 40¢ to 60¢ per pound to the product's cost.

Competition from less expensive imports and the lack of automated processing equipment have hindered the development of processed squid markets. Foreign squid processing equipment, including Taiyo Manufacturing Company's fully-automated squid cleaning machine, have been tried on the California market squid without success. Japanese equipment is designed for larger squid, and is not usually adaptable to market squid. An automated squid cleaning machine for market squid has been designed at the University of California, Davis, which may soon be available. The machine design features a three-step process that first cuts then cleans and ejects the squid. The food machinery industry is now refining the prototype to increase its capacity.

Figure 12. **Breaded squid filets, one of many new products being developed**

Future Outlook

The Market

It appears that the market squid resource may sustain a significantly higher catch. The major constraints to expansion of the fishery include lack of market demand, lack of landing and processing facilities near potential new fishing grounds, insufficient knowledge of squid distribution and abundance, fluctuations in abundance from year to year, and a lack of research on alternative fishing methods and grounds.

Almost all of the squid landed in California is exported, primarily to southern Europe and Japan. The rest is marketed domestically to restaurants, supermarkets, specialty processors, and as bait. The market squid's small size limits its export value, while domestic markets are limited because of the high cost of hand-cleaning squid into a product acceptable to the U.S. consumer. A few small firms are aggressively marketing cleaned and processed squid products, and the demand for these products is increasing. The development of a large domestic market, however, will not occur until low-cost, automated squid cleaning machines are developed, refined, and adopted by the industry.

Any significant increase in market demand may require fishing on new grounds. In some years the traditional fishing grounds have not been able to supply enough squid. Most of the potential new fishing areas (for example, between Point Conception and Monterey Bay) are located a long distance from processing facilities, so it may be necessary to have fishing vessels refrigerate the squid. The slowness of squid fishermen to adopt new fishing methods is another factor that could hamper expansion into new, more distant fishing grounds.

Research

There has been limited research into the distribution and abundance of the market squid. Sea Grant-funded research by Moss Landing Marine Laboratories and the California Department of Fish and Game has located several other exploitable concentrations of squid, particularly off the central California coastline. Other researchers

and commercial fishermen have noted substantial concentrations of market squid along the northern California, Oregon, Washington, and British Columbia coasts. These concentrations are reported sporadically, and it is unknown whether landings would be consistent enough to support a fishery. Increased research on the distribution, abundance, and population structure of the market squid along the Pacific coast would clarify the potential for expansion. In addition, examining the relationship between oceanographic conditions and squid abundance would help to predict availability.

Little developmental work has been done on fishing methods and gear. Southern California fishermen have not adopted the efficient pumping system developed by Sus Kato in 1970 because of high initial investment costs, low squid prices, physical damage to some 2 to 5 percent of the squid, and a desire to maintain a certain crew size. Future innovations in fishing methods and gear will have to be compatible with the fishermen's needs and social system.

Midwater trawling has been suggested as one alternative fishing method. A research expedition in 1975 successfully captured squid in sixteen out of seventeen midwater trawls. However, a joint research cruise with a Spanish research vessel in February and March of 1979 along the entire California coast captured very little squid and had an unacceptably high by-catch of valuable fishes. Those results may be due to the fact that the midwater gear was not fished in areas of known high squid concentrations, where it might have been more effective. A 1965 attempt captured market squid only in otter trawls and not in midwater trawls. The future of midwater trawling for market squid seems to depend on developing acoustical techniques for identifying squid concentrations and lessening the incidental catch of juvenile fishes. The improvement of existing gear and methods (nets, lighting systems, brailing systems, acoustical gear) and the development of improved handling and processing methods appear to be the most likely areas to pursue in order to improve the efficiency and harvesting capability of the squid industry. Technological advances may occur if aggressive marketing and product development increase the market demand.

The Jumbo Squid Fishery

The jumbo squid, *Dosidicus gigas*, is growing in importance in the U.S. squid market. This large squid (up to 90 kilograms) is found from Chile to southern California, but occurs only rarely in sizeable numbers off California. The fishery takes place primarily off Mexico's Pacific coast, using jigs. The mantle of this large squid is cut into round portions and marketed as "squid steaks" in the United States. The product resembles abalone in appearance, and is replacing that very expensive and erratically-supplied food on some restaurant menus.

A Japanese exploratory jig-fishing cruise in 1971 resulted in catches of 23,000 kilograms in 27 days. Since then the fishery has been expanded by both the Japanese and the Mexicans. The 1980 landings were 22,000 metric tons.

Sportfishing Information

Market squid are captured for food and bait by recreational anglers, using several methods. Often at night the squid can be captured with dip nets under lights. Skippers of charter boats will often capture squid under lights for use as live bait. Anglers should check the sportfishing regulations for the area and possess a sportfishing license.

Another method, used in both day and night fishing, is to catch squid with a small, silvery lure or jig with a treble hook, which is jigged up and down in areas of known squid concentrations. Leaders with a long series of small, feathered hooks (mackerel jigs) are also effective.

Consumer Information

Squid is available frozen throughout the year. Only 2 to 3 percent is marketed fresh because of the high perishability factor. Squid sold in supermarkets is usually thawed. One of the best

bargains in squid is to buy it frozen in 3- or 5-pound boxes for later use at home. Because of its low fat content, frozen squid stores well and is of high quality if properly handled. Squid can be purchased in processed forms such as steaks, rings, tubes, or as a prepared product ready for cooking (for example, stuffed).

Squid is highly nutritious, being similar to other seafoods in protein content (about 15 grams per hundred grams of weight). It is also relatively low in fat (about 1 gram per 100 grams of weight) and low in calories (about 89 calories per 100 grams of weight). Numerous leaflets and books discuss the cleaning and cooking of squid, which is becoming more and more popular in both restaurants and the home kitchen. Squid is gaining wide recognition through such cuisines as the Italian, Spanish, Chinese, and Japanese.

Annotated Bibliography

Ally, J.R.R., R.G. Evans, and T.W. Thompson. The 1975. results of an exploratory fishing cruise for *Loligo opalescens* in southern and central California. Tech. Publ. 75-2 Calif. State Univ. (Moss Landing Marine Lab.) 22 pp.

Presents results of an initial cruise looking for new squid fishing areas. Gives locations of squid concentrations.

Bernard, F.R. Preliminary report on the potential com- 1980. mercial squid of British Columbia. Canadian Tech. Rept. of Fisheries and Aquatic Sci., No. 942.

Summarizes the biology, habitat, and probable abundance of several potential commercially important squids. Good background information for those interested in more northerly squid fishery development.

Brown, D.E. and R.P. Singh. A machine to eviscerate 1981. and skin squid. Trans. ASAE 24(1): 259–264.

Describes a machine designed specifically to clean the market squid. Includes diagrams and discussion of industrial applications.

Cronin, I. *The International Squid Cookbook*. Berkeley: 1981. Aris Books.

Supplies detailed information on squid preparation, with many recipes.

FAO. *FAO Catalogue of Fishing Gear Designs*. Surrey, 1972. England: Fishing News Books, Ltd. 155 pp.

Contains accurate diagrams of fishing gear, including gear used to capture squid.

Fields, W.G. A preliminary report on the fishery and 1950. on the biology of the squid *Loligo opalescens*. Calif. Fish and Game 36(4): 366–377.

The initial fisheries biology work done on the market squid.

Fields, W.G. The structure development, food rela- 1965. tions, reproduction, and life history of the squid *Loligo opalescens* (Berry). Calif. Fish Bull. (131). 108 pp.

The first in-depth biological study of the market squid.

Frey, H.W. *California's Living Marine Resources and Their* 1971. *Utilization*. Sacramento: Calif. Dept. of Fish and Game. 148 pp.

Provides excellent information on the history, gear, methods, and processing involved in the squid fishery as well as a summary of life history information up to 1971. Contains similar summaries for most commercial and recreationally important fish.

Gulland, J.A. (ed.) *The Fish Resources of the Ocean*. 1971. West Byfleef, Surrey, England: Fishing News Books, Ltd. 255 pp.

Reviews the potential world fishery resources, using maps and diagrams to show the location depth of distribution. Estimates of abundance are included.

Higgins, E. and H.B. Holmes. Methods of sardine 1921. fishing in southern California. Calif. Fish and Game 7(4): 219–237.

An early, detailed summary of nets used in the sardine and squid fisheries.

Hochberg, F.G., Jr. Molluscs—cephalopods and 1981. bivalves. *In: Literature Review of the Resources of Santa Rosa and Santa Rosa Islands and the Marine Waters of Channel Islands National Park, California*. Santa Barbara Museum of Natural History.

Describes the squid resources found around southern California's Channel Islands.

Hochberg, F.G., Jr. and W.G. Fields. Cephalopoda: 1980. The squids and octopuses. *In:* Morris, R.H., D.P. Abbott and E.C. Haderlie. *Intertidal Invertebrates of California.* Stanford: Stanford University Press (Chapter 17).

This is a chapter in a major work. The squids and octopuses found intertidally and in shallow waters are described.

Kato, S. Catching squid by the ton with pumps. Natl. 1970. Fisherman, June, 1970.

Describes the pumping system developed to lessen the labor involved in squid fishing. The system worked well but hasn't been widely adopted by fishermen.

Kato, S. and J.E. Hardwick. The California squid 1975. fishery. *In: Expert Consultation on Fishing for Squid.* FAO Fish. Rep. (170) Suppl. 1: 107–127.

The first work to describe the California squid fishery in detail. The in-depth description of the gear and fishing methods is enhanced by numerous photographs.

McGowan, J.A. Observations on the sexual behavior 1954. and spawning of the squid, *Loligo opalescens,* at La Jolla, California. Calif. Dept. of Fish and Game 40(1): 47–54.

One of the first scientific accounts of squid spawning behavior.

New England Fisheries Development Foundation. 1982. *Proceedings of the International Squid Symposium.* New York: Unipub.

A comprehensive look at the world's squid fisheries. Includes practical papers on gear, methods, processing, quality control, marketing, and fishing strategies.

Pearcy, W.G. Species composition and distribution of 1965. pelagic cephalopods from the Pacific Ocean off Oregon. Pacific Science 19: 261–266.

Gives a preliminary indication of the distribution and abundance of squid off Oregon. Describes how and where squid were captured in otter trawls.

Recksiek, C.W. and H.W. Frey. (eds.) *Biological, Ocean-*1978. *ographic, and Acoustic Aspects of the Market Squid, Loligo opalescens.* Calif. Dept of Fish and Game, Fish Bull. 169. 185 pp.

The most complete and current group of papers on the biology of and fishery potential for the market squid. Summarizes three years of Sea Grant/California Department of Fish and Game research. Includes information on population structure, spawning, feeding, variables determining abundance, importance as forage, growth rates, and acoustic location of squid schools.

Sato, T. Results of exploratory fishing for *Dosidicus* 1976. *gigas* off California and Mexico. FAO Fish. Rep. (170) Suppl. 1: 61–67.

Reports the results of a successful Japanese exploratory jigging cruise for "jumbo" squid off Baja California.

Scofield, W.L. Purse seines and other roundtable nets 1951. in California. Calif. Fish Bull. (81). 83 pp.

Describes the nets commonly used in the squid and pelagic wetfish fisheries.

Schultz, J.S.F.T.W. and B. Regardz. *The Calamari* 1981. *Cookbook.* Santa Cruz, CA: Orenda-Unity Press.

Supplies numerous squid recipes.

Sidwell, V.D., P.R. Foncannon, N.S. Moore, and J.C. 1975. Bonnet. Composition of the edible portion of raw (fresh or frozen) crustaceans, finfish, and mollusks. Marine Fish. Rev. 36(3): 21–35.

Lists the protein, fat, moisture, ash, carbohydrate, caloric, and cholesterol levels of many important fish and shellfish.

Stauffer, G.D. Cruise report—R/V vessel Freire Lopez 1979. (Spain)—California midwater squid survey. Southwest Fisheries Center (NMFS), La Jolla, California.

Describes an exploratory cruise testing the feasibility of midwater trawling for squid off California. The results of the cruise were inconclusive.

Takahashi, T. Utilization of squid as food. *In: Fishery* 1974. *Products* (R. Kreuzer, ed.) Surrey, England: Fishing News (Books) Ltd. p. 244.

Describes the different products made from squid. Emphasizes Japanese products, because that is where much of the world's squid catch is consumed.

Time-Life Books (eds.) *The Good Cook—Shellfish.* Alex-1982. andria, Virginia: Time-Life Books.

Includes several squid recipes along with preparation information for many types of American shellfish.

Townsend, M., C.M. Dewees, and R.J. Price. 1979. Catching, cleaning, and cooking squid. Univ. of California, Div. of Agr. Sci. Sea Grant MAP Leaflet 21112.

Describes how angler can capture squid. Includes directions for cleaning and cooking squid.

Voss, G.L. Cephalopod resources of the world. FAO 1973. Fish Circular (149). 75 pp.

A major overview of the world's squid and octopus resources with some estimates of abundance.

This work is sponsored in part by NOAA, National Sea Grant College Program, Department of Commerce, under grant number NA80AA-D-00120, through the California Sea Grant College Program, and in part by the California State Resources Agency, project number A/EA-1. The U.S. Government is authorized to produce and distribute reprints for governmental purposes.

The authors are Christopher M. Dewees, Marine Fisheries Specialist, and Robert J. Price, Seafood Technology Specialist.

COOPERATIVE EXTENSION **UNIVERSITY OF CALIFORNIA**

This information is provided by Cooperative Extension, an educational agency of the University of California and the United States Department of Agriculture. Support for Cooperative Extension is supplied by federal, state, and county governments. Cooperative Extension provides the people of California with the latest scientific information in agriculture and family consumer sciences. It also sponsors the 4-H Youth program. Cooperative Extension representatives, serving all counties in California, are known as farm, home, or youth advisors. Their offices usually are located in the county seat. They will be happy to provide you with information in their fields of work.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture, Jerome B. Siebert, Director, Cooperative Extension, University of California.

PRINTED APRIL 1983

3m–4/83–PE/PF