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Fish Bulletin No. 112
Relationships of Some Marine Organisms of the Northeast Pacific to Water Temperatures Particularly During 1957 Through 1959

By
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1. ABSTRACT

After nine consecutive years of subnormal temperatures, the ocean off the Pacific Coast of North America warmed up in 1957, heralding the beginning of a warm period which continued at least through 1959. Concurrently, many southern marine species wandered north of their usual range and some warm-water forms spawned successfully off southern California. An analysis of past records showed similar intrusions of southern species during previous warm-water years.

In addition to fish moving northward during 1957, 1958 and 1959, some rare species were caught which showed no latitudinal movement, and some were collected south of their usual ranges. However, even some of these may have resulted from oceanic changes taking place during this period.

Other vertebrates, including whales and birds, many invertebrates, and some marine plants were affected in one way or another by the change. The northward distribution of some invertebrates seemed more closely related to the development of the countercurrent than to the increase in temperature.

2. ACKNOWLEDGMENTS

Many individuals were kind enough to make their records and information available to me. Among those to whom I am particularly indebted are: Carl L. Hubbs, Scripps Institution of Oceanography, who gave me helpful information regarding several unusual occurrences of organisms and their ranges; W. I. Follett, California Academy of Sciences and Kenneth S. Norris, Department of Zoology, U.C.L.A., who supplied me with additional records and information; J. C. Stevenson, Biological Station, Nanaimo, British Columbia, who contributed information on sperm whales; and John Isaacs, Scripps Institution of Oceanography, who called my attention to some anomalous fish distributions in the southern hemisphere.

Several Department of Fish and Game staff member assisted in the preparation of this paper, including: Doyle E. Gates, marine biologist, who spent considerable effort locating distributional records of many of the species discussed; John E. Fitch, Supervisor of Southern California Investigations, who supplied information regarding several anomalous occurrences of fish, some of which he had personally verified; and Patricia Powell, Librarian, who assisted in obtaining reference material and edited the list of references.

3. INTRODUCTION

It is generally known that the waters off our coast warmed up in 1957. It is also common knowledge that for many species, fishing improved dramatically at the same time. In fact, there has become a general awareness that ocean climate can strongly affect fishing—a concept not too prevalent prior to 1957. During the preceding decade there was a strong feeling that "overfishing" alone was responsible for any decline in fishing success for a given species. There were a few, however, who believe environment, and not man, was the important factor. Now, the pendulum has swung and "environmentalism" has become popular.

Careful consideration of the problem reveals all factors are pertinent; some may dominate for a period becoming secondary or tertiary later. An important parameter may be completely masked by interplay of one or more others so that a researcher may be unable to find the relationship for which he is searching. It is obvious that no single phenomenon can explain all the variations observed in a fishery.

This paper attempts to explore a single oceanic feature, temperature, and its effect on some marine organisms. I have not intended to imply that temperature is the most important factor governing fish distribution (although it might be for some species during some years) or that water temperature was the controlling factor in the correlations which follow (although it may have been).

4. POSSIBLE EFFECTS OF TEMPERATURE

Perhaps the most dramatic way temperature can influence the size of a fish population is in causing mass mortalities. Such die-offs have been noted on several occasions. In fact, a die-off of the Japanese sardine (Sardinops melanosticta) resulted in the discovery of the resource and development of a major fishery. It occurred from October 24 to 26, 1923 along more than 80 miles of the eastern coast of North Korea. Thousands of people crowded on the beach to gather the dead fish, an estimated 20 to 40 thousand metric tons. The Korean sardine fishery began with this discovery, and 10 years later the catches averaged over 80,000 metric tons annually. The heavy mortality was occasioned by an abnormal drop in surface water temperatures from 14.3 degrees C. on October 20 to 6.2 degrees C. on October 23 (Nakai, 1956). Experimentally, the temperature in which this species could live was found to range between 7 and 29 degrees C. (Suehiro, 1951).

Another mass mortality, associated with a sudden drop in water temperature, occurred along the Pacific side of Hokkaido, Japan from November 12 to 14, 1933. Dead sardines were piled in a belt 1½ meters wide, by 1½ to 2 meters high, and more than two miles long (Nakai, 1956; 1959).

A sudden rise in temperature or one of considerable magnitude may kill fish, also. The warm *El Niño* condition off the Pacific coast of South America frequently is cited as being responsible for mass mortalities of marine organisms. At steam-generating plants in Southern California, heat is used to kill the marine fouling organisms in the intake pipes. Many species of fish find their way into the intake system and all are killed when warm sea water is released. According to Fitch (California Department of Fish and Game, mimeographed report), most of the mortalities occur with a temperature rise of 20 to 25 degrees F.

Aside from its direct effect on the metabolism and survival of adult fish, water temperature may influence the size of an adult fish population in several other ways. The amount or types of food, predators or competitors which might be influenced by changes in water temperature could have a decided effect upon fish populations. Similarly, preference for specific temperatures may cause fish to inhabit areas unfavorable for survival, such as within range of a fishery.

Temperatures might also influence survival of eggs or young fish in many ways: larval life could be prolonged and thus subject them to heavy predation (Simpson, 1956); off-season spawning, by causing the young to grow at a different time of the year, could secure them either an advantage or disadvantage over close competitors or predators (Marr, in press); lengthening or shortening the spawning period or changes in spawning area boundaries could jeopardize or enhance spawning success by placing the eggs in a greater or smaller range of environmental conditions (Miller, 1956); lengthening or shortening the spawning period might also affect the number of eggs produced; changes in the distribution of spawn might place larval fish in favorable or unfavorable environments; increased or decreased metabolism may cause young fish to operate at different levels of efficiency, thereby affecting mortality rates; and temperatures could affect the availability of food organisms, which in turn might influence the amount of young fish surviving.

Many other environmental factors may influence the size of a population and some have been investigated, particularly in relation to such pelagic fishes as the clupeids. It is sufficient to say that no single feature of the environment yet revealed controls the size of pelagic marine fish populations. However, many correlations have been demonstrated between catch and temperature.

Jensen (1930) found the catch of mackerel (Scomber scombrus) off Denmark was better when the surface temperature was colder. This, presumably, was due to a tendency for fish to move upward as the surface water cooled.

Ketchen (1956) correlated winter surface temperatures off the west coast of Vancouver Island, British Columbia with the catch-per-effort of petrale sole (Eopsetta jordani) six years later. He also found a negative correlation between winter temperatures and catch-per-effort of rock sole (Lepidopsetta bilineata) five years later and English sole (Parophrys vetulus) six years later. Using the temperature history since 1910, he showed that it was similar to the catch-per-effort of halibut (Hippoglossus stenolepis) 10 years later for the southern grounds, and 12 years later for the western grounds. He suggested that long-term environmental trends may have influenced the survival of young and that this may aid in the explanation of changes in catch-per-effort which cannot be accounted for solely by the effects of fishing.

Bell and Pruter (1958) criticized some of the reports of climatic-temperature-fish productivity relationships and demonstrated that unless exhaustive tests of the representativeness of both the temperature and fishery data are made, significant but invalid correlations may result. They concluded that any possible effects of climatic-temperature changes upon the Pacific and Atlantic halibut stocks appear to have been overwhelmed by fishing.

Buys (1959) revealed a striking relationship between the average annual temperature in the upper 50 meters in the St. Helena Bay area of South Africa and the catch of pilchards (Sardinops ocellata) the following year. Regarding this relationship, Du Plessis (1959) concluded that the availability of pilchards may have been affected by a combination of factors of which temperature was a symptom.

In the Mediterranean Sea, along the coast of Israel, a correlation has been shown between the sea surface temperatures during the prespawning month and the catch-per-unit-of-effort the same year for Sardinella aurita (Ben Tuvia, 1959).

One factor, the effect of food or productivity on population size or distribution, has received greater consideration than most. This has been popular because the relationship has been demonstrated on so many terrestrial and aquatic species, and because the entire organic production of an ecosystem obviously is dependent upon phytoplankton production. However, the interrelationships of thousands of different competitors and predators in a highly complex system precludes finding a direct relationship between population size and productivity for each fish species.

TABLE 1

Average Sea Surface Temperatures in Degrees Centigrade for the First Half of Each Year and for the Entire Year at Scripps Pier, La Jolla, and from Two Five-Degree Squares off Southern California and Baja California [1]

Year	Scripps Pier, La Jolla		Five-Degree Square lat. 25°-30° N., long. 110°-115° W. (excluding the Gulf)		Five-Degree Square lat. 30°-35° N., long. 115°-120° W.	
	Average of first six months	Annual average	Average of first six months	Annual average	Average of first six months	Annual average
1917	14.6	16.6				
1918	15.6	17.4				
1919	15.7	16.9				
1920	15.5	16.5				
1921	15.0	16.5	16.4	18.7	14.0	15.8
1922	14.9	16.5	16.4	18.8	14.0	15.9
1923	15.6	17.4	17.1	19.1	14.9	16.4
1924	16.2	16.6	17.6	18.6	15.6	15.9
1925	15.2	16.8	17.4	19.0	15.1	16.4
1926	17.6	18.0	18.9	19.8	16.6	17.2
1927	15.1	16.6	17.4	19.3	14.6	16.0
1928	15.7	16.6	17.7	19.4	15.3	16.2
1929	15.2	17.0	16.5	19.1	14.7	16.5
1930	16.1	17.4	17.9	19.7	15.4	16.9
1931	17.6	18.4	18.6	20.1	16.8	17.8
1932	15.2	16.3	17.6	19.2	14.7	15.8
1933	14.4	15.6	16.1	17.1	13.8	15.0
1934	16.4	17.4	16.9	19.1	15.5	16.6
1935	15.5	16.6	17.4	19.1	14.7	16.0
1936	15.6	17.6	17.1	19.4	15.0	16.7
1937	15.4	17.0	16.4	18.8	14.5	16.2
1938	15.6	16.6	17.2	19.2	15.2	16.4
1939	15.0	17.2				
1940	16.6	17.4				
1941	17.0	17.6				
1942	15.6	17.0				
1943	15.8	17.0				
1944	15.4	16.4				
1945	15.0	16.6				
1946	15.4	16.8				
1947	15.8	16.9				
1948	14.8	16.0				
1949	15.0	16.5				
1950	14.8	16.4				
1951	15.4	16.6				
1952	15.1	16.3				
1953	14.7	16.3				
1954	15.4	16.8				
1955	15.0	16.5				
1956	14.6	16.4				
1957	15.9	17.4				
1958	16.6	17.8				
1959	17.1	18.4				
Mean	**15.6**	**16.9**	**17.2**	**19.1**	**15.0**	**16.3**

[1] The data from which the average temperatures of the five-degree squares were computed came from the Imperial Marine Observatory, Kobe, Japan.

TABLE 1

Average Sea Surface Temperatures in Degrees Centigrade for the First Half of Each Year and for the Entire Year at Scripps Pier, La Jolla, and from Two Five-Degree Squares off Southern California and Baja California

Most fish do not seem to be specific feeders, but will eat a variety of organisms within given ranges of size and shape. On the other hand, a species may tend to congregate where there are large amounts of food.

Rather than consider the effect of temperature changes on the lowest forms in the food chain and then relate these to each succeeding higher form, let us consider the direct effect of temperatures on fish distribution.

Fish are poikilothermic animals; their metabolism and efficiency are affected by temperature. Furthermore, fish can detect temperature changes and some can move great distances. Therefore, when water temperatures change substantially, one would expect many species of fish to move either horizontally or vertically, in order to remain in an optimum environment. Those moving greater distances may relocate themselves, temporarily, near food concentrations until further temperature changes stimulate them into moving on. Although such movements frequently may place fish in favorable locations for food, the initial stimulus could have been a temperature change. Indeed, a fast-moving predator species responding to temperature changes may arrive in a favorable area earlier than a species upon which it usually feeds in its normal range.

5. THE TEMPERATURE RECORD

Obviously, before fish distributions can be related to temperature changes, it is necessary to find temperature records which are representative of the area being considered. I am indebted to Scripps Institution of Oceanography for information on monthly averages of surface temperatures for five-degree squares of latitude and longitude along the coasts of California and Baja California, Mexico, between 1921 and 1938. These have been obtained from the Kobe Marine Observatory in Japan and are now out-of-print. Comparable data were not available for any years since 1938. Therefore, it was necessary to rely on records from certain shore stations for a longer series (Table 1).

Sea surface temperatures have been recorded daily at a prescribed time from the pier at Scripps Institution of Oceanography, La Jolla, since 1917 and represent the longest series from the California coast.

A comparison of Scripps Pier temperatures with those from two five-degree squares, lat. 25°–30° N., long. 110°–115° W. and lat. 30°–35° N., long. 115°–120° W., revealed strong similarities, especially between the northern square and Scripps Pier (Figures 1 and 2).

The three sets of data show exceptionally high ocean temperatures during 1926 and 1931 and very cold ones during 1933. After 1938, data from Scripps Pier show warm temperatures in 1940–41. These data also reveal that for nine consecutive years following 1947 the annual temperatures, and those during the first six months of each year, were below the period mean. This, the longest run of subnormal water temperatures since 1917, came to an end following 1956, the coldest year of the nine. Water temperatures then rose in 1957 and became even higher in 1958 and 1959.

The dramatic manner in which the warm period began gave early indication it was no local phenomenon: Hawaii had its first recorded

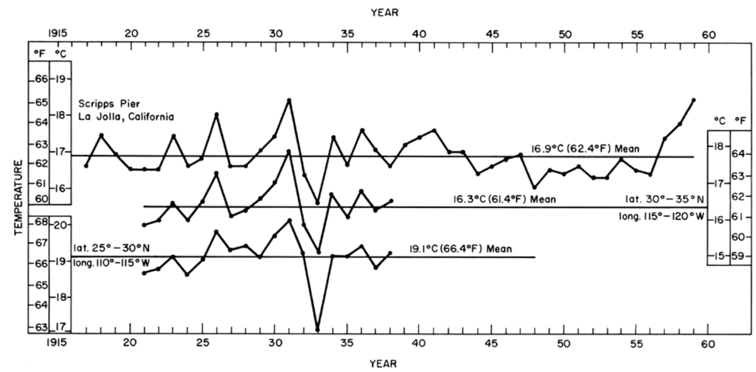

FIGURE 1. Annual average of monthly mean sea-surface temperatures collected from: Scripps Pier, La Jolla, California (upper); the 5-degree square lat. 30°-35° N., long. 115°-120° W. (middle); and the 5-degree square, lat. 25°-30° N., long. 110°-115° W. (lower).

FIGURE 1. Annual average of monthly mean sea-surface temperatures collected from: Scripps Pier, La Jolla, California (upper); the 5-degree square lat. 30°–35° N., long. 115°–120° W. (middle); and the 5-degree square, lat. 25°–30° N., long. 110°–115° W. (lower)

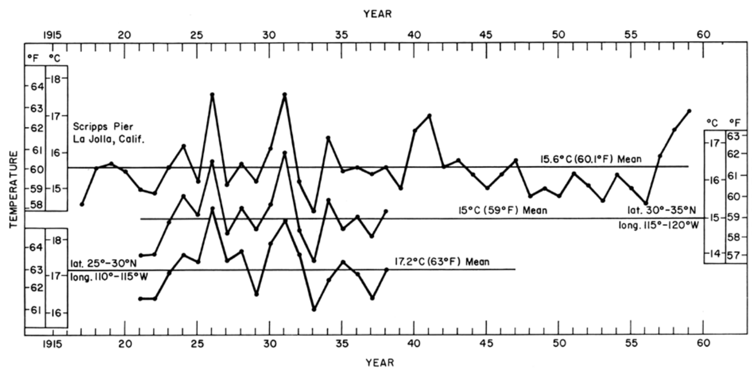

FIGURE 2. Average of sea-surface temperatures during the first half of the year (January through June) collected from: Scripps Pier, La Jolla, California (upper); the 5-degree square lat. 30°-35° N., long. 115°-120° W. (middle); and the 5-degree square, lat. 25°-30° N., long. 110°-115° W. (lower).

FIGURE 2. Average of sea-surface temperatures during the first half of the year (January through June) collected from: Scripps Pier, La Jolla, California (upper); the 5-degree square lat. 30°–35° N., long. 115°–120° W. (middle); and the 5-degree square, lat. 25°–30° N., long. 110°–115° W. (lower)

hurricane; the Peruvian coast was afflicted with the fish-killing, *El Niño*; and the ice at Pt. Barrow, Alaska went out the earliest in history (Calif. Mar. Res. Comm., 1957).

Although many other broad climatological events have been associated with the warm period beginning in 1957, none will be considered in this paper since they have been discussed elsewhere in considerable detail (Calif. Mar. Res. Comm., 1960).

6. PREVIOUS NORTHWARD INTRUSIONS OF SOUTHERN SPECIES

There is considerable evidence that the ocean waters off California were quite warm about 100 years ago. Hubbs (1948) states: “"The fish fauna of San Diego, as sampled from 1853 to 1860, particularly by the Pacific Railroad Survey from 1853 to 1857 (Girard, 1858; etc.), was definitely more tropical than that of any subsequent decade. of the 30 odd species reported, six (about 20 percent) do not now occur so far north or have been so rare recently that one certainly would not expect any to be caught at present by such incomplete and superficial collecting as that of the 1850's and 1860's."” Regarding the fauna of Monterey Bay, Hubbs (op. cit.) states only about 20 species were reported by the Pacific Railroad Survey, including five or six that either do not occur now, or are quite rare. He found a close relationship between air and water temperatures at San Diego, enabling him to reconstruct a trend of the ocean climate back to 1850, and add to the biological evidence that the waters off California were warm at that time.

More recently, during the period for which ocean temperature records exist, there have been other years in which southern species swarmed northward. In 1926, there was a distinct influx of southern species into areas far north of their usual range (Hubbs and Schultz, 1929). Walford (1931) described many northward occurrences of southern fish off San Pedro in 1931; and in 1941, pelagic red crabs (Pleuroncodes planipes) were present in quantities off southern California (Calif. Conserv., 1941; Hubbs, 1948). Pleuroncodes is often conspicuous at the surface in great numbers south of central Baja California. A hundred years ago pelagic red crabs washed ashore in March, 1859 at Monterey (Schmitt, 1921).

Two facts have emerged: all three warm periods, 1926, 1931 and 1941 (Figures 1 and 2), were typified by northerly dispersions of southern species; and, ocean temperatures and fauna off California about 100 years ago were similar to those found much farther south during recent years.

Table 2 lists all eastern Pacific marine organisms noted during the three years, 1957, 1958 and 1959. Henceforth only common names will be used.

TABLE 2

Common and Scientific Names of the Marine Organisms Discussed, Which Were Noted During 1957, 1958 and 1959

Common name	Scientific name
Mammals	
Whale, sperm	*Physeter catodon* Linnaeus
Turtles	
Turtle, east Pacific green	*Chelonia mydas agassizii* Bocourt
Turtle, Pacific leatherback	*Dermochelys coriacea schlegelii* (Garman)
Turtle, Pacific Ridley	*Lepidochelys olivacea* (Eschscholtz)
Fishes	
Albacore, Pacific	*Thunnus germo* (Lacépède)
Anchovy, northern	*Engraulis mordax* Girard
Barracuda, California	*Sphyraena argentea* Girard
Bass, striped	*Roccus saxatilis* (Walbaum)
Blacksmith	*Chromis punctipinnis* (Cooper)
Bonefish	*Albula vulpes* (Linnaeus)
Bonito, Pacific	*Sarda chiliensis* (Cuvier)
Burrfish, Pacific	*Chilomycterus affinis* Günther
Cod, Pacific	*Gadus macrocephalus* Tilsius
Dolphinfish, common	*Coryphaena hippurus* Linnaeus
Flyingfish, sharpchin	*Fodiator acutus* (Valenciennes)
Greenling, kelp	*Hexagrammos decagrammus* (Pallas)
Grouper, broomtail	*Mycteroperca xenarcha* Jordan
Grunion, California	*Leuresthes tenuis* (Ayres)
Halfbeak, longfin	*Hemiramphus saltator* Gilbert and Starks
Halfmoon	*Medialuna californiensis* (Steindachner)
Halibut, California	*Paralichthys californicus* (Ayres)
Halibut, Pacific	*Hippoglossus stenolepis* Schmidt
Herring, Pacific round	*Etrumeus acuminatus* Gilbert
Herring, Pacific thread	*Opisthonema libertate* (Günther)
Jack, green	*Caranx caballus* Günther
Jack, Pacific yellowtail	*Chloroscombrus orqueta* Jordan and Gilbert
Louvar	*Luvarus imperialis* Rafinesque
Mackeral, bullet	*Auxis*, sp.
Mackeral, Monterey Spanish	*Scomberomorus concolor* (Lockington)
Manta, Pacific	*Manta hamiltoni* (Newman)
Marlin, striped	*Makaira audax* (Phillipi)
Mobula, spinetail	*Mobula japanica* (Müller and Henle)
Moonfish, Pacific	*Vomer declivifrons* Meek and Hildebrand
Mullet, striped	*Mugil cephalus* Linnaeus
Opah	*Lampris regius* (Bonnaterre)
Opaleye	*Girella nigricans* (Ayres)
Pilotfish	*Naucrates ductor* (Linnaeus)
Poacher, tubenose	*Pallasina barbata* (Steindachner)
Pomfret	*Brama brama* (Bonnaterre)
Pomfret	*Taractes asper* Lowe
Pomfret, bigscale	*Taractes longipinnis* (Lowe)
Pompano, gafftopsail	*Trachinotus rhodopus* (Gill)
Pompano, paloma	*Trachinotus paitensis* Cuvier
Porgy	*Calamus taurinus* (Jenyns)
Puffer, oceanic	*Lagocephalus lagocephalus* (Linnaeus)
Ribbonfish, polka-dot	*Desmodema polystictus* (Ogilby)
Rockfish, Coral-red	*Sebastodes macdonaldi* (Eigenmann and Beeson)
Rockfish, greenspotted	*Sebastodes chlorostictus* (Jordan and Gilbert)
Roosterfish	*Nematistius pectoralis* Gill

TABLE 2 Common and Scientific Names of the Marine Organisms Discussed, Which Were Noted During 1957, 1958 and 1959

TABLE 2—Continued

Common and Scientific Names of the Marine Organisms Discussed, Which Were Noted During 1957, 1958 and 1959

Common name	Scientific name
Fishes—Continued	
Salmon, king	*Oncorhynchus tshawytscha* (Walbaum)
Salmon, sockeye	*Oncorhynchus nerka* (Walbaum)
Sardine, Pacific	*Sardinops caerulea* (Girard)
Scabbardfish, razorback	*Assurger anzac* (Alexander)
Scad, Mexican	*Decapterus hypodus* Gill
Sculpin, grunt	*Rhamphocottus richardsoni* Günther
Seabass, white	*Cynoscion nobilis* (Ayres)
Searobin, lumptail	*Prionotus stephanophrys* Lockington
Shad, American	*Alosa sapidissima* (Wilson)
Shark, bonito	*Isurus glaucus* (Müller and Henle)
Shark, bramble	*Echinorhinus brucus* (Bonnaterre)
Shark, slender requiem	*Carcharhinus improvisus* Smith
Shark, smooth hammerhead	*Sphyrna zygaena* (Linnaeus)
Sheephead, California	*Pimelometopon pulchrum* (Ayres)
Skipjack	*Katsuwonus pelamis* (Linnaeus)
Snakeblenny, Pacific	*Lumpenus sagitta* Wilimovsky
Snake-eel, yellow	*Ophichthus zophochir* Jordan and Gilbert
Snipefish, slender	*Macrorhamphosus gracilis* (Lowe)
Spearfish, shortbill	*Tetrapturus angustirostris* Tanaka
Stargazer, smooth	*Kathetostoma averruncus* Jordan and Bollman
Stingray, pelagic	*Dasyatis violacea* (Bonaparte)
Sturgeon, green	*Acipenser medirostris* Ayres
Squaretail, smalleye	*Tetragonurus cuvieri* Risso
Swordfish	*Xiphias gladius* Linnaeus
Threadfin, Pacific	*Polydactylus approximans* (Lay and Bennett)
Triggerfish, finescale	*Balistes polylepis* Steindachner
Trunkfish, spiny	*Lactoria diaphana* (Block and Schneider)
Tuna, bigeye	*Parathunnus sibi* (Temminck and Schlegel)
Tuna, California bluefin	*Thunnus saliens* Jordan and Evermann
Tuna, Pacific yellowfin	*Neothunnus macropterus* (Temminck and Schlegel)
Whitefish, ocean	*Caulolatilus princeps* (Jenyns)
Wolf-eel	*Anarrhichthys ocellatus* Ayres
Yellowtail, California	*Seriola dorsalis* (Gill)
Tunicate	
Tunicate, pelagic	*Doliolum denticulatum* Quoy and Gaimard
Crabs	
Crab, pelagic red	*Pleuroncodes planipes* Stimpson
Crab, sand	*Emerita analoga* (Stimpson)
Mollusk	
Clam, Pismo	*Tivela stultorum* (Mawe)
Alga	
Kelp, giant	*Macrocystis pyrifera* (Linnaeus)

TABLE 2 Common and Scientific Names of the Marine Organisms Discussed, Which Were Noted During 1957, 1958 and 1959

7. NORTHWARD OCCURRENCES OF SOUTHERN FISH IN 1957

Although many species were recorded north of their usual range in 1957, this in itself was not conclusive evidence of a general northward dispersion of fish. It can be argued that greater effort expended obtaining such records might account for the increase. It also can be pointed out that many species caught north of their range in 1957 were taken during other years, some not particularly warm (Table 3).

Even the occurrence of Pacific yellowfin tuna at Davidson Seamount September 25, does not prove the contention that a northward shift took place, since range extensions are recorded for one species or another every year (although it must be regarded as corroborating evidence). It may be argued further that the number of range extensions in a given year might be an artifact of the collecting methods used that year, *i.e.* large numbers of rare specimens were collected off southern California during 1948 and 1949 following detonations of dynamite during seismic explorations for oil. On the other hand, there were no seismic operations during 1957, and collecting methods did not differ substantially from those of previous years. Although more effort may have been expended obtaining records in the latter part of the year, it was the distribution and behavior of the fish which first focused attention on the fact something unusual was happening in 1957.

Sport fishing for California yellowtail was exceptionally good off southern California during March, and by the end of April, the yellowtail sport catch had exceeded the total catch of the previous year (Radovich, 1960). In addition, California barracuda sport fishing was exceptional in 1957, as was angling for Pacific bonito, common dolphinfish, skipjack and Pacific yellowfin tuna (Calif. Mar. Res. Comm., 1958).

Great increases in catches of warm-water species north of their usual ranges demonstrated the northward redistribution of fish in 1957 more dramatically than the single specimen collections. Large amounts of common dolphinfish were caught off central California by albacore fishermen and some were caught as far north as Grays Harbor, Washington. Pacific bonito were abundant northward to Eureka, California, and skipjack were common to Cape Blanco, Oregon. Swordfish were caught commercially in Monterey Bay, and white seabass were numerous off Oregon, Washington, and British Columbia.

The range of Pacific yellowfin tuna was extended northward from about Point Conception by two specimens. The first, weighing about 15 pounds, was caught an unknown distance off Pt. Buchon by a commercial albacore troller on August 18, 1957. It was identified by Robert Menchen, marine biologist of the California Department of Fish and Game, on August 23, 1957, at Morro Bay, California. The second weighed 71 pounds and was caught by the albacore trolling vessel chum, on September 25, 1957, just seaward of Davidson Seamount (lat. 35° 45' N., long. 123° 10' W.).

TABLE 3

Southern Species of Fish Collected North of Their Usual Range During 1957

Common Name	Number Collected	Date of Collection	Location of Capture	Remarks
Monterey Spanish mackeral	1		Off Santa Barbara	This species was described from 4 specimens from Soquel, California (near Santa Cruz) in 1879. Caught off California in 1931, 1937, 1939, 1944, 1947, 1948, 1949, 1951, 1953, 1954 and 1956.
Porgy	1		Oceanside	Known from the Gulf of California south to Peru. Formerly taken off California in 1953.
Spiny trunkfish	1	Feb.	Santa Monica Bay	From tropical seas throughout the world. Caught in California in 1932, 1933, 1949 and 1951.
Bonefish	1	May 27	Long Beach	Worldwide in warm seas. Rare north of Los Angeles Harbor. Recorded once north of Point Conception (San Francisco Bay). Formerly taken on October 9, 1949, several between November, 1951 and May, 1952.
Finescale triggerfish	5	Summer	Laguna Beach, Dana Point, San Diego, Santa Monica Bay and Paradise Cove	Numerous in Baja California waters. Caught off southern California in 1924, 1931, 1946, 1950, 1951 and 1956, and from Monterey Bay in 1951 (Bolin, 1952).
Sharpchin flyingfish	2	Summer	Long Beach	From tropical and semi-tropical waters. Sometimes ranging as far north as San Pedro. Last California record was in 1931.
Smooth hammerhead shark	10-15	Summer and fall[1]	Throughout southern California	Usually in tropical and warm-temperate seas. Ocasionally off southern California.
California bluefin tuna	Numerous Numerous	July[1] Oct. [1]	Monterey and Eureka Off Brandon Bar, 80-100 miles off Cape Flattery	Recorded from Columbia River to Cape San Lucas. Common only from Point Conception to Central Baja California.
Common dolphinfish	Numerous Numerous Numerous	July[1] Sept.[1] Sept.	Off San Diego Off Farallon Islands Off Grays Harbor, Washington	Worldwide in warm seas. In some years taken in fair numbers at San Diego. Recorded as far north as Columbia River.
Skipjack	Numerous Numerous Numerous Numerous Numerous	July [1] Sept.[1] Sept.[1] Oct. Oct.	San Diego Off Davidson Seamount Off Farallon Islands Off Eureka Off Cape Blanco, Oregon	Rare north of Point Conception and not common in southern California. Cosmopolitan in temperate and tropical seas.
Ocean whitefish	1 1	Aug. Sept. 22	Near Farallon Islands Southeast Farallon Island	From central California to and into the Gulf of California. Not common north of Point Conception.

TABLE 3
Southern Species of Fish Collected North of Their Usual Range During 1957

TABLE 3—Continued

Southern Species of Fish Collected North of Their Usual Range During 1957

Common Name	Number Collected	Date of Collection	Location of Capture	Remarks
Pilotfish	2 1	Aug. 17 Sept.	San Clemente Island 15-20 miles south of Los Coronados Islands	A pelagic species known from all warm seas. Formerly caught off California in 1926, 1936 and 1945.
Pacific yellowfin tuna	1 1	Aug. 18 Sept. 25	Off Point Buchon[2] Davidson Seamount[2]	Spans Pacific Ocean to Asia. Eastern Pacific, from Point Conception to Peru. Usually found off southern California in summer and fall, but not common there.
Opaleye	2	Sept.	Monterey Bay (Norris, 1959)	Common off Baja California and southern California. Recorded once from San Francisco in 1861 (Norris, 1959).
Pacific bonito	Numerous Numerous	Sept.[1] Oct.[1]	Off Farallon Islands 60 miles northwest of Eureka	Recorded range—Vancouver Island to Magdalena Bay. Not common north of Point Conception.
Swordfish	Several seen	Sept.[1]	Davidson Seamount area (many were caught in Monterey Bay by commercial fishermen)	From warm and temperate seas of the world. Usually south of Point Conception but known as far north as Oregon.
White seabass	2 2 2 1 Several Several 2 12	Sept. 10 Sept. 13[1] Sept. 17[1] Sept. 22[1] Sept.[1] Sept.[1] Sept. Oct.[1]	Winchester Bay, Oregon Winchester Bay, Oregon Ilwaco, Oregon Newport, Oregon Off Columbia River Grays Harbor, Washington Off Juneau, Alaska Sooke, British Columbia	Recorded range is from Alaska to Magdalena Bay, Baja California, becoming less common north of Point Conception and uncommon north of San Francisco.
Bullet mackerel	1	Nov. 4	Los Coronados Islands	Common off Mexico and Central America. Reported from southern California in 1918, 1919 and 1935.
Green jack	1	Nov. 24	Belmont Shore, Long Beach, California	Known from San Pedro to Peru. Formerly caught off California in 1858, 1924, 1945, 1953 and 1955.
Yellow snake-eel	1	Dec. 11	Off Newport Beach	Ranges from Los Angeles County to Panama. Formerly caught off California in 1914 and 1953.

[1] Continuously or sporadically abundant after this date.
[2] Extension of range.

TABLE 3
Southern Species of Fish Collected North of Their Usual Range During 1957

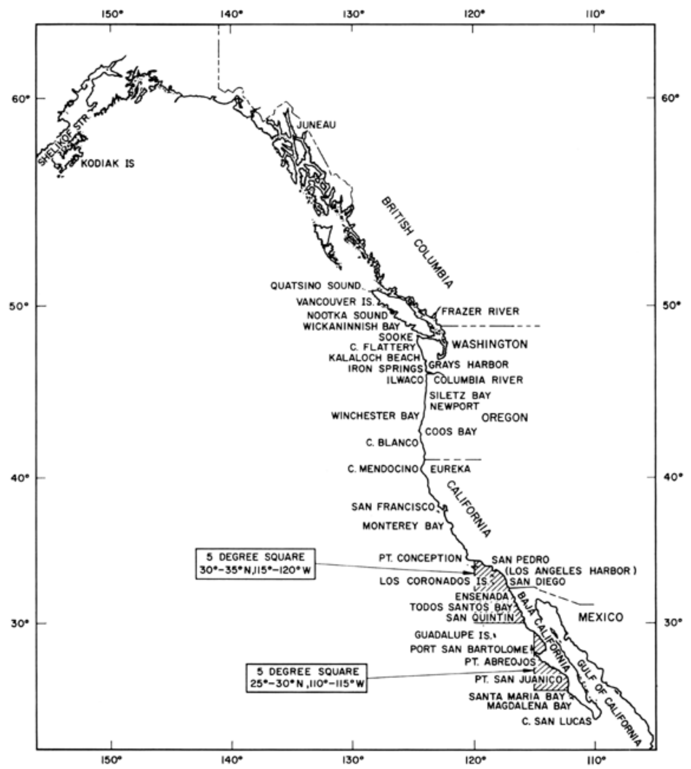

FIGURE 3. Reference chart of the Pacific coast of Alaska, Canada, United States, and Baja California, Mexico.

FIGURE 3. Reference chart of the Pacific coast of Alaska, Canada, United States, and Baja California, Mexico

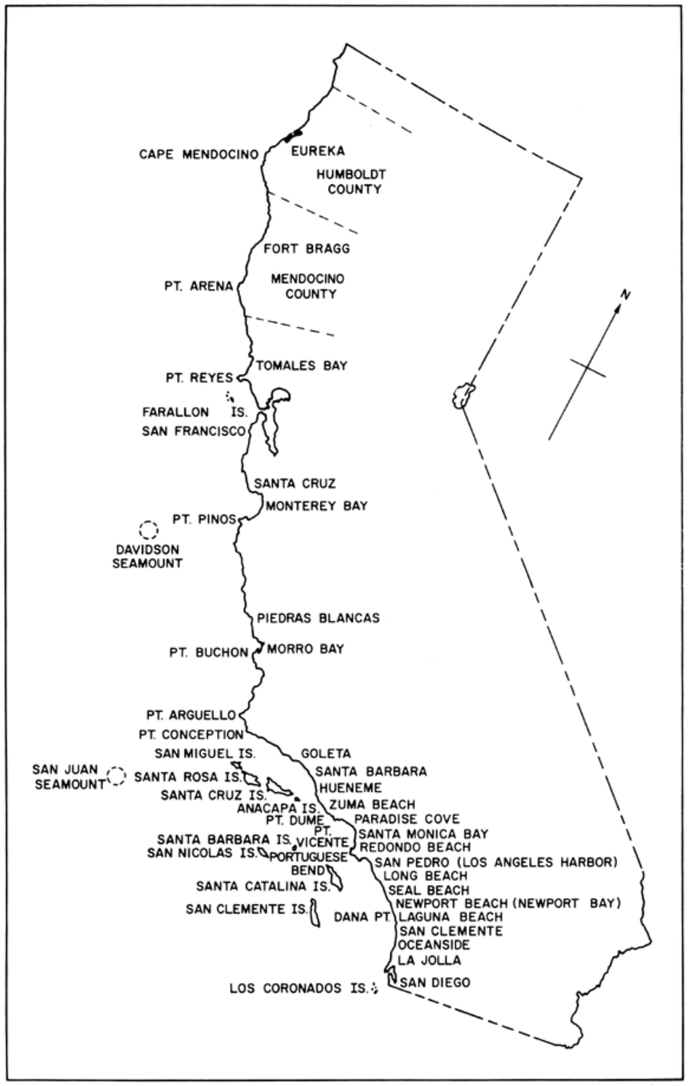

FIGURE 4. Reference chart of the California coast.

FIGURE 4. Reference chart of the California coast

8. NORTHWARD OCCURRENCES OF SOUTHERN FISH IN 1958

In 1958, 23 southern species of fish were reported north of their usual ranges. Ten of these represented extensions of range, and two had not been recorded from California previously (Table 4).

One of the California records was established when the purse-seine vessel *San Antonio IV* netted 10 spinetail mobula off Santa Cruz Island, California at about 2:00 a.m. on November 5 (Figure 5). All but three of the smaller fish were released. One female aborted an advanced live foetus on deck, which unfortunately was thrown back so no measurements could be made. One of the three saved measured 84 inches between the tips of the pectoral fins, and weighed 253 pounds. All were sent to Scripps Institution of Oceanography, La Jolla.

At Zuma Beach, California, a gafftopsail pompano was caught on November 2, by an angler (Figure 6). It was placed in the fish collection at U.C.L.A.

Sharpchin flyingfish were recorded from near San Pedro during another warm year, 1931 (Walford, 1931), and again in 1957 (Table 3). However, many were observed and two captured near Goleta, California, in a bait net on October 22. This extended the known range in a northerly direction by nearly 100 miles. Several of these were placed in the fish collection of U.C.L.A.

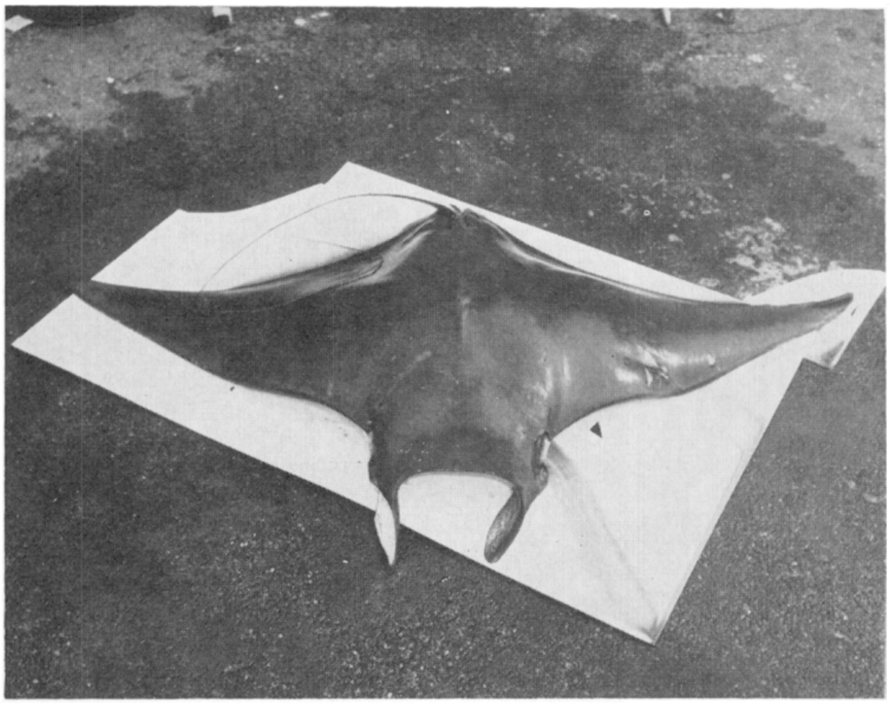

FIGURE 5. One of 10 spinetail mobulas (*Mobula japanica*) caught by the purse-seine vessel *San Antonio IV* off Santa Cruz Island, California, on November 5, 1958. *Photograph courtesy of Marineland of the Pacific.*

FIGURE 5. One of 10 spinetail mobulas (Mobula japanica) caught by the purse-seine vessel San Antonio IV off Santa Cruz Island, California, on November 5, 1958. Photograph courtesy of Marineland of the Pacific.

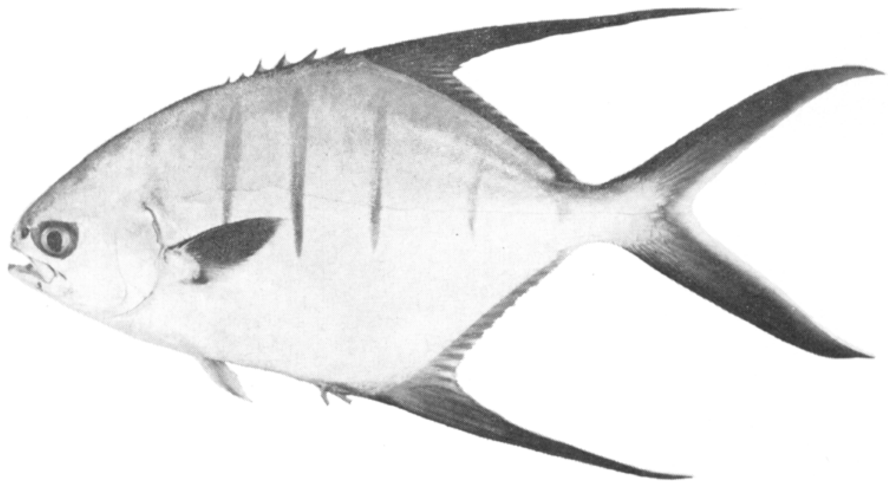

Figure 6. Gafftopsail pompano (*Trachinotus rhodopus*) caught in the surf at Zuma Beach, California, November 2, 1958. *Photograph by Jack W. Schott.*

FIGURE 6. Gafftopsail pompano (Trachinotus rhodopus) caught in the surf at Zuma Beach, California, November 2, 1958. Photograph by Jack W. Schott.

Another northern record, a female broomtail grouper weighing 12 ¾ pounds was caught on hook and line off Paradise Cove, California (10 miles west of Pt. Dume) in 70 feet of water on November 13. It was identified by John E. Fitch, California Department of Fish and Game, who determined its age at seven years. Its total length was 730 mm., its standard length, 595 mm.

A polka-dot ribbonfish was caught at San Juan Seamount July 15; a 15-pound 27-inch California bluefin tuna was caught by a salmon seiner July 28, in the Shelikof Straits north of Kodiak Island, Alaska (Pacific Fisherman, 1958a and 1958b); two halfmoons were collected on June 19, off Humboldt County, California, and a greenspotted rockfish was caught off Buck Creek, Humboldt County, California, on June 10. The greenspotted rockfish was found in a load of fish by A. Urbani, Paladini Fish Company, Fort Bragg. Walter Dahlstrom, marine biologist, Department of Fish and Game, sent it to the California Academy of Sciences where W. I. Follett, Curator of Fishes, identified it.

On July 13, an adult fine-scale triggerfish was caught in a seabass net by Trub Ghio, between Moss Landing and Santa Cruz, Santa Cruz County, California, and was exhibited alive in the aquarium on the Santa Cruz wharf by Vieux Rawls until the middle of December 1959, when it died (W. I. Follett, personal communication).

Two Pacific yellowfin tuna reported from off Grays Harbor, Washington, in September, would have been northern records if verified; however, they may have been bigeye tuna. Because of this uncertainty, no northern record could be established for either.

An oceanic puffer was caught on July 10, after it was observed in a school of mackerel in Los Angeles Harbor by Ronnie Bunn and Richard Sepeda from the bait boat *Donna K.* Dead anchovies thrown overboard were snapped up by the fish, whereupon it was scooped up in a dip net. The fish, 325 mm. in standard length, was identified by Kenneth S. Norris, Department of Zoology, U. C. L. A.

TABLE 4

Southern Species of Fish Collected North of Their Usual Range During 1958

Common Name	Number Collected	Date of Collection	Location of Capture	Remarks
Fine-scale triggerfish	1	March	Off Dana Point, California	Numerous in Baja California. Caught off southern California in 1924, 1931, 1946, 1950, 1951, 1956 and 1957, and from Monterey Harbor in 1951 (Bolin, 1952).
	1	July 13	Between Moss Landing and Santa Cruz[1]	
California barracuda	6	Mar. 1[2]	Monterey Bay	Alaska to Magdalena Bay, Baja California. Not common north of Point Conception. Recorded off Sooke, B. C. and Kodiak Island in 1937.
	1	June 16	Sooke, British Columbia	
	1	June 17	Sooke, British Columbia	
	11	Summer	Queen Charlotte Strait, British Columbia	
	1	June 18	Sooke, British Columbia	
	2	July 4	Sooke, British Columbia	
	1	July 11	Queen Charlotte Sound, British Columbia	
	2	Aug. 19	Sooke, British Columbia	
White seabass	1	Apr. 20[2]	Siletz Bay, Oregon	Alaska to Magdalena Bay, becoming less common north of Point Conception and uncommon north of San Francisco.
	1	June 17[2]	Sooke, British Columbia	
	2	July 18	Sooke, British Columbia	
	Abundant	Entire year	San Francisco-Monterey Area	
Razorback scabbardfish	1	May 3	North point of north Coronado Island	Fourth recorded specimen. Second from California. It was formerly taken off California in 1951.
California sheephead	2	May 25	Point Pinos, California	Monterey Bay south into Gulf of California. Rare in central California.
Pacific thread herring	1	May 29	Belmont Shore Pier, Long Beach, California	Common off southern Baja California. Ranges south to Peru. Formerly taken off southern California in 1947, 1948 and 1949.
	1	Dec. 21	Los Angeles Harbor	
Smooth hammerhead shark	1	June 20	East end of San Clemente Island	Usually in tropical and warm seas. Occasionally off southern California.
	15	Sept. 22	Off Portuguese Bend, California	
	2	Oct. 23[2]	Between Point Conception and Santa Barbara, California	
Pacific sardine	1	July[2]	Sooke, British Columbia	Southeastern Alaska to and into the Gulf of California. Rare off British Columbia since 1947.
Oceanic puffer	1	July 10	Los Angeles Harbor	Widespread in the Atlantic and Indian Oceans and is primarily a pelagic fish.
	1	Sept. 14	Alder Creek Beach, Mendocino County, California	
Greenspotted rockfish	1	June 10	Off Buck Creek, Humboldt County, California[1]	From Cedros Island, Baja California, to San Francisco.

TABLE 4
Southern Species of Fish Collected North of Their Usual Range During 1958

TABLE 4—Continued

Southern Species of Fish Collected North of Their Usual Range During 1958

Common Name	Number Collected	Date of Collection	Location of Capture	Remarks
Halfmoon	2	June 19	Humboldt County, California	Rare off central California (Follett *et al.*, 1960).
	1	July 24	Santa Cruz Municipal Wharf	
	About 50	Sept. 10	Tomales Bay	
Polka-dot ribbonfish	1	July 15	San Juan Seamount, California[1]	Warm seas throughout the world.
California bluefin tuna	1	July 28	Shelikof Straits near Kodiak, Alaska[1]	Previously recorded from the Columbia River to Cape San Lucas. Common only from Point Conception to central Baja California.
Pacific manta	Numerous sightings	Aug. 7	East side of San Clemente Island	Tropical waters of America. Seldom seen as far north as San Diego. Once recorded from Redondo Beach.
	Numerous sightings	Aug. 17	Anchorage at Santa Barbara Island	
Pacific yellowfin tuna[3]	2 (unverified)	Sept.	Off Grays Harbor, Washington	Spans Pacific to Asia. Eastern Pacific from Point Conception to Peru. Usually found off southern California in summer and fall and then not common.
	2 (unverified)	Oct.	Fort Bragg, California	
Pacific round herring	1	Sept. 8	Los Angeles Harbor	Monterey Bay to Panama; recorded only once north of the Los Angeles area.
Sharpchin flyingfish	Several	Sept. 27	Outside west end Santa Catalina Island	From tropical and semitropical waters. Sometimes ranging as far north as San Pedro. Formerly taken in 1931 and 1957.
	2	Oct. 22[2]	Near Goleta, California[1]	
Pilotfish	1	Oct. 1	Redondo Beach, California	A pelagic species known from all warm seas. Formerly caught in 1926, 1936, 1945 and 1957.
Gafftopsail pompano	1	Nov. 2	Zuma Beach, California[4]	Pacific coast of tropical America from Cape San Lucas south to Tumaco, Columbia.
Skipjack	4	Oct. 7[2]	Fort Bragg, California	Cosmopolitan in temperate and tropical seas. Rare north of Point Conception and not common in southern California.
	14	Oct. 19[2]	Northwest of Point Reyes, California	
Mexican scad	1	Oct. 31	Los Angeles Harbor[1]	Abundant in northern Baja California and at Guadalupe Island. Recorded from San Clemente Island.
Broomtail grouper	1	Nov. 13	10 miles west of Point Dume, California[1]	Oceanside, California, to Peru.
Spinetail mobula	10	Nov. 5	Santa Cruz Island[4]	Never taken off California coast before.

[1] Extension of range.
[2] Continuously or sporadically abundant after this date.
[3] Would have been northern records if verified—may have been bigeye tuna.
[4] First California record.

TABLE 4
Southern Species of Fish Collected North of Their Usual Range During 1958

A second oceanic puffer was found wounded and struggling in shallow water at Alder Creek Beach, Mendocino County, California, on September 14, by James P. Ridge (Follett and Dempster, MS). Both specimens have been deposited in the California Academy of Sciences collection.

The 1958 list of northern occurrences of southern species is more impressive than that of 1957, and the list of warm water game species caught north of their usual ranges is as striking in 1958 as in 1957.

Smooth hammerhead sharks were seen and caught continuously off southern California; skipjack were taken off northern California; and California barracuda and white seabass were captured frequently in Monterey Bay, off San Francisco, and as far north as Vancouver Island, British Columbia.

9. NORTHWARD OCCURRENCES OF SOUTHERN FISH IN 1959

At least 26 species of warm-water fish were caught north of their usual ranges in 1959. Eleven of these were northern records and six of the 11 were new to the marine fauna of California (Table 5).

According to Elvn Gunderson, California Department of Fish and Game, Eureka (personal communication), a bonito shark was caught off the mouth of the Columbia River during August by Frank Larsen, while trolling for albacore. It was 1170 mm. in total length and weighed 37 pounds.

During August, a longfin halfbeak collected off southern California was deposited in the fish collection at U. C. L. A.

A roosterfish was reported by the crew members of a bait boat at San Clemente, California, on June 10. It was observed feeding upon a school of anchovies around which the boat was setting its net. Although not captured, it was seen distinctly and unhesitatingly identified as a large adult with dorsal fin spread.

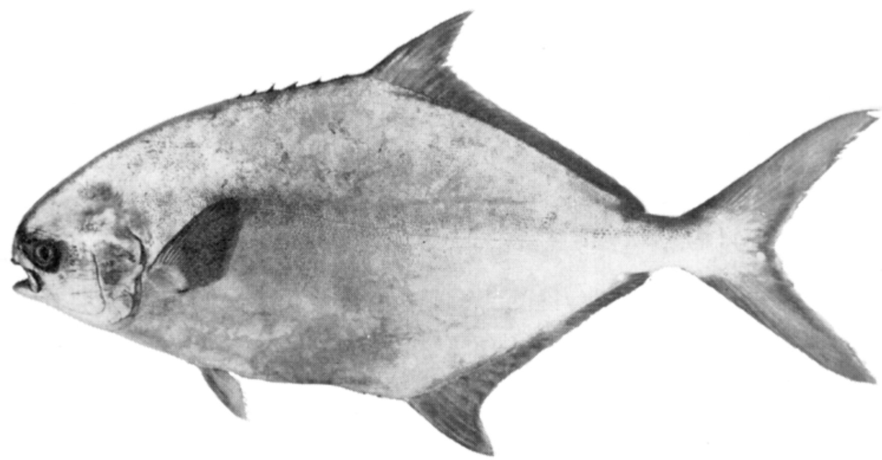

FIGURE 7. Paloma pompano (*Trachinotus paitensis*) caught in the surf at Redondo Beach, California, November 18, 1959. *Photograph by Jack W. Schott.*

FIGURE 7. Paloma pompano (Trachinotus paitensis) caught in the surf at Redondo Beach, California, November 18, 1959. Photograph by Jack W. Schott.

TABLE 5

Southern Species of Fish Collected North of Their Usual Range During 1959

Common Name	Number Collected	Date of Collection	Location of Capture	Remarks
Monterey Spanish mackerel	1	Feb. 22	Redondo Beach	Occasionally caught off southern California. In years past was known from Monterey Bay.
Pacific threadfin	1	Mar. 3	Seal Beach	Normal range extends from Magdalena Bay to Peru. They stray to the north during warm-water years. Since 1905, 15 or 20 have been reported from California waters, once from Monterey Bay. Seven fish were collected off California during the warm-water period 1940-1941.
Pacific moonfish	1 juvenile	Mar. 18	Off Rainbow Pier, Long Beach[1]	Previously ranged from Cape San Lucas to Peru.
Pacific yellowtail jack	1 1 1	May 12 Sept. 13 Dec. 8	San Pedro Harbor Seal Beach Pier Los Angeles Harbor	Usually range from Magdalena Bay to Panama. Previously caught in California in 1940.
Mexican scad	1	June 2	Santa Catalina Island	Abundant off northern Baja California and at Guadalupe Island. Recorded from San Clemente Island south at least to San Benedicto Island.
Pacific burrfish	1	June 9	Newport Beach	Tropical seas, reported in California on only one occasion around 1880.
Roosterfish[2]	1 (sighted)	June 10	San Clemente[1]	Turtle Bay, Baja California southward to Panama.
Smooth stargazer	1	June 18	5¾ miles west of Ballona Creek (Santa Monica Bay, California)[1]	Cedros Island to Panama.
Bigeye tuna	1 1 1	July 13 Sept. 16 Oct.	Iron Springs, Washington[3] 90 miles west southwest of Cape Mendocino[1] Off Cape Mendocino	Galapagos Islands, Guadalupe Island, Alijos Rocks and numerous pelagic areas of Pacific ocean.
Coral-red rockfish	1	July 16	Point Sur, California[3]	Previous northern limit was Santa Monica.
Bonefish	1	July 19	San Clemente Pier	Worldwide in warm seas. Rare north of Los Angeles Harbor. Recorded once north of Point Conception (San Francisco Bay). Formerly taken in 1949, 1951, 1952 and 1957.
Fine-scale triggerfish	1 1	July 24 Aug. 1	Off Flat Rock Point, Palos Verdes, Santa Monica Bay, California Fort Point, San Francisco, California[3]	Numerous in Baja California. Caught off southern California in 1924, 1931, 1946, 1950, 1951, 1956, 1957 and 1958; and from Monterey Harbor in 1951 (Bolin, 1952) and 1958.
Bonito shark	1	Aug.	Off the Columbia River (E. G. Gunderson, personal communication)[3]	Central California to northern Baja California (Roedel, 1953).

TABLE 5

Southern Species of Fish Collected North of Their Usual Range During 1959

TABLE 5—Continued

Southern Species of Fish Collected North of Their Usual Range During 1959

Common Name	Number Collected	Date of Collection	Location of Capture	Remarks
Longfin halfbeak	1	Aug.	Southern California[1]	Never previously reported north of Magdalena Bay.
Pacific bonito	Several 10 Numerous	Aug.[4] Sept. 30 Mid-Oct.	Monterey 20 miles west of Morro Bay 60-90 miles southwest of Cape Mendocino	Vancouver Island to Magdalena Bay; not common north of Point Conception.
White seabass	Numerous taken commercially	Aug. and Sept.	Monterey Bay	Alaska to Magdalena Bay; becoming less common north of Point Conception and uncommon north of San Francisco.
Sharpchin flyingfish	1 1 Several juveniles	Aug. 6 Sept. 17[4] Oct.	Long Beach Harbor Oceanside Southern California	From tropical and semi-tropical waters. Sometimes ranging as far north as San Pedro. Formerly taken in 1931, 1957 and 1958.
California halibut	1 1	Aug. 15 Nov. 10-11	Shelter Cove (north of Fort Bragg, California) Redding Rock, north of Eureka, California (Gunderson, 1960)[3]	Central California south to Magdalena Bay.
Bullet mackerel	40	Aug. 23	Between Santa Catalina Island and San Clemente Island	Common off Mexico and Central America. Reported from southern California in 1918, 1919, 1935 and 1957.
California bluefin tuna	1 1	Sept. 4 Sept. 24	30 miles west of Point Arena 70 miles west of Morro Bay	Recorded from Columbia River to Cape San Lucas. Common only from Point Conception to Central Baja California.
Skipjack	100 10	Sept. 15[4] Nov.	40 miles west of Point Arena 60-70 miles west of Fort Bragg	Rare north of Point Conception and not common in southern California. Cosmopolitan in temperate and tropical seas.
Blacksmith	1	Sept. 23	Monterey Bay[3]	Previous northern limit was Point Conception.
Spiny trunkfish	1	Oct.	Outside Los Angeles Harbor	Taken in tropical seas throughout the world.
California grunion	Numerous 260 pounds	Oct. 15 Oct. 16	Monterey Bay Monterey Bay	Uncommon north of Point Conception.
Pacific thread herring	1	Nov. 9	Redondo Beach	Southern Baja California to Peru. Formerly taken off southern California in 1947, 1948 and 1949.
Paloma pompano	1	Nov. 18	Redondo Beach[1]	Previous recorded range was Sebastian-Viscaino Bay to Peru.

[1] First California record.
[2] Reported by bait fishermen at San Clemente City. The large roosterfish was observed feeding on the surface on a school of anchovies upon which the boat was setting. Its dorsal fin was spread.
[3] Extension of range.
[4] Continuously or sporadically abundant after this date.

TABLE 5
Southern Species of Fish Collected North of Their Usual Range During 1959

On August 15, a California halibut was caught at Shelter Cove, Humboldt County. Later, on November 10–11, another California halibut was caught by Jim Riley from the drag boat *Ina* trawling 4 to 6 miles northwest of Redding Rock (north of Eureka, California) in 30 to 35 fathoms (Gunderson, 1960). This fish, which extended the range of California halibut north of Humboldt Bay, was deposited in the California Academy of Sciences collection.

A Paloma pompano 500 mm. total length and weighing 1,655 grams was caught on hook and line in the surf at Redondo Beach (Santa Monica Bay), California, on November 18 (Figure 7). It was placed in the U.C.L.A. fish collection.

On March 18, a juvenile Pacific moonfish 89 mm. total length was caught off Rainbow Pier, Long Beach, California, by the bait boat *City of Long Beach* (Figure 8). It was sent to U.C.L.A.

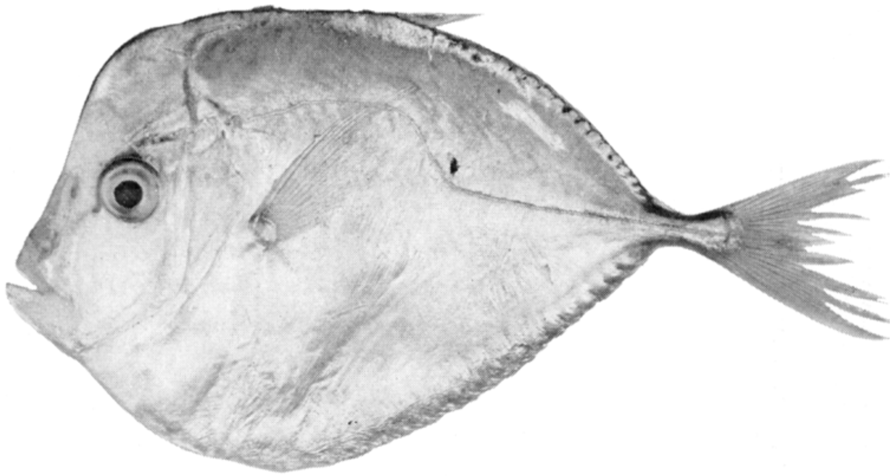

FIGURE 8. Pacific moonfish (*Vomer declivifrons*) found in a net full of anchovies caught off Long Beach, California, March 18, 1959. *Photograph by Jack W. Schott.*

FIGURE 8. Pacific moonfish (Vomer declivifrons) found in a net full of anchovies caught off Long Beach, California, March 18, 1959. Photograph by Jack W. Schott.

A bigeye tuna was caught in the surf by an angler at Iron Springs, Washington, on July 13. The fish, which weighed 95 pounds, was first identified from a newspaper photograph as a Pacific yellowfin tuna; however, after critical examination of the photograph, Clark E. Blunt and John E. Fitch, marine biologists, California Department of Fish and Game, identified it as a bigeye tuna. This was subsequently confirmed by Carl L. Hubbs, Scripps Institution of Oceanography. On September 16, a second bigeye tuna was caught north of its usual range. This fish was caught by Louis Zermatten, from his albacore trolling boat *Lumina* about 90 miles west southwest of Cape Mendocino and identified by William L. Craig, marine biologist, California Department of Fish and Game (Figure 9). A third bigeye, weighing 65 pounds, Bay on September 23.

A blacksmith 11 inches in total length was collected in Monterey was reported from off Cape Mendocino in October.

A 22-inch long coral-red rockfish was caught on July 16, in 100 fathoms off Pt. Sur, California by the otter trawler *Two Brothers*.

On June 18, a smooth stargazer was collected by John L. Baxter, marine biologist, California Department of Fish and Game (Figure 10) during trawling operations by the City of Los Angeles with its vessel, *Prowler*. It was taken 5¾ miles west of Ballona Creek, Santa Monica Bay, California, in 300 feet of water.

On August 1, an adult fine-scale triggerfish was caught on hook and line by Walter Gerrans, in the Golden Gate at Fort Point, San Francisco

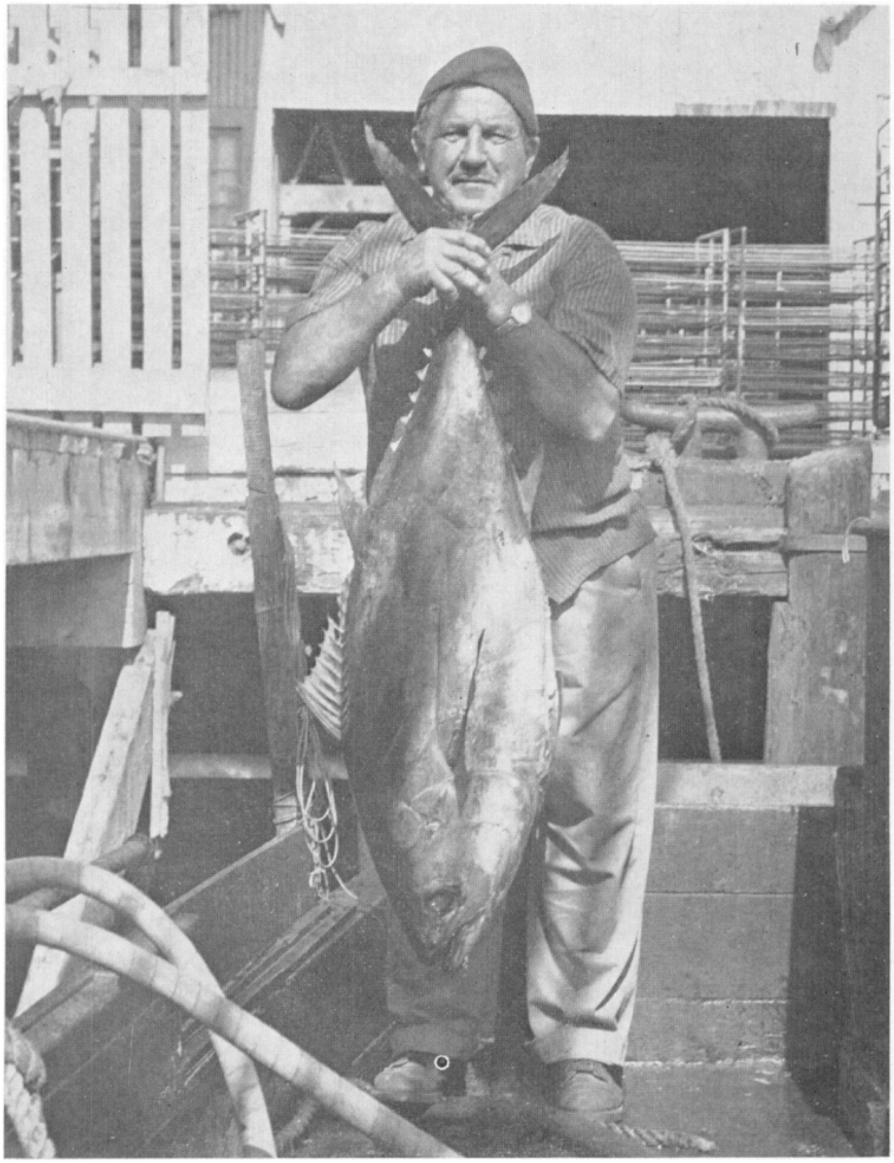

FIGURE 9. The first bigeye tuna (*Parathunnus sibi*) caught off California, being held by Louis Zermatten, the fisherman who caught it on September 16, 1959, about 90 miles WSW of Cape Mendocino. Its fork length was 1184 mm. and its weight 42¾ pounds. *Photograph by John L. Baxter.*

FIGURE 9. The first bigeye tuna (Parathunnus sibi) caught off California, being held by Louis Zermatten, the fisherman who caught it on September 16, 1959, about 90 miles WSW of Cape Mendocino. Its fork length was 1184 mm. and its weight 42¾ pounds. Photograph by John L. Baxter.

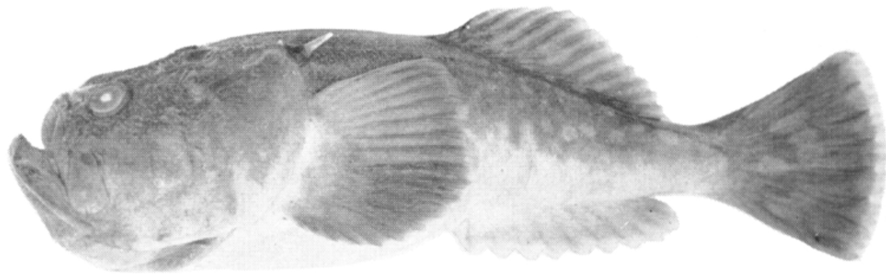

FIGURE 10. Smooth stargazer (*Kathetostoma averruncus*) trawled during a bottom-fish survey of Santa Monica Bay, California, June 18, 1959. *Photograph by Jack W. Schott.*

FIGURE 10. Smooth stargazer (Kathetostoma averruncus) trawled during a bottomfish survey of Santa Monica Bay, California, June 18, 1959. Photograph by Jack W. Schott.

(W. I. Follett, personal communication). It is now deposited in the California Academy of Sciences collection.

As in 1957 and 1958, the continued high abundance of certain warmwater species such as Pacific bonito, skipjack and white seabass was noticed by more fishermen than the rarer, but still very significant occurrences itemized above.

10. OTHER UNUSUAL OCCURENCES OF FISH DURING 1957, 1958 AND 1959

10.1. Occurrences of Rare Fish Representing No Latitudinal Movement

Not every rare fish collected during the three warm years represented a northern occurrence of a southern species. At least 12 species showed no latitudinal movement (Table 6). One, the shortbill spearfish, was quite significant for two reasons. First, it represented an eastern extension of range in 1957 and 1959; and second, this species may have been responsible for numerous "sailfish" sightings as far north as Oregon during the three warm years. The first coastal record of shortbill spearfish was August 31, 1957, when a specimen was caught off Sixty-Mile Bank (lat. 32° 05' N., long. 118° 14' W.) by Louis Sadler, owner of the vessel *California Republic*. It was thought to be a Pacific sailfish (Istiophorus greyi) by Mr. Sadler; however, it was identified by Craig (1958) as a shortbill spearfish, and was deposited in the U.C.L.A. fish collection. Another "sailfish" was caught off Morro Bay on August 17, 1959. A description of the fish by Mr. Brebes of Brebes' Abalone Plant, Morro Bay, California, who had seen and handled it, fitted Tetrapturus angustirostris. It weighed 44 pounds in the round and its sail (dorsal fin) was about eight inches high. Subsequently, Mr. Brebes confirmed this identification after examining photographs of a Pacific sailfish, a marlin and a shortbill spearfish.

In addition to the shortbill spearfish, three other species reported in this paper as having occurred north of their usual range may have moved inshore as well as northward during 1957, 1958 and 1959. These three, skipjack, common dolphinfish and bigeye tuna generally range farther north in the mid-Pacific than they do along the North American

TABLE 6

Rare Fish Specimens Collected During 1957, 1958 and 1959 (Not Necessarily Showing Directional Movements)

Common Name	Number Collected	Date of Collection	Location of Capture	Remarks
Smalleye squaretail	1	July, 1957	100 miles offshore from Point Arguello	A fish of the open seas. One taken off San Pedro. Taken off California in 1917, 1947, 1948, 1949, 1950 and 1956.
	1	Aug. 29, 1957	225 miles SWxS of Pt. Arguello	
	1	Aug. 29, 1958	80 miles SWxW of Pt. Arguello	
	1	July 13, 1959	Monterey Bay	
Opah	1	Aug. 4, 1957	San Clemente Island	Found in warm seas worldwide. Taken uncommonly in California waters.
	1	Oct. 1, 1957	Off Monterey	
	1	May 16, 1959	70 miles off Dana Point	
	1	June 5, 1959	Off east end Anacapa Island	
	1	Aug. 15, 1959	25 miles southeast Santa Catalina Island	
	1	Oct. 1, 1959	Off Monterey	
Lumptail searobin	1	Aug. 10, 1957	Los Angeles Harbor	Rarely collected. Taken off California in 1880, 1944, 1946, 1949 and 1950.
	1	Aug. 20, 1958	Off Dana Point	
	1	Sept. 7, 1958	Santa Monica Bay	
Shortbill spearfish	1	Aug. 31, 1957	60-Mile Bank (Craig, 1958)	Found in western Pacific. Considered rare throughout range. These represent eastward range extensions of approximately 1,000 miles.
	1	Aug. 17, 1959	Off Morro Bay[1]	
Slender snipefish	1	Feb. 15, 1958	Stomach content of albacore taken between Guadalupe Island and mainland	Rare. Taken off Hawaii, 1901; Santa Catalina Island, 1920; Guadalupe Island, Asuncion Bay, San Juanico Bay and San Quintin Bay in 1948; and Punta Baja, 1954.
	1	Oct., 1959	Coronado Island	
Slender requiem shark	1	May 13, 1958	6 miles SE of San Pedro light[1]	The type specimen was from South Africa. This was the second occurrence of the species and the first from California (Rosenblatt and Baldwin, MS).
Wolf-eel	1	May 22, 1958	1 to 1½ miles off Imperial Beach, San Diego County, in 8½ fathoms	Found from Kodiak Island, Alaska to San Diego, California.
	1	July 30, 1958	3 miles south by west of San Pedro light	
Bramble shark	1	Aug. 17, 1958	2 miles WSW of Dana Point	Collected from California in 1939 and 1944.
Louvar	1	Oct., 1959	In surf off Santa Monica	Taken infrequently from warm seas of the world. Eleven specimens have been reported off west coast of North America.

TABLE 6
Rare Fish Specimens Collected During 1957, 1958 and 1959 (Not Necessarily Showing Directional Movements)

TABLE 6—Continued

Rare Fish Specimens Collected During 1957, 1958 and 1959 (Not Necessarily Showing Directional Movements)

Common Name	Number Collected	Date of Collection	Location of Capture	Remarks
Big scale pomfret	1	Oct. 25, 1958	Manhattan Beach, Santa Monica Bay	Previously reported from various locations in the Atlantic and from Australia and Japan in the Pacific. Reported from California in 1953 (Fitch, 1953b).
Pomfret	1	July, 1959	120 miles SW of Pt. Arguello, California[1]	Previously reported from Madeira Island and from the Azores. This represents the first Pacific record.
Pelagic stingray	1	Sept. 12, 1959	2¼ miles off Redondo Beach, California[1]	Reported from the Mediterranean, off Japan, vicinity of Galapagos Islands and some other tropical localities.
	1	Oct. 14, 1959	Between Malibu and Pt. Dume, California	

[1] First California record.

TABLE 6

Rare Fish Specimens Collected During 1957, 1958 and 1959 (Not Necessarily Showing Directional Movements)

coast. Graham (1957) reports that between longitudes 140° W. and 150° W.; skipjack have been taken northward to lat. 43° 34' N.; common dolphinfish, to lat. 39° 49' N. and bigeye tuna, to lat. 37° 36' N.

On the other hand, tagging experiments have demonstrated that skipjack move northward along the coast of Baja California during late spring and early summer. Furthermore, during 1958, two skipjack tagged off southern Baja California on two different July cruises were recovered just south of San Clemente Island, California in October. One tagged July 4 at lat. 26° 15' N., long. 114° 30' W., was recovered October 1, at lat. 32° 05' N., long. 118° 15' W. and the other, tagged July 24, at lat. 26° 16' N., long. 114° 19' W. was recovered October 2, at lat. 32° 05' N., long. 118° 15' W. (Blunt and Messersmith, 1960). These returns and the northerly progression of catches in 1957, strongly suggest that skipjack move northward.

Common dolphinfish also were caught farther up coast as the 1957 season progressed and ultimately were captured near shore considerably north of the mid-Pacific record. The coastwise range-extension of bigeye tuna in 1958 was about 10 degrees of latitude farther north than their offshore northern record.

It appears then, that skipjack, common dolphinfish and bigeye tuna did move northward along the coast during the warm-water period; however, some eastward movement may also have taken place.

A slender requiem shark was caught six miles southeast of the Los Angeles Harbor entrance in 6½-inch stretched-mesh webbing of a gill net by Homer Moore from his boat *GM* on May 13, 1958. It was a male, weighing 145 pounds and measuring 2,436 mm. total length. It was caught at lat. 33° 38' N., long. 118° 10' W. and represented the second recorded specimen of this species (Rosenblatt and Baldwin, MS). The first, a juvenile, was caught off South Africa. The California specimen was sent to U. C. L. A.

Another rare species, a female pelagic stingray, was caught on September 12, 1959, from the sportfishing barge *California*, anchored 2¼ miles off Redondo Beach, Santa Monica Bay (Figure 11). Although it was the first California record for this species, a second was caught one month later on October 14, 1959, by the purse seiner *Sea Scout*, between Malibu Beach and Pt. Dume, California, about 1½ miles offshore. The two were identified by Anita E. Daugherty, marine biologist, California Department of Fish and Game, and ended up in the fish collection at Scripps Institution of Oceanography.

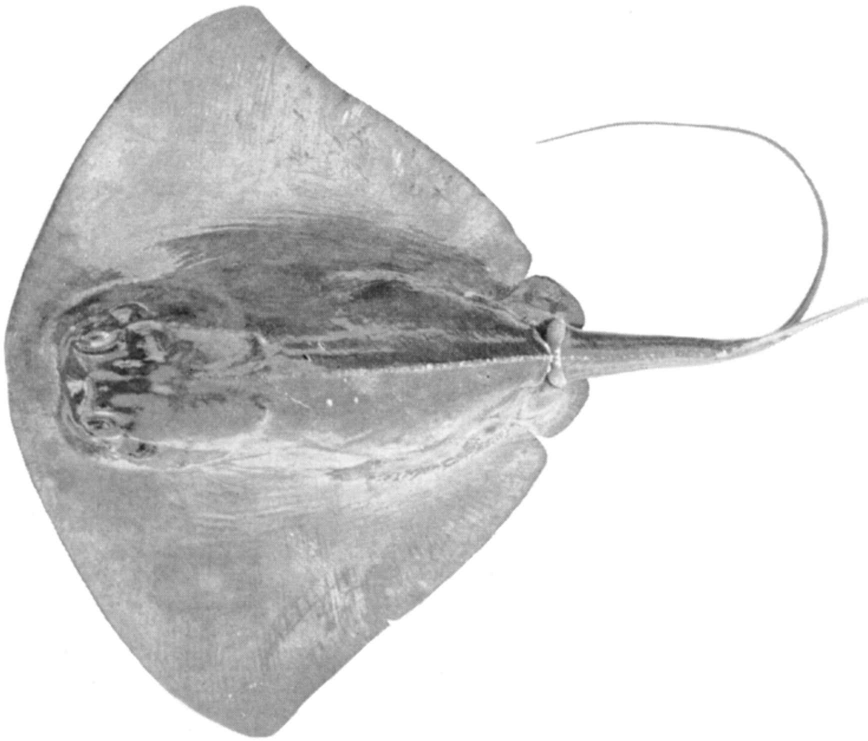

FIGURE 11. Female pelagic stingray (*Dasyatis violacea*). Caught from a sportfishing barge off Redondo Beach, California, September 12, 1959. *Photograph by Jack W. Schott.*

FIGURE 11. Female pelagic stingray (Dasyatis violacea). Caught from a sportfishing barge off Redondo Beach, California, September 12, 1959. Photograph by Jack W. Schott.

A bigscale pomfret, the second for California, was picked up in the surf at Manhattan Beach (Santa Monica Bay) on October 25, 1958. It was identified by John Prescott, Marineland of the Pacific. Its standard length was 25½ inches and its weight was 24 pounds.

A different pomfret, a juvenile Taractes asper, was spit up by a Pacific albacore. It was saved by Kenneth Ennis of the albacore boat *Renabel* and identified by John E. Fitch, California Department of Fish and Game, who sent it to U.C.L.A. The albacore was caught at lat. 33° 10' N., long. 122° 25' W., a location about 120 miles southwest of Point Arguello, commonly known as the "2000 fathom spot."

10.2. Southerly Moving Species

In addition to the non-directional occurrences of rare fishes, five of at least ten species collected south of their usual range during the warmwater period represented extensions of range (Table 7).

TABLE 7

Northern Species of Fish Collected South of Their Usual Range During 1957, 1958 and 1959

Common Name	Number Collected	Date of Collection	Location of Capture	Remarks
Green sturgeon	1	Apr. 27, 1957	Off Pt. Vicente, California	This was the second record south of Monterey Bay (Norris, 1957).
Tubenose poacher	1	July 20, 1957	Mendocino County, California[1]	This record extended the range 170 miles south from Oregon (Hemphill and Follett, 1958).
Pacific halibut	1	Sept. 11, 1957	4 miles south of Piedras Blancas (Phillips, 1958)	Found from central California northward to the Bering Sea. Reported once from Santa Rosa Island.
	1	Mar. 29, 1959	Pt. Buchon, California	
Grunt sculpin	2	Oct. 2, 1957	Santa Monica Bay (Phillips, 1958)[2]	Range extensions from Monterey Bay where records are rare or vague.
	1	Nov. 19, 1959	SE of San Nicolas Island	
Pacific cod	1	Dec. 2, 1957	6 miles south of Piedras Blancas, California[2]	Extension of southern range about 50 miles (Phillips, 1958).
Pomfret	1	July 12, 1958	30 miles southwest of San Juan Seamount, California	Worldwide distribution.
	1	July 2, 1959	250 miles WSW of San Nicolas Is., California	
American shad	1[3]	July 16, 1958	Todos Santos Bay area (Claussen, 1959)[2]	The range formerly extended from Alaska to San Diego. Not common south of Monterey Bay.
	Several	July, 1958[4]	Los Angeles Harbor	
Striped bass	1	Dec., 1958	Zuma Beach, California	On the Pacific Coast, known from southern California to Washington; uncommon south of Monterey Bay.
	1	Oct. 3, 1959	Approximately 25 miles below the U. S.-Mexican Border[2]	
Kelp greenling	1	July 9, 1959	Horseshoe Kelp (off Long Beach, California)	Found from Kodiak Island to southern California. Rare to the south. Three recorded south of Pt. Conception in 1953.
	1	Sept. 30, 1959	Horseshoe Kelp	
Pacific snake-blenny	1	July 12 or 14, 1959	Humboldt Bay, California (Follett, personal communication)	Found from northern California to northwestern Alaska.

[1] First California record.
[2] Extension of range.
[3] This and several other American shad were taken in the area.
[4] Continuously or sporadically abundant after this date.

TABLE 7

Northern Species of Fish Collected South of Their Usual Range During 1957, 1958 and 1959

A Pacific cod caught December 2, 1957 six miles south of Piedras Blancas, California extended the range about 50 miles southward (Phillips, 1958). Two grunt sculpins trawled in Santa Monica Bay October 2, 1957 were several hundred miles south of their previously reported southernmost point in Monterey Bay (Phillips, 1958). Another was spit up by a rockfish caught at a depth of 100 fathoms southeast of San Nicolas Island, November 19, 1959.

A tubenose poacher collected off Mendocino County, California, July 20, 1957 was the first from California and extended the range to 170 miles south of Oregon (Hemphill and Follett, 1958).

The ranges of two introduced species, American shad and striped bass, were also extended to the south. Several American shad were captured in Los Angeles Harbor during and after July, 1958. This was not too unusual since shad had been taken in this area previously. However, their range was extended when some were caught near Ensenada in Todos Santos Bay, Baja California, Mexico, on July 16, 1958 (Claussen, 1959). On October 3, 1959, a striped bass was caught by William Carmody, Compton, California, about 25 miles below the Mexican-United States Border. Mr. Carmody caught the 12-pounder on a plug. These two species have several things in common: both were introduced from the east coast of the United States during the latter part of the last century; both became well-established in the San Francisco Bay area; and both are dependent on fresh water for spawning. Both might have become established off southern California or northern Baja California, had there been sufficient fresh water in which to spawn. Therefore, the "southerly extensions" of their ranges probably do not represent southerly movements of "cold-water" species. On the contrary, warm water might stimulate their dispersal both north and south. There is some evidence that this has happened with striped bass.

Hubbs and Schultz (1929) noted the appearance of striped bass off Oregon during the summer of 1925, and in commerical quantities in Coos Bay, Oregon, during the summer of 1926. This reference carries a footnote by F. N. Clark reading: “"The striped bass is now maintaining itself in sufficient number at Coos Bay, Oregon, to be of commercial importance. While definite figures are not available, the general opinion of the fishermen is that this fish is increasing in abundance in that region each year. It would seem that the movement of this species to the northward is the normal spreading out of the species following its establishment in the California streams. Its occurrence in numbers sufficient to attract general attention in 1925 and 1926 may have been coincident with, rather than dependent on, the unusual temperatures of these years. If the warmer temperatures played a part in the northward distribution of striped bass, it has successfully maintained itself thereafter."”

Striped bass on the Atlantic coast are considered surf fish by the many anglers who seek them every summer. However, on the Pacific coast, they are caught primarily in inland waters. During the recent warm-water period, striped bass became a surf fish off central California.

TABLE 8

Average Number of California Yellowtail Caught per Party Boat Angler in the Vicinity of the Los Coronados Islands, and of California Barracuda and Pacific Bonito Throughout Southern California

Year	Yellowtail Catch from the Los Coronados Islands			Barracuda Catch from Southern California			Bonito Catch from Southern California		
	Number Caught	Anglers	Number per Angler	Number Caught	Anglers	Number per Angler	Number Caught	Anglers	Number per Angler
1947	5,388	23,332	.23	677,449	318,192	2.13	36,496	318,192	.11
1948	8,094	34,621	.23	384,056	352,578	1.09	14,519	352,578	.04
1949	11,904	40,789	.29	366,423	396,424	.92	5,372	396,424	.01
1950	5,966	34,016	.18	256,367	439,270	.58	2,359	439,270	.00
1951	20,091	44,182	.45	269,545	434,992	.62	14,475	434,992	.03
1952	26,241	42,011	.62	336,550	437,241	.77	7,649	437,241	.02
1953	14,558	39,758	.37	170,550	378,897	.45	6,321	378,897	.02
1954	34,542	51,631	.67	282,552	392,181	.72	70,078	392,181	.18
1955	33,876	52,241	.65	154,962	350,112	.44	22,409	350,112	.06
1956	25,907	53,320	.48	87,603	370,144	.24	61,404	370,144	.16
1957	162,905	84,556	1.93	577,060	429,801	1.34	258,555	429,801	.60
1958	82,075	61,986	1.32	782,624	407,357	1.92	422,565	407,357	1.04
1959	169,989	39,133	4.34	1,079,868	445,652	2.42	730,600	445,652	1.64

TABLE 8
Average Number of California Yellowtail Caught per Party Boat Angler in the Vicinity of the Los Coronados Islands, and of California Barracuda and Pacific Bonito Throughout Southern California

In contrast to the high summer ocean temperatures off the Atlantic coast, the water adjacent to San Francisco is quite cool during summer as well as winter. Therefore, one may hypothesize that a cold-water barrier off San Francisco may keep striped bass from running to sea and dispersing along the coast, except during warm years. This hypothesis could explain the northward establishment of striped bass in Coos Bay in the summers of 1925 and 1926, and the exceptional catches in the surf around San Francisco during the recent warm period. The southward extension of range in 1959 may also be related to their oceanic migration.

11. RELATIONSHIP OF FISH DISTRIBUTION OFF CALIFORNIA TO WATER TEMPERATURES

11.1. California Yellowtail

As mentioned before, a dramatic improvement in yellowtail fishing success early in 1957 first called attention to the unusual events taking place. Good yellowtail fishing continued through at least 1959, even during the winters.

The California yellowtail is the principal species sought by party boats which depart from San Diego and Mision Bays to fish around Los Coronados Islands, Mexico. Therefore, the average catch-per-angler of yellowtail in this area (Table 8) probably reflects the amount present, even though other species frequently are caught. California yellowtail rarely are found north of southern California, but southward they range along the coast of Baja California and into the Gulf of California. Their greatest abundance is far south of the southern California sportfishery. Therefore, angling success varies substantially due to shifts in fish distribution.

Since the sportfishery usually develops in the early spring, the average sea-surface temperature at Scripps Pier, La Jolla, for the first half of each year was compared with the average daily catch of California yellowtail per party boat angler fishing at Los Coronados Islands (Figure 12). The results demonstrate that from 1947 through 1959, fishing success varied with water temperatures, even though the waters were monotonously cool during much of this 13-year period.

In a boat-catch study of the small-scale commercial yellowtail fishery between 1922 and 1932 in the vicinity of San Diego and Los Coronados Islands, Whitehead (1933) found the catch-per-effort declined steadily. In only two years did he find an increase, the two warm-water years of 1926 and 1931. Although the trend of fishing success was downward between 1922 and 1932, and upward between 1947 and 1959 (Figure 12), the effect of warm water on fishing success stands out clearly during both periods.

11.2. California Barracuda

The barracuda sportfishery began more slowly in 1957 than did that for yellowtail, but before the year was over, the catch was higher than it had been for several years. Barracuda fishing continued excellent through 1958 and 1959. As with yellowtail, the barracuda fishery exploits only the northern edge of the population, although California barracuda are found farther north than yellowtail.

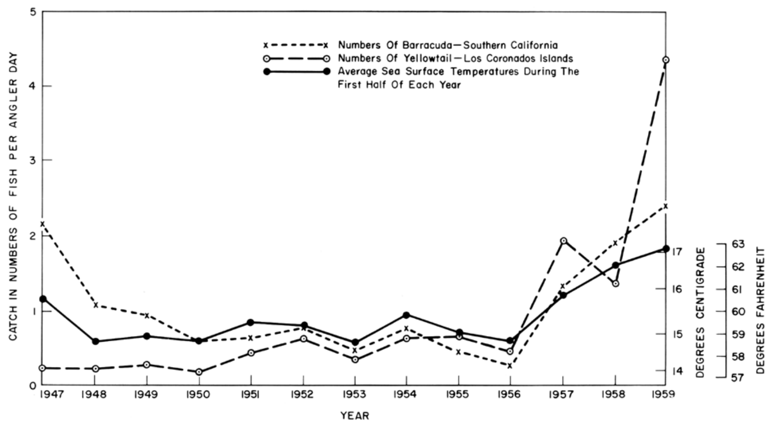

FIGURE 12. Average daily catch of yellowtail per party-boat angler in the vicinity of the Los Coronados Islands, and of barracuda throughout southern California, compared with the average of monthly sea-surface temperatures taken at Scripps Pier during the first half of each year (January through June).

FIGURE 12. Average daily catch of yellowtail per party-boat angler in the vicinity of the Los Coronados Islands, and of barracuda throughout southern California, compared with the average of monthly sea-surface temperatures taken at Scripps Pier during the first half of each year (January through June)

California barracuda range from Magdalena Bay, Baja California, to Alaska but are uncommon north of Pt. Conception (Fitch, 1958). Since they are highly prized by southern California party boat anglers, the average catch-per-angler on these boats probably reflects their local abundance. A comparison of the catch-per-effort for them (Table 9) with average temperatures during the first half of each year at Scripps Pier, La Jolla (Table 1), reveals a close relationship between water temperature and barracuda angling success (Figure 12). Therefore, as with the yellowtail, fishing success for barracuda seems strongly related to water temperature. The same might be said for Pacific bonito since phenomenal catches were made during 1957, 1958 and 1959, after a paucity of them for many years. However, because party boats fish for many species, catch-per-effort values for the less preferred ones are severely limited as indices of local abundance, *i.e.* rockfish catches on party boats declined during the warm period because more effort was directed toward preferred fishes. In using catch-per-effort values as indices of local abundance, for yellowtail and barracuda, the assumption was made that whenever party boats were fishing it was for these species.

Catches of barracuda made by sportfishermen in Monterey Bay during 1958 were considered unusual since they had not been found there for many years. In addition, 200 pounds were caught by commercial fishermen in the same area. Although barracuda previously have been caught commercially off central California, the inability to determine the effort expended catching them precludes obtaining estimates of local abundance. Occasionally catches were made by sardine purse seiners who came upon schools of barracuda and netted them. After a few loads of 2 to 20 tons, the market price would drop and the seiners would turn to other species.[1] However, records of commercial barracuda catches do show they were present off northern California during the warm years, 1926, 1931 and 1941 (Table 9). Although the catch is not a measure of relative abundance, it is interesting to note that the decline following each warm year, although quite rapid, was less abrupt than the dramatic increase associated with the warm year. During the very cold year, 1933, a few barracuda were still in the Monterey area, presumably from the upsurge in 1931. This suggests the barracuda schools do not leave as rapidly when the water cools as they arrive when it warms up.

Since southern California is not as far from the center of the barracuda population as is Monterey, one would expect the decline following a warm year to be even less abrupt. In fact, the downward trend of their catch-per-effort off southern California following 1947 (Figure 12) suggests a curvalinear decline tending to become asymptotic. If this is true, a variable environment with warm water once every few years might be sufficient to maintain a high barracuda population off California, while a long series of cool years would result in a decline which would tend to flatten out at a low level.

Obviously, factors other than distribution may affect the local abundance of fish. The size of the total population may decline or increase over a period of time, or the appearance of super-abundant year classes may cause large fluctuations from year to year. These influences would

[1] Purse seining for barracuda has been prohibited since June, 1940.

TABLE 9

Commerical Landings (in pounds) of Barracuda for Northern California 1916 Through 1958

Year	Eureka Area	San Francisco Area	Monterey Area	Total	Year	Eureka Area	San Francisco Area	Monterey Area	Total
1916	----	96	357	453	1941	----	----	1,550	1,550
1917	----	----	275	275	1942	----	----	----	----
1918	----	17,160	104,471	121,631	1943	----	----	60	60
1919	150	814	98,833	99,797	1944	----	----	----	----
1920	25	8,560	97,258	105,843	1945	----	----	----	----
1921	----	71	----	71	1946	----	----	----	----
1922	----	81	13,548	13,629	1947	----	----	----	----
1923	----	56	6,982	7,038	1948	----	----	----	----
1924	----	487	138	625	1949	----	----	----	----
1925	----	----	----	----	1950	----	----	----	----
1926	----	----	66,751	66,751	1951	----	----	----	----
1927	----	----	2,644	2,644	1952	----	----	----	----
1928	----	----	984	984	1953	----	----	----	----
1929	----	----	28	28	1954	----	----	----	----
1930	----	----	30	30	1955	----	----	----	----
1931	----	8,730	139,835	148,565	1956	----	----	----	----
1932	----	44	2,968	3,012	1957	----	----	----	----
1933	----	----	29	29	1958	----	----	200	200
1934	----	----	58	58	1959	----	----	----	----
1935	----	----	----	----					
1936	----	----	----	----					
1937	----	----	----	----					
1938	----	----	----	----					
1939	----	----	----	----					
1940	----	----	----	----					

TABLE 9

Commercial Landings (in pounds) of Barracuda for Northern California 1916 Through 1958

be felt in the fishery. The fact that the catch-per-effort of California barracuda closely follows sea temperatures (Figure 12) indicates the population size has been relatively stable or else it has changed at a uniform rate over a period of 13 years.

Prior to 1926, there seem to have been two other years, 1918 and 1922, when sharp increases in barracuda catches took place. That of 1918 was not followed by a decrease until after 1920; but following the 1922 increase, the decline was similar to those succeeding 1926 and 1931.

The lack of sea-temperature data for these early years makes it difficult to understand environmental conditions prior to 1916. It is obvious that barracuda were present off central California during all the years from 1916 to 1934, except 1925. Whether they were present during 1925 and to what extent the catches reflect actual abundance are not known.

11.3. White Seabass

According to Skogsberg (1939), the center of the white seabass fishery was off San Francisco in 1889, whereas by 1939 it was south of Point Conception. He indicated the dislocation was probably associated with changes in environmental conditions. He classified the remaining northerly representatives as "relics" of a once abundant population. He stated that a typical characteristic of "relics" of warm-water species is their preference for the warmest parts of their general habitat. He pointed out that by 1939 white seabass appeared to have been eliminated nearly everywhere except in and around Soquel Cove, the warmest part of Monterey Bay, and in and near Tomales Bay (north of San Francisco), where the water in the summer is warmer than in neighboring regions. He indicated that the shift took place over several years, spanning 1920. However, Skogsberg attributed a large catch made off Monterey County in 1926 to the abnormally high temperatures along a large section of the coast.

Since 1939, the white seabass population has been southerly; in fact, the fish have been abundant off Baja California and in the northern portion of the Gulf of California. Skogsberg's "relics" have persisted in the warm spots even supporting a small, erratic fishery at the mouth of Tomales Bay.

Therefore, the sportfishery for white seabass which developed off Monterey during 1957, and the catches made off Oregon, Washington, British Columbia, and Alaska during the three recent warm-water years, tend to confirm Skogsberg's conclusions of 20 years ago.

11.4. Pacific Sardine

The catch-per-effort of Pacific sardines is an indicator of the amount of fish adjacent to the fishery. However, of the many things affecting the catch-per-effort, the two most important seem to be the total size of population and its distribution with respect to the fishery. To arrive at an index of distribution along the coast which is independent of population size, Radovich (1959b) divided the catch-per-effort of sardines for northern California (Widrig, 1954) by the catch-per-effort for southern California, for each season from 1932–33 to 1950–51. This index has been compared with the average sea-surface temperatures for the last half of each year at Scripps Pier, La Jolla (Table 10). Through the 1944–45 season, a positive correlation has been demonstrated between water temperatures and sardine distribution (Figure 13). The sardines have been distributed more northerly during warm years and more southerly during cold years. After the 1944–45 season, their distribution apparently has been affected more strongly by other factors, since they have remained more southerly than one would have expected from the temperatures.

Until 1944, the density of sardines was generally higher off central California than off southern California. There were only two years, 1933 and 1944, during which densities were greater off southern California. The coldest recorded ocean climate occurred in 1933 (Figures 1 and 2); and 1944 was the year preceding the dramatic decline of the fishery. In all years since 1944, their distribution has been southerly, *i.e.*, the index of distribution is less than 1.0.

Although water temperature seems to be a factor in the Pacific sardine distribution, the failure of the fishery following the 1944–45 season (Radovich, 1959b) cannot be attributed entirely to a southerly movement caused by a drop in water temperature. Other possible reasons for their southerly distribution after 1944 include: heavy mortality of adults or poor survival of young in the northern part of the range; better survival of young south of the major fishing areas; southward movement of fish due to some other factor; or, some combination of these. Whether or not fishing was responsible for heavier mortalities in the north and to what extent poor recruitment in that area was due to a small spawning stock are subjects beyond the scope of this paper.

TABLE 10

Latitudinal Index of Pacific Sardine Distribution, and Average Sea-Surface Temperature for the Last Six Months of Each Year at Scripps Pier, La Jolla, California

Season	Total Catch-per-Effort in California[1] (Thousands of fish)		North:South Ratio of Catch-per-Unit-of-Effort	Average July-December Sea-Surface Temperature at Scripps Pier	
	North	South		Year	Temperature (Degrees F.)
1932-33	2,546	2,045	1.24	1932	63.3
1933-34	2,554	2,829	.90	1933	62.4
1934-35	4,115	3,239	1.27	1934	65.4
1935-36	3,533	2,441	1.45	1935	64.2
1936-37	3,776	1,725	2.19	1936	67.1
1937-38	1,941	1,276	1.52	1937	65.5
1938-39	2,903	1,983	1.46	1938	63.9
1939-40	3,128	1,487	2.10	1939	66.9
1940-41	2,922	2,350	1.24	1940	64.7
1941-42	3,817	1,984	1.92	1941	64.9
1942-43	2,752	2,622	1.05	1942	65.1
1943-44	2,690	1,498	1.80	1943	64.7
1944-45	2,059	2,147	.96	1944	63.6
1945-46	1,241	1,930	.64	1945	64.9
1946-47	293	1,269	.23	1946	64.7
1947-48	205	558	.37	1947	64.2
1948-49	880	1,221	.72	1948	63.1
1949-50	2,055	2,172	.95	1949	64.6
1950-51	350	1,378	.25	1950	64.4

[1] North includes the average catch-per-effort of Monterey and San Francisco; south represents the catch-per-effort of San Pedro (Widrig, 1954).

TABLE 10

Latitudinal Index of Pacific Sardine Distribution, and Average Sea-Surface Temperature for the Last Six Months of Each Year at Scripps Pier, La Jolla, California

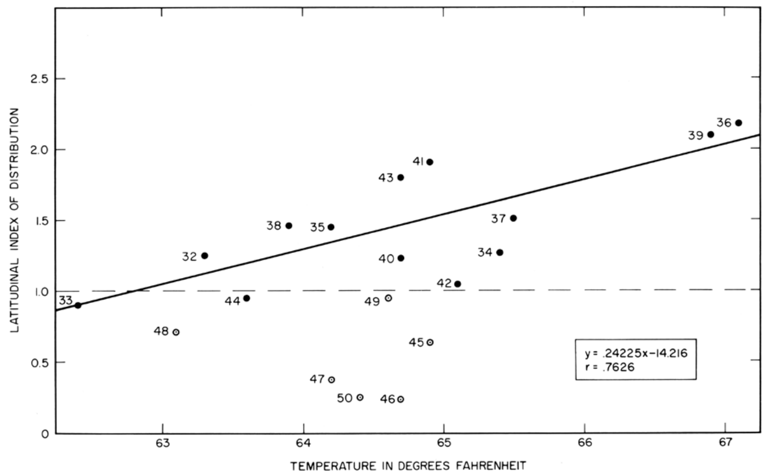

FIGURE 13. The relationship of the latitudinal index of Pacific sardine distribution to the average of sea-surface temperatures for the last six months of each year (taken at Scripps Pier, La Jolla). Black dots represent years prior to the 1944-45 season; white dots, the years after the 1944-45 season. The numbers preceding the dots indicate year.

FIGURE 13. The relationship of the latitudinal index of Pacific sardine distribution to the average of sea-surface temperatures for the last six months of each year (taken at Scripps Pier, La Jolla). Black dots represent years prior to the 1944–45 season; white dots, the years after the 1944–45 season. The numbers preceding the dots indicate year

During 1958 and 1959, Pacific sardines were caught off Monterey after an absence of several years. Evidence (Calif. Mar. Res. Comm., 1960) indicates the return of sardines to central California was not due to an increase in population size but to a northward shift of the population.

11.5. Pacific Albacore

In the north Pacific, albacore range from Japan to the North American continent. For several years preceding 1957, their appearance along the North American coast has been reasonably dependable. They approached the Baja California coast in June passing south of Guadalupe Island and later in the season they moved northward. About 65 percent of those caught by the California fishery from 1954 through 1956 were from water with surface temperatures between 60 and 64 degrees F.

In 1957, the first albacore were caught on June 9 from the California Department of Fish and Game vessel *N. B. Scofield* about 80 miles WNW of Guadalupe Island in 62-degree F. water. After encountering high water temperatures in the area south of Guadalupe Island, the vessel cruised northward to intercept the schools. The fishery subsequently developed farther north than during the previous six years. The anomolous behavior of albacore during 1957 is discussed by Radovich (1960), and in greater detail by Clemens (MS).

On the basis of an apparent relationship of the location of albacore catches to sea temperatures, H. B. Clemens, marine biologist, California Department of Fish and Game, predicted the fishery would develop even farther north in 1958. The several fishermen who went directly to the area suggested, caught fish. Those who headed for their traditional southerly areas changed their minds and headed north when it became apparent that albacore were scarce except in the predicted location (Radovich, 1959a).

In 1959, Clemens again predicted that albacore would appear in the northern offshore area. The Department's vessel *N. B. Scofield* departed June 1, 1959, to scout for incoming schools, and on June 5, encountered the season's first albacore about 90 miles W x N of Point Arguello. During the month of scouting, the U. S. Fish and Wildlife Service vessel *Hugh M. Smith* ran a scouting pattern south of the *N. B. Scofield* but caught no albacore (Craig and Graham, MS). The fishery subsequently developed in the northern area.

Hubbs and Schultz (1929) demonstrated that, similar to striped bass, albacore made their appearance in large numbers northward of their usual range in 1925 and 1926. They showed that the water temperatures were higher than normal off central California during the last half of 1925 and the first half of 1926.

During the warm-water year, 1931, albacore fishing was very poor, particularly off southern California. The total California catch was less than 40,000 pounds, all but 1,000 pounds being taken off Monterey and San Francisco. On the basis of their observed distribution along our coast during the past several years, it seems reasonable to speculate that in 1931 they approached the coast farther north than usual, moved northward rapidly, and did not come within range of the southern California fleet.

Thus, it appears that Pacific albacore distribution along the North American coast is influenced by the environment, of which temperature is a strong indicator if not a primary factor in itself.

12. NORTHWARD OCCURRENCES OF OTHER ANIMALS

12.1. Turtles

Many East Pacific green turtles were caught off southern California during 1957 and 1958, and several, presumably the same species, were sighted off central California. A few were seen near Nootka Sound, British Columbia.

According to Carr (1952), East Pacific green turtles range from southern California south to southern Chile; they are known from San Diego Bay, California; and there are old records for San Francisco which may be questionable.

During the summer of 1957, several green turtles were seen and some were caught by live bait haulers in Los Angeles Harbor. One collected by Herb Mueller on the bait boat *Donna K* on August 20, was 21¼ inches long (carapace length) and weighed 36# pounds. It was captured in a lampara net about one mile from shore. The depth of water was 70 feet; the turtle, however, was near the surface where the water temperature was between 71 and 74 degrees F.

Between September 10 and 16, 1957, several green turtles were seen in the vicinity of Davidson Seamount by the crew of the albacore boat *Aquarius*. Several turtle sightings near the Farallon Islands (off San Francisco) were reported during September. During April and May, 1958, turtle sightings were reported from near Nootka Sound, British Columbia. Green turtles were observed intermittently during 1958 at various places off southern California.

On October 18, 1957, a Pacific Ridley turtle was captured in Humboldt Bay, California. First reported as a green turtle, it was identified as a Pacific Ridley at Humboldt State College where the specimen was retained. Carr (1952) gave as the range for the Pacific Ridley turtle, "Warmer parts of the Indian and Pacific Oceans. It ranges northward in the western Pacific to southern Japan while in the eastern Pacific it is known from Baja California to Chile."

Intermittently, during the three warm years, there were numerous sightings and several captures of Pacific leatherback turtles. One weighing approximately 50 pounds was caught on the bottom in 60 feet of water at San Miguel Island on November 16, 1959, and five were recorded from the San Pedro Channel-Santa Catalina Island area in 1959 (Kenneth Norris, personal communication). During July, 1957, one weighing 405 pounds was captured in Barkley Sound, Vancouver Island, British Columbia. This large pelagic species is found throughout the Indian and Pacific Oceans, ranging from British Columbia to Chile in the eastern Pacific (Carr, 1952).

12.2. Pelagic Red Crab

This partially pelagic, partially demersal, warm-water species, became very common off southern California after the latter part of 1957. They are abundant from the middle of Baja California to about 150 miles south of Cape San Lucas, frequently near the surface in swarms several miles wide. At times, they are carried by currents and may wash ashore in great numbers. The author has observed such mass strandings at Santa Maria Bay and Port San Bartolome, Baja California. At other times, although none are seen at the surface, mid-depth or bottom trawling may yield large amounts.

When they are dipnetted and placed in bait tanks or aquaria, they usually settle to the bottom where they remain, since they are heavier than sea water. They maintain themselves near the surface by alternately giving a few quick, forward flips with their tails and then spreading their legs, on which fine, hair-like filaments fan out, allowing them to parachute slowly downward. The reason for their swarming at the surface is not known.

Although P. planipes is a warm-water species, it was described by Stimpson in 1860 from a collection made in March, 1859, at Monterey, California, where considerable numbers washed ashore (Schmitt, 1921). Hubbs (1948) considered this further evidence that the ocean climate off California was warm about 100 years ago.

During the warm year 1941, pelagic red crabs were seen off southern California and large quantities were noted in Santa Monica Bay (Calif. Conserv., 1941). They were noted next on December 5, 1957, at La Jolla, and were collected by sportfishermen on party boats off Point Vicente on December 9, 1957. After these occurences, they became quite common all over southern California. Their appearance seems associated with the countercurrent which apparently developed during the winter of 1957–58.

On January 24, 1959, about 100 were collected by the author 2.4 miles south of Point Vicente in a two-meter diameter mid-water trawl from the University of Southern California vessel *Velero IV*. The estimated depth of the two was 500 feet and the water depth was 400 fathoms. Since none of these bright red crabs was visible at or near the surface, they must have been occupying a mid-depth region. The sea-surface temperature was 59.5 degrees F. These were sent to Scripps Institution of Oceanography.

On March 24, 1959, large quantities washed ashore on Cabrillo Beach, San Pedro, California and during October, November and December, 1959, vast quantities were reported from the Santa Cruz, Anacapa and Santa Barbara Islands, and from as far north as Monterey Bay.

Although the warm-water period was continuing into 1960, with but two exceptions, records beyond 1959 have not been included in this report (although a supplement may be desirable). Between January 4 and 8, 1960, many Pleuroncodes planipes washed onto the beach at the Isthmus, Santa Catalina Island and on January 12 and 13, thousands were cast ashore in Monterey Bay (Glynn, MS). Thus, 100 years and 10 months after the species was discovered following a mass stranding at Monterey, the event was recorded there for the second time.

12.3. Other Invertebrates

During 1957 and 1958, numerous species of euphausiids were distributed more northerly than usual along the California coast (Brinton, 1960) as were many other kinds of organisms (Calif. Mar. Res. Comm., 1960). The pelagic tunicate, Doliolum denticulatum, was also found farther north reaching a maximum during the winter and spring of 1957–58 which coincided with the countercurrent period (Berner and Reid, in press).

Although many of these invertebrates live within certain temperature ranges, their northerly distribution during the warm-water period probably was assisted by the development of a countercurrent. This was particularly apparent with the tunicate Doliolum denticulatum whose distribution in 1958 moved southwestward, following the end of the countercurrent conditions but before the seasonal maximum of temperature was reached (Berner and Reid, in press).

The sand crab, a demersal crustacean with a pelagic larval life, became established, at least temporarily, off the west coast of Vancouver Island, British Columbia (Butler, 1959). This represented an extension of range, since previously they had not been recorded north of Kalalock Beach, Washington. The bed of sand crabs was found on June 23, 1959 by D. B. Quayle and W. E. Ricker, on the sandy beach bordering Wickaninnish Bay. It seems likely that larvae were carried northward by a countercurrent and the subsequent warm temperatures allowed them to become established. The 23 specimens collected were females and 20 were carrying eggs.

13. NORTHERLY SPAWNING SURVIVAL OF WARM-WATER SPECIES

13.1. Invertebrates

Some of the northerly occurrences of invertebrates, probably involved spawn survival north of their usual range. The occurrence of the sand crab off Vancouver Island obviously was a result of spawn survival and transport of larvae, since adult sand crabs are demersal, living in the sand in the intertidal zone, and the eggs are carried by the female until they hatch. Plankton collections made off southern California during 1958 containing Pleuroncodes planipes larvae indicated a northerly spawning for that species, also.

13.2. California Yellowtail

On May 4, 1958, several small yellowtail weighing from two to three pounds were seen schooled with Pacific bonito along the Long Beach Breakwater. On the same day a small yellowtail 12 inches long, weighing 16 ounces, was caught at Horseshoe Kelp (off Long Beach) on the party boat *Pierpoint*. This was the first record the Department of Fish and Game had of juvenile yellowtail off southern California. It probably was spawned during the summer of 1957; however, it may have moved into the southern California area as a juvenile.

On November 11, 1958, the live bait boat *City of Long Beach* caught a very small yellowtail 138 mm. in total length (112 mm. standard length) weighing 20 gms. in Los Angeles Outer Harbor.

During September and October 1959, several juveniles three to four inches long were caught by bait haulers from several areas off southern California, particularly the Los Angeles Harbor. Also in October 1959, Kenneth Mais, marine biologist, California Department of Fish and Game, collected 32 juvenile yellowtail 3½ to 6¼ inches long off southern California during a survey cruise on the Department's research vessel *Alaska*. They were collected from 11 different stations off Los Coronados, Santa Catalina and Santa Cruz Islands, and from along the mainland. Despite considerable effort trying to obtain juvenile yellowtail for age and growth studies, these 32 fish represented the largest collection made to date by Department of Fish and Game personnel. Most of them were sent to U.C.L.A.

There is conclusive evidence, therefore, that yellowtail had a successful spawn survival off southern California during 1959. Some survival occurred off southern California during 1958, and probably during 1957 also.

13.3. California Barracuda

Juvenile barracuda, common off southern California in the past, were encountered frequently by bait haulers from San Diego and Los Angeles Harbors during the latter part of 1958 after an absence of several years.

13.4. Striped Mullet

By April 1959, striped mullet had become re-established in San Diego and Newport Bays. They had been absent for several years.

13.5. Sharpchin Flyingfish

Sharpchin flyingfish, which seem to move northward only during warm years, spawned successfully off southern California during 1959. This was concluded on the basis of the numerous juveniles collected locally.

13.6. Swordfish

During the second week of July 1958, a small swordfish was caught from the vessel *Adaline H* off Santa Catalina Island. It was 73¾ inches long from the tip of its "sword" to the fork of its tail and weighed 38 pounds. It was identified by John E. Fitch, and represented the smallest locally caught swordfish on record at the California State Fisheries Laboratory.

On July 26, 1958, a ripe female swordfish, weighing 224 pounds dressed, was caught from the vessel *Suana* seven miles off Long Point, Santa Catalina Island. One ovary was 15½ inches long and 8 inches across.

14. OTHER BIOLOGICAL ANOMALIES

Several other anomalous animal behaviors occurred during 1957, 1958 and 1959. Some may have been coincident with rather than related to the warm water; however, they are recorded here for whatever reference value they may have.

14.1. Pismo Clam

At Pismo Beach survival of Pismo clams was poor during the 10 cool years preceding 1957. However, there were sizeable sets of young clams during the warm years of 1957, 1958 and 1959 (Baxter, MS).

14.2. Birds

Many tropical sea birds were seen far north of their usual range (Radovich, 1960).

14.3. Sperm Whales

According to J. C. Stevenson, Assistant Director, Biological Station, Nanaimo, British Columbia (personal communication), the percentage of female sperm whales in the catches of the whaling station at Coal Harbor, Quatsino Sound, Vancouver Island, was high in 1957 (23 percent). In 1956, it was 16 percent; in 1954 and 1955, 5 percent; and in 1952 and 1953, 3 percent. In 1951, 11 percent were females, and during 1948, 1949 and 1950, no females were caught. Female sperm whales appear to avoid waters of 17 degrees C. or colder, seldom venturing beyond latitude 40° N. while the males spread into the polar regions. During the winter breeding season, both males and females are found in the tropics. Male sperm whales were scarce during 1956 and 1957. It is possible they were farther north during these years.

14.4. King Salmon

The king salmon fishery off California was very poor in 1957, following several years of abundance which were characterized by uniformly cool water. The poorest California salmon fishing in over 40 years was recorded during a year of great change, 1939. The first half of 1939 was extremely cold, and the last half, extremely warm. The year 1939 was also one of exceptionally high sardine spawn survival; successful spawning having occurred off Oregon, Washington and British Columbia, far north of the usual spawning area.

One might speculate that king salmon are sensitive to temperature changes and that widely fluctuating temperatures are less desirable than uniform conditions. Pacific sardines, on the other hand, may be more successful in a variable environment.

14.5. Sockeye Salmon

Normally during their spawning migrations, sockeye salmon approach the Frazer River through Juan de Fuca Strait and the southern passages after first appearing in the commercial troll fishery off the west coast of Vancouver Island. However, during 1957 and 1958 most of the troll catches were made north of Vancouver Island and an unusually high proportion of salmon approached the Frazer River through the northern passages (Tully *et al.*, 1960).

14.6. Northern Anchovy

Bait haulers had difficulty obtaining large northern anchovies throughout southern California during 1957, 1958 and 1959. However, stomachs of California bluefin tuna, which were netted over deep water betwen Santa Catalina and San Clemente Islands, were filled with large anchovies. In addition, numerous samples of large anchovies were collected offshore by Department of Fish and Game personnel. These facts suggest that large anchovies move offshore and deep when inshore waters become too warm. As a result of similar anchovy behavior, guano birds off Peru were reported starving in 1957 because of a scarcity of anchovies at the surface while large catches were being made by deep fishing purse seines.

14.7. Southern Hemisphere

Through the courtesy of John Isaacs, Scripps Institution of Oceanography, La Jolla, several anomalous distributions of fish off the coast of Chile are included in this paper.

In the southern hemisphere the *El Niño* condition prevailed, and the water temperatures off Chile in 1957 and 1958 were the highest in 18 years. As a consequence, many warm-water species were recorded farther south than normal (Isaacs, personal communication): striped marlin were caught for the first time at the Juan Fernandez Islands; a shortbill spearfish was taken off Coquimbo, the first record for the southeast Pacific; common dolphinfish were collected from Chanaral to Coquimbo; and the albacore catch was the poorest reported in years, being only about 15 percent as high as the recent average when water temperatures were much lower.

14.8. Giant Kelp

The giant kelp beds off southern California sloughed off badly, and diminished in size to the extent that the California kelp industry suffered from a shortage of raw material during 1957, 1958 and 1959.

Sloughing occurs every summer when the water is warmest and beaches frequently are littered with kelp fronds. However, during the winter when the waters cool, the beds become luxuriant, except in certain areas where other deterring factors may be in effect. In 1957, sloughing was more severe during the summer, and recovery was inhibited during the following winter, a trend that continued through 1958 and 1959.

15. DISCUSSION

From the foregoing, it is obvious that environmental variations are important contributors to vagaries in distribution of many kinds of fishes. Consequently, fishing success for some species is affected by environmental conditions, one of which is water temperature. The effect of environment is more apparent when a fishery exists near the edge of a fish population. Under those conditions, changes in distribution may cause large fluctuations in catch.

When a fishery encompassing a large part of a fish's distribution is near the center of the normal range, it is less likely to be affected by changes in fish distribution. In this case, the catch will be affected to a greater extent by the amount of fish in the population.

Therefore, fringe fisheries such as those for California barracuda and California yellowtail may be subject to large environment induced variations; whereas fisheries for California halibut, and in the past, for Pacific sardines, may have been less affected by changes in the environment since they encompassed larger parts of the ranges of the two species. Yet the latter two fisheries declined. Either or both may have been influenced by the environment in some more subtle manner or the fish may have been subjected to excessive mortalities from fishing or other causes. In recent years, the Pacific sardine fishery has changed to a fringe fishery due to reduction in numbers, particularly in the northern portion of its former range. As such, it has responded in typical fashion by fluctuating widely at a low level.

The mere fact one can demonstrate the environment has a large effect on the catch does not imply man's effect is inconsequential. To understand man's effect, one must study the effect of man. However, a satisfactory understanding may never be achieved so long as one fails to recognize the existence of some of the other factors constantly confusing his data. **The effects of environment and man on fish populations are not mutually exclusive.**

16. SUMMARY AND CONCLUSIONS

1. Sea-surface temperatures at Scripps Pier, La Jolla, and in the 5-degree squares of latitude and longitude adjacent to southern California and northern Baja California were quite similar when compared for an eighteen-year period. Therefore, sea temperatures from Scripps Pier were considered indicative of coastal ocean temperatures.
2. Ocean temperatures off the Pacific coast of North America were high during 1926, 1931 and 1941.
3. Southern organisms, primarily fish, moved northward during 1926, 1931 and 1941.
4. Water temperatures were very low in 1933 and during the years 1948 through 1956, were colder than the long-term average.
5. Ocean conditions apparently were warm about 100 years ago (during the 1850's). At that time, warm-water species were observed farther north than during recent years.
6. During 1957, the ocean climate along the California coast warmed up and many fish ranged north of their usual haunts. Some warm-water species were caught in large quantities off California.
7. In 1958, high catches of southern game fish continued and for some even increased. Twenty-three fish species were taken north of their usual range, 10 farther north than ever previously recorded.
8. Warm water and northerly distributions of game species continued during 1959 and 26 fish species were recorded north of their usual range. Eleven of these represented northern records and six were additions to the marine fauna of California.
9. Some rare species captured during 1957, 1958 and 1959 showed no latitudinal movement; and some fish were caught south of their usual range.
10. Eleven species of marine fishes not previously reported among the fauna of California were taken during the three warm-water years. These were: Mobula japanica, Trachinotus rhodopus, Trachinotus paitensis, Hemiramphus saltator, Nematistius pectoralis, Vomer declivifrons, Parathunnus sibi, Kathetostoma averruncus, Carcharhinus improvisus, Dasyatis violacea, Taractes asper.
11. There is some evidence suggesting seaward movements of striped bass are influenced by the ocean temperatures adjacent to the inland waters.
12. Yellowtail and barracuda distribution and fishing success off California are strongly influenced by the ocean temperatures.
13. Local fishing success for other warm-water species such as bonito and yellowfin tuna seems to be affected by sea temperatures.
14. During the recent warm years, white seabass redistributed themselves to areas off the northern part of the state where they were abundant about 70 years ago.
15. Although water temperatures seem to affect sardine distribution, the collapse of the Pacific sardine fishery cannot be attributed entirely to a southerly movement of fish caused by a drop in water temperature.
16. The latitude at which albacore approach the North American west coast seems related to ocean temperatures.
17. Many other animals, including sea turtles and numerous kinds of plankton, were distributed northward of their usual range during the warm period.
18. During the three years, the northward redistribution of planktonic and partially planktonic forms including doliolids, pelagic red crabs and sand crabs, demonstrated existence of a countercurrent, in addition to warming of the environment north of their usual ranges.
19. Several southern marine species spawned successfully off California during the period 1957 through 1959.
20. The distributions of whales, sea birds, and kelp also seem to be affected by ocean temperatures.

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