

BOTTOMFISH RESOURCES OF THE CALIFORNIA CURRENT SYSTEM

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INTRODUCTION

Bottomfish resources as included in this report are the marine species of flatfish, roundfish, and shellfish traditionally caught in gear on or near the ocean bottom and used fresh or frozen. The principal species are soles, flounders, rockfishes, crabs, oysters, abalones, and shrimp (Table 1). Species of lesser commercial importance are lingcod, sablefish, and Pacific hake. Utilization of California's bottomfish resources occurs mainly off the central and northern coast.

In terms of pounds and dollars, the several bottomfish resources of California are being harvested to a yield of 67 million pounds and contribute approximately 24 million dollars to the economy of the State. Of this, more than half, 41 million pounds and about 14 million dollars, is from fin fisheries. The remainder, 26 million pounds and 10 million dollars is from shellfisheries.

The status of our knowledge of the bottomfish resources is very complete from the standpoint of total landings and time of harvest. From trawler logs we get very accurate records of location of catch and effort expended. However, for other fishing, information on harvest becomes progressively less detailed in regard to location of catch and effort expended. We know, for example how many pounds of crab were taken, but we cannot give location of gear more accurately than groups of Fish and Game blocks (30 x 60 miles) or say what the effort was more precisely than pounds per boat landing.

The status of our knowledge of facets of life history and population dynamics varies from very precise age growth relationships of the better known flatfish to statistical confusion for age composition of species of some areas.

The reasons for the wide gaps in our knowledge are not of ineptness and lack of interest on the part of researchers. They are of lack of application in terms of manpower and facilities for the job at which we only piddle here and there. What we know is valuable and is used for management recommendations. What we have not studied or have only begun to study is awesome in magnitude and is of great importance for progress in management.

FIN FISHERIES

The California trawl fleet fishes along the coast from southern California into waters off southern Oregon. (Figures 1, 2, 3 and 4) In northern and central

TABLE 1
COMMON AND SCIENTIFIC NAMES

Common Name	Scientific Name
FISHES	
Bocaccio	<i>Sebastes paucispinis</i>
Chilipepper	<i>Sebastes goodei</i>
Flounder, arrowtooth	<i>Atheresthes stomias</i>
Flounder, starry	<i>Platichthys stellatus</i>
Halibut, California	<i>Paralichthys californicus</i>
Hake, Pacific	<i>Merluccius productus</i>
Lingcod	<i>Ophiodon elongatus</i>
Rockfish, canary	<i>Sebastes pinninger</i>
Rockfish, shortspine channel	<i>Sebastes alascanus</i>
Sablefish	<i>Anoplopoma fimbria</i>
Sole, Dover	<i>Microstomus pacificus</i>
Sole, English	<i>Parophrys vetulus</i>
Sole, petrale	<i>Eopsetta jordani</i>
Sole, rex	<i>Glyptocephalus zachirus</i>
CRUSTACEANS	
Crab, market	<i>Cancer magister</i>
Lobster, California spiny	<i>Panulirus interruptus</i>
Shrimp, ocean	<i>Pandalus jordani</i>
MOLLUSKS	
Abalone, pink	<i>Haliotis corrugata</i>
Abalone, red	<i>Haliotis rufescens</i>
Oyster, giant Pacific	<i>Crassostrea gigas</i>

California the trawling grounds extend from the three-mile limit to offshore depths of over 400 fathoms (372 m). Flatfish and roundfish are caught throughout this area but gear selectivity, fish abundance and distribution, bottom characteristics, and market demand for definite species influence the selection of fishing areas by trawler captains. The fish in greatest demand are Dover, English and petrale sole; and canary and shortspine channel rockfish. Southern California trawl grounds extend from three miles offshore to depths of about 200 fathoms (366 m). The fishing emphasis in this area is mainly for petrale and English sole; bocaccio and chilipepper rockfish; and animal food. Little effort is expended in deeper water for Dover sole.

The California trawl fleet landed 35.2 million pounds of bottomfish in 1966. This catch was 1 percent greater than the 34.8 million pounds of 1965 and 2 percent more than the 10-year average of 34.5 million.

Fishing effort of 54,098 trawling hours in 1966 exceeded by 3 percent the 1959-1965 mean annual effort of 52,598 hours. The size of the vessels, and the nets, cables, and winches with which they are equipped

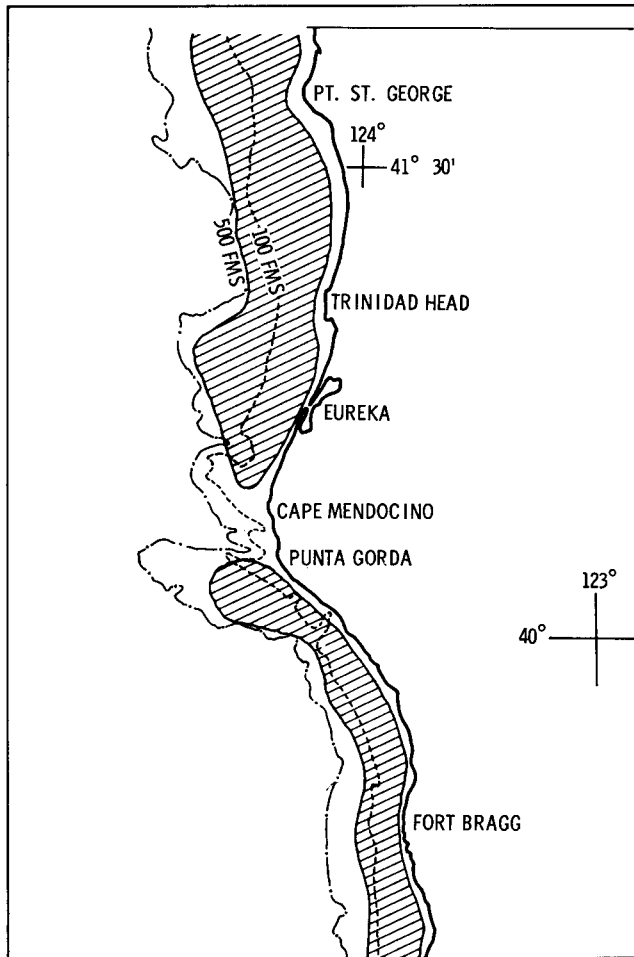


FIGURE 1. Northern California trawling grounds.

limits fishing operations to waters of 500 fathoms (915 m) or less.

In 1966 there were slight decreases in catches of English sole, Dover sole, and lingcod, while petrale sole and rockfish landings increased 10 and 11 percent, respectively over 1965 totals (Table 2). Favorable marketing conditions prevailed throughout both years.

Flatfish

The annual harvest of the soles and flounders, has been about 25 million pounds during the past ten years (Table 2).

In 1967, market demand for flatfish declined and catch limits were imposed by dealers. Landings this year were also affected by price negotiations which caused a fleet tie-up in April. Nevertheless, preliminary data for the year show only a six percent decrease from comparable 1966 data. The market limits affected Dover sole more than other species and a 41 percent decline of 1.7 million pounds from that of 1966 occurred. However, increases in landings of English sole and petrale sole nearly offset the decline in the Dover sole catch. The increase in catch of these species was a consequence of severe Dover sole limits

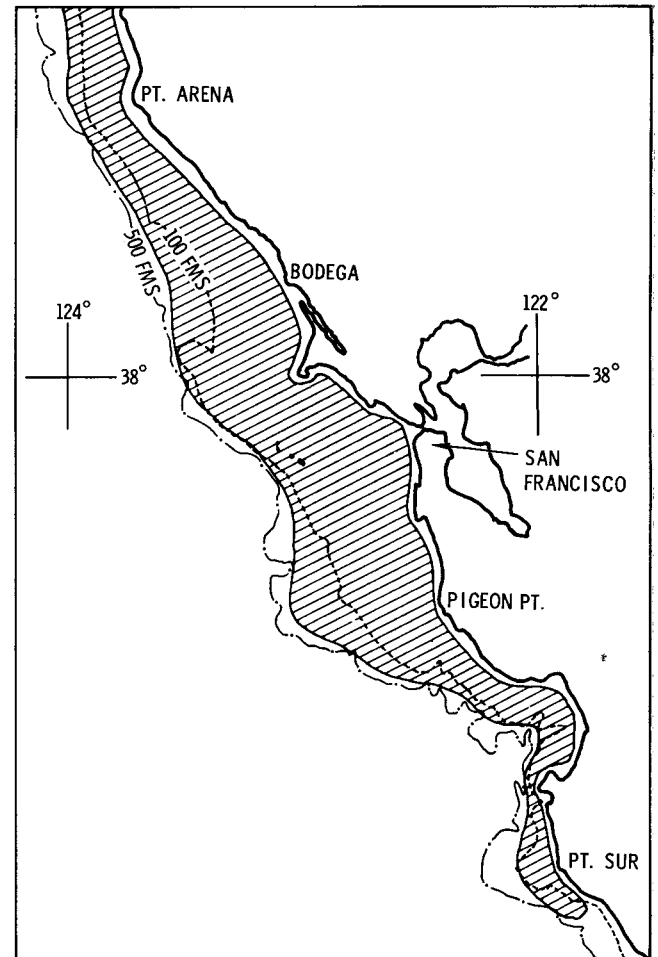


FIGURE 2. Central California trawling grounds.

since trawl effort was diverted from deep water to inshore areas. Total 1967 landings of flatfish are expected to be slightly less than the 25.2 million pound catch of 1966.

The kinds of fluctuations in landings of flatfish species described for 1967 exemplify the conditions which have prevailed in the fishery for many years. The prospects for an enlarged fishery with greater production exist. However, the impetus for information needed on extent, distribution, and renewable capabilities of the flatfish populations is only now becoming acute because of greater interest in sources of protein from the sea and the exploitation of marine resources by foreign fleets off our coast. If increased demands for fish occur, the fleet will modernize and become capable of harvesting from more distant and deep grounds.

Dover sole stocks can support more utilization, particularly on the deeper trawlable grounds off central and southern California. Five million pounds of English sole can be taken with little added effort. Increased trawling off our southern coast would do the most for more adequate use of this species. Petrale sole are rather fully utilized. Expansion of fishing grounds will be necessary to raise production above

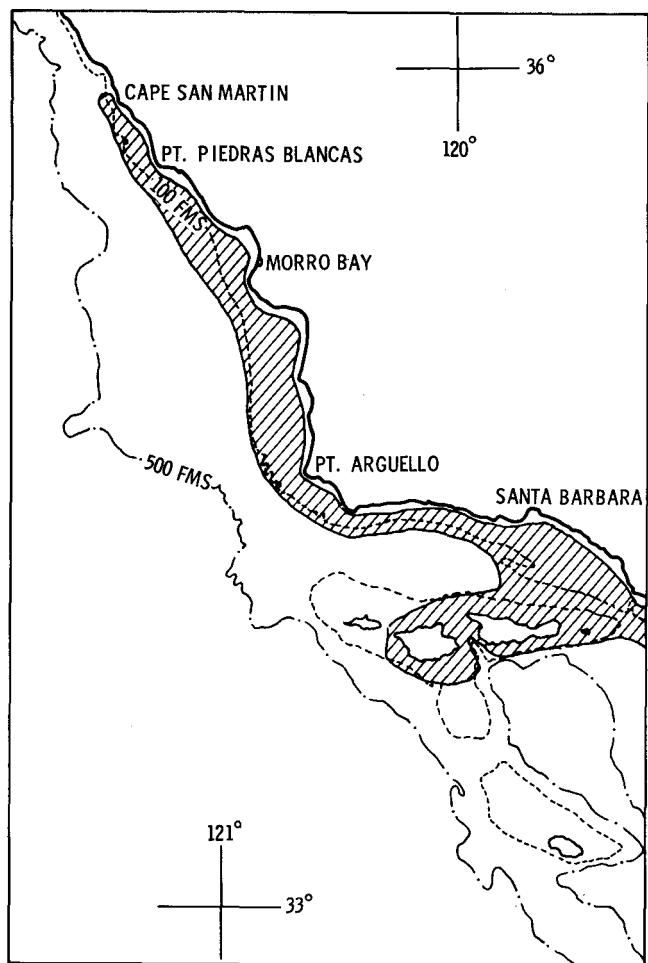


FIGURE 3. Southern California trawling grounds, northern portion.

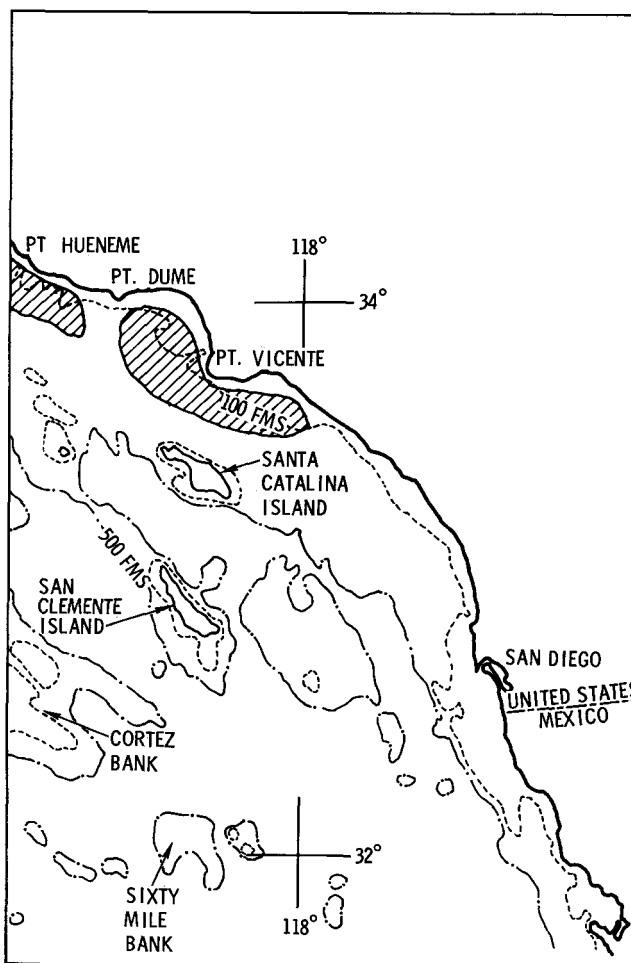


FIGURE 4. Southern California trawling grounds, southern portion.

TABLE 2
CALIFORNIA TRAWL LANDINGS
1956-1966
(Thousands of Pounds)

Species	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
English Sole	4,820	5,150	4,618	2,376	3,646	4,209	4,254	4,594	4,893	4,841
Rock Sole	1	1	--	3	1	--	1	2	--	--
Petrale Sole	3,454	3,155	2,632	2,475	3,391	3,038	3,317	2,699	2,659	2,925
Dover Sole	7,932	8,053	7,327	9,185	7,826	8,851	9,780	9,267	10,760	10,301
Rex Sole	1,234	1,423	1,443	1,107	1,209	1,408	1,565	1,409	1,491	1,635
Starry Flounder	500	466	1,043	248	296	298	461	370	324	284
Other Flatfish	1,856	1,214	1,657	1,908	934	1,160	1,312	1,384	1,224	1,319
Lingcod	1,239	1,358	1,153	1,099	1,163	819	857	673	618	586
Sablefish	1,268	1,415	1,703	2,133	1,340	1,690	1,660	1,618	1,880	2,077
Rockfish	14,280	14,632	12,240	11,732	8,912	7,757	9,807	6,785	7,673	8,499
Misc. Species	1,529	1,536	1,415	618	329	356	491	437	405	342
Animal Food	--	--	--	--	3,777	1,879	1,034	1,738	2,875	2,375
TOTAL	38,113	38,403	35,231	32,884	32,824	31,465	34,539	30,976	34,802	35,184

4 million pounds. Other flatfish such as rex sole, California halibut, sanddab, and starry flounder contribute a minor amount to the total landings but would yield more as effort for other species increased.

Roundfish

Prior to World War II rockfish landings had fluctuated between 2 and 8 million pounds in response to market demands. Stimulated by the World War II

demand for sea food, landings increased to 13 million pounds in 1945. Following a post-war slump, total annual landings by trawl and longline gear increased to an all-time high of 18 million pounds in 1958. Since then the landings have dropped and are now at about 10 million pounds per year (Table 3).

TABLE 3
ANNUAL ROCKFISH LANDINGS, CALIFORNIA
1957-1966

Year	Pounds			Total
	Northern*	Central*	Southern*	
1957.....	3,794,601	8,289,084	4,007,594	16,091,279
1958.....	3,814,268	10,052,104	3,975,791	17,842,163
1959.....	3,333,682	9,620,352	2,327,248	15,281,282
1960.....	3,193,668	6,853,642	3,666,576	13,713,886
1961.....	2,117,410	5,449,776	3,263,576	10,830,762
1962.....	1,993,213	4,844,064	2,997,116	9,834,393
1963.....	3,373,251	4,825,308	3,550,901	11,749,460
1964.....	1,885,160	3,925,178	2,307,574	8,117,912
1965.....	2,524,174	4,194,621	2,673,629	9,392,424
1966.....	1,912,261	4,994,068	3,151,948	10,058,277

* Northern—from Oregon border south to Sonoma County.

* Central—includes Sonoma County south to San Luis Obispo County.

* Southern—includes San Luis Obispo County south to Mexican border.

The balloon trawl net, introduced in northern California in 1943, was the principal gear used for the highest landings. In previous years set longlines were the primary gear for rockfish. Catches by trawlers were incidental to flatfish. Longline fishing now accounts for about 15 percent of the commercial rockfish take. The most productive longline areas are at about 100 fathoms (183 m) between Pt. St. George and Trinidad Head, just south of Punta Gorda, off Fort Bragg, and from Pigeon Pt. to Pt. Sur. South of Santa Barbara county, possession of trawl nets in State waters was prohibited from 1925 to 1966. Therefore, setlines have been the primary gear for taking rockfish off southern California. The line fishing for rockfish has been about the islands of San Miguel, Santa Rosa, San Nicolas; on Cortez Bank, Sixty Mile Bank, and off San Diego. The use of trawl gear off the southern coast can result in an increase in landings, but the trawlable grounds are not extensive.

Increased effort in response to a greater market demand would result in a considerably greater harvest from all areas, and in all probability a sustained annual yield of 15 to 20 million pounds could be realized.

Better catches might also be made by adding large rollers on the lead line of nets to permit trawling over rough bottom, or by the use of large mid-water trawls not far off the bottom.

Because a large portion of the catch is listed by dealers simply as rockfish, we were prompted to sample for species composition of rockfish landed by trawlers at important California ports for the years 1962-1963. At ports from Santa Barbara to Fort Bragg, bocaccio and chilipepper are the most important rockfish, while at Eureka, canary rockfish and the shortspine channel rockfish are dominant. State-wide, bocaccio account for 44 percent of the rockfish

landings. Chilipepper is second at 18 percent, and canary and shortspine channel rockfish follow at 11 and 6 percent respectively.

Sablefish. The peak in sablefish landings of over 6 million pounds occurred in 1945 concurrent with World War II demand for fisheries products and the use of fish livers for the production of vitamin A. Annual landings of recent years have averaged slightly more than 2 million pounds. However, landings have displayed an upward trend since the early sixties. Eureka, San Francisco, and Monterey are the main ports of landings which by 1960 were more from trawlers than longliners. Sablefish landings for 1966 totaled 3,215,939 pounds. This moderately harvested resource could withstand additional harvesting at a much higher level—at least 4 to 5 million pounds more each year.

Lingcod. Lingcod are caught with handlines and longlines as well as coincidental with sole and rockfish in trawl operations. The majority of landings are by trawl vessels which, since 1958, have accounted for nearly 80 percent of the landings. Lingcod occur at depths over 100 fathoms (183 m) but most are taken at about 60 fathoms (110 m). They occur along the entire coast but are more abundant off central and northern California.

Landings have fluctuated between 314,334 pounds in 1942 to over 2 million pounds in 1948. In recent years landings have displayed a declining trend with 797,710 pounds recorded for 1966. Since lingcod are incidental to catches of other trawl-caught fish and the number of longline boats has declined, the landing fluctuations do not express the condition of the resource. We believe the lingcod resource could withstand additional fishing pressure to yield 3 million pounds per year without adverse consequences.

Animal Food Fisheries

Since the inception of the animal food fishery in 1953, landings for this use have fluctuated between 932,000 and 4,007,000 pounds. Following the peak catch in 1960, landings dipped to 1 million pounds in 1963 because of price negotiations and the shift by the industry to other sources of raw material. In recent years landings have risen to nearly 3 million pounds.

Fish landed as animal food are generally the unmarketable portion of trawl catches which were formerly discarded at sea. These are principally small-size species and those species least desired by the fresh fish markets. Some of the small desirable market species, such as English sole, Dover sole, and sanddabs occur in landings for animal food, but they are not sought for this purpose. Sablefish, hake, arrowtooth flounder, and many small rockfish species occur in the landings (Table 4). At northern ports small sablefish predominate while hake become more numerous in landings to the south. In general there is a potential for enlargement of the fishery for animal food.

TABLE 4
COMPOSITION OF ANIMAL FOOD LANDINGS BY PERCENT

Species	1964	1965	1966
Sablefish.....	44.8	40.0	42.6
Pacific hake.....	15.9	25.5	10.3
Arrowtooth flounder.....	12.2	13.1	10.8
Rockfish.....	12.6	8.8	15.0
Dover sole.....	5.3	4.6	5.3
English sole.....	4.2	5.0	5.8
Other species.....	5.0	3.0	10.2

SHELLFISHERIES

Of the approximately 26 million pounds of shellfish landed in California annually the crab resource yields an average of 11 million pounds worth \$1.7 million to fishermen (Table 5), while abalone bring

TABLE 5
AVERAGE ANNUAL SHELLFISH HARVEST

Resource	Weight in Pounds	Value to Fishermen
Abalone.....	4,000,000	\$500,000
Crab.....	11,000,000	1,700,000
Lobster.....	600,000	390,000
Oyster.....	8,000,000	300,000
Shrimp.....	2,000,000	200,000
	25,600,000	\$3,090,000

\$500 thousand to commercial fishermen for 4 million pounds. Shellfish culture provides 8 million pounds of oysters and about \$300 thousand to the growers. Ocean shrimp and prawn yield 2 million pounds for which fishermen receive approximately \$200 thousand each year, while the lobster fishery contributes 600 thousand pounds and \$390 thousand. In addition, more than a million pounds of abalone, clams, and crabs are taken annually by sportsmen.

Expanded to represent their total contribution to the economy of the state, the nearly 26 million pounds landed are worth \$16 million per year.

Crab

The fishery for the market crab in California is unique in that it is based on the harvest of one sex predominantly of one year class. Only male crabs with carapace width of 6¼ inches (15.875 cm) and greater are taken. Through the crab ranges the entire length of the California coast, its commercial abundance is from Morro Bay north over relatively shallow sandy areas, 75 fathoms (137 m) and less. The San Francisco-Bodega and the Eureka-Pt. St. George areas are the main crabbing grounds. The north coast leads in production with a long-term average of 7.4 million pounds, while the central coast fishery averages 3.1 million. Both areas have experienced wide fluctuations: 0.8 to 12.4 million pounds for north coast ports and 0.39 to 8.9 million pounds for central California (Table 6). Because the fishery is dependent on crabs predominantly 3½ to 4 years of age, the fluctuations

reflect year class abundance on the traditional crab grounds. We believe at least 90 percent of the legal sized portion of the resource is harvested each season. Our population estimates, based on pre-season random sampling, have been rather accurate. The reasons for the record low harvest (390 thousand lbs.) for the San Francisco area during the 1966-67 season are not known. However, we feel that the continually increasing fishing pressure has not been the cause. Variations in near shore ocean conditions are thought to be the most likely causes affecting larval survival and distribution. Data from our most recent research cruises reveal that a moderately strong year class will support a 2 million pound harvest from central California during the 1967-1968 season. A very abundant year class in the separate population off the north coast is expected to yield an all time high of 13 million pounds. The efficiency of the crabbing fleet and its coverage of the crabbing grounds and our post-season survey indicates the resource is completely utilized.

TABLE 6
CALIFORNIA MARKET CRAB LANDINGS
IN THOUSANDS OF POUNDS
1956 to 1967

Season	Northern California	San Francisco	Monterey and Morro Bay
1956-57.....	9,980	8,919	380
1957-58.....	9,610	7,391	286
1958-59.....	12,378	5,014	394
1959-60.....	10,727	4,783	344
1960-61.....	10,043	2,255	99
1961-62.....	3,251	710	25
1962-63.....	900	1,331	11
1963-64.....	808	1,158	12
1964-65.....	3,979	760	10
1965-66.....	9,933	441	9
1966-67.....	10,200	390	10
	$\bar{x} = 7,437$	$\bar{x} = 3,014$	$\bar{x} = 144$

Shrimp

Ocean shrimp were first determined to be present in beds off the California coast and in potential commercial abundance during research cruises of the *N. B. SCOFIELD* in 1950 and 1951. All these concentrations of shrimp have been on green mud bottoms at depths ranging from 40 to 120 fathoms (73 to 220 m).

Utilization of the shrimp began in 1952, landings increased and, in 1956 over one million pounds were harvested. The take of shrimp has been regulated to prevent a "boom and bust" fishery. The total landings each season relate closely to the quota set. The landings have been mainly from the largest bed off northern California—from Eureka to Brookings, Oregon. Last year this bed yielded 1.4 million pounds. The other beds are just north of Fort Bragg, off Bodega, and just south of Avila. The fishery has, during several seasons, landed slightly over 2 million pounds. We have reason to believe there will not be

greater landings because the species is short-lived, the beds are small, very high natural mortalities occur, and fishing pressure is high. The two southern-most beds fluctuate widely in size from year to year, so much in fact that some years fishermen have not fished them. The highest take from these beds has been about 450 thousand pounds.

Lobster

Since the turn of the century, the California spiny lobster has been an important segment of the fresh fish catch. Total landings from California waters have varied from less than 200 thousand pounds in 1916 to over 900 thousand pounds in 1950. Since that time, landings have declined and the catch has stabilized at about 600 thousand pounds despite ever-increasing demands for lobsters, and both sport and commercial fishermen striving to increase their take.

The species, recorded from Monterey to Magdalena Bay, Baja California, is fished in California along the mainland from Point Conception south, around the offshore islands, and on some of the offshore banks. Deep water, separating these various areas, may act as a barrier to free intermixing of population segments.

Tagging studies and extensive surveys could delimit the populations and the extent of intermixing. If subpopulations exist, management of the resource must proceed on an area basis, not a range-wide basis.

Recognizing the need for information about spiny lobsters on which a sound management program can be based and in response to a Senate Resolution, we have proposed that shellfish studies be augmented to increase knowledge about the spiny lobster: its population size, life history, movements, and general ecology.

Oyster

Oyster production by several companies occurs in Humboldt, Tomales, Drakes, and Morro Bays with the greatest yield from Humboldt Bay. This culture is not meeting the market demand, but improved culture methods and use of more acres of bay waters could increase the yield manifold. The giant Pacific oyster from Japan is the principal species grown. Oyster production in California is based on seed and shell stock planted, cultured, and harvested by several oyster growers. There have been wide fluctuations over the years due to commercial interest and effects of wars. However, at no time has the market demand been met. In 1951 and 1952 rebirth of the industry occurred and landings rose from a few hundred thousand pounds to 13.8 million in 1959. Shortages of seed in Japan in recent years resulted in a drop in California's production. The harvest is at about 8 million pounds. The area yielding the greatest portion of the harvest is Humboldt Bay. The east coast oyster and clams as well as scallops from Japan and oysters from Europe have yielded very encouraging results in hatching and culturing experiments. The use of hanging culture is being adopted by several California growers. This method provid-

ing additional production from areas too deep for conventional culture on tidal flats is now being used on a commercial scale in Humboldt and Drakes Bays.

During the past several years, there have been increasing reports of significant oyster mortalities on the Pacific Coast due to unknown causes. Heaviest mortalities have occurred in fast-growing Pacific oysters in areas where industrial pollution appears unlikely. Since no common causative factor is apparent, it is generally believed some disease or toxins are responsible. Our pathologists and our men monitoring pesticides in estuaries are investigating these problems to gain information to assure greater returns from shellfish culture.

Recent laboratory advances in marine biology have enabled biologists to hatch and raise marine shellfish larvae in the laboratory. Further research on the development of mass culture methods of clams, oysters, abalone, shrimp, scallops, and crabs may open avenues to increase both the potential for food production and the recreational uses of California's coastal areas. Techniques developed and demonstrated in the Fish and Game Marine Culture Laboratory to be established at Pacific Grove may instill industry with sufficient confidence to utilize additional areas where natural larval set is poor.

Abalone

Abalone are intensively harvested from coastal waters from the Cambria area south and about the offshore islands. The red abalone is the principal species north of Point Conception and the pink abalone dominates the take from the Channel Islands and the southern coast of California. The long term average annual abalone harvest of 4 million pounds has been exceeded during the last few years (Table 7).

TABLE 7
CALIFORNIA ABALONE HARVEST IN THOUSANDS OF POUNDS
1964-1966

Species	1964	1965	1966
Red.....	2,370	2,491	2,656
Pink.....	1,612	2,071	2,163
Green.....	97	15	144
Total.....	4,079	4,577	4,963

The major fluctuations in abalone landings occurred in conjunction with World War II and again after the warm water years of 1957-1959 when kelp beds were reduced and pink abalone, because of food shortage, did not grow to legal size. Though both the red (in 1936) and pink (in 1952) resources have yielded high annual harvests of about 4 million pounds each; we do not believe a total harvest of 8 million pounds will occur; six million would more likely be the highest to be realized on a sustained basis.

SUMMARY

Bottomfish resources of California are species of flatfish, roundfish, and shellfish traditionally caught

by gear on or near the ocean bottom. The principal species taken are soles, flounders, rockfishes, crabs, shrimp, abalone, and oysters. These resources are being harvested to a yield of over 60 million pounds per year. Of this, more than half is of fin fish; the remainder, from the shellfish resources.

The status of our knowledge about landings and areas of harvest is much more complete than our storehouse of data on life history and biological relationships pertaining to the organisms available for harvest.

The state of development of gear and size and power of the vessels engaged in harvesting bottomfish

resources limits operations to 500 fathoms, and less. Living resources are available for harvest at greater depths, but it will not be until greater economic pressures occur that larger, better equipped vessels with greater harvesting capacities will take part in an American fishery beyond depths of 500 fathoms (915m) where flatfish and rockfish are the most available and desired species.

I believe that exploratory fishing and gear development can result in an increase in landings of offshore fishes while more efficient harvesting and application of new culture techniques can yield more from shellfisheries.