Title
Fish life in the kelp beds and the effects of kelp harvesting

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FISH LIFE IN THE KELP BEDS AND THE EFFECTS OF KELP HARVESTING

Conrad Limbaugh

Final résumé of results of investigations
conducted from 1948 to 1954 under
Fellowship Grant from Kelco Company

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INTRODUCTION

This final report is the result of research during the five and one-half year period from September 1948 to March 1954. Modern techniques and equipment were utilized and were in part developed especially for this problem.

Throughout the investigation the apparent decline of sport fish was causing sport fishermen great concern. Among other factors, kelp harvesting was blamed for the poor catch of the sportsman.

Early methods of investigation were primitive. With limited financial support and insufficient equipment, the investigation proceeded at a slow rate and many of the problems encountered seemed insurmountable.

More than a year after the beginning of this investigation, the Kelco Company approached the Scripps Institution of Oceanography of the University of California, with the request that the problems of kelp cutting in relation to the fish supply be attacked by the University under a fellowship grant, by unprejudiced research. The Company wanted to determine whether the kelp operations were adversely affecting fishing, and if so, how harvesting methods might be altered to prevent this.

The grant of money given the University provided my salary and funds to purchase research supplies, equipment, and services. With this aid, along with the laboratory and ship facilities at Scripps Institution of Oceanography, I was able to carry out a much more extensive research program. The investigation was carried out with the cooperation of the California Department of Fish and Game.

The first phase of the program was concerned with observation and identification. Thousands of hours were spent above and below the surface observing the organisms in their own environment. Extensive use was made of self-contained diving equipment for observations, collection, and placing of equipment. Underwater photography was developed to a point where many observations could be recorded.

The second phase of the program was to appraise the effects of kelp harvesting on fish life. All materials or ideas furnished by sportsmen were given consideration.

Because of the lack of pertinent published data on the ecology of the inshore waters, it was necessary to investigate not only the beds of the main commercial kelp (Macrocystis pyrifera), but also many other regions, in order to obtain comparative data. Such areas included bays, rocky areas below the levels where kelp grows, rocky areas with no kelp, the surf zones, sandy areas, and regions outside the West Coast range of Macrocystis.

Kelp beds were studied as far north as Monterey and as far south as the San Benito Islands, Baja California. Diving observations in the kelp were made at Monterey, Morro Bay, Goleta, Santa Barbara, Point Dume, Palos Verdes, Newport, Laguna, Dana Point, San Clemente, Del Mar, Solana Beach, La Jolla, Point Loma, Ensenada, Punta San Carlos, Punta Blanca, Punta Santa Rosalia, and numerous other points along the mainland; also at San Miguel, Santa Rosa, Santa Cruz, Anacapa, Santa Catalina, Coronado, San Martin, and San Benito Islands. Intensive studies of the problem were carried out in Orange and San Diego Counties, with special concentration on the nearby La Jolla kelp beds (Fig. 1).

One portion of the La Jolla kelp beds was left uncut as a control. Little difference has been noted in the fish life within the bed as contrasted with harvested beds. The kelp itself became more sparse, probably because of reduced light penetration through the heavy canopy that developed temporarily. In the 1952-53 winter season (Fig. 2) much of the kelp was destroyed by storms.

These studies yielded a vast amount of information bearing not only on the kelp problem but also on the life ways of the fishes. Such information is a material contribution to science and will aid in fish management in the future--for the benefit of fishing in general.

As a result of these long and thorough studies, it is concluded that kelp harvesting, as currently practiced, has no seriously detrimental effects on fishing.

The various claims as to the ways in which kelp harvesting was supposed to destroy fish life and to decrease the fish catch were completely investigated and found to be in error. Spawning and nursery grounds of fish are not being destroyed. Sufficient cover and food are always available during and after harvesting. The kelp beds are not destroyed by harvesting methods. Harvesters do not frighten sportfish from an area.

For several decades California has experienced a tremendous increase in population. Cities have grown where deserts and foothills were the homes of deer, rabbits, ground squirrels, ground owls, doves, and quail. In most places these animals have largely disappeared, and with them the intertidal mollusks--Pismo clams, butter clams, abalone, and many other species. The shore fishes such as corbina and spotfin croaker are less common in the individual fisherman's catch. Over kelp beds where a man might have fished alone a decade or two ago, we may see 50 sport boats with a total of 1000 anglers. Thus, even though the annual catch may be the same as or higher than 10 or 20 years ago, the catch per fisherman is much lower.

The kelp industries have arisen indirectly from our social-economic needs for new raw materials to fill new markets. They have become established in our economy and are essential for the production of certain new products.

FIGURE 1. Aerial photograph of the La Jolla kelp beds. The lines running through the beds are the paths of a kelp harvester. The plants are anchored on a rocky bottom from a depth of 45 feet on the inner edge of the beds to a depth of 90 feet on the outer edges of the beds. The photographs were made with infra-red film which pictures only the surface kelp.

FIGURE 2. Kelp torn loose from an uncut La Jolla kelp bed and deposited on the beach during the 1952-53 winter season.

As is typical of modern, young industries, they have conducted research to determine the maximum sustained yield. The industry naturally has no desire to destroy kelp.

The sportfishing industry is large and provides recreation, necessary for our nation's health, to thousands of persons. With the addition of thousands of newcomers to sportfishing and the reduction of catch per unit of effort, it is not difficult to understand the fishermen's concern over factors supposedly destroying their sport. It is necessary, however, to determine the real reason for the apparent decline of fish before any constructive action can be taken. It may be a problem of overfishing or of natural population fluctuations, but the blame cannot be laid to the kelp harvesting.

THE KELP PLANT AND THE KELP BEDS

Kelp beds are submarine forests of giant algae (Fig. 3). The major kelp beds of southern California are composed of a single species of giant kelp, Macrocystis pyrifera. The distribution of Macrocystis pyrifera along our coast is rather scattered. It is found from Sitka, Alaska, south to Magdalena Bay, in southern Baja California, Mexico. In the northern portion of its range it is restricted to small inshore beds, usually at the entrances of bays or in the lee of islands. Large offshore beds are found only from Santa Cruz, California, south into central Baja California. In the more southern part of its range the warm summer waters may destroy the beds. Macrocystis is not found in abundance anywhere else in the northern hemisphere. In the southern hemisphere it exists in almost all temperate waters, especially in areas of nutrient-rich upwelled water.

Twisted columns of slender, round, stemlike stipes rise from 20 to 100 feet or more, from a rootlike holdfast (Figs. 4 and 7) to the growing terminal tip of the individual stipes (Fig. 5). The ends of the stipes bend at the surface to form a canopy, often 4 feet thick. Alternately attached to the thin unbranched stipes are leaflike blades, each with a round to egg-shaped supporting float (Fig. 6). The number of stipes arising from a single holdfast varies from only 1 to 40 or more. At any time the stipes are in various stages of growth. A foliose growth of twisted stipes near the base of the plant is the sporophyte or reproductive element of the plant.

Macrocystis has two special adaptations for keeping it from being torn from its specific marine environment. First, it has a holdfast which anchors the plant firmly to the substrate so that it will not be carried away by currents. Secondly, the stipes are sufficiently elastic to take up the shock from sudden surge. The roughly conical holdfast (Fig. 7) varies from less than an inch to more than 4 feet in diameter, depending largely on the age of the particular plant. The holdfasts consist of rootlike haptera which arise at the apex of the cone, below the stipes, and dichotomously branch downward over the older haptera until they reach the substrate. They cement themselves to solid objects in much the same manner as ivy cements itself to a

stucco wall. The inner haptera are always dead in older plants, possibly because of the boring of an isopod, Limnoria sp. The plants are secured only at the periphery of the base of the cone.

Kelp is frequently subjected to very sudden and strong changes in currents. The plant is held upright by small gas-filled floats, known as pneumatocysts (Fig. 6), into lighter, but more turbulent surface water. The plant grows only in the upper eulittoral zone, usually on rough rocky substrate, where horizontal and vertical wave motions are exaggerated because of bottom interference. The plants, however, are well adapted to withstand these rugged conditions. When strong currents are running during heavy seas the surface canopy with its slight positive buoyancy may sink to depths of 20 feet or more; in this manner the plants are somewhat protected from the strong vertical motions of the waves. The small round stipes, 1/3 to 1/2 inch in diameter, are strong; they were found to have a tensile strength of 11 to 42 pounds per stipe, depending largely upon the age and diameter of the particular stipe. They are elastic, with a stretch of about 20 percent. In addition the individual stipes grow in a zigzag or sometimes coiled pattern. The last two factors tend to reduce the shock on the holdfast. (Oceanographers might well adapt these principles in buoying their instruments at sea.)

Relatively solid substrates are required for these plants. Commonly they attach to rocks, but sometimes they grow attached to water-soaked wood, concrete, metal, hard clay or sand, old holdfasts, rhizomes (underground stems) of eelgrass (Zostera marina), or the stipes of other plants. Often little or no solid substrate is available for the new haptera. Without the continuous attachment to a solid object the plants are easily torn from the bottom by waves and their own buoyancy. The free plant may either remain tangled in the kelp bed and continue to grow with its holdfast suspended above the bottom, or it may be cast adrift to float ashore and die (Fig. 2), or out to sea to drift until it meets conditions which cause it to die and sink. Occasionally the plant may re-anchor if the holdfast regains contact with the substrate.

Kelp beds vary in size from a few plants forming several hundred square feet of surface canopy, to hundreds of thousands of plants forming canopies of several square miles (Fig. 1).

The growth of this plant is extremely rapid. Plants appeared on painted metal objects (placed by the Scripps Institution of Oceanography Division of Geology) and formed reproductive sporophyte growth ten months after their placement. The metal objects were located on the sand floor at a depth of 50 feet, 3/4 mile from the kelp beds. The remarkable growth of this plant is partially responsible for the quick canopy recovery of harvested kelp beds.

Kelp beds are sometimes destroyed by natural causes. Beds growing on weak substrates or having holdfasts weakened by the boring isopod Limnoria are often torn loose and cast ashore during severe storms (Fig. 2). Recovery

FIGURE 3. A submarine forest of giant algae (Macrocystis pyrifera) photographed off the Coronado Islands.

FIGURE 4. A kelp holdfast attached to a rocky substrate 55 feet below the surface, at the Coronado Islands. The leaflike structures are the sporophyte or reproductive growths. Extending out of the picture from the holdfast to the surface are the stipes. Photograph by Earl Murray.

FIGURE 5. Tip of a growing stipe. Note the manner in which the leaflike fronds split from a single terminal blade.

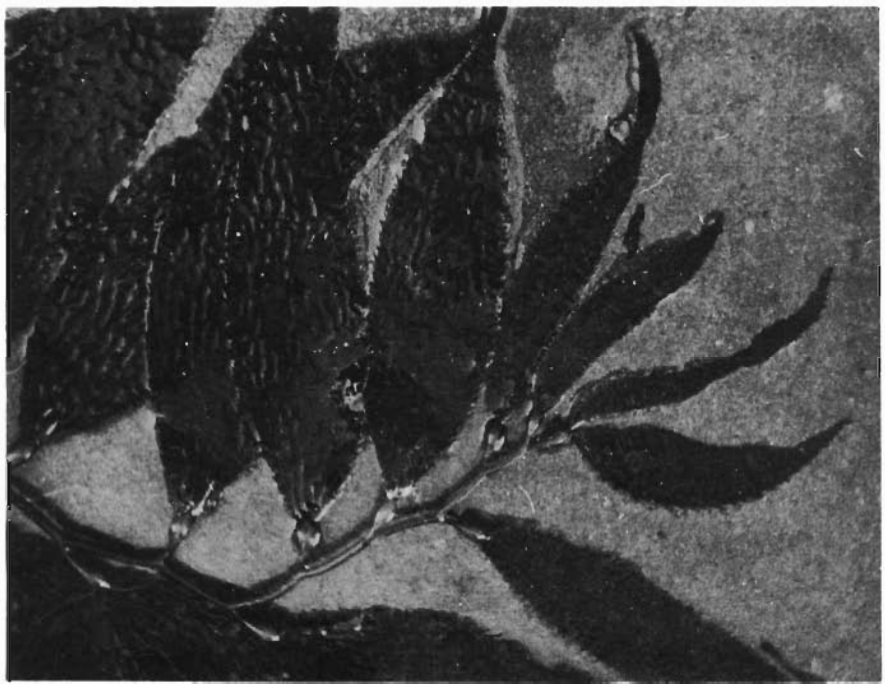


FIGURE 6. Tip of a stipe that has completed its growth. The egg-shaped bulbs at the base of the leaflike fronds are the pneumatocysts that buoy the plant into the upper, more illuminated areas of the water.

FIGURE 7. A typical cone-shaped holdfast washed up on the beach at La Jolla. Note the rootlike haptera which dichotomously branch downward to attach to the solid substrate.

of storm-destroyed beds takes more than a year. Beds may possibly be injured or destroyed by sea urchins (Strongylocentrotus franciscanus). Several square miles of kelp beds that used to exist just north of the Mexican border are gone without a trace. Diving observations revealed a barren cobble-boulder bottom covered with sea urchins of this species. High surface temperatures kill the surface canopy occasionally, but it is doubtful that temperatures in southern California would ever kill an entire bed. Bacteria or other microorganisms might conceivably destroy or severely damage kelp beds although there is little evidence to support this idea. None of the larger organisms, except for Limnoria and sea urchins, has had any obvious detrimental effects. The encrusting bryozoan Membranipora serrilamella (Fig. 8) may occasionally cause an old stipe to sink away from the light, but usually without destroying the entire plant.

Sewage pollution may destroy kelp beds. Strong evidence indicates that the Whites Point kelp beds in Los Angeles County have been destroyed by raw sewage. The bed that existed there a number of years ago dwindled in size until it completely disappeared north and south of the sewer outlet to a distance of several miles. The Tijuana sewage may have caused the mysterious disappearance of the Tijuana kelp beds.

Much kelp is cut at the surface by boat propellers. Outboards, as well as large craft, cut the kelp.

As they move through the kelp in search of their produce, abalone divers kill a large number of plants each year by cutting the plants at the holdfast, to allow them to drift up and away from air hoses and life lines. The surface canopy is often cut by the diver tender to keep the surface lines clear.

Growth is primarily from the terminal tips of the stipes (Fig. 5). Additional growth must also occur along the major portion of the stipe, for the distances between the pneumatocysts increases. Growth eventually stops on mature stipes (Fig. 6). The factor that determines when a stipe should stop growing is unknown. Some food is probably transported through the stipes to the growing terminal tips, the haptera, and to the reproductive sporophyte growth.

Individual plants of Macrocystis may attain a length of over 165 feet. The length of the plants in any one area is determined in part by the depth of the growing plant, which in turn is dependent upon the clarity of the water. These plants, like terrestrial plants, depend on light as their source of energy. Around the offshore islands, where the water is clearest, the plants may grow at depths of over 100 feet. These plants attain the maximum growth.

In the more turbid coastal waters Macrocystis grows at shallower depths. However, in certain coastal areas such as La Jolla where the water is relatively clear, plants may grow at depths of 90 feet. The beds of Macrocystis inhibit the growth of other seaweeds.

The depth of the beds is also determined in part by the temperature of the water. North of southern California and in areas of upwelling in Baja California, as on the southwest side of Punta Banda, the beds grow close to the shore, even into the intertidal belt. There has been some question as to whether these inshore plants are identical with those of deeper water.

Within the kelp beds, currents are almost always present, especially at the surface. Because of the resistance of the canopy, the subsurface portions of the stipes are sometimes bent to angles of 45° or more with the substrate. The removal of the canopy during harvesting operations reduces the "drag" of the canopy and the plants move to a more upright position, reforming a lighter canopy. The rapid growth of the new stipes, always present just below the surface, allows the canopy to recover its original thickness almost completely within a few months.

THE KELP HABITAT AS AN ENVIRONMENT FOR FISHES

The growths of giant kelp enrich the environment for animals. The stipes provide substrate for many small invertebrates. Others use the kelp for food or cover. Often a single blade of kelp will be encrusted with hundreds of organisms, some of which form part of the food of certain fishes. One species of fish, opaleye, feeds directly upon the fronds, devouring invertebrates along with the seaweed.

The stipes of kelp form dense bundles in which certain fishes seek cover. A fish can easily lose a pursuing predator by dashing through a kelp jungle and then hiding abruptly in a mass of kelp.

The holdfasts are individual communities with dense populations of animals. A single holdfast may contain 30 to 40 species of crustaceans, 20 to 30 species of mollusks, in addition to echinoderms, bryozoans, worms, brachipods, hydroids, and even small fish.

Most of the fishes in the kelp congregate in the bottom areas near the rocky substrate or in the region of the canopy. Each species has its own particular niche within the kelp bed.

One hundred and twenty-five species of fish were found to occur in the kelp beds of southern California (see Appendix). This represents almost 23 percent of the known fishes of California. Fifty of these (9 percent of all the California species) are insignificant and economically unimportant. Of the 14 percent of edible and forage fishes, only two unimportant species (or less than 0.4 percent of all California fishes) are significantly dependent upon giant kelp. Another 4.5 percent are partly dependent on the kelp beds. The rest are wanderers or stragglers from other biotopes.

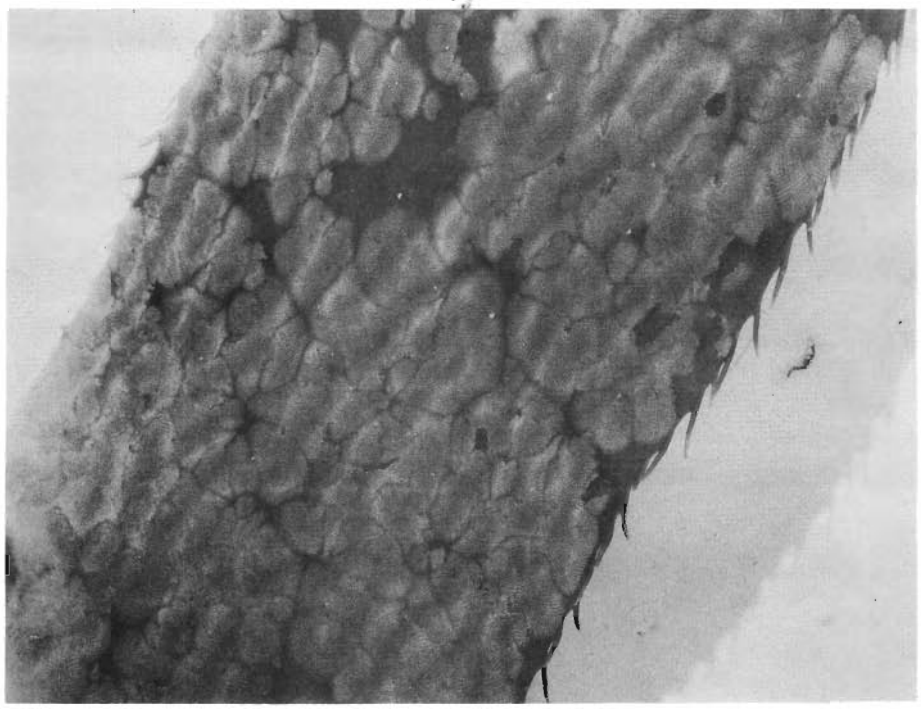


FIGURE 8. The encrusting bryozoans, Membranipora serriamella, encrusting a leaflike blade of giant kelp. Occasionally a portion of giant kelp plant may be sunk by the weight of these encrusting organisms.

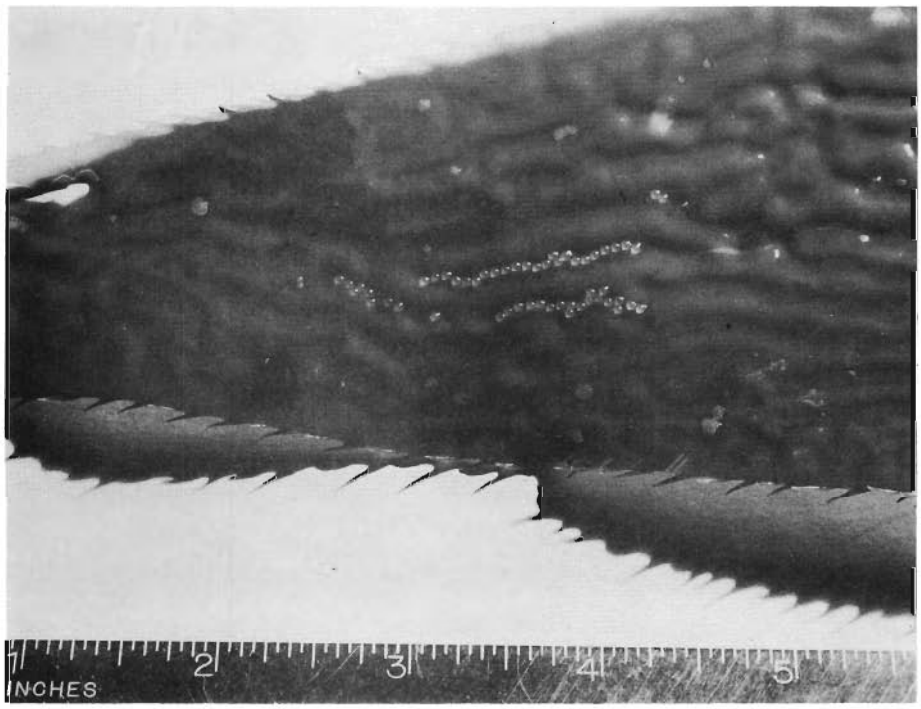


FIGURE 9. The eggs of the kelp clingfish, Rimicola muscarum, attached to a frond of giant kelp. (This fish reaches a total length of 1 inch.)

The forage and edible fishes that are dependent or partly dependent upon the kelp thus total less than 5 percent of all California species. Included in these edible fishes are many of poorer food quality: morays, common mola, leopard sharks, guitarfish, etc. The list also includes fishes that are edible but uncommon.

The kelp does serve a number of fishes which utilize it as cover or as a feeding ground; however, their numbers are small in comparison with the total California fish fauna. The majority live close to the bottom or at mid-depths where harvesting has no effect. The few that live in the unstable canopy environment are not adversely affected by harvesting and their populations remain at high levels.

A close examination of the morphology and habits of kelp fishes reveals few well-established affinities for giant kelp.

Specific morphological characters such as color and shape which might appear to be especially adapted for the giant kelp biotope are applicable to other kelp biotopes in nearby areas.

Spawning, feeding, protective and agressive habits of various fishes are somewhat adjusted to the giant kelp habitat. Only a few species have habits that are highly specialized in relationship to Macrocystis. Only one species of fish, Rimicola muscarum, is thought to be almost wholly restricted to the giant kelp habitat and a strong possibility exists that it may be found on other kelps, such as the elk kelp Pelagophycus porra.

The present fish communitiies of the kelp biotope may owe their rather loose relationship to the kelp to the circumstance that it was recently derived. It is possible that Macrocystis pyrifera invaded the Pacific Coast of North America from the temperate waters off the coast of South America in geologically recent times and that few of the organisms associated with it were able to complete a similar dispersal.

The types of fishes found within the kelp beds may be divided into three large categories, each of which may be further subdivided. These include: (1) fish populations that depend primarily on the kelp beds; (2) those that are associated with the bottom found in kelp beds; and (3) those that wander from pelagic and nearshore provinces.

The latter two groups are of minor concern in this study for their activities, although often interrelated with the organisms of the kelp beds, do not depend on giant kelp for the maintenance of their present population sizes.

The first group, that of fishes which are largely or entirely dependent directly or indirectly on the kelp beds, may be organized into a variety of groupings: phylogenetic, morphological, or habitudinal.

The fishes found in the kelp beds have little phylogenetic consistency. No family or groups of related families seem to dominate. Morphologically they are also varied. However, the color and shapes of the individual species may be grouped into two categories. The schooling species that inhabit the more open waters between the plants, like open-water fishes in general, blend with the open background waters in color and are not specifically modified in shape for protective camouflage. The more numerous non-schooling species, comprising the second category, blend well with the kelp background in bizarre shape and in color. This latter group is the more diversified. It ranges from the spindle-shaped brown-and-white-spotted kelp bass to the yellow-brown stemlike kelp gunnel, and may be subdivided into groups that resemble stems, leaves, or parts of leaves; or are just colored like a mass of kelp.

The feeding habits are correlated in some degree to the general morphology of the fish. The variable spawning and breeding habits have little relationship to general size, shape or color, but, as might be expected, follow phylogenetic patterns.

One specific morphological character common to two kelp species of quite different families is the small mouth and protruding teeth of the kelp perch and the señorita. Both feed directly on the external parasites attached to other fishes and on small organisms attached to the kelp or other substrate. This specific example of convergent evolution seems to fit diverse groups of fishes all over the world.

To give a clearer picture of the ecological relationships of the common kelp fishes a more detailed description of the individual habits, niches, and morphology is necessary. The kelp bass, Paralabrax clathratus, an important sportfish, may be ranked first among the kelp sportfishes. Compared with the other common kelp fishes, this roughly spindle-shaped fish is relatively large, attaining a maximum weight of approximately 18 pounds. It is solitary, except when aggregating to spawn and feed. Most voracious of the kelp forms, it sometimes leaps clear of the water in pursuit of its prey. Its food consists of small fishes, crustaceans, and squid. Squid and small fishes make up the major portion of the diet of the older fishes. Most of the kelp bass population lives close to the bottom among rocks. Most of the larger individuals live in deeper water, often deeper than 100 feet, while most of the smaller ones live in shallow waters, as far as the intertidal region. They wander little and are not disturbed by kelp harvesting. They tend to remain in a restricted location for a number of years. An individual fish or even an aggregation of bass may be enticed to the surface from deep water with proper food or bait. The eggs are broadcast during the summer into the currents within the kelp beds and the larvae become part of the plankton. In midsummer and fall the young enter the nearshore waters, including bays. A few enter the surface canopy and bottom kelp biotopes. As they grow larger they inhabit deeper water.

Very similar in size, shape, and color is the olive rockfish, Sebastodes serranoides. It replaces the kelp bass in the northern part of the range, above Point Conception, and tends to dominate the population in the Santa Barbara region, but it constitutes a small proportion of the joint population in the rest of southern California. Mimicry in shape and color pattern appears to be of mutual benefit to both species. Their evasive actions are quite dissimilar and may prove confusing to predators. The kelp bass tends to make a more horizontal path when startled, while the olive rockfish follows a more vertical pattern. Their similar color patterns and shapes probably evolved as a result of similar habits and habitat. They compete directly for food and cover. The olive rockfish gives birth to large numbers of rather small young during the winter months. Schools of the young are found in many places inshore around rocks and in bays. As do the kelp bass, the young enter deeper and deeper levels as they grow older.

Another kelp gamefish of minor importance, of the same genus as the bass rockfish, is the kelp rockfish, Sebastodes atrovirens, which in moderate numbers inhabits the kelp beds, especially in the lower life zones. Its color, vaguely blending with the kelp, and its habit of remaining motionless render it inconspicuous in the kelp. Its mildly poisonous spines presumably deter predators. It is not a schooling fish, but aggregations of several hundred have been observed at times, sometimes far beyond the limits of the kelp beds. The food consists primarily of small crustaceans, a few squid, and an occasional small fish.

The opaleye, Girella nigricans, another sportfish, occurs in almost unbelievable numbers. Its olive-green back resembles rather closely the murky green color of the plankton-rich coastal waters where the majority of the population lives. It is primarily a schooling fish which seeks shelter in the shallow waters and among kelp plants. The planktonic eggs are spawned during most of the warmer months. The larval and early young stages are pelagic. The later stages live in the tide pools where they search for bits of flesh from almost any animal. As they grow older they seek deeper water and become primarily herbivores, feeding directly on Macrocystis and other seaweeds.

Another fish, the halfmoon, Medialuna californiensis, is closely associated with Girella nigricans, and often schools with it. In general, however, the larger schools of halfmoon are found on the outer edges of the kelp beds and around islands, while the opaleye seems to prefer the inner edges of the beds, especially near beds of ribbon kelp, Egregia laevigata. The gray-blue of the halfmoon reflects its preference for blue offshore waters. However, it does occur close inshore in sufficient numbers so that an observer can almost always find a few at depths less than 10 feet. It too feeds on bits of brown seaweed, but prefers red seaweed. The pelagic eggs, like those of the kelp bass and opaleye, are broadcast during the warmer months. The larvae and young are pelagic.

They enter the kelp beds and nearshore zone as sub-adults. They seem to prefer mid-depths, but may aggregate at the surface while feeding on plankton.

The kelp topsmelt, Atherinops affinis, is another schooling fish which inhabits the interspace and edges of the kelp beds. It spends most of its life just below the surface. It is a relatively small fish with a very small mouth, and can be caught by snagging or with very small hooks. Often schools of these fish wander great distances from the kelp, usually following patches of green water. Related subspecies live on the offshore islands and in the bays. The eggs are laid on seaweed, but very rarely on Macrocystis. The larvae and young live in the surface canopy, schooling in the top few centimeters. They are a minor forage fish and are always abundant. They feed on small free-swimming and planktonic organisms, especially crustaceans. They are extremely abundant and their presence probably has a great effect on reducing the numbers of small organisms that live in the kelp bed or are carried by incoming currents.

Small adult and juvenile blacksmith, Chromis punctipinnis, school in the kelp beds, especially where incoming currents carry rich loads of plankton. They seek shelter among rocks and the adults probably spawn deep in the rocky crevices. At the entrances of bays and harbors, large numbers aggregate in the incoming and outgoing currents. Although they are good eating, they are seldom caught, probably because of the feeding habits that allow them to select only small particles of food. They are extremely abundant and probably form one of the important future sources of protein. The young are pelagic and occur in large and compact schools during favorable summers. The eggs are spawned in late spring and summer.

The kelp-colored señorita, Oxyjulis californica, aggregates or schools, but commonly is solitary. Señoritas feed on almost any flesh and will even bite chunks from abalones. Their most interesting feeding habit is that of eating fish parasites. Fishes of many different families often allow themselves to be cleaned of external parasites by this species; sometimes the host fish will contort itself in order to place the infected portion in front of a señorita. Small groups of blacksmith often corner a señorita and do not allow it to swim away until it has picked parasites. The señorita blends well with the kelp and utilizes it for cover, often piercing the fronds in flight as it dives into a clump of kelp. Señoritas often burrow in the sand to escape predators and often sleep there with only their heads projecting. The pelagic eggs and larvae have been collected far at sea, but the young live inshore in shallow water, sometimes in the kelp beds.

The kelpperch, Brachyistius frenatus, a fish of a different build and relationship, has similar food habits and mouth structure. It is a more solitary fish, but often aggregates in loose schools. Mating occurs in

the late fall and winter and the young are born in late spring and summer. The large young breed late in their first year. Kelpperch abound in the kelp beds, but are seldom caught by fishermen. They are not eaten by predaceous fish, but have been taken from the stomachs of cormorants.

The kelpfish, Heterostichus rostratus, one of the larger fishes of the kelp, alters its color and pattern to blend with its seaweed background. Green and silver striped ones may be found in the sea grasses, while red to purple ones are found among the red and purple seaweeds. Those taken in the kelp beds are yellow-brown like the giant kelp. Kelpfish are not considered a good food fish by most sportsmen and are despised by spearfishermen. The eggs are usually laid on the short seaweeds close to the rocky bottom, where the greatest numbers of this species live. On very rare occasions the eggs have been taken from giant kelp. The larvae are pelagic and the young enter the shallow waters and kelp beds.

A related fish, the kelp klipfish, Gibbonsia metzi, resembles the kelpfish in general habits, hiding among the fronds and feeding on the crustaceans and other small organisms found there. It is presumed to spawn on the short seaweeds inshore close to the bottom, where its close relative, Gibbonsia elegans, does spawn. The larvae are pelagic, but approach the kelp beds in schools at a postlarval stage. This species is too small to be of sport value and is not common enough to be a valuable forage fish.

The kelp gunnel, Ulvicola sanctaerosae, and the kelp pipefish, Syngnathus californiensis, entwine their slender stemlike bodies in the stipes of the kelp. They feed on the mysids and amphipods they find there. They are not caught on hook and line and are too small to be of any food value. Their numbers are insignificant as compared with other fishes. The female kelp pipefish lays her eggs in a pouch of a male. He hatches them and the young are released to fend for themselves. The kelp gunnel lays small yellowish eggs which are probably placed at lower levels in the kelp.

The kelp clingfish, Rimicola muscarum, is so small and occurs in such small numbers that it is insignificant in the kelp ecology. It is the only species thought to be essentially restricted to the kelp. The eggs and larvae may be found throughout the kelp (Fig. 9). The entire life cycle is probably completed in the kelp beds.

Summarizing the significant habits of the common kelp fishes, it is clear that there is no strong dependency on the surface kelp by any of these common forms. This is clearly illustrated by the relatively small numbers of species involved and their lack of highly adaptive characters.

THE LIFE HISTORY OF MACROCYSTIS PYRIFERA

The large plants that form the kelp beds (Fig. 10) are the sporophyte stage of the life cycle. Microscopic spores are produced by the bushy sporophyte growth at the base of the plant. They are released from small pores (sori) on the surface of the leaflike fronds. These tiny mobile spores, known as zoospores, are distributed by currents until they settle. If they happen to settle on a suitable substrate they will develop into tiny separate male and female microscopic gametophytes. The females produce eggs (oogonia) and the males form antherozoids. The oogonia are extruded and combine with the antherozoids to form zygotes that eventually develop into the giant sporophyte plants. The complete cycle may take place in less than a year.

Drifting Macrocystis plants picked up during this investigation had an unusually heavy sporophyte growth. Apparently when this plant is subjected to adverse conditions it diverts its energy toward reproduction.

The maximum life span is still unknown, but judging from the sizes of the larger holdfasts, one might guess that it is between 6 and 10 years.

The larger sporophytes reproduce vegetatively. An examination of a large number of holdfasts reveals that often more than one plant is involved in a single holdfast. The rootlike haptera arise from a higher and higher position on the stipes, as the older ones die below. The haptera occasionally arise from separate branches and as the lower connecting part of the holdfast dies, two plants are formed from one.

THE POSSIBLE ORIGIN OF MACROCYSTIS PYRIFERA ON THE CALIFORNIA COAST

Macrocystis pyrifera has a disjunct distribution. It is found in both the southern and northern hemispheres, but does not occur in the intermediate warm waters, where survival would be impossible under the present warm surface temperatures. The possibility is remote that the microstages of this plant have been carried by migrating birds. Another even more remote possibility is that the crossing of the tropics may have been effected by several plants which had become tangled (as they often do), to form a chain floating with the lower parts of one plant at a depth where the temperatures would not be lethal. Living detached plants may be carried long distances by currents. Drifting plants were observed in this investigation several hundred miles west-southwest-by-west of Magdalena Bay, the southernmost point in their range. The most probable explanation of the distribution is that the ocean temperatures were sufficiently lowered during the recent past (geologically speaking), presumably during the Ice Age, to allow Macrocystis to maintain a continuous distribution along the eastern Pacific, as held by Hubbs (Proc. 7th Pac. Sci. Congr., 3, 1952, pp. 324-329).

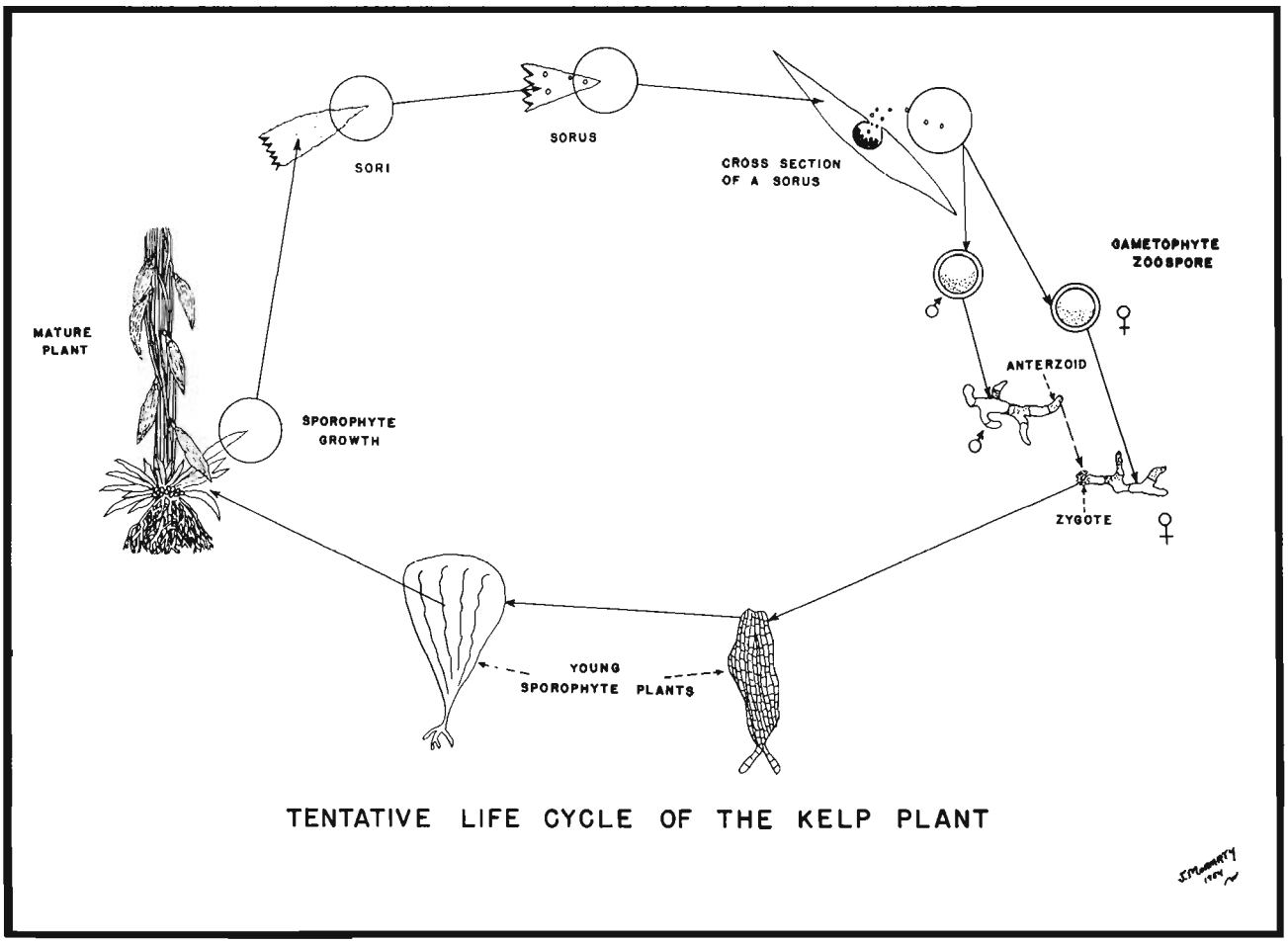


FIGURE 10. A diagrammatic illustration of the life cycle of the giant kelp plant.

The very limited amount of endemism among organisms associated with Macrocystis suggests that this species is a relatively recent arrival and that the distribution was not continuous for a long period.

KELP AS A FACTOR IN SUBMARINE EROSION

Thick beds of kelp divert the bottom surge into channels, causing high surge velocities, thereby increasing the power of the surge to erode the bottom. The damping of the smaller wind waves is noticeable in the lee of the beds. However, long-period (and therefore deep) waves appear to pass through with little interference. For this reason it has been thought that neither the thickness nor the presence or absence of kelp beds plays an important part in the wave erosion of the beaches. However, short-period storm waves of local origin do increase the net movement of water toward shore, which creates stronger return ("rip") currents, which are effective in beach erosion. Such storms, on the other hand, induce currents that tend to pull the canopy below the surface, so as to limit the blocking effect of the canopy on the short-period waves. The answer to the problem of beach erosion should come from sand-level studies correlated with kelp harvesting. I understand that such studies have not shown a significant correlation between kelp cutting and the erosion of the adjacent beaches.

Sometimes the holdfasts of drifting and stranded plants contain parts of the substrate. A large holdfast found during this investigation at Pacific Beach, San Diego, California, contained a single boulder weighing 11 pounds. The plant was large and probably came from water at a depth of 40 or more feet. Several holdfasts of drifting plants collected at sea contained smaller cobbles. Pieces of the substrate may be carried hundreds of miles to sea and deposited in the deep water, or they may be cast ashore to help form a cobble beach.

Indirectly, kelp of several types, including Macrocystis, may aid in the destruction of the substrate by serving as food for rock-burrowing animals. Sea urchins (Strongylocentrotus franciscanus) and several species of abalone (Haliotis), which cause holes in the rocks, depend on kelp as food.

THE KELP-BED BIOTOPES

The canopy biotope is the area of tangled stipes just below the surface of the water. It contains a greater concentration of kelp per unit volume of water than the other biotopes. It is a loosely compact mass floating at the surface, anchored by the columns of tangled kelp which pass through the intermediate biotope to the holdfast on the bottom.

The holdfast region is the kelp-bed bottom biotope. It is a richer area owing to the addition of benthic organisms to the kelp fauna.

The intermediate region between the kelp-bottom biotope and the canopy biotope is the mid-kelp biotope. This is an area similar in some respects to the trunk areas of dense forests. The fauna here is not as rich as it is in the canopy or bottom biotopes.

The organisms of the offshore kelp beds may be divided into three groups: first, those that occupy the kelp canopy (surface to 10 feet below the surface); second, those that occupy the holdfast regions (bottom to 10 feet above the bottom); and third, those that occupy the intermediate zone. None of the zones is independent of the others and many organisms are found in all three biotopes. However, enough difference is obvious, even to the casual observer, to allow them to be used as convenient groupings.

In addition to the three groups mentioned above, there are major differences with latitude, and minor differences between the inner and outer edges of the kelp.

A difference in substrate will modify all the biotopes. For instance, in the San Clemente kelp beds which have a predominantly sand bottom, the holdfast region has predominantly sand forms. Even the canopy fauna is slightly modified. In the San Clemente beds, over the sandy areas, almost no kelp klipfish (Gibbonsia metzi) and very few kelp gunnels (Ulvicola sanctaerosae) are found in the canopy. In areas where the substrate is rock these two fishes are common inhabitants of the canopy as well as the lower layers.

THE CANOPY BIOTOPE

The lush-appearing canopy is a rather unstable environment. During storms, currents sometimes submerge the canopy to depths of 20 feet or more. Wave action may break up the canopy and large temperature changes subject it to desiccation and organic decay. Occasionally large areas of the canopy are carried away by such natural processes. Rapid growth and the short life of the individual stipes do not form a desirable substrate for most sessile forms.

Life within the canopy is not nearly so complex as that of the bottom or intertidal biotopes. A few forms feed directly on kelp; others use it as a permanent or temporary substrate; and a few organisms utilize it as cover. There are, in addition to the groups mentioned above, wanderers and drifters from other biotopes. These forms, although not directly related to the kelp, do form important relationships in the ecology of the kelp beds. Such forms include the pelagic and nearshore fishes and invertebrates, especially larval forms.

The numbers of invertebrates--as individuals and as species--is relatively small as compared with the bottom and intermediate biotopes. An examination of the plankton in the canopy region revealed it to be poorer in quantities

Barracuda and yellowtail have been observed near the kelp beds at all seasons of the year. However, like the kelp bass, they feed and spawn heavily during the warmer months; hence they are more frequently caught during the summer. They broadcast their eggs, which the currents carry about. The chances of survival for the eggs that enter the kelp are presumably diminished by the many plankton-feeding animals that live there. The larvae too are open-water pelagic animals with a better chance of survival outside the kelp.

Many times during this investigation fishermen reported fish eggs in the surface kelp. Investigation of these reports revealed no fish eggs. Often the reported fish eggs were eggs of mollusks, colonies of bryozoans, or tiny individual tube worms. However, attached eggs of several species of fishes were occasionally found during this investigation in the canopy region. They include the eggs of the tiny inch-long kelp clingfish, Rimicola muscarum (Fig. 9); the kelpfish, Heterostichus rostratus; the tube-nose, Aulorhynchus flavidus; the saury, Cololabis saira; the California flyingfish, Cypselurus californicus; and the kelp topsmelt, Atherinops affinis cedroscensis.

The kelp clingfish, because of its relatively small size and numbers, plays no important part as a forage fish. The kelpfish spawn has been found more often attached to other seaweeds closer to the bottom and only rarely in the canopy. It is of little or no value as a forage fish and is despised as a sport or food fish. The tube-nose spawns in the deeper and colder water. The only eggs of the fish found in the canopy during this investigation were on a broken kelp stipe presumed to have broken free near the bottom. The eggs of the saury and the California flyingfish are often found attached to floating objects far at sea. Occasionally these objects drift into the canopy and are sometimes held there until the eggs hatch. The eggs of the topsmelt are generally laid on bits of red seaweed over submerged reefs, but on rare occasions are attached to the surface fronds of Macrocystis. The large numbers of these fish, both young and adults, that are found in cut beds, is strong evidence that their populations have not been hurt by cutting methods.

The other fishes that are found in or near the kelp are known to give birth to their young, broadcast their eggs for the currents to distribute, or lay their eggs on the bottom. No evidence supports the theory that the canopy is widely used as a spawning ground.

Many larval fishes are found in all nearshore waters, and the kelp beds are no exception. However, only a limited number are found there in greater abundance than elsewhere. These include the kelp topsmelt, the halfblind goby Lethops connectens, the kelp clingfish, and the weed klipfish Gibbonsia metzi.

The larvae of the kelp topsmelt and the adult opossum shrimp are so abundant at times in the surface region of the kelp, especially in the top 10 cm., that it is little wonder that fishermen observing these tiny creatures schooling throughout the canopy think of the kelp beds as nursery grounds for fishes. However, in this case the young topsmelt is often misidentified as a more important forage or sport fish such as sardine or barracuda.

During the spring and summer seasons the larvae of the weed klipfish and the larvae of the halfblind goby may be observed in extremely large numbers, usually in the lower portion of the canopy or in the mid-kelp region. During this larval period they may serve as forage for some fishes.

A number of juvenile fishes inhabit the kelp canopy. The more common forms are: kelp bass, Paralabrax clathratus; kelp topsmelt, Atherinops affinis cedroscensis; kelpperch, Brachyistius frenatus; blacksmith, Chromis punctipinnis; señorita, Oxyjulis californica; olive rockfish, Sebastodes serranoides; kelp pipefish, Syngnathus californiensis; kelp clingfish, Rimicola muscarum; kelpfish, Heterostichus rostratus.

Juvenile kelp bass inhabit all the nearshore seaweed and rocky areas. They are more common in the beds of eelgrass, Zostera marina, and among the fronds of the ribbon kelp, Egregia laevigata. They occur from shore to depths of over 100 feet, but their optimum depth lies between 8 and 65 feet. They occur sporadically in the canopy, sometimes in aggregations of a half a dozen or more. They feed on small crustaceans and fish.

Juvenile kelp topsmelt swim near the surface, usually less than 4 feet deep. They inhabit the open spaces in the kelp beds and the area between the beds and shore. They swim in relatively tight schools of nearly equal-sized fish. They feed on free-swimming and planktonic animals, especially small crustaceans. They appear to be more common in the recently cut portions of the kelp beds.

Juvenile or newborn kelpperch inhabit the canopy and mid-kelp areas. Although they are more common in the mid-kelp region, they are numerous in the canopy area. They tend to aggregate under bent stipes. They feed primarily on small crustaceans and organisms attached to kelp fronds and other fishes. They do not serve as an important forage fish, but have been taken from the stomach of a kelp bass.

Juvenile blacksmith occur in large, rather dense schools during the summer and fall. They are more common in the nearshore waters, but may occasionally be observed at sea. They feed on plankton and are no more common in the canopy region than they are in the rocky inshore areas.

Juvenile señoritas school throughout the shallow waters down to depths of over 100 feet. They prefer the rocky areas but are quite common over beds of eelgrass. They occasionally enter the canopy region, probably in their

search for food. When frightened they may pierce a net or kelp frond by swimming through it. Near the bottom they burrow into the sand or mud.

Juvenile olive rockfish inhabit the inshore rocky areas, kelp beds and eelgrass beds. In the smaller stages they often school in mixed sizes from 1 to 4 inches. At 3.5 to 4.5 inches they become solitary in their habits, but utilize similar habitats. They have been observed as deep as 200 feet, far below the depth of living kelp.

Juvenile kelp pipefish are more common in the canopy region than elsewhere. They feed on small crustaceans and are in turn fed upon by kelp bass, olive rockfish, and kelp rockfish, Sebastodes atrovirens.

Juvenile kelp clingfish live attached to the kelp fronds. They are probably more common in the canopy than elsewhere. They are solitary and small. They have been found in the stomachs of juvenile kelp bass and adult olive rockfish.

Juvenile kelpfish are common throughout the seaweeds, blending with their backgrounds. They are less common in the canopy than they are among the shorter seaweeds.

Adult Fishes Observed in the Canopy Biotope During the Investigation

The adult fishes of the canopy, listed here, include a large number that merely wander into the canopy; others, marked by a single asterisk, which at some times or in some places include the canopy as a portion of their usual habitat; and a smaller number, marked by a double asterisk, which typically select the canopy as their habitat.

Triakis semifasciata - leopard shark (very rare)
Prionace glauca - blue shark
Holorhinus californicus - bat ray
Sardinops caerulea - (Pacific) sardine
Anchoa delicatissima - slough anchovy (very rare)
Engraulis mordax mordax - Ocean northern anchovy
Cololabis saira - (Pacific) saury
Cypselurus californicus - California flyingfish
Fundulus parvipinnis - southern California killifish (very rare)
*Stereolepis gigas - (California) black seabass
*Mycteroperca xenarchus - broomtail grouper
*Mycteroperca jordani - Gulf grouper
*Paralabrax clathratus - kelp bass
Paralabrax nebulifer - sandbass (rare)
Leuresthes tenuis - (California) grunion
Atherinopsis californiensis - jacksmelt
Atherinops affinis littoralis - bay topsmelt (rare)
**Atherinops affinis cedroscensis - kelp topsmelt
**Atherinops affinis insularum - island topsmelt

*Sphyraena argentea - (California) barracuda
*Seriola dorsalis - (California) yellowtail
Trachurus symmetricus - jackmackerel
Pneumatophorus japonicus diego - (Pacific) mackerel
Sarda lineolata - (California) bonito
Xenistius californiensis - (California) salema (rare)
Anisotremus davidsoni - (California) sargo
*Cynoscion nobilis - white seabass
Caulolatilus princeps anomalus - (California) ocean whitefish
Hyperprosopon ellipticum - silver surfperch (rare)
Hyperprosopon argenteum - walleye surfperch (usually rare)
Embiotoca jacksoni - bay blackperch
Embiotoca sp. - ocean blackperch
Taeniotoca lateralis - striped seaperch
Hypsurus caryi - rainbow seaperch
Phanerodon furcatus - white seaperch
Damalichthys vacca - pileperch
Rhacochilus toxotes - rubberlip seaperch
Cymatogaster aggregata - shiner seaperch (rare)
Cymatogaster gracilis - island seaperch
**Brachyistius frenatus - kelpperch
*Chromis punctipinnis - blacksmith
Hypsypops rubicunda - garibaldi (rare)
Pimelometopon pulchrum - sheephead
*Oxyjulis californica - señorita
*Girella nigricans - (California) opaleye
Hermosilla azurea - zebraperch (rare)
*Medialuna californiensis - (California) halfmoon
Sebastodes mystinus - blue rockfish
*Sebastodes serranoides - olive rockfish
*Sebastodes atrovirens - kelp rockfish
Sebastodes rastrelliger - grass rockfish (rare)
Scorpaenichthys marmoratus - cabezon (rare)
Aulorhynchus flavidum - tube-nose
**Syngnathus californiensis - kelp pipefish
Syngnathus sp. - slimnose pipefish
**Rimicola muscarum - kelp clingfish
*Heterostichus rostratus - (California) kelpfish
*Gibbonsia metzi - weed klipfish
*Xererpes fucorum - rockweed gunnel
**Ulvicola sanctaerosae - kelp gunnel
Mola mola - common mola

The five species of fish that select the canopy habitat over any other biotope are the kelp topsmelt, kelpperch, kelp pipefish, kelp clingfish, and kelp gunnel. These five species have similar food habits, selecting the small free-swimming crustaceans of the canopy. All of them are small as compared with commercial and sportfishes.

Kelp topsmelt are of some economic importance, being included in the commercial smelt catch, taken incidentally by sportfishermen, and utilized as forage by other fishes. Although they enter the bottom and mid-kelp areas, the largest proportion of the population lives within the canopy biotope. They swim during the day at an average depth of about 7 feet, and usually lie at the surface at night. There has been no recorded drop in the population of this species and the concentration in cut and uncut beds appears to be about the same.

Kelpperch are not taken by either sports or commercial fishermen and play almost no part as a forage fish. However, they serve as a check against the larger external parasites of other fishes, for they include them in their diet, picking them directly from the other fishes. The kelp gunnel and the kelp pipefish mimic in color and shape the yellow-brown stipes of the canopy kelp and are rarely seen by fishermen. They are utilized to a small extent as forage by other fishes. Their relatively small numbers and small size render them of doubtful value even as forage.

The 1-inch-long kelp clingfish mimics in color the kelp fronds to which it attaches. It too is utilized to a small extent as forage, but can be considered of negligible economic importance because of its extremely small size and relatively small numbers.

Many fishes, including several that form a large part of the sport catch, include the canopy in their habitat, but more commonly occur in some other habitat. These species include:

Species highly regarded as food or game	Preferred habitat in California
Black seabass	Rocks
Broomtail grouper (rare)	Rocks
Gulf grouper (rare)	Rocks
Kelp bass	Holdfast region
Barracuda	Pelagic nearshore
Yellowtail	Pelagic nearshore
White seabass	Mid-kelp
Opaleye	Nearshore rocks
Halfmoon	Mid-kelp
Olive rockfish	Holdfast region
Kelp rockfish	Holdfast region

Species not highly regarded as food or game	
Blacksmith	Rocks
Señorita	Rocks and seaweeds
Kelpfish	Nearshore seaweeds
Weed klipfish	Nearshore seaweeds
Rockweed gunnel	Nearshore seaweeds

The canopy serves as a "landmark" to fishermen. By locating a kelp bed at the surface they are sure of a solid substrate from which they can catch the fish that dwell on the rocky bottom. Often they may chum the bottom and mid-depth fish to the surface with live bait. Usually the fisherman fishes the edges of the kelp beds, where the fish fauna is much richer than in the inner portions of the beds. This illustrates the commonly observed "edge effect." Forest-meadow, forest-lake, and lake-meadow boundaries of the terrestrial world, as well as the sand-rock, kelp-rock, and land-sea boundaries of the ocean, are richer in fauna than the areas on either side.

The canopy-inshore boundary yields nearshore pelagic and reef-dwelling fishes, in greater abundance than the kelp bed itself, while the canopy-offshore boundary may yield pelagic and nearshore pelagic forms in greater abundance than areas of no boundary.

THE KELP-BED BOTTOM BIOTOPES

The holdfast biotopes are by far the most complex of the three major kelp-bed biotopes. They are far more complex than most terrestrial environments and are as complex as the rocky intertidal and subtidal environments. Many of the smaller organisms of the holdfast bottom area are impossible to identify and some of the larger forms are quite difficult. There are, however, dominant organisms which are widely known and which can be used as indices of the type of bottom fauna to be expected in a specific area.

The Kelp-Bed Sand-Bottom Biotope

The least complex of the holdfast bottom biotopes are those which are predominantly sand. Such areas are common off the towns of San Clemente and Santa Barbara. The kelp may grow directly onto old holdfasts partially buried in the sand or to other solid objects such as hard clay, cobble, scattered rocks, underground stems of eelgrass (Zostera), anchors, and even discarded rubber tires. In such areas the normal sand-dwelling organisms are influenced to a large degree by the presence of the kelp (Macrocystis pyrifera) and the organisms associated with the kelp. Compared with that of the desert-like stretches of relatively barren sand bottom, the bottom fauna seems rich; compared with rocky regions, however, the bottom fauna is sparse.

The predominant benthic fauna is qualitatively similar to that of the nearby sand areas, but is quantitatively different. For instance, the common sand dollar, Dendraster excentricus, which lives in great profusion in sandy areas of similar depth, is quite scarce in the holdfast region. At such depths, just the opposite is true of the speckled sanddab, Citharichthys stigmaeus.

Adult Fishes Observed in the Rocky-Bottom Kelp-Bed Biotope

Fish	Preferred habitats in southern California with estimated depths
Branchiostoma californiense, lancelet	Sand, mud, surface to 100 feet.
*Heterodontus francisci, horned shark	Rock, 8-35 feet.
*Cephaloscyllium uter, swell shark	Rock, 40-75 feet.
Triakis semifasciata, leopard shark	Cobble, 4-25 feet.
Squatina californica, angel shark	Fine sand, 40-100 feet.
Rhinobatos productus, shovelnose guitarfish	Sand, 3-44 feet.
Zapteryx exasperata, mottled guitar fish	Rocks, 8-30 feet.
Platyrhinoidis triseriata, thornback	Sand, 3-98 feet.
Dasyatis dipterurus, diamond stingray	Sand near rocks, summer 5-11 feet, winter 45-55 feet.
Urobatis halleri, round stingray	Sand, mud, 3-50 feet.
*Holorhinus californicus, bat ray	Sand patches in rocks, 8-100 feet.
Torpedo californica, electric ray	Fine sand, 40-100 feet.
Sardinops caerulea, sardine	Nearshore, pelagic, surface to 90 feet.
Engraulis mordax mordax, ocean northern anchovy	Nearshore pelagic, surface to 50 feet.
*Gymnothorax mordax, California moray	Rock crevices, 2-65 feet.
Paralichthys californicus, California halibut	Sand, 4-100 feet.
Xystreurys liolepis, fantail sole	Sand, 15-82 feet.
Citharichthys sordidus, Pacific sanddab	Sand, 45 feet to deep water
Citharichthys stigmaeus, speckled sanddab	Sand, 1-160 feet.
Hypsopsetta guttulata, diamond turbot	Sand, 4-60 feet.
*Pleuronichthys coenosus, C-O turbot	Rocks, sand, 6-90 feet.
*Stereolepis gigas, black seabass	Rocks, 18-100 feet.
**Mycteroperca xenarchus, broomtail grouper	Rocks, kelp, 12-50 feet.
**Mycteroperca jordani, Gulf grouper	Rocks, kelp, 32-50 feet.
**Paralabrax clathratus, kelp bass	Rocks, kelp, 2-72 feet.
Paralabrax nebulifer, sandbass	Rocks near sand, 17-85 feet
Paralabrax maculatofasciatus, spotted bass	Eelgrass: bays, 8-18 feet; ocean 35-60 feet.
Leuresthes tenuis, grunion	Rocky areas, 4-25 feet.
Atherinopsis californiensis, jacksmelt	Sandy areas, 5-48 feet.
Atherinops affinis littoralis, bay topsmelt	Bays, surface to 10 feet.
Atherinops affinis cedroscensis, kelp topsmelt	Mainland kelp, surface to 85 feet.
Atherinops affinis insularum, island topsmelt	Island kelp, 1-30 feet.

Sphyraena argentea, California barracuda	Nearshore pelagic, 10-50 feet.
Seriola dorsalis, yellowtail	Nearshore pelagic, 10-25 feet.
Trachurus symmetricus, jack mackerel	Nearshore pelagic, 4-140 feet.
Pneumatophorus japonicus diego, Pacific mackerel	Nearshore pelagic, 10-120 feet.
*Xenistius californiensis, salema	Rocks, seaweed, 4-35 feet.
*Anisotremus davidsoni, sargo	Rocks, 8-75 feet.
*Cheilotrema saturnum, black croaker	Rocks caves, 8-40 feet.
Roncador stearnsi, spotfin croaker	Sand, 8-12 feet.
Seriphus politus, queenfish	Sand, 9-25 feet.
Menticirrhus undulatus, California corbina	Sand, 3-18 feet.
*Cynoscion nobilis, white seabass	Rocks, kelp, 10-42 feet.
*Caulolatilus princeps, ocean whitefish	Rocks, kelp, 10-65 feet.
Hyperprosopon ellipticum, silver surfperch	Sand near rocks, cold water, 3-10 feet.
Hyperprosopon argenteum, walleye surfperch	Sand inshore from submerged reefs, 5-22 feet.
Embiotoca jacksoni, bay blackperch	Bay eelgrass, 4-20 feet.
**Embiotoca sp., ocean blackperch	Seaweeds, rocks, 2-80 feet.
*Taeniotoca lateralis, striped seaperch	Cold water, seaweeds, rocks: southern southern California, 30-45 feet; northern southern California, 2-38 feet; northern California, 4-21 feet.
*Hypsurus caryi, rainbow seaperch	Cold water, rocky areas, 10-95 feet.
Phanerodon furcatus, white seaperch	Rocky bottom, 10-140 feet.
Phanerodon atripes, sharpnose seaperch	Rocks to deep water.
*Damalichthys vacca, pileperch	Rocks, 5-115 feet.
**Rhacochilus toxotes, rubberlip seaperch	Kelp, rocks, 6-140 feet.
Cymatogaster aggregata, shiner seaperch	Eelgrass, 4-20 feet.
*Cymatogaster gracilis, island seaperch	Kelp, rocks, 5-17 feet.
*Brachyistius frenatus, kelpperch	Macrocystis, 2-80 feet.
Micrometrus minimus, dwarfperch	Surf grass and eelgrass, 3-20 feet.
*Chromis punctipinnis, blacksmith	Rocky bottom, 7-140 feet.
Hypsypops rubicunda, garibaldi	Rocky bottom, 2-42 feet.
*Pimelometopon pulchrum, sheephead	Rock bottom, 2-140 feet.
Halichoeres semicinctus, rock wrasse	Rocky bottom, 10-52 feet.
*Oxyjulis californica, señorita	Seaweeds, rocks, 5-75 feet.
**Girella nigricans, opaleye	Seaweeds, 1-65 feet.
Hermosilla azurea, zebraperch	Rocks, 4-12 feet.
*Medialuna californiensis, halfmoon	Rocks, kelp, 6-68 feet.
Scorpaena guttata, California scorpionfish	Rocks, 2-160 feet.

CRUSTACEA

Balanus tintinnabulum, barnacle
Mysidopsis californica, opossum shrimp
Iodothea (Pentidotea) resecata, kelp isopod
Paracerceis sp., broadtail isopod
Hyale frequens, kelp flea
Ampithoë humeralis, kelp curler
Taliepus nuttalli, southern kelp crab
Pugettia producta, common kelp crab

MOLLUSCA

Loligo opalescens, squid
Norrisia norrisae, smooth turban shell
Tegula aureotincta, gilded top snail
Calliostoma arincolor, ring top
Lacuna unifasciata, kelp lacuna
Mitrella carinata, keeled dove snail
Melibe leonina, lion nudibranch
Pecten latiuratus, kelp scallop

ECHINODERMATA

Leptasterias aequalis, six-rayed star
Linckia, little star
Pisaster giganteus, common star

The Fishes of the Canopy

At present no group of organisms in the kelp is more important to man than the fishes. Few of them are of commercial value, but many of them are important as sportfish. Thousands of fishermen enjoy healthful outdoor activity fishing in the kelp beds each year. Fortunately none of the sportfish or important forage fish are so dependent upon the kelp canopy that their numbers are affected by present harvesting methods.

The conventional mental picture of the kelp beds is somewhat distorted because of the lack of valid data in the past. For many years it has been thought that the kelp beds, especially the canopy region, were the spawning and nursery grounds of many sport and forage fishes. Barracuda, yellowtail, and even tuna were thought to attach their eggs to the kelp. These are invalid concepts, based on misinterpreted observations. During the summer season when barracuda and yellowtail are caught on the edges of the kelp beds, heavy with roe and milt, it is not difficult to picture the association of the kelp to spawning.

than that examined in nearby areas, such as the submarine canyon, over the sandy nearshore bottom, and over rocky nearshore bottom. At first this seems rather surprising. However, when one realizes that the majority of the canopy organisms are plankton feeders, it is not so surprising. Even the fishes, kelp topsmelt (Atherinops affinis edroscensis), blacksmith (Chromis punctipinnis), and the señorita (Oxyjulis californica) feed partly on plankton. Thick schools of young to half-grown blacksmith often form where a plankton-rich current enters the kelp bed. While a diver watches, they will pick particles from the water, too small for him to see. Stomach content analyses reveal larval fish, squid, and other planktonic forms. This screen of fish, almost impenetrable for some minute forms, may be responsible for the dearth of planktonic forms within the kelp beds. Some of the swimming forms may actually avoid the kelp beds.

The more common organisms of the canopy, easily visible to the naked eye, consist, in addition to Macrocystis, of two other large seaweeds, several hydroids, a sea anemone, a serpulid worm, several bryozoans, a moderate number of crustaceans, including one barnacle, three larger snails and several smaller ones, one moderate-sized and a number of smaller species of nudibranchs, a scallop, a number of young starfish, and a number of fishes.

Two other species of algae are occasionally observed in the southern California kelp canopy: ribbon kelp (Egregia laevigata) grows on the inner edge of the kelp beds, into the intertidal zone; and elkhorn kelp (Pelagophycus porra) grows in the deeper parts of the outer edge of the kelp. Elkhorn kelp does not grow to the surface, but may, when it becomes detached, float to the surface and tangle with the surface canopy.

Common Invertebrates of the Canopy Biotope

HYDROZOA

Sertularella sp., moss hydroid
Campanularia sp., moss hydroid

COELENTERATA

Epiactis (prolifera?), prolific anemone

ANNULATA

Spirorbis sp., serpulid worm

BRYOZOA

Membranipora serrilamella, encrusting bryozoan
Bugula nerritina, moss bryozoan

I have found no organisms that prefer the sand-bottom holdfast region to other habitats. However, there is no doubt that the presence of kelp on an otherwise barren sandy bottom tremendously enriches the fauna, especially the fish fauna. Large numbers of sand-dwelling and even some reef-dwelling and nearshore pelagic species concentrate around the kelp. Small organisms found in the holdfasts are similar to those found in the holdfasts of rocky areas. The sediments in the kelp-bed sand-bottom regions are less uniform than in the desert-like stretches at similar depths. The ripple marks are confused by the surge interference due to the kelp plants. Scouring takes place around the plants, moving aside the finer sediments and leaving the coarser. Interference with surge and other bottom currents often causes the deposition of piles of fine sediment in areas void of strong currents.

Variations in the sizes of sand grains in different parts of the kelp beds add extra habitat sites for many organisms. This is balanced in the opposite direction by the fact that constant scouring and filling are often damaging to most sessile organisms, because of the temporary nature of the substrate.

Common Invertebrates Of The Holdfast Sand-Bottom Biotope

Organism	Preferred habitat in southern California with estimated depths
COELENTERATA	
Corymorpha palma, palm hydroid	Sand-mud bottom, calm water.
Renilla kollikeri, sea pansy	Fine to medium sand bottom, slightly turbulent water, surface to 60 feet.
Edwardsiella californica, small sand anemone	Sand bottom, surface to 45 feet.
Cerianthus sp., tube-dwelling anemone	Sand over solid substrate, 8 to at least 200 feet.
Pelagia sp., purple-striped jellyfish	Nearshore pelagic.
Scrippsia sp., Scripps jellyfish	Nearshore, surface to 150 feet.
CTENOPHORA	
Pleurobrachia sp., sea walnut	Pelagic, at thermocline.
BRYOZOA	
Membranipora serrilamella, encrusting bryozoan	Blades of seaweeds, surface to 90 feet.
Phidolopora pacifica, lace coralline bryozoan	Rocks and holdfasts, surface to 100 feet.
Idmonea and similar bryozoans, common coralline bryozoans	Rocks and holdfasts, 1-100 feet.

Annelida

ANNULATA

Eudistylia polymorpha, featherduster worm	Rocky substrate, surface to 210 feet.
Spirorbis sp., serpulid worm	Surface to 180 feet on solid surfaces.
Terebellidae, sticky tentacle worm	Sand-mud bottom, surface to 150 feet.
Chaetopterus variopedatus, parchment tubeworm	Sand-mud to rock bottom, 10-155 feet.
Diapatra ornata, gray tubeworm	Sand-mud bottom, 20-150 feet.

ECHINODERMATA

Astropecten armatus, common sandstar	Mud-medium sand bottom, surface to 90 feet.
Luidia folialata, soft sandstar	Mud-fine sand, 50 feet to at least 180 feet.
Ophiuroid, sand-burrowing brittle star	Mud-medium sand, 30-210 feet.
Dendraster excentricus, common sand dollar	Medium sand, surface to 65 feet.
Lovenia cordiformis, heart urchin	Fine-medium sand, surface to 95 feet.
Leptosynapta inhaerens, transparent seacucumber	Fine-coarse sand, surface to 100 feet.
Stichopus californicus, California seacucumber	Sand or rock, 60-190 feet in southern California.
Malpodia arenicola, sweet potato	Medium sand, surface to 60 feet.

CRUSTACEA

Holopagurus pilosus, sand burrowing hermit crab	Surface to 35 feet.
Pagurus ochotensis, sand burrowing hermit crab	18-65 feet.
Blepharipoda occidentalis, giant sand crab	Fine-medium sand, 8-45 feet.
Cancer gracilis, agile cancer crab	Mud-medium sand, 8-65 feet.
Heterocrypta occidentalis, elbow crab	Medium sand, 10-45 feet.
Randallia ornata, purple globe crab	Medium sand, 15-45 feet.
Loxorhynchus crispatum, moss-covered crab	Sand and rocks, 15-165 feet.

MOLLUSCA

Pleurophyllidia californica, pansy nudibranch	Fine-medium sand, surface to 60 feet.
Acteon punctocaelata, barrel shell	Fine-coarse sand, surface to 200 feet.

Conus californicus, California cone	Sand-rocks, surface to 180 feet.
(Cryptoconus) carpenterianus, Carpenter's turret	Fine sand-gravel, 45-130 feet.
Olivella biplicata, purple olive	Fine-medium sand, surface to 50 feet.
Olivella pedroana, Pedro olive	Mud-medium sand, surface to 110 feet.
Kellettia kelletti, Kellett's spindle	Fine sand-rock, surface to 100 feet.
Nassarius fossatus, channeled basket snail	Fine-medium sand, surface to 45 feet.
Bursa californica, California frog mollusk	Fine sand-gravel, 35-200 feet.
Polinices draconis, fat moon snail	Fine sand-medium sand, surface to 45 feet.
Norrisia norrisae, smooth turban	Brown seaweeds, 1-100 feet.

Fishes Observed In The Sand-Bottom Holdfast Biotope

Fish	Preferred southern California habitat
Branchiostoma californiense, (California) lancelet	Mud-sand bottom
Triakis semifasciata, leopard shark	Shallow flat bottom
*Squatina californica, (California) angel shark	Sand bottom
Rhinobatos productus, shovelnose guitarfish	Shallow sand bottom
*Platyrhinoidis triseriata, (California) thornback	Sand bottom
*Dasyatis dipterurus, diamond stingray	Sand bottom
Urobatis halleri, round stingray	Sand or mud bottom
*Holorhinus californicus, bat ray	Mud, sand or rock bottom
*Torpedo californica, (California) electric ray	Deeper mud and sand bottom
Sardinops caerulea, (Pacific) sardine	Nearshore pelagic
Engraulis m. mordax, ocean northern anchovy	Nearshore pelagic
Synodus lucioceps, (California) lizardfish	Sand-mud bottom
*Paralichthys californica, California halibut	Sand-mud bottom
Xystreurys liolepis, fantail sole	Sandy mud bottom
Citharichthys sordidus, Pacific sanddab	Deeper sand-mud bottom
*Citharichthys stigmaeus, speckled sanddab	Sand-mud bottom
*Hypsopsetta guttulata, diamond turbot	Sand bottom
*Pleuronichthys coenosus, C-O turbot	Rocky and sandy bottom
Paralabrax clathratus, kelp bass	Rocky bottom
Paralabrax nebulifer, sand bass	Rocks near sand
Paralabrax maculofasciatus, spotted bass	Eelgrass beds
Atherinopsis californiensis, jacksmelt	Nearshore pelagic
Atherinops affinis cedroscensis, kelp topsmelt	Kelp canopy
Pneumatophorus japonicus diego, (Pacific) mackerel	Pelagic
Anisotremus davidsoni, (California) sargo	Rocky bottom
Roncador stearnsi, spotfin croaker	Sand bottom

Umbrina roncador, yellowfin croaker	Sand bottom
Menticirrhus undulatus, (California) corbina	Shallow sand bottom
*Seriphus politus, queenfish	Fine sand bottom
Hyperprosopon ellipticum, silver surfperch	Shallow rock and sand areas
Hyperprosopon argenteum, walleye surfperch	Shallow rock and sand areas
Embiotoca jacksoni, bay blackperch	Seaweeds of bays and baylike areas
Taeniotoca lateralis, striped seaperch	Rocky bottom
Hypsurus caryi, rainbow seaperch	Rocky bottom
Phanerodon furcatus, white seaperch	Rocky bottom
Damalichthys vacca, pileperch	Rocky bottom
Rhacochilus toxotes, rubberlip seaperch	Seaweeds
Brachyistius frenatus, kelpperch	Kelp beds
Chromis punctipinnis, blacksmith	Rocks
Pimelometopon pulchrum, sheephead	Rocks
Oxyjulis californica, señorita	Rocks and seaweeds
Girella nigricans, (California) opaleye	Seaweeds and rocks
Medialuna californiense, (California) halfmoon	Rocks and seaweeds
Sebastodes paucispinis. bocaccio	Deeper rock bottom
Sebastodes serranoides, olive rockfish	Rocky bottom
Sebastodes atrovirens, kelp rockfish	Rocky bottom
Scorpaenichthys marmoratus, cabezon	Rocky bottom
Leiocottus hirundo, lavender sculpin	Sand near rocks
Aulorhynchus flavidum, tubenose	Seaweeds and rocks
Syngnathus californiensis, kelp pipefish	Seaweeds
Coryphopterus nicholsi, crested goby	Sand near rocks
Rimicola muscarum, kelp clingfish	Kelp canopy
Heterostichus rostratus, kelpfish	Seaweeds
Neoclinus blanchardi, sarcastic fringehead	Sand-mud bottom
Xererpes fucorum, rockweed gunnel	Shallow water seaweeds

*Sand-bottom fishes which are more abundant in the sand-bottom kelp beds than on flat sandy bottoms at similar depths.

Many of the sand-bottom fishes listed above appear to prefer the presence of kelp on the otherwise barren sand bottom and a number of forms more typical of rock and seaweed may extend their habitat into the sandy areas because of the presence of the kelp. It is evident that by supplying suitable substrate for Macrocystis on the many desert-like stretches of sandy bottoms we could increase the number and spread of sand, rock, and kelp fishes. Suitably designed substrate would in addition increase the numbers of abalones and lobsters.

The Kelp Rock-Bottom Biotopes

Irregular rocky bottoms are the richest in both quality and quantity of organisms. The more irregular the bottom, the more surface, the more crevices, the more turbulence, and the more ecological niches available.

Irregular bottoms provide vertical, oblique, and under surfaces, as well as crevice bottoms, cave roofs, and horizontal surfaces. They offer niches of varying degrees of turbulence from the calm, deep crevices and caves to the accelerated velocities of surge channels and tunnels. Crevices, caves, and holes of various sizes accommodate a greater variety of organisms. To fishermen these rich geological irregularities are often known as "bass holes," "cod holes," or "sculpin holes," depending on the predominant fish caught there. Often these irregularities are not holes but submarine hills, mounds, or piles of rock.

The term flat rock bottom has only a relative meaning, for all exposed rocks are covered with an irregular epibiose, carved by animals, eroded by currents, and full of structural irregularities. However, the flora and fauna are markedly different from those of the more irregular rocky bottoms. The qualitative difference is only slight but quantitatively they are quite unlike.

The flat rocky bottoms do not have the large quantities of fishes found on the irregular rock bottom, but they are far richer than the sand-bottom biotopes, although lacking the sand forms.

Because of the extreme complexity and the thousands of different organisms involved, only the most common and conspicuous forms can be discussed.

Solid substrates essential for most marine plants are afforded by the rocky bottoms.

Common Marine Plants Of The Kelp-Bed Rock-Bottom Biotopes

Plant	Preferred habitats in southern California with estimated depths
Codium cuneatum, flat pickleweed	Nearshore irregular rocky bottom, 5-35 feet.
Petrospongium rugosum, sponge alga	Nearshore, calm water, rocky bottom, surface to 40 feet.
**Desmarestia munda	Rocky bottom, deep moderate surge, 65-110 feet.
*Laminaria andersoni, palm streamer kelp	Deep water, 55-110 feet.
*Laminaria farlowi, giant streamer kelp	Flat rock bottom, 30-150 fee
*Macrocystis pyrifera, giant kelp	Rock bottom, surface to 110 feet.
*Dictyoneuropsis reticulata, one-ribbed streamer kelp	Flat rock bottom, 50-110 feet.
*Costaria costata, three-ribbed streamer kelp	Flat rock bottom, 60-100 feet.

Pelagophycus porra, elk kelp	Rock bottom, 60-130 feet.
**Pterygophora californica, smooth palm kelp	Rough rock bottom, 75-130 feet.
**Eisenia arborea, southern California palm kelp	Rough rock bottom, surface to 130 feet.
Egregia laevigata, ribbon kelp	Flat rocks, surface to 45 feet.
Cystoseira setchelli, sargassum	Rock bottom, surface to 80 feet.
Porphyra perforata, red sea lettuce	Rocks near sand, 60-140 feet.
Lithothamnium species, coral algae	Calm rocky bottom, surface to 150 feet.
Bossea and related genera, coralline algae	Irregular rocks, surface to 100 feet.
*Botryocladia pseudodichotoma, sea grapes	Flat rock bottom, 10-70 feet.
Rhodymenia pacifica	Rough rock, 40-140 feet.
Phyllospadix torreyi, Torrey's surfgrass	Flat tops of irregular rocky bottom, surface to 40 feet.

*Seaweeds that are especially characteristic of the flat rock habitat in the kelp beds.

**Seaweeds that are especially characteristic of the irregular rock-bottom habitat in the kelp beds.

These plants add cover to the rocky bottom and make it possible for it to support a higher fish population. Forage, cover, and additional substrate are provided for many invertebrates that serve as food for fishes and man.

The brown palm kelps form an understory, 1 to 2 feet over the bottom. The streamer kelps lie as broad streamers over the bottom. The short red and brown seaweeds form a carpet over the rocks. These additions to the habitat are especially important to fishes on the flat rock bottom, where they form the only available cover.

Invertebrate Fauna Common To The Rocky Bottoms Of The Kelp Beds

Organisms	Preferred habitat in southern California with estimated depths
PORIFERA	
**Geodia mesotriaena, geode sponge	Flat rock bottom, 60-110 feet.
**Tethya aurantia, puffball sponge	Rock bottom, 45-130 feet.
Hemecton hyle, leaf sponge	Sides of rocks, 85-225+ feet.

Rhabdodermella nuttingi, urn sponge	Rocks, surface to 90 feet.
Leuconia heathi. thistle sponge	Sides of rocks, surface to 90 feet.
Spheciospongia confoederata, liver sponge	In tunnels and crevices, surface to 40 feet.
Ferangia thiona, sulphur sponge	Sides of rocks, surface to 200+ feet.
Chora celata, burrowing sponge	Shells, 60-130 feet.

COELENTERATA

Aglaophenia struthionides, ostrich plume hydroid	Irregular rocky bottom, cold water, 20-130 feet.
Scrippsia sp., jellyfish	Nearshore, surface to 150 feet.
Pelagia sp., purple-striped jellyfish	Pelagic nearshore, surface to 100 feet.
Muricea fructosa, rust gorgonian	Rocks, surface to 120 feet.
Muricea californica. California gorgonian	Rocks, surface to 70 feet.
Lophogorgia chilensis, pink gorgonian	Cold waters, rocks, 35-150 feet.
Eugorgia rubens, purple fan gorgonian	Deep rocks, 60-160 feet.
Balanophyllia elegans, cup coral	Rocks, surface to 200+ feet.
Astrangia sp., colonial cup coral	Rocks, surface to 70 feet.
Epiactis prolifera, prolific anemone	Rocks and seaweeds, surface to 90 feet.
Corynactis californica, pink anemone	Rocks, 10-180 feet.
Cerianthus sp., tube anemone	Sand near rocks, 8-200+ feet

PLATYHELMINTHES

Turbellidae, free-living flatworms	Small dark crevices, surface to 200+ feet.

BRYOZOA

Membranipora serrilamella, encrusting bryozoan	Blades of seaweeds, surface to 90 feet.
Phidolopora pacifica, lace coralline bryozoan	Rock crevices, surface to 100 feet.
Idmonea and similar genera, common coralline bryozoans	Rock crevices, surface to 100 feet.

BRACHIOPODA

Terebratulina unguicula, snakehead lamp shell	Sides of rocks, 30-190 feet.
Terebratalia transversus, red lamp shell	Sides of rocks, cold water, 40-110 feet.

ANNULATA

Spirorbis sp., serpulid worm	Solid surfaces, surface to 180 feet.
Serpula columbiana, red flower worm	Rock surfaces, surface to 65 feet.
Eudistylia polymorpha, featherduster worm	Rocky, surface to 210 feet.
Sabellaria californica, honeycomb worm	Rocks near sand, surge, surface to 35 feet.

SIPUNCULA

Sipunculoids, peanut worms	Sand among rocks, surface to 40 feet.

ECHINODERMATA

**Linckia columbiae, irregular starfish	Flat rocks, surface to 45 feet.
*Pycnopodia helianthoides, sun star	Sea urchins, 60-200+ feet.
Evasterias troschelii. colorful star	65-150 feet.
Leptasterias hexactis, six-rayed star	Kelp fronds, surface to 65 feet.
Astrometis sertulifera, soft star	Rock crevices, surface to 75 feet.
*Henricea sp., little red star	Rocks, 35-90 feet.
*Henricea sp., little tan star	Rocks, 55-110 feet.
Asterina miniata, bat star	Sea urchins, surface to 60 feet.
Dermasterias imbricata, leather star	Cold water, rocks, 25-100 feet.
*Mediaster aequalis, vermilion star	Cold water, rocks, 65-140 feet.
Ophiothrix spiculata, spiny brittlestar	Rocky bottom, holdfasts, surface to 150 feet.
Strongylocentrotus purpuratus, purple sea urchin	Irregular rocks, surface to 110 feet.
Strongylocentrotus franciscanus, large sea urchin	Irregular rocks, surface to 110 feet.
Cucumaria sp., little sea cucumber	Seaweeds, rocks, 20-90 feet.
*Stichopus parvimensis, southern sea cucumber	Rocks, surface to 65 feet.
Stichopus californicus, California sea cucumber	Rocks, sand, 60-190 feet.

CRUSTACEA

Balanida, barnacles	Solid substrate, surface to 250+ feet.
Amphipoda, flea shrimps	Particular seaweeds, surface to 150+ feet.

Caprellidae, ghost shrimp	Seaweeds, hydroids, gorgonians, surface to 50 feet.
Idothea resecata, kelp isopod	Seaweeds, surface to 50 feet
Limnoria sp., kelp-burrowing isopod	Seaweed holdfasts, 35-110 feet.
Hippolysmata californica, red-and-white shrimp	Crevices, surface to 130 feet.
Betaeus harfordi, abalone shrimp	Surface to 130 feet.
Spirontocaris sp., bent-back shrimp	Seaweeds, rocks, surface to 130 feet.
Panulirus interruptus, California spiny lobster	Rock crevices, surface to 200+ feet.
Crangon sp., snapping shrimp	Rocks, surface to 100 feet.
Paguristes tugidis, hairy hermit crab	Flat rocks, 25-100 feet.
Porcelain crabs	Crevices, surface to 150 feet.
Pugettia productus, kelp crab	Mid-kelp and canopy, surface to 130 feet.
Taliepus nuttalli, southern kelp crab	Rock crevices, surface to 90 feet.
Small spider crabs	Rocky, surface to 225+ feet.
Loxorhynchus crispatus, moss-covered crab	Sand and rock, 15-165 feet.
Loxorhynchus grande, sheep crab	Rocks, 10-70 feet.
Cancer productus, red crab	Rocks and sand, surface to 65 feet.
Cancer antennarius, rock crab	Rocks and sand, surface to 65 feet.
Paraxanthias taylori, lumpy crab	Rocks, surface to 150 feet.

MOLLUSCA

Hinnites multirugosus, rock scallop	Protected crevices, surface to 160 feet.
Pecten latiuratus, broad-eared scallop	Seaweed, surface to 120 feet
*Lima dehiscens, file shell	Holdfasts, surface to 150 feet.
Pododesmus macroschisma, jingle	Rocks, 10-90 feet.
Botula falcata, pea-pod borer	In rocks, surface to 40 feet
Lithophaga plumulata, date mussel	In rocks and shell, surface to 250+ feet.
Semele decisa, rock semele	Sand between rocks, 15-60 feet.
Pholadidea penita, common pholad	Rocks, surface to 60 feet.
Tethys californica, California sea hare	Seaweeds, surface to 45 feet
Diaulula sandiegensis, circle spotted nudibranch	Rocks, surface to 100 feet.
Chromodoris californiensis, California nudibranch	Rocks, surface to 40 feet.

Cadlina marginata, yellow-margined nudibranch	Rocks, 20-110 feet.
Doriopis fulion, orange-brown nudibranch	Rocks, 10-50 feet.
Flabellina iodinea, purple nudibranch	Rocks, surface to 40 feet.
Melibe leonina, lion nudibranch	Kelp, surface to 35 feet.
Mitra idae, Ida miter	Rocks, surface to 200 feet.
**Kellettia kelletti, Kellett's spindle	Rocks, surface to 100 feet.
Columbella carinata, kelled dove shell	Rocks and seaweeds, surface to 110 feet.
Cypraea spadicea, nut-brown cowry	Rock crevices, surface to 90 feet.
Bursa californica, California frog shell	Fine sand, 35-200 feet.
Aletes squamigerus, scalyworm mollusk	Rock crevices, surface to 40 feet.
**Spiroglyphis lituellus, crooked worm mollusk	Flat rock, surface to 90 feet.
Acmaea mitra, white cap limpet	Lithothamnium, cold water, 40-100 feet.
*Norrisia norrisae, smooth turban	Brown seaweeds, surface to 100 feet.
*Astraea undosa, wavy top	Rocks, surface to 45 feet.
Astraea inaequalis, red top	Cold water, rocks, 45-75 feet.
Tegula aureotincta, gilded turban	Seaweeds, surface to 40 feet.
Calliostoma canaliculatum, channeled top	Seaweeds and rocks, 40-90 feet.
Haliotis fulgens, green abalone	Rock crevices, surface to 35 feet.
*Haliotis rufescens, red abalone	Rocks, 30-100 feet.
*Haliotis corrugata, pink abalone	Rocks, 15-65 feet.
Megathura crenulata, giant keyhole	Rocks, surface to 110 feet.
Octopus sp.	Various habitats, surface to 250 feet.

TUNICATA

Styela montereyensis, common ascidian	Rocks, surface to 50 feet.
Melanodrocarpa dura, jelly ascidian	Seaweed, 25-75 feet.

*Invertebrates that are especially characteristic of the irregular rocky-bottom habitat in the kelp beds.

**Invertebrates that are especially characteristic of the flat rocky-bottom habitat in the kelp beds.

Fishes of the Kelp-Bed Rocky-Bottom Biotopes

Fishes observed in the kelp-bed rocky-bottom region form a large list. Fishes correlated with almost any nearshore environment may occasionally be found in the kelp beds.

Sebastodes paucispinis, bocaccio	Rocks, 85-100 feet.
Sebastodes mystinus, blue rockfish	Rocks of southern California 130 feet to deep water.
**Sebastodes serranoides, olive rockfish	Kelp, rocks, cool water, 10-90 feet.
Sebastodes miniatus, vermilion rockfish	Rocks, 85 feet to deep water.
**Sebastodes atrovirens, kelp rockfish	Rocks, kelp 2-130 feet.
Sebastodes saxicola, popeye rockfish	Rocks, deep water.
Sebastodes semicinctus, halfbanded rockfish	Rocks, 90 feet to deep water.
Sebastodes auriculatus, brown rockfish	Rocks, seaweeds, 15-40 feet.
Sebastodes rastrelliger, grass rockfish	Rocks, seaweeds, 3-50 feet.
Sebastodes chrysomelas, black-and-yellow rockfish	Rocks, northern southern California, 10-22 feet.
Sebastodes carnatus, gopher rockfish	Rock holes, 40-110 feet.
Sebastodes serriceps, treefish	Rocks, 12-100 feet.
Hexagrammos decagrammus, kelp greenling	Rocks of northern southern California, 10-70 feet.
Ophiodon elongatus, lingcod	Rocks, 38-125 feet.
Oxylebius pictus, convictfish	Rocks, 4-120 feet.
*Scorpaenichthys marmoratus, cabezon	Rocks, seaweeds, 2-120 feet.
Icelinus cavifrons, pithead sculpin	Rocks, 100 feet to deep water
Artedius creaseri, roughcheek sculpin	Rocks, 10-35 feet.
Artedius corallinus, coralline sculpin	Rocks, 3-70 feet.
Artedius lateralis, smoothhead sculpin	Rocks, 1-25 feet.
Orthonopias triacis, snubnose sculpin	Rocks, short seaweeds, 10-100 feet.
Clinocottus analis, wooly sculpin	Rocks, 1/4 to 12 feet.
Leiocottus hirundo, lavender sculpin	Sand patches in rocky areas, 8-55 feet.
Odontopyxis trispinosa, pithead poacher	Rocks, 40 feet to deep water.
Liparis mucosus, slimy snailfish	Seaweeds, 10-22 feet.
Aulorhynchus flavidum, tube-nose	Seaweeds, 8-80 feet.
Syngnathus arcta, snubnose pipefish	Coralline algae, 10-45 feet.
Syngnathus californiensis, kelp pipefish	Macrocystis, surface to 30 feet.
Coryphopterus nicholsi, crested goby	Sand near rocks, 1-180 feet.
Lythrypnus zebra, zebra goby	Rock crevices, 9-52 feet.
Lythrypnus dalli latifascia, (Catalina) bluebanded goby	Rocks, 11-80 feet.
*Lethops connectens, halfblind goby	Gravel among rocks, surface to 50 feet.
Typhlogobius californiensis, blind goby	Sand among rocks, intertidal to deep water.
Porichthys notatus, northern midshipman	Solid substrate, and sand or mud, intertidal to deep water.

Porichthys myriaster, slim midshipman	Mud, near rock, surface to 130 feet.
Rimicola muscarum, kelp clingfish	Kelp canopy, surface to 10 feet.
Gobiesox rhessodon, California clingfish	Rocks, surface to 35 feet.
Paraclinus integripinnis integripinnis, California reef finspot	Coralline algae, 2-25 feet.
Alloclinus holderi, island klipfish	Rocks, 10-60 feet.
*Heterostichus rostratus rostratus, (California) kelpfish	Seaweeds, 1-50 feet.
Gibbonsia metzi, weed klipfish	Seaweeds, 2-18 feet.
Gibbonsia elegans elegans, tidepool ocellated klipfish	Bottom seaweeds, 6-65 feet.
Gibbonsia erythra, scarlet klipfish	Rocks, 60 feet.
Neoclinus stephensae, yellowfin fringehead	Rocks, 18 feet.
Rathbunella hypoplectus, smooth ronquil	Rocks, 22-140 feet.
*Genus, sp., weed prickleback	Rocks, seaweeds, 25-80 feet.
Xererpes fucorum, rockweed gunnel	Seaweeds, 2-25 feet.
Ulvicola sanctaerosae, kelp gunnel	Seaweeds, 1-25 feet.
Mola mola, common mola	Surface pelagic.

*Fishes that include the rocky bottom kelp bed biotope as an important part of their habitat.

**Fishes that prefer the rocky bottom kelp bed habitat.

ORGANISMS OF THE MID-KELP BIOTOPE

In this study the arbitrary boundaries of the mid-kelp biotope are 10 feet below the canopy and 10 feet above the bottom. The fauna of this region is composed of forms that prefer the surface canopy, forms that prefer the bottom, and a very few that prefer this intermediate area.

Almost all organisms that occur in the canopy biotope are found in the mid-kelp biotope. Relatively few of the truly benthic forms enter this region. Most of the rocky and sandy bottom forms require specific substrates. The organisms that do enter the intermediate area are the motile forms that are free to climb or swim, and the few sessile forms that attach to the kelp.

ALGAE

*Egregia laevigata, ribbon kelp
*Pelagophycus porra, elk kelp

HYDROZOANS

*Campanularia sp., moss hydroid
*Sertularella sp., moss hydroid

ANEMONES

Epiactis prolifera, prolific anemone

CTENOPHORA

Pleurobrachia sp., sea walnut

WORMS

Spirorbis sp., serpulid worm

BRYOZOA

**Membranipora serrilamella, encrusting bryozoan
*Bugula neritina, moss bryozoan

CRUSTACEA

Balanus tintinnabulum, barnacle
Mysidopsis californica, opossum shrimp
*Iodothea resecata, kelp isopod
**Paracerceis sp., broadtail isopod
*Hyale frequens, kelp fleas
*Ampithoë humeralis, kelp curler
Caprellidae, ghost shrimp
Spirontocaris sp., bent-back shrimp
Taliepus nuttalli, southern kelp crab
*Pugettia producta, common kelp crab
Loxorhynchus grande sheepcrab

MOLLUSCA

Melibe leonina, lion nudibranch
Tethys californica. California sea hare
*Norrisia norrisae, smooth top
Tegula aureotincta, gilded top
*Calliostoma arincolor, ring top
*Lacuna unifasciata, kelp lacuna
**Mitrella cavinata, keeled dove snail
**Pecten latiauratus, broad-eared scallop

ECHINODERMATA

Leptasterias aequalis, six-legged star
Linckia, little star
Pisaster giganteus, common star

FISHES

Triakis semifasciata, leopard shark
Holorhinus californicus, bat ray
Sardinops caerulea. Pacific sardine
Engraulis mordax mordax, ocean northern anchovy
Cololabis saira, Pacific saury
Cypselurus californicus, California flyingfish
*Stereolepis gigas, California black seabass
*Mycteroperca xenarchus, broomtail grouper
*Mycteroperca jordani, Gulf grouper
*Paralabrax clathratus, kelp bass
Paralabrax nebulifer, sandbass
Leuresthes tenuis, grunion
Atherinopsis californiensis, jacksmelt
Atherinops affinis littoralis, bay topsmelt
*Atherinops affinis cedroscensis, kelp topsmelt
*Atherinops affinis insularum, island topsmelt
*Sphyraena argentea, (California) barracuda
**Seriola dorsalis, California yellowtail
Trachurus symmetricus, (Pacific) jackmackerel
Pneumatophorus japonicus diego, (Pacific) mackerel
Xenistius californiensis, (California) salema
*Anisotremus davidsoni, (California) sargo
Cheilotrema saturnum, black croaker
Seriphus politus, queenfish
**Cynoscion nobilis, white seabass
*Caulolatilus princeps anomalus, (California) ocean whitefish
Hyperprosopon ellipticum, silver surfperch
Hyperprosopon argenteum, walleye surfperch
Embiotoca jacksoni, bay blackperch
*Embiotoca sp., ocean blackperch
*Taeniotoca lateralis, striped seaperch
Hypsurus caryi, rainbow seaperch
Phanerodon furcatus, white seaperch
*Damalichthys vacca, pileperch
**Rhacochilus toxotes, rubberlip seaperch
Cymatogaster aggregata, shiner seaperch
*Cymatogaster gracilis, island seaperch
*Brachyistius frenatus, kelpperch
Micrometrus minimus, dwarfperch
*Chromis punctipinnis, blacksmith

Hypsypops rubicunda, garibaldi
Pimelometopon pulchrum, sheephead
Halichoeres semicinctus, rock wrasse
*Oxyjulis californica, señorita
*Girella nigricans, opaleye
**Medialuna californiensis, halfmoon
Sebastodes mystinus, blue rockfish
*Sebastodes serranoides, olive rockfish
*Sebastodes atrovirens, kelp rockfish
Sebastodes rastrelliger, grass rockfish
Scorpaenichthys marmoratus, cabezon
Aulorhynchus flavidum, tube-nose
*Syngnathus californiensis, kelp pipefish
**Lethops connectens, halfblind goby (as young)
*Rimicola muscarum, kelp clingfish
*Heterostichus rostratus rostratus, California kelpfish
Gibbonsia metzi, weed klipfish
Xererpes fucorum, rockweed gunnel
*Ulvicola sanctaerosae, kelp gunnel
Mola mola, common mola

*Organisms which include the mid-kelp as an important part of their habitat range.

**Organisms that are more characteristic of the mid-kelp than of other habitats.

THE EFFECTS OF HARVESTING ON KELP BEDS

On the Pacific Coast of North America kelp is harvested from Point Conception, California, south to the Mexican border. So far as is known no kelp has yet been harvested south of the border. North of Point Conception the beds are too close to shore for harvesters to operate. In addition, the northern beds are more or less seasonal; they are thicker during the summer and fall, and almost absent during the winter.

Kelp harvesters cut the kelp about 4 feet below the surface. More of the plant is taken if cutting occurs at low tide. However, no attempt is made to cut only at low tide. The beds may be harvested one to four times a year. The beds closest to the processing plants are usually harvested most frequently. Smaller proportions of the kelp are taken where the currents within the beds are strong enough to force a portion of the canopy beneath the surface. Only the offshore beds are cut. Those that occur from the intertidal area to depths less than 25 feet are not harvested.

The entire canopy is never completely removed and is usually so thick in two or three weeks that even an experienced fisherman could not point out the harvested area. The kelp cutters seldom harvest a complete bed at one cutting period. As they cut they remove the canopy, relieving the individual plants of the surface "drag." In this manner they allow the stipes to straighten and form a new but lighter canopy (Figs. 11A and 11B) New subsurface stipes, always present, uncut by the harvester and aided by the increase in light energy, quickly reach the surface and help thicken the new canopy. Young plants, hitherto retarded by the inadequate light under a thick canopy, are given an opportunity to grow in harvested beds.

Uncut beds are thinned at the surface by natural causes such as storms and high temperatures. A portion of the La Jolla kelp beds left uncut as a part of this program, became thin and straggly, while the nearby harvested portion remained thick and healthy (Fig. 12). Diving observations within the kelp revealed a thicker growth of younger plants in the harvested bed.

The effects of harvesting may be summarized as beneficial to society both from the point of view of the fisherman and from the point of view of the industries directly and indirectly utilizing kelp.

Only the offshore harvestable kelp beds (those deeper than 25 feet) are considered in detail in this report although considerable attention was given to the inshore beds during this investigation. The inshore kelp fauna is extremely complex, comprising a mixture of organisms characteristic of the intertidal belt, the subtidal bottom, the kelp-bed canopy, and the nearshore semi-pelagic area. The shallow-water beds are not harvested because navigation in shallow water is extremely hazardous.

EFFECTS OF KELP HARVESTING ON FISH LIFE

The effects of kelp harvesting were thoroughly investigated and the effects on fish were found to be negligible.

Few fish or fish eggs are actually brought on board the cutter. Those that are thus destroyed are seldom sport or forage fishes. The amount of invertebrate material brought on board attached to the kelp is so small in comparison with that left on the plants below the canopy that its absence can have little effect on the available food supply of the few fishes that feed on this material. Most of the free-swimming crustaceans and other fish-food organisms fall back through the screen.

Fishes are not driven away during harvesting operations. Diving has revealed them to be extremely plentiful just behind the kelp harvesters. Many species, including kelp bass, are attracted by such disturbances in the kelp, and probably find extra food at the time.

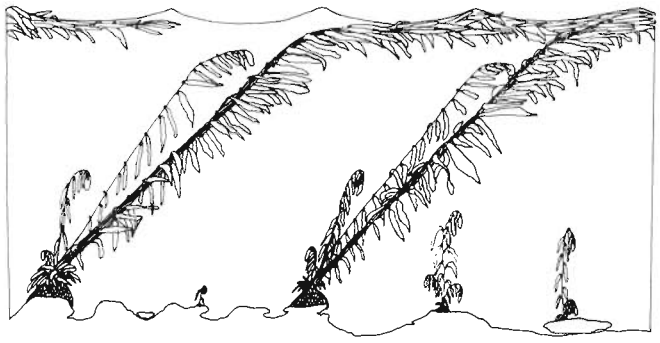


FIGURE 11A. A diagrammatic cross-section of an uncut kelp bed. Note how the stronger surface currents bend the plants.

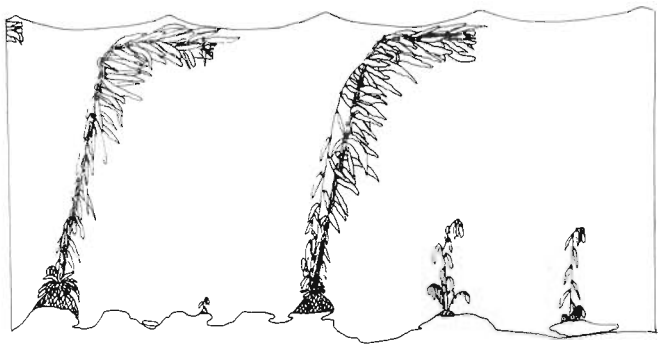
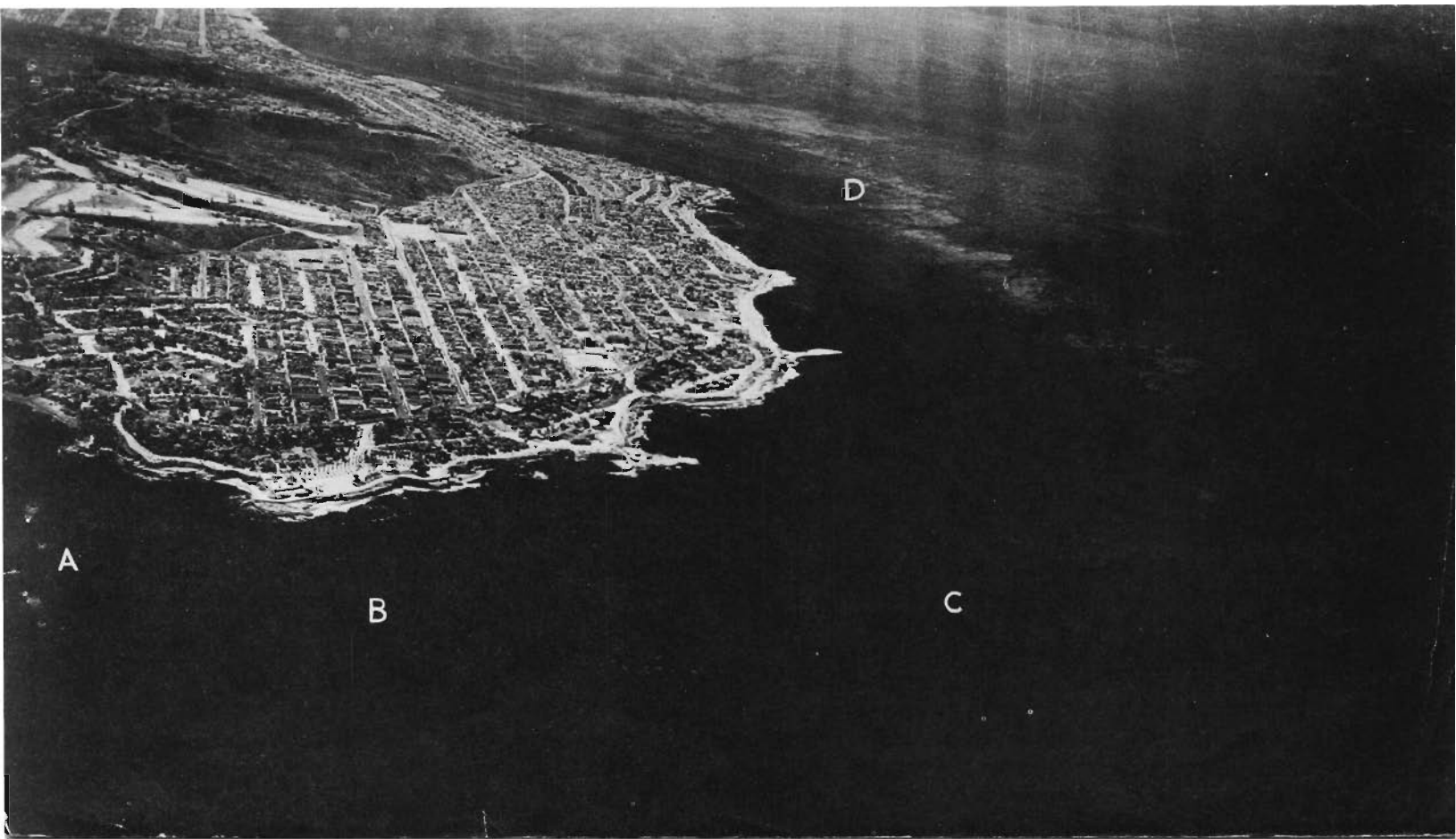


FIGURE 11B. A diagrammatic cross-section of the same kelp bed shortly after harvesting. Note how the plants straighten up once the surface drag is decreased. A new but lighter canopy is formed, providing sufficient cover for the canopy organisms. The removal of the heavy canopy allows light to reach the younger plants, causing them to grow more rapidly, eventually thickening the kelp beds.

FIGURE 12. This aerial photograph of the La Jolla kelp beds illustrates the beneficial effects of harvesting on kelp beds. The thicker portion of the kelp bed (C-D) represents the normally harvested kelp bed. The thin portion of the kelp (B-C) represents a portion of the same bed that was left uncut for over a year. The portion of the bed with the very thin canopy (A-B) was cut two days before the photograph was taken. Kelp bass tagging experiments were conducted in this area and no significant movements due to the action of kelp harvesters were noted either in the cut or uncut beds of kelp.



Tagging experiments show no significant movements of kelp bass in either cut or uncut kelp beds.

Kelp harvesting increases the density of the kelp plants in the beds by allowing light to reach the bottom, making it possible for new plants to grow. This was clearly demonstrated when a section of the La Jolla beds was allowed to remain uncut. The uncut portion became straggly and sparse, while the cut portion became denser.

In addition harvesting thins the dense canopy, thereby reducing the drag which uproots whole plants during storms, and reducing the natural sloughing. These changes prevent the beds from being destroyed and cast on the beach.

The La Jolla-San Diego kelp beds are heavily fished by sportfishermen and are the most cut by the harvesters. It is significant to note that sport boats congregate in the most recently harvested areas in the La Jolla region.

Reports of fish eggs in the canopy were always investigated and were all found to be inaccurate. For the most part, the reported "eggs" were encrusting bryozoans or mollusk eggs. The fish eggs of the tiny 1-inch-long kelp clingfish were collected on board the kelp harvesters on several occasions. No other fish eggs were found on board the kelp cutters, despite prolonged and intensive search by the author, Dr. Hubbs, and others.

Reports that large numbers of larval sport and forage fish utilize the kelp beds as a nursery ground were the result of misidentification of larval and juvenile topsmelt, which are readily and certainly identifiable by an expert using a microscope. They were believed to be young sardines, mackerel, yellowtail, or even barracuda. Kelp topsmelt and island topsmelt are extremely abundant in the canopy during their larval and juvenile stages. However, their abundance has remained at a high level. They seem to be slightly more abundant in the harvested kelp beds. Sufficient cover is always available for these fishes after harvesting.

A number of fishes have been collected on board the harvesters. Most of them are small and insignificant, even as forage. The numbers are extremely small as compared with sportfish or commercial fish catches.

The weight of fishes brought on board ranges from 5 to 20 pounds per 100 tons of kelp; an estimated one-third of this weight is considered sport and forage fish. An estimate of sport and forage fish taken, based on these figures, amounts to between one and two tons per year, an extremely small figure when compared with the sport and commercial fish catch.

Fishes Collected on Kelp Cutters

Forage fish:	Cololabis saira, saury
Food and game fish:	Paralabrax clathratus, kelp bass
	Atherinops affinis, topsmelt
	Embiotoca sp., ocean blackperch
	Girella nigricans, opaleye
	Sebastodes serranoides, olive rockfish
	Sebastodes atrovirens, kelp rockfish
	Sebastodes rastrelliger, grass rockfish
	Scorpaenichthys marmoratus, cabezon
Non-forage, non-game fish:	Brachyistius frenatus, kelpperch
	Oxyjulis californica, señorita
	Syngnathus californiensis, kelp pipefish
	Rimicola muscarum, kelp clingfish
	Heterostichus rostratus, kelpfish
	Gibbonsia metzi, weed klipfish
	Xererpes fucorum, rockweed gunnel
	Ulvicola sanctaerosae, kelp gunnel

FISH TRAPPING AND TAGGING

Trapping, marking, and recovering marked fish were important phases of this investigation. This work was done in the La Jolla kelp beds.

TRAPPING

Fish were collected by means of chicken-wire traps with steel concrete-reinforcing rod frames. A cylindrical trap 5 feet in diameter and 2 feet tall with three funnel-shaped openings proved to be the most satisfactory for kelp bass. Traps of this size and shape tended to tangle with the kelp less than traps of other designs. Their large size lessened poaching.

The traps were baited with ground fish. Mackerel and other nearshore pelagic forms were preferred by the fishes. The traps were pulled a number of times each day. Between one and two hours seemed to be the optimum time for collecting kelp bass.

The depths at which the traps were placed varied from just below the surface to the bottom, at depths of 20 to 90 feet. Most of the traps, however, were placed on the bottom, because they fished better there. The average depth was approximately 40 feet.

The traps that were left out overnight tended to fill with lobsters, which killed the fish. Certain species of fishes were found more abundantly in the morning, presumably because they are nocturnal and were captured during the night. The most prominent of this group was the black croaker.

Traps left longer than a day or two became badly entangled with seaweeds and many of them were lost. A number of traps disappeared during storms and a few were cast ashore. Several traps were known to have been stolen.

Divers salvaged many of the traps. In spite of this, however, the trap loss was about 50 percent for a 30-day period.

The collecting effort was directed toward collecting kelp bass. Over 45 percent of the trapped fishes were kelp bass. The success in collecting such a high proportion of one species was due in part to the large numbers of this species available, to the design of the traps, to a knowledge of the habits of this fish and to a familiarity with the bottom topography.

It may be noted from the following chart that 10 of the 38 species trapped make up over 80 percent of the total fishes collected.

The list correlated well with the fishes a fisherman could expect to catch, fishing near the bottom in the La Jolla kelp beds. A spear fisherman, however, would have a slightly different catch owing to his ability to take opaleye and halfmoon, which are predominantly herbivorous, and a variety of other fishes which have specialized feeding habits.

Fishes Trapped at La Jolla During 1952 and 1953

Fish	Number of Specimens	Percent of Total
Paralabrax clathratus	908	45.84
Gymnothorax mordax	288	14.54
Embiotoca sp.	144	7.27
Sebastodes, including: S. mystinus S. atrovirens S. rastrelliger S. carnatus	79	3.99
Scorpaena guttata	75	3.79
Hypsypops rubicunda	64	3.23
Oxyjulis californica	61	3.08
Heterostichus rostratus	52	2.62
Hyperprosopon argenteum	43	2.17
Cheilotrema saturnum	41	2.07

Chromis punctipinnis	37	1.87
Pimelometopon pulchrum	36	1.82
Urobatis halleri	20	1.01
Scorpaenichthys marmoratus	19	0.96
Rhacochilus toxotes	17	0.86
Halichoeres semicinctus	15	0.76
Sebastodes serriceps	14	0.71
Girella nigricans	11	0.56
Paralabrax nebulifer	7	0.35
Hypsurus caryi	7	0.35
Brachyistius frenatus	7	0.35
Paralichthys californicus	6	0.30
Damalichthys vacca	5	0.25
Pleuronichthys coenosus	4	0.20
Anisotremus davidsoni	4	0.20
Medialuna californiensis	4	0.20
Heterodontus francisci	3	0.15
Xenistius californiensis	2	0.10
Caulolatilus princeps	2	0.10
Citharichthys stigmaeus	1	0.05
Hypsopsetta guttulata	1	0.05
Menticirrhus undulatus	1	0.05
Micrometrus minimus	1	0.05
Artedius creaseri	1	0.05
Porichthys myriaster	1	0.05
Total:	1,981	100.00

FISH TAGGING

Cooperating with the California Department of Fish and Game, we tagged 1,500 kelp bass in the La Jolla area during 1952 and 1953. In addition to those tagged at La Jolla, the Department of Fish and Game tagged 3,500 kelp bass in the southern California region. Approximately 12 percent of the tagged fish have been recovered.

With the data obtained during tagging and from tagged fish recovered, the growth rate, movements, population size, and fishing pressure were analyzed. In the La Jolla area, emphasis was placed on analyzing small movements and movements in relation to kelp harvesting (Fig. 13).

The growth rate of the kelp bass was determined to be relatively slow. The bass were observed to reach a length of approximately 90 to 115 mm. (3.5 to 4.5 inches), in the summer at the end of their first year (the peak of spawning is in June, July, and August). Maturity is reached at the end of the second year at a length of about 180 to 230 mm. (7 to 9 inches), as determined by plotting the sizes of tagged fish (Fig. 14). At the end of their third year, they average 255 to 295 mm. (9.5 to 11.5

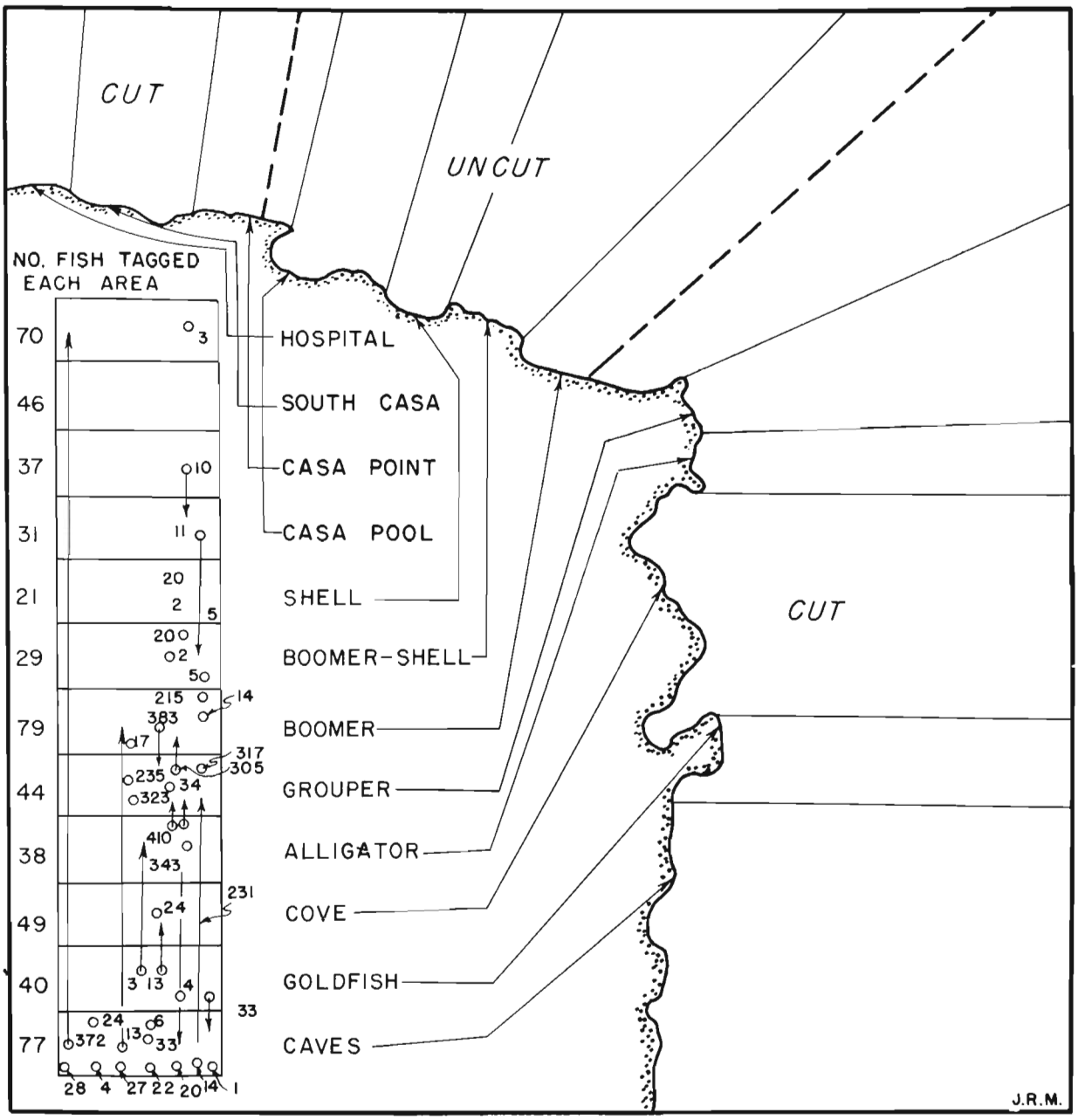


FIGURE 13. Represents the movements of tagged kelp bass in the La Jolla kelp beds in both cut and uncut areas.

In the diagram at the left the column of rectangles represents the areas in which the fish were tagged. The numbers at the left represent the numbers of kelp bass tagged in each area. Each small circle represents the place of tagging and release of each recovered kelp bass. The arrows represent the movements from one area to another. The numbers represent the number of days each fish was out before it was caught again.

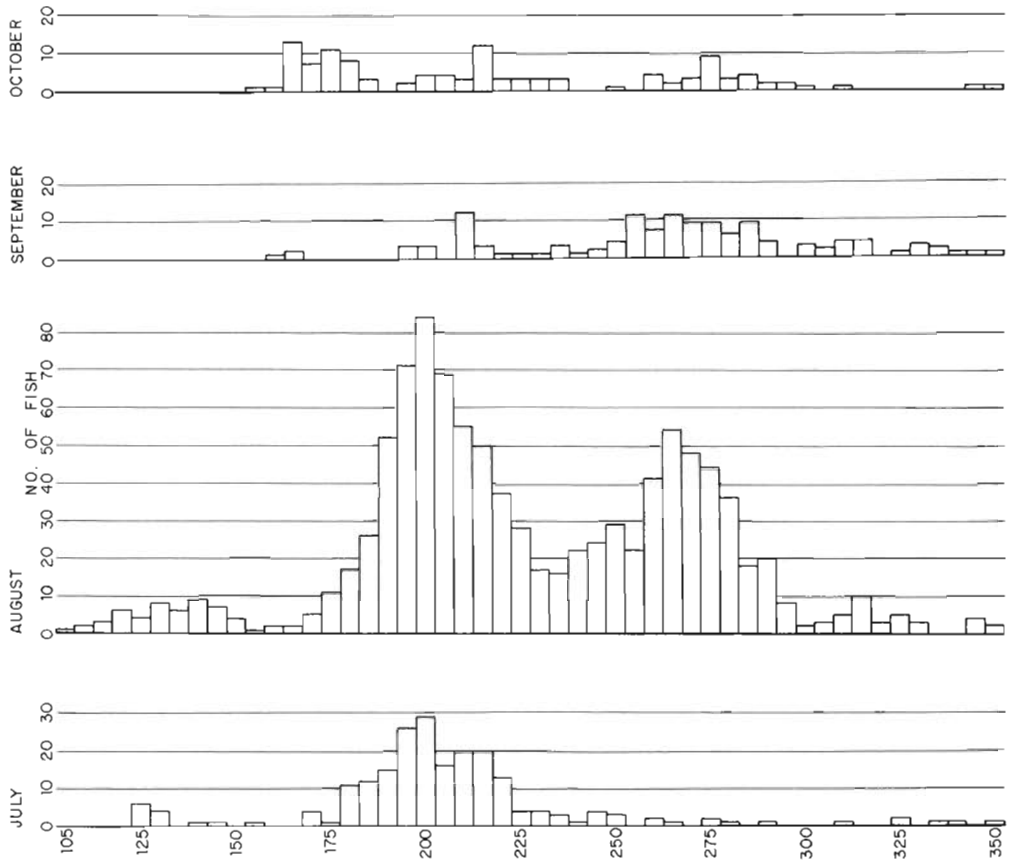


FIGURE 14. The numbers of individual kelp bass are plotted in size classes by months to show the age classes. The month of August shows the 2 and 3 year old peaks with a possible peak for 4 years.

The slight shift downward from July to October in the peak of the 2-year-olds represents growth rate.

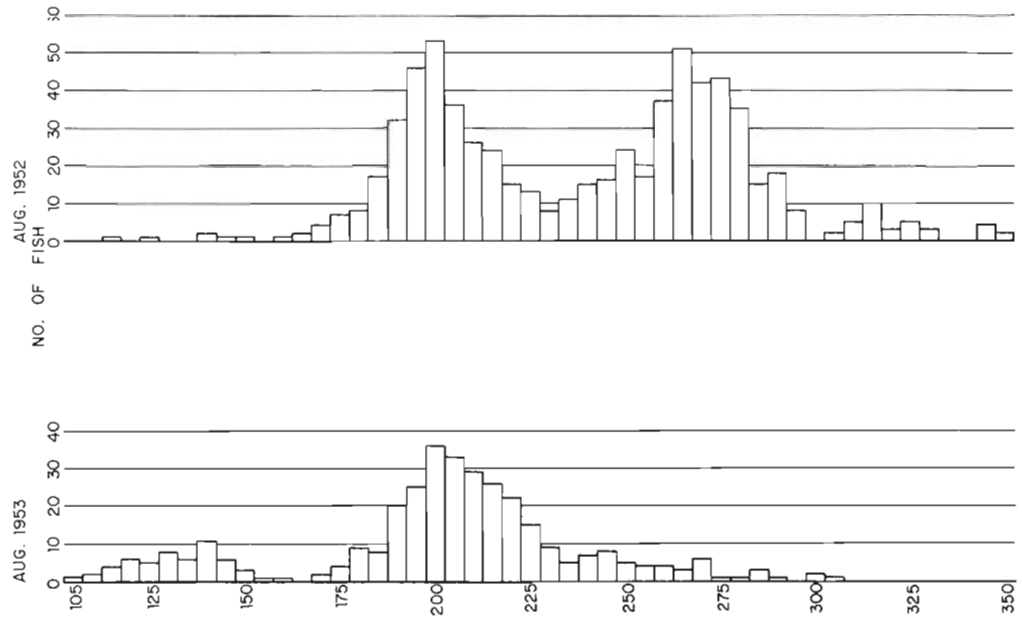


FIGURE 15. The sizes of the kelp bass are plotted against frequency. In the August, 1952, population, the two major peaks represent the 2- and 3-year-old kelp bass. In August, 1953, the 3-year-old peak which represents the August, 1952, 2-year-old peak is missing. The factors which might contribute to this are probably either a poor year class, heavy fishing intensity, or a slight difference in my collecting methods.

inches). The year-classes become obscure after the third year, but growth rates calculated from measurements of returned tagged fish indicate that the older the fish, the slower it grows.

Movements of kelp bass analyzed by the California Department of Fish and Game showed no significant movements for 95 percent of the kelp bass in either cut or uncut kelp beds. Fish moved from their place of first capture to a new location and released showed significant movements. A higher proportion of these fish were recovered. Apparently once removed from their original habitat they continue to move. Possibly the available niches are filled, or possibly they are searching for their original surroundings.

Minor movements were noted in the La Jolla kelp beds, but few were significantly longer than normal movements of diver-pursued specimens observed in situ. Part of the bed was left uncut as a control, to determine if fish move from the cut into the uncut beds, but the movements could not be correlated definitely with harvesting (Fig. 13). Of the 153 bass tagged in the southerly cut section where the bed is particularly wide, and continuous with the beds running to off Mission Beach, only two were recovered, one in the cut area and one in the adjacent uncut area; one of the two tagged bass caught in the southern cut area came from the far end of the northerly cut area, having passed through the entire uncut area. The few returns from the southern cut sections are attributable to the low proportion of fish tagged here. Of the 160 bass tagged in the intervening uncut area, eight were recovered, of which one had moved into the adjacent cut section. Of the 153 tagged in the southerly cut sections, only one was recovered in the uncut area, suggesting that no great influx had occurred. Of the 248 tagged in the northerly cut sections, where a higher proportion of the fish were tagged, only two were recovered in the adjacent section of the uncut area. Of the 23 others recovered, 22 were still in the northern cut area, one in the southern cut area. Obviously the tagged fish showed no significant tendency to seek refuge in the uncut area, despite the fact that the handled, marked, and often somewhat displaced fish would be expected to wander more than fish not so disturbed.

A population size of less than, but near, 2,147 kelp bass 6 inches or over in total length was calculated for September, 1953, in the La Jolla area from Boomer Beach to the Caves. This heavily fished area has many factors which contribute to a high bass population. The bottom, rocky into shore and out to depths of hundreds of feet, provides many niches for cover. Heavy growths of ribbon kelp and eelgrass provide nursery grounds in a baylike environment near a biologically rich submarine canyon head.

During September 15 to 25, 1953, a diving survey revealed 9 tagged kelp bass out of 161 kelp bass over 6 inches in total length counted in this area. Estimates based on tag losses experienced by the California

Department of Fish and Game indicate that 4 percent or 16 fish of the 400 fish tagged here in 1952 should still be alive and retain tags. Of the 327 bass tagged in July and August, 1953, the Fish and Game tag-survival data would indicate that about 104 should have retained tags between September 15 and 25, 1953. From these figures, the bass population in the area can be calculated, as follows:

$$\frac{\text{Tagged fish observed}}{\text{Fish observed over 6"}} = \frac{\text{Tagged fish in area}}{\text{Fish in area over 6"}}$$

$$\frac{9}{161} = \frac{16 + 104}{X}$$

$$X = 2{,}147 \text{ (fish in area over 6")}$$

Fishing pressure is extremely high in this area. Live-bait boats from San Diego and Oceanside fish the La Jolla kelp beds consistently during the warmer half of the year. Small boats launched at the head of the La Jolla submarine canyon fish the beds throughout the year. In addition to the sportfishing pressure, the commercial lobster fisheries probably have an indirect effect on the population. Kelp bass trapped during the day fall victims to morays and lobsters during the night.

Length frequencies plotted for August, 1952, and for August, 1953, (Fig. 15) show a definite decline in the numbers of fish three years old and older. This may be due to overfishing, to a poor year-class, or to differences in collecting techniques.

In areas where there is sufficient cover from the shallow sub-tidal zone to depths of 60 feet or more, the young bass makes the shift from shallow to deep water without incident. However, in areas where cover is provided only in shallow water, the young fish are probably forced to make a break and travel long distances to new cover. During this movement they are susceptable to predation for lack of cover. In those areas where cover is provided only in deeper water, recruitment is spotty and less dependable. In specific areas artificial cover in small amounts might increase the kelp bass population significantly. In any event, such experiments relative to other organisms should be made in the near future.

SUMMARY AND CONCLUSIONS

An intensive study of the fish life in the kelp beds and the effects of kelp harvesting on fish life was carried out over a five and one-half year period.

The extensive kelp beds along the southern California coast are inhabited by a large number of fishes. Most of them live near the bottom, associated not with the kelp, but with the rocky substrate. Of the 125 species of fish found to occur in the kelp beds, most are wanderers and bottom species completely independent of the kelp itself. Most of them are inedible and uncommon species, not abundant enough to serve as forage for other fishes.

Many pelagic and semi-pelagic forms are associated with the area immediately beyond the kelp beds. This group of fishes represents a few of the prized game fish such as yellowtail and barracuda, which are common in areas where no kelp grows.

Certain fishes seek cover in the kelp beds. A few, such as the extremely abundant topsmelt, even seek cover in the surface kelp.

The eggs of certain species of non-game fish have been found in the surface kelp, but their economic importance is negligible.

The young of some fishes occupy the surface kelp. The important species include the always abundant topsmelt. Young kelp bass are common in the surface canopy. However, the numbers are insignificant when compared with those found inshore along the bottom.

Specific forage for kelp-bed fishes in the form of small organisms is always present in the canopy as well as at lower depths, even after harvesting.

Harvesting has had no detrimental effects on fish populations. Those species most closely associated with the harvested area maintain high population levels.

Contrary to popular belief, harvesting methods now employed do not destroy kelp beds, but instead actually cause them to grow thicker by allowing light to penetrate to young plants far below.

Harvesting has had no detectable detrimental effect on fishing. In no stage in the life of game fishes are they destroyed or even seriously bothered by harvesting methods. Sufficient cover and forage are always available, even after harvesting.

SUGGESTIONS FOR FUTURE STUDIES

This study has opened new possibilities for research, many of which would benefit the fisherman and even a few which would benefit both the fisherman and the kelp harvesting companies.

LIFE HISTORY STUDIES OF GIANT KELP

Many stages in the life history of giant kelp have been studied, but the overall picture of its growth and development is not thoroughly understood.

Growth rate, length of life, methods of reproduction, conditions of reproduction, and ecological relationships with invertebrates are special problems within a life-history study that need attention.

The answers to the following questions would be totally or partially answered by such an investigation:

(1) What caused the destruction of certain kelp beds?
(2) Why haven't such beds been replaced by natural processes?
(3) Can man profitably cultivate new kelp beds by use of artifical substrates?
(4) How can we prevent the destruction of and improve the existing kelp beds?

KELP DISEASE STUDIES

Little is known of the diseases which affect kelp. A thorough study in this field might answer such questions as:

(1) Do diseases kill kelp or destroy kelp beds?
(2) Does harvesting eliminate or spread such diseases?
(3) Do kelp infections have adverse effects on animals living in or near the kelp beds?

NORTHERN KELP BEDS

The kelp beds above Point Conception which are not currently harvested have a radically different fish fauna than the southern California beds.

A study of these beds would benefit the fisherman of that area and would help the biologist to answer such questions as:

(1) Will harvesting affect fishing in this area?
(2) What is happening to specific fish populations associated with the kelp?

POLLUTION

A study of pollution is urgent. Obvious effects have been observed on organisms in the Whites Point area in Los Angeles County. Strong evidence suggests that pollution in certain areas has reduced or completely destroyed kelp beds.

BEACH EROSION IN RELATION TO KELP HARVESTING

Additional studies on the possible relationship of kelp harvesting to beach erosion are needed. In all probability the beaches would receive more protection from properly harvested beds.

STRIP CUTTING OF KELP BEDS

A study of strip cutting of kelp beds has been suggested by Dr. Carl L. Hubbs and by several sportfishing groups. In my opinion such a study would be of scientific value only if it were carried out under the supervision of a competent biologist. It would have some value in temporarily bettering the relations between fishermen and kelp harvesting companies. However, if the study is improperly conducted, this better relationship would be completely destroyed.

The need for more study of fishing problems is always evident. However, the amount of funds and the number of competent investigators is limited. Proper emphasis must be placed on the need for additional studies. Each problem must be carefully considered as a part of a single idea--conservation through proper use.

APPENDIX

HABITS OF THE FISHES FOUND IN THE KELP BEDS OF SOUTHERN CALIFORNIA

Branchiostoma californiense Andrews -- California lancelet

The adults grow to a length of about 3 inches. Their color is translucent pink. They are slender and lance-shaped. They live burrowed into the soft substrate of mud or fine sand. They were observed during this investigation from the intertidal mud-sand at Newport Beach to depths of 100 feet at Santa Cruz and Santa Catalina Islands. Observed distribution in this investigation was Newport Beach, La Jolla, Santa Cruz Island, Santa Catalina Island. They were observed only in the spring and summer, but observations were too few to be significant.

These tiny, almost wormlike, animals live buried just beneath the surface in the fine sand or mud. A slight pressure on the bottom causes them to swim out of the sand or mud and quickly re-burrow a few inches to a foot or more away.

They have no known significant relationship with giant kelp.

Heterodontus francisci (Girard) -- horn shark

Large adults may reach a length of 4 feet. The color is a kelp brown above to a lighter brown below, with scattered small black dots. The body is not as streamlined as in other sharks. The head is blunt with ridges over the eyes. A thick horny spine is located in front of each dorsal fin.

Horn sharks live among rocks in the shallower waters, usually with their heads in a crevice. They were observed at depths averaging 18 feet, ranging from shallow tide pools to 55 feet, with most of the population concentrated between 8 and 35 feet.

The observed distribution in this investigation was Newport Beach, Laguna Beach, La Jolla, on the California mainland; Bahía San Carlos, Punta Blanca, Bahía Playa María, Punta Rocosa, Bahía Santa Rosalía, and Bahía Magdalena, on the Baja California mainland; Santa Cruz and Santa Catalina Islands of California, and the Coronado Islands of Baja California. They were observed throughout the year.

They feed on crustaceans and small fishes.

A few scattered eggs have been found at Catalina Island, La Jolla, and Magdalena Bay during summer and fall. The large stiff eggs take 8 to 9 months to hatch.

Young specimens have been observed on a few occasions at Catalina Island and La Jolla during the early summer through late fall.

Horn sharks are prized by certain skin divers who collect them with spears or bare hands. The spines are utilized as ornaments and the shark discarded. This fad may have reduced the population in highly fished areas. They are taken incidentally by fishermen on set lines and in lobster traps. When disturbed this shark will bite and hold on tenaciously for a number of minutes to half an hour.

This shark has no known significant relationship to giant kelp and enters the beds only rarely.

Cephaloscyllium uter (Jordan and Gilbert) -- (California) swell shark

Adults of this species reach a length of 3 feet. The general color is brown above, marked with dark saddles on the back and with round blackish dots. The underside is yellowish. The head is blunt and rather flat. The abdomen is loose and can be greatly inflated.

The habitat of this shark is the rocky areas at depths averaging, as observed, 39 feet, with an observed range of 25 to 50 feet. It was observed in this investigation at Goleta and La Jolla on the California mainland; Santa Catalina Island, California; and San Benito Islands, Baja California. It was observed only in the summer and fall, but observations are entirely too few to be significant.

Swell sharks feed on rotting fish and probably some living organisms. They probably forage at night and rest in crevices during the day.

A living egg was found in June at Goleta, California, at a depth of 25 to 50 feet. An empty egg case was found in September at Catalina Island at a depth of 75 feet.

One half-grown specimen was collected in June on Catalina Island at a depth of 35 to 50 feet.

Little is known of the habits of swell sharks except that they are generally caught at night in fish or lobster traps. Formerly they were quite common and were utilized as lobster bait. However, they were quite rare during this investigation and a lobster fisherman may fish an entire season without catching one in his traps.

This shark has no known direct relationship to giant kelp, but lives at similar depths and on similar substrates.

Triakis semifasciata Girard -- leopard shark

Adult females reach a length of 6 feet and males may reach a length of 4 feet. The color is dark gray above to light gray below. The back is marked with black saddles interspaced with black spots. This shark is more streamlined than the previously mentioned sharks and is quite slender.

Leopard sharks are generally found in shallow bays and coves, often close over cobble bottom. They prefer depths averaging 12 feet, but range from the surface to 35 feet, with most of the population between 3.5 and 25 feet. They were observed at the following localities: Newport Beach and La Jolla on the mainland and Catalina Island, California; Bahía Blanca, Punta Blanca, Bahía Playa María, Punta Rocosa and Punta San Rosarito on the Mexican mainland, and the Coronado and San Benito Islands, Baja California. They were observed from early spring through late fall. None was seen in the winter in California.

Stomach contents reveal crustaceans and small fish.

The young were collected in the winter and early spring. Half-grown specimens were observed in the fall. The adults are viviparous.

Leopard sharks are gregarious and large schools mixed with the gray smoothhound (Mustelus californicus) are sometimes seen in extremely shallow water. They aggregate at particular coves, although they do not remain for long periods. They may remain for several days or for only a few hours, and then move out. The extremely heavy aggregations may be related to breeding. Adult females collected from these groups contained almost mature embryos.

Leopard sharks are taken by hook-and-line fishermen and spearfishermen, and although they are excellent eating, most of them are discarded after being killed.

They have no known significant relationship to giant kelp and only rarely enter the shallower bottom portions of the harvested beds.

Prionace glauca (Linnaeus) -- blue shark

This shark was observed to reach an estimated 10-foot length. The color is gray-blue above to white below. They are heavier and more vicious-looking than the leopard shark. They have a relatively large mouth with sharp cutting teeth.

They are pelagic and are commonly observed at sea with their dorsal and caudal fins projecting through the surface. When disturbed, they disappear into deeper water. Occasionally they are encountered at the outer edges of the surface kelp, especially around islands.

They were observed at the following locations during this investigation: 8 to 10 miles off the Farallon Islands, 15 to 20 miles off San Francisco, 10 to 20 miles off Carmel, 2 to 6 miles off Anacapa Island, Santa Cruz Island, and Santa Rosa Island, off Catalina Island, 10 to 20 miles off San Pedro, over the Cortes Bank, off La Jolla, off San Diego, off Coronado Islands, off Guadalupe Island, off Cedros Island, and 200 miles off Bahia Magdalena.

They are vicious carnivores.

Blue sharks are viviparous. No young were observed among hundreds of individuals at the surface although half-grown individuals were quite common.

They are caught incidentally on hook and line and are considered good eating and excellent game fish by sportsmen. They are capable of killing a man and have been reported to have attacked the victims of a boat explosion off Santa Monica.

Blue sharks have no known significant relationship to giant kelp, but may feed on kelp-dwelling fishes on the outer edges of the beds.

Squatina californica Ayres -- (California) angel shark

Adults may reach a length of 4 feet. The color is sandy gray speckled with darker spots above, and white below. Unlike the typical sharks, they are flattened and have extremely large pectoral fins. Superficially they look more like rays than sharks. They have typical sharp shark teeth.

They live buried in sand, especially near rocks and around submarine canyon heads. They prefer depths averaging 64 feet, with an observed range of 15 to 150 feet. Most of the population was concentrated between 40 and 100 feet.

The observed distribution in this investigation was Point Dume, Redondo, Whites Point, and La Jolla on the California mainland; and San Miguel, Santa Cruz, and North Coronado Islands offshore.

They have no special season and occur throughout the year in southern California.

They feed on active fishes such as corbina and queenfish.

No young or half-grown specimens were observed in nature. Young were born to a female collected during the summer at La Jolla at a depth of 18 feet. The young were slightly premature and did not survive more than a few days.

Angel sharks are sluggish creatures with extremely tough skins. They lie buried in the sand with only their eyes and upper portions exposed. Occasionally they will snap with surprising vigor when disturbed. The bite of this shark could be quite dangerous. They should be considered a hazard to skin divers.

They are caught by hook and line fishermen, speared by sport divers, and occasionally collected with bare hand by skin divers.

They have little relationship to giant kelp, but prefer it to barren sandy areas.

Rhinobatos productus (Ayres) -- shovelnose guitarfish

Adults may reach a length of over 4 feet. They are uniformly gray-brown above and white below.

These guitarfish live in shallow sandy areas at an average observed depth of 17 feet. They range from shore to depths of 50 feet with most of the population concentrated between 3 and 40 feet. Observed occurrences in this investigation were at Point Dume, Newport Beach, Laguna Beach, La Jolla; Punta Blanca, Playa María, and Santa Rosalía Bays; and the Coronado Islands. They were observed from early spring until fall. None was observed in the winter.

They feed on worms and crustaceans in the shallow water.

Mating behavior was observed during the summer months. On one occasion a pair of adults was observed on a sandy patch at a depth of 18 feet at La Jolla. The male was thought to be using his nose in preparing the female for copulation. The female rested apparently unconcerned while the male pushed the female in the area of the genitalia with his rostrum. The courtship was cut short when my presence disturbed them.

On another occasion at a similar depth at La Jolla a diver, Charles Fleming, was the unharmed victim of an unprovoked attack by a male from a pair of guitarfish. Mr. Fleming was collecting sand dollars, swimming to the bottom and then returning to the surface for air. Two guitarfish, a female followed by a male, were passing close to the bottom, about 10 to 12 feet away. The female made a deliberate turn and left the bottom 12 to 16 feet to pass close to me, then drop down to Mr. Fleming and go on. This same route was followed, close behind the female, by the male. As the male came close to Mr. Fleming, who was by now working on the bottom with his feet 4 to 5 feet above, the guitarfish deliberately bit him on the calf of the leg.

Young appear in the summer and fall. Half-grown individuals were observed in the fall and spring.

Shovelnose guitarfish are gregarious, often occurring in tremendous numbers. They prefer to burrow into the sand when resting. They do not remain much more than a day in any one area. They appear to be more common in the summer.

They are caught by hook and line fishermen and skin divers. They are excellent eating but are rarely saved by sportsmen.

They have no known significant relationship to the giant kelp and only enter the sandy shallow portion of the harvested beds.

Zapteryx exasperata (Jordan and Gilbert) -- mottled guitarfish

Adults may reach a size of slightly over 3 feet. They are dark brown banded with irregular black bars. The underside is cream splotched with black. They are shorter and heavier than the shovelnose guitarfish.

They inhabit the rocky areas, particularly flat-bottomed crevices and caves. They were observed at depths averaging 24 feet, but ranging from tide-pools to 70 feet. The majority of the population was concentrated between 8 and 30 feet.

They were observed at the following localities during the investigation: Newport Beach, La Jolla, Bahía Playa María, Punta Rocosa, Bahía Santa Rosalía, Guaymas, and the Coronado Islands. They were observed throughout the seasons but fewer in the winter.

The food habits were not investigated.

Mating probably occurs in the summer. A female was observed to follow a male being carried by me underwater. The pair was observed together at a depth of about 20 feet off La Jolla in the summer.

One young specimen was observed during this investigation, and collected in November.

Unlike the shovelnose guitarfish, the mottled guitarfish seldom burrow, but rest among the rocks, usually with their heads in crevices.

Skin divers collect them by hand to demonstrate their diving skill.

They have no known relationship to giant kelp, but are correlated with nearshore rocky bottoms.

Platyrhinoidis triseriata (Jordan and Gilbert) -- (California) thornback

Specimens observed in this investigation ranged up to a maximum size of 15 inches. The color is gray-brown on top and white below. The general outline is that of a banjo. Along the back are three rows of non-toxic spines.

Thornbacks live in fine sand to mud bottoms, where they remain buried most of the time. They were observed at depths averaging 26 feet, ranging from shore to 150 feet, with most of the observed population between 3 and 100 feet.

They were observed at the following localities during this investigation: Point Arguello, Newport Beach, La Jolla, San Carlos and Santa Rosalía Bays, Santa Rosa, and Santa Cruz Islands. They are found throughout the year.

The food taken from a few stomachs was predominantly sand-dwelling worms.

Adult males taken from a set-line in September were observed to drip milt from their claspers. Embryos were found in heavy females in August.

Thornbacks are somewhat gregarious wanderers, appearing for short periods at certain localities and then moving on.

They are taken by fishermen incidentally, but are not utilized for food. They usually swallow the bait and the recovery of the hook necessitates taking the life of the animal.

They have no known direct relationship to giant kelp but prefer the fine sand below the kelp to the barren sand bottoms.

Dasyatis dipterurus (Jordan and Gilbert) -- diamond stingray

Those observed in this investigation ranged up to 4 feet in width. The color is dark brown above and white below. They have one or more rather large serrated and poisonous spines at the base of the tail.

They prefer sandy areas near rocks or kelp. In southern California during the summer they inhabit the shallow water at depths averaging 7 feet, ranging from shore to 20 feet. During late fall and winter they inhabit deeper water at an average observed depth of 48 feet, with the population concentrated between 40 and 55 feet.

They were observed at La Jolla and Guaymas.

They were observed from midsummer through midwinter. None was seen during the spring months in southern California. They burrow and cover their backs with sand. No young ones were observed and only a few half-grown or small adults were observed. The food habits were not investigated.

These stingrays have no known relationship to giant kelp. They were more numerous around the kelp than on the flat sand bottom during the winter.

Urobatis halleri (Cooper) -- round stingray

Adults attain a length of over 1 foot. The color varies with the substrate. In general they are light to dark gray-brown with small light dots. The anterior part of the animal is a disk. The tail has a poisonous spine near its base.

Round stingrays live in all shallow water, sand and mud bottoms of southern California, including bays and sloughs. They were observed most commonly at depths of about 15 feet, ranging from the surface to 70 feet, with most of the population concentrated between 3 and 50 feet.

They were observed at the following localities during this investigation: Santa Monica, Redondo, Cabrillo, Newport Beach, La Jolla, Bahía Blanca, Playa María, Punta Rocosa, San Rosarito, and Santa Rosalía bays, Bahía Magdalena, Bahia Los Angeles, San Felipe, and Guaymas.

They are observed throughout the year. The food consists of worms, small crustaceans, and mollusks. Half-grown specimens were observed in the winter.

Round stingrays are edible, but seldom utilized. They are a nuisance to bathers. According to Dr. Bruce W. Halstead, who is making a special study of venomous fishes, about 75 people are stung in southern California each summer month. Most of the cases required a doctor's attention. The rays are not aggressive, but will sting when stepped on. The tremendous concentrations in which they sometimes occur make it difficult to wade in safety.

They have no known relationship with giant kelp.

Holorhinus californicus (Gill) -- bat ray

Adults reach a width of 4 feet, 2 inches. The top is uniform dark brown, almost black, and the underside is white, except near the tips of the wings. They have a long ratlike tail which is almost always incomplete, probably bitten off by predators. A sharp poisonous spine lies at the base of the tail.

The preferred habitat is a flat rocky bottom, or sand patches among rocks. The average observed depth is 26 feet, with an observed range from the surface to 150 feet. Most of the population is concentrated between 8 and 100 feet. They are found in southern California throughout the year.

Bat rays were observed at the following localities during this investigation: Point Dume, Palos Verdes Coves, Long Point, Newport Beach, La Jolla, Bahía Playa María, Punta Rocosa, Bahía Santa Rosalía, Santa Rosa, Santa Cruz, Santa Catalina, and the Coronado Islands.

In the rocky environment they feed chiefly on shellfish, including abalone, wavy-top and smooth-top snails. They crush the shell with a pair of crushers, spit out the broken shell and swallow the animal. Because they feed so heavily on abalones they may be a host of the abalone worm.

Mating behavior was observed twice. At Punta Rocosa, Baja California, in August, at a depth of approximately 20 feet along a sandy bottom inside a rocky reef, bat rays were numerous, resting on the bottom and swimming freely a few feet above the bottom. A medium-sized female was being followed closely by two smaller males. The head of one male was under the female, pushing her in the region of the genitalia. Identical behavior was observed from the Scripps Institution pier in August. The water depth was about 15 feet, over a sand bottom. The female was quite large and the two smaller males only about 2 feet across. The activity took place within a couple of feet of the surface.

Young bat rays appear in late summer and fall. Half-grown, sub-adults or small adults appear throughout the year, but nearshore are usually most abundant, sometimes inordinately so, in summer.

Adults tend to aggregate in similar size groups. These aggregations may be observed resting on the bottom or swimming far at sea.

Solitary adults and young are not uncommon. And occasionally they may be observed resting on the kelp.

They are taken occasionally by hook-and-line fishermen, and are considered good sport. A yearly derby in northern California even considers them in its prize awards.

They have only a remote relationship to giant kelp. They feed on seaweed-eating mollusks which include some giant kelp in their diet.

Torpedo californica Ayres -- (California) electric ray

The electric rays may grow to a length of over 3 feet. They are dark bluish, fairly uniform gray. The skin is of smooth texture, but has wrinkles even in life.

They prefer fine sand bottoms, but are not uncommon around rocks or in the kelp beds. They have been observed at depths of 30 to 140 feet, averaging 75 feet. Most of the population is concentrated between 40 and 100 feet.

They were observed at the following localities: Whites Point, La Jolla, and Coronado, and Guadalupe Islands. They are present in southern California throughout the year.

The food habits were not investigated. No young or half-grown specimens were observed.

The sluggish electric rays are geared to a life protected by a powerful electric shock. They burrow into the fine sand and rest or feed there, or wander slowly and apparently aimlessly close to the bottom. They are solitary, but two or three sometimes bury within 30 to 60 feet of each other.

They are taken by curious and unwary spearfishermen, none of whom has reported being shocked.

They have no known relationship to giant kelp, but rarely enter the kelp, probably accidentally.

Sardinops caerulea (Girard) -- (Pacific) sardine

Adults observed in this investigation reached an estimated maximum size of 10 inches. They are blue above, silver below, with a row of blackish dots along the sides. They are roughly cigar-shaped.

Pacific sardines are nearshore pelagic fish that school close to shore at observed depths from the surface to 40 feet (they probably go much deeper).

They were observed only in the summer months, at the following localities, during this investigation: La Jolla, San Carlos, Santa Rosa, Punta Rocosa, Santa Cruz Island, Santa Catalina Island, San Benito Islands, and Guadalupe Island.

They feed on plankton forms which they strain with their gillrakers, but also take individual particulate plankton.

The eggs and larvae are pelagic. Young specimens were collected at Guadalupe Island, San Benito Islands, and at Punta Rocosa near shore.

Sardines are important as forage for most of our game fishes. They are utilized as live bait by sportfishermen and canned commercially. They are caught in round-haul nets and purse seines. In recent years there has been a drastic reduction in the number of available sardines, probably owing to a combination of oceanographic conditions and heavy fishing pressure.

There is no known relationship between sardines and the giant kelp, which they enter occasionally, especially when driven by barracuda, yellowtail, mackerel, or bonita. More often they are driven away by kelp bass and other inhabitants of the kelp and rocky substrate. They do serve in part as forage for many fishes that inhabit the kelp beds.

Engraulis mordax mordax Girard -- Ocean northern anchovy

These slender-headed and rather slim-bodied fish were observed to reach a maximum length of about 6 inches. Their color is blue above and silver below.

They are nearshore pelagic fish and were observed from the surface to 50 feet, but probably they range much deeper. The dense schools of anchovies move along shore, apparently most commonly along the sandy shores. Their presence is often marked by birds, sea lions, or predaceous fishes.

They were observed at the following localities: Santa Monica, La Jolla, San Carlos, Bahía Colnett, Santa Cruz, Santa Catalina, and Guadalupe Islands.

They occur throughout the year, although they seem most abundant in the summer.

The eggs and small larvae are pelagic. The larger larvae tend to school close over the bottom at estimated depths of 35 to 55 feet. Juveniles and sub-adults school in patterns similar to the adults.

Anchovies school in tremendous numbers. The schools avoid solid objects and interfaces, remaining a foot or two below the surface and several feet over the bottom. White seabass and sea lions are allowed to pass through tunnels which form at the approach of the animal and which close behind them.

Many fishes utilize this species as forage and man utilizes it as bait.

There is no known relationship between this fish and giant kelp, although it is utilized as forage by kelp fishes when the anchovies come near or enter the kelp beds.

Cololabis saira (Brevoort) -- (Pacific) saury

This fish has been observed during this investigation to attain a length of up to an estimated 11 inches. The color is blue above, silver below. It is a very slender, thin fish with a delicate skin.

Sauries are pelagic and apparently prefer the surface area, often only a few inches down. They were observed at the following localities: La Jolla, Santa Rosa Island, Santa Cruz Island, Coronado Islands, San Martin Island, San Gerónimo Island, Santa Margarita Island, San Benitos Islands, Guadalupe Island, and Cedros Island.

Adults and young were observed in the spring, summer, and fall in southern California.

The food habits were not investigated in this study.

Eggs were found attached to bits of floating seaweeds and other objects during the spring and summer. The newly hatched young were observed just under the surface film throughout the spring, summer, and fall in southern California and in the winter at Guadalupe Island.

The juveniles and sub-adults inhabit the same areas as adults.

This saury is thought to be one of the most important forage animals of the open ocean. It may be caught in nets under light at night and occasionally is washed on board boats at night.

It has little relationship to the kelp. The eggs are sometimes held at the surface on their floating substrates by the kelp canopy until they hatch. The occasional adult that accidentally enters the kelp might be eaten by kelp bass.

Cypselurus californicus (Cooper) -- California flyingfish

Adults attain a length of 1.5 feet. The color is dark blue above and silver below.

They are pelagic, but concentrate around the offshore islands. They were seen at the surface flying away from the boats during the day. They were observed during late spring through summer to early fall.

They were observed at the following localities: La Jolla, Santa Cruz Island, Catalina Island, Coronado Islands, and San Benito Islands.

The food habits were not investigated.

The eggs were found attached to floating objects in late spring and early summer. No young or half-grown specimens were observed.

California flyingfish are sold on the fresh fish market, primarily for bait during marlin season, but are quite good eating. They are captured by dip netting under a light at night.

They have little relationship to giant kelp. Their eggs sometimes drift into the kelp beds attached to floating objects. They are, in this manner, prevented from being cast ashore to die. The adults are rarely observed in the kelp beds, and never below the canopy.

Gymnothorax mordax (Ayres) -- California moray

Large adults may attain a length of 4.5 feet. The color of the larger adults varies from dark brown marked with yellow to yellow-brown marked with darker brown.

California morays live in rocky crevices. They were observed at depths averaging 26 feet, ranging from the tide-pools to 130 feet, with most of the population concentrated between 2 and 65 feet. They are found throughout the year in southern California.

They were observed at the following localities: Newport Beach, Laguna Beach, Del Mar, La Jolla, Santo Tomás, Punta Blanca, Bahía Playa María, Punta Rocosa, Punta San Rosarito, Santa Catalina Island, Coronado Islands, and Guadalupe Island.

They feed heavily on crustaceans and small fish. Small lobsters, red-and-white shrimp, kelp bass, and ocean blackperch are some of their favorite foods. Although fond of abalone removed by divers, they probably do not eat many of the shellfish because of their inaccessibility.

Nothing is known of the early life history of this eel.

Half-grown and sub-adults seem to prefer the shallower water. Adults have been kept in the Scripps Aquarium for 22 years. The population is relatively small in a given area. By removing all specimens caught in fish traps in a small area off La Jolla for several weeks, the population was drastically reduced. Two years later the population had returned to normal.

These morays occasionally bite skin divers, and although their reputation has been greatly exaggerated, they are still a hazard, for they sometimes strike from hidden crevices without warning, causing lacerations that often require stitching.

They enter lobster traps where they eat the bait, other trapped fishes, and some lobsters. Occasionally they are killed by the lobsters. They are despised by lobster fishermen, who have a healthy respect for their bite. They must remove them from the traps, often with their bare hands. Recently a Mexican lobster fisherman lost a finger to a moray while removing lobsters from a receiving cage.

They are considered edible, but I do not regard them as extremely desirable.

They have no known relationship with giant kelp and are associated with the irregular rocky bottoms.

Fundulus parvipinnis parvipinnis Girard -- (Southern California) killifish

The few killifish observed in the kelp were scarcely over 3 inches in maximum size. They were olive to yellow-olive below. Normally the species lives in the back bays and sloughs, near the surface. They were observed only during the winter months at La Jolla.

Killifish were observed at La Jolla, Mission Bay, and San Diego Bay.

Their food habits and life history were not investigated.

Killifish are used sparingly for bait by sportsmen, but have no other commercial value. They may be caught by traps or nets in the back bays.

They have no known relationship to kelp. Only a few scattered individuals have been observed in the La Jolla kelp bed canopy.

Paralichthys californicus (Ayres) -- California halibut

The largest adults collected measured only 39 inches. Larger specimens have been observed. The color is a mottled brown above and white below.

California halibut were found to live buried in the sand near rocks or seaweeds, at depths that average 31 feet, and range from low-tide to 100 feet (and probably much deeper), with most of the population between 4 and 65 feet. They occur throughout the year in southern California. They feed on squid and smaller fishes, including their own species, other flatfishes, sardines, grunion, jacksmelt, queenfish, corbina, walleye surfperch, tubenose, and klipfish. During good grunion runs halibut are found in shallower water.

Males are rarely caught. Among 19 of all sizes definitely checked recently for sex, only one was a male. I recall having collected only two males among several hundred taken. Many spearfishermen who regularly collect halibut cannot remember having collected any males. The two males collected during this investigation were only slightly over a foot long and were mature, with milt flowing quite freely. The females collected in the spring and summer were ripe.

Young and juveniles are more common than the adults and sub-adults.

Halibut are excellent food fish and are prized by hook-and-line fishermen and by spearfishermen. Old-time spearfishermen claim that the halibut population has declined. I do not think this is true, but the spearfishing pressure is much greater and the catch per unit of effort is necessarily smaller.

They have no direct relationship to kelp but prefer to burrow in the sand where many fish are available. On flat sandy bottoms they will almost always search out an irregularity or any object such as a rock, tin can, or discarded tire, near which they will burrow with only their eyes and mouth above the sand.

Xystreurys liolepis Jordan and Gilbert -- fantail sole

The largest adult observed and collected measured 15 inches in length. The color is brown above, marked with two large darker brown ocelli, and white below.

Fantail soles were observed in sandy mud at depths, averaging 55 feet, with a range of 30 to 110 feet. They probably live deeper. They occur throughout the year in southern California.

They were observed at the following localities: Point Dume, Redondo, La Jolla, and San Carlos and Playa María bays.

Giant sand crabs were found in the stomach of one adult.

No young or juveniles were observed during this investigation.

Fantail soles are not extremely abundant in southern California. They remain buried and are not easily disturbed by divers. They are excellent eating, but are rarely captured by fishermen in southern California.

They have no direct relationship to giant kelp.

Citharichthys sordidus (Girard) -- Pacific sanddab

Specimens 9 inches long were observed during this investigation. The back is brown spotted with yellow-orange; the underside is white.

These sanddabs live on fine sand to mud bottoms and are dominant organisms in certain deep sand or mud areas.

They were observed from depths of 45 to 290 feet. They occur throughout the year.

Postlarvae, young, juvenile, sub-adults, and adults inhabit the same areas.

These sanddabs are sold commercially. They are taken in trawls in the northern part of the state.

They have no important relationship to giant kelp. They do, however, appear to concentrate near the kelp, where they occur within the depth range of this plant.

Citharichthys stigmaeus Jordan and Gilbert -- speckled sanddab

Adults were observed to reach a maximum estimated size of 4.5 inches. The color is sandy above, with blackish specks, and white below. They are able to change their color pattern to match the color and texture of the sand.

They were found on all the nearshore sand, even in the tiny patches between or among rocks, at depths averaging 45 feet, with an observed range from the surface to 180 feet, and with most of the population between 1 and 160 feet. They are present throughout the year.

They were observed at the following localities: Elkhorn Slough, Monterey, Pacific Grove, Point Dume, El Segundo, Redondo, Portuguese Bend, San Clemente, La Jolla, Bahia San Rosarito, Punta Rocosa, Bahía Playa María, Punta Blanca, Punta Cono, Bahía San Carlos, San Miguel Island, Santa Rosa Island, Santa Cruz Island, Santa Catalina Island, and Coronado Islands.

They feed on small crustaceans, worms and fish, especially larval and post-larval northern anchovies.

The eggs and larvae are pelagic. Postlarvae, young, juveniles, and sub-adults occupy the same habitat as the adults.

They are extremely abundant. A close inspection of the sand bottom in almost any area will reveal a number of this species. They prefer irregularities and foreign objects in their habitat. Sometimes dozens of adults will follow a diver. Amazingly adapted for blending with their environment, they are almost impossible to see once they have settled on the sand.

They are too small to be of commercial or sport value. They will readily take a hook and are excellent eating. Their small size makes the trouble of preparing them too great.

They are much more numerous in the sandy bottom of the kelp-bed region, under piers, and at the edges of submarine canyons than they are on the open sand bottom at similar depths. They have no other significant relationship to giant kelp.

Hypsopsetta guttulata (Girard) -- diamond turbot

Large adults were estimated to attain a length of 12 inches. The color on the top is brown, spotted with gray-blue. The underside is white with yellow under the head. The general outline of the body is roughly diamond-shaped.

Diamond turbot were observed in the sand and mud at depths averaging 28 feet, with a range from the surface to 140 feet. Most of the observed population was concentrated between 4 and 60 feet. They are present throughout the year.

They were observed at the following localities: Elkhorn Slough, Newport Beach, La Jolla, Santa Rosalía, San Rosarito, and Bahía Playa María.

They feed primarily on large sand-dwelling worms, but may include isopods, young sand crabs, worm mollusks, and barnacles in their diet.

The pelagic eggs are laid during the summer and fall. No larvae, post-larvae, or young were observed. The smallest specimens seen were half-grown over 3 inches in length.

They are common although not extremely abundant. They prefer to live on or buried in sand, near solid objects. They are seldom taken on hook-and-line, probably because of their small mouth size. However, they do make up a fair portion of the skin diver's catch. They are somewhat difficult to prepare, but are excellent eating.

They have no known significant relationship to giant kelp.

Pleuronichthys coenosus Girard -- C-O turbot

The largest adults observed were less than a foot in length. The color is usually a dark brown, but occasional specimens from bottoms of coralline algae are vividly mottled with pink, purple, and yellow as well as brown. The caudal fin has a design which resembles the letters C and O. The general outline of the body is diamond-shaped.

C-O turbots live on all flat bottoms and are not uncommon even in areas of irregular rocky bottoms. They are able to blend with their background, whether it be sand or rocks. They were observed at an average depth of 33 feet and have an observed depth range from the surface to 100 feet. Most of those seen were between 6 and 90 feet.

They are present throughout all seasons of the year in southern California. The food habits were not investigated.

They were observed at the following localities: Point Dume, Newport Beach, La Jolla, Blanca , and Playa María bays, San Miguel, Santa Rosa, Santa Cruz, and Santa Catalina Islands.

The eggs are pelagic. The young, 1 to 3 inches long, appear throughout the year. They are often brightly marked with pink, yellow, cream, white, and brown. Young ones will often take on the color of scattered objects in their environment and not necessarily their immediate substrate. For instance, a fish 3 inches long may take on a white or cream color if there are a few shells of similar size within a few feet, although the substrate is dark gray.

They are commonly taken by spearfishermen and are excellent eating.

They occur frequently in the kelp beds and other rocky areas.

Stereolepis gigas Ayres -- (California) black seabass

Large adults observed in this investigation had attained a length of 7 feet. The color is dark brown above and lighter brown below. They are heavy-bodied fishes.

Black seabass live in rocky areas and in the kelp. They swim generally 5 to 10 feet over their substrate, but will swim at mid-depths or even near the surface in kelp beds. They were not numerous in southern California. They were observed at depths ranging from 18 to 100 feet. They were observed from late spring to midfall in southern California, but observations on season are too few to be significant.

They were observed at the following localities during this investigation: Corona del Mar, La Jolla, Bahía Playa María, Punta Rocosa, Coronado Islands, and Guadalupe Island.

They feed on squid and smaller fish, including kelp bass and sardines.

The eggs are pelagic. The colors of the young are similar to the colors of fishes found in the deep littoral zone. A 14-inch half-grown specimen was captured at La Jolla in September at a depth of 18 feet.

The adults are somewhat gregarious. Six to eight of these giants swimming together over a shallow reef is not an uncommon sight along the central Baja California coast.

Black seabass are taken by hook-and-line fishermen, especially by those using live bait. Skin divers prize them as sport and spear them with complex assemblies of lines, floats, and exploding arrow heads.

They occur frequently in the kelp beds at lower depths, but in general they occupy the rocky areas.

Mycteroperca xenarchus Jordan -- broomtail grouper

The largest observed were an estimated 5 feet. They have various mottled and spotted brown patterns. The caudal fin is scalloped between the rays at the outer edged giving the broomtail appearance.

Broomtails prefer irregular rocky bottoms with large crevices and caves. They enter the mid-kelp and canopy biotopes occasionally, but the majority remain near the bottom at depths averaging 38 feet, with an observed depth range of 4 to 60 feet. The majority of the population lies between 12 and 50 feet. They occur throughout the year at La Jolla.

They were observed at La Jolla, Bahía Magdalena, and Coronado Islands.

The food of one individual consisted of several small kelp bass.

The eggs are pelagic. No young or half-grown specimens were observed.

They are rarely caught by hook-and-line fishermen or spearfishermen at La Jolla.

They do live in the kelp beds at La Jolla, probably because of the relatively warm temperature and because the underlying bottom is filled with suitable crevices and caves. The kelp is only a small addition to the habitat.

Mycteroperca jordani (Jenkins and Evermann) -- Gulf grouper

This grouper is similar in size to the broomtail. The color is mottled olive-brown with larger, darker brown blotches. The tail fin is not scalloped.

In southern California Gulf groupers live with the broomtail grouper, in identical habitats close to irregular rocky bottoms, at depths averaging 42 feet, with an observed range from 10 to 60 feet. They occur throughout the year at La Jolla.

They were observed in the following localities during this investigation: La Jolla, Bahía Playa María, Bahía Magdalena, and Coronado Islands.

They feed on smaller fishes.

The eggs are pelagic. No larvae or young stages were observed.

They are caught by gill-net fishermen, live-bait fishermen, and spearfishermen.

They have no important direct relationship with giant kelp but utilize it as cover in the La Jolla area.

Paralabrax clathratus (Girard) -- kelp bass

The largest adult taken measured 26 inches. The adults are rich brown to greenish-gray, spotted in a linear pattern with roughly rectangular blotches of white or greenish-white. They are greenish white to yellow below.

Kelp bass live among seaweeds and rocks. The larger ones tend to live deeper. The larger adults often live in deep rocky areas where there is little or no seaweed. They live, on the average, as observed, at a depth of 27 feet, and have an observed depth range from the surface to 130 feet, with most of the population concentrated between 2 and 70 feet. They are present throughout the year and show little tendency to move or wander, although they do not display aggressive territorial behavior.

They have been observed in the following localities during this investigation: Goleta, Point Dume, El Segundo, Palos Verdes Cove, Long Point, Whites Point, Newport Beach, Laguna Beach, Dana Point, San Clemente, Oceanside, Del Mar, La Jolla, Mission Beach, Point Loma, Punta San Rosarito, Punta Rocosa, Bahía Playa María, Santa Rosa, Santa Cruz, Santa Catalina, Coronado, San Martín, San Gerónimo, San Benitos, and Guadalupe Islands.

Kelp bass feed on crustaceans, including bottom and seaweed forms, squid and smaller fish, including sardines, anchovies, topsmelt, tube-nose, kelp clingfish, and kelpfish.

The eggs are pelagic. Spawning occurs from early May through August. The ripe adults tend to aggregate during spawning activities, usually in the kelp in relatively deep water. Hundreds of kelp bass and other fishes may aggregate in a small area while spawning goes on. Both ripe females and males have been taken from such aggregations. Ripe sand bass have also been found in these groups. The other fishes attracted to the activity include sargo, pileperch, kelpperch, blacksmith, señorita, and sheephead.

The larval stages were not discovered in this investigation. The young, ranging from slightly less than 1 inch to 2 inches, are common throughout the inshore seaweeds, including the eelgrass in bays. Their favorite habitats are the inshore heavy clumps of ribbon kelp. They are also found in the canopy, in the holdfast regions, at mid-depths, and sporadically in areas below the growth of giant kelp in the La Jolla submarine canyon. They occur in the late summer through December. By the following summer they are 4 inches long. They mature at a length of 8 inches at an age of two years. The smaller adults begin their spawning late in the season.

In general they are solitary, but bunch up to feed on schooling bait fish. When feeding on schooling forage fish they all rush together at the school from different directions. Each grabs a fish, swallows it, and then follows the bait at some distance; later they all rush the school again.

They are one of the most important sportfish and are taken by hook-and-line, with live bait and cut bait, and by trolling and spearfishing. They feed lightly during the winter and are almost impossible to catch then. They are excellent eating.

Kelp bass include giant kelp in their habitat, but do not require it. Large numbers of young to adult kelp bass inhabit Guadalupe Island where there is no giant kelp. They also inhabit rocky areas such as the La Jolla submarine canyon where there is no kelp. Harvesting has no material effect on these fishes. A very few adults are carried onto the kelp harvesters along with the canopy, but on the average less than one per 300 tons of kelp. The total destruction by the harvester is inconsequential in comparison with the sport catch.

Paralabrax nebulifer (Girard) -- sand bass

Large adults were observed to reach an estimated length of 2 feet. The color is mottled gray, with a few irregular dark bars across the back. They are lighter below. They resemble the kelp bass in general shape, but have a higher and more sharply pointed dorsal fin.

Sand bass live among rocks close to the bottom, especially near sand. The depths of observation averaged 38 feet; the observed range, 4 to 120 feet. Most of the population was found to be concentrated between 17 and 85 feet. They are present throughout the year.

The stomach contents contain squid, small fish, and (once) the eggs of the tube-nose.

Sand bass were observed in the following localities: Newport Beach, Del Mar, La Jolla, Point Loma, Bahía San Carlos, Punta San Rosarito, and Catalina Island.

The adults aggregate and spawn during the warmer months. The eggs are pelagic. The larvae were not observed.— The striped young appear in the entrances of Newport and Mission Bay in the eelgrass beds during fall and winter.—

—The adults are primarily bottom fish, which remain several feet to a few inches over the substrate, seeking cover when necessary in caves and holes.

They are caught less commonly than kelp bass, but the two species are often caught together close to the bottom.

Sand bass have no important relationship to giant kelp, but their rocky habitats are often marked by the presence of surface kelp.

Paralabrax maculatofasciatus (Steindachner) -- spotted bass

Adults observed seldom attain a length of 16 inches. Spotted bass are similar in shape to the kelp bass and sand bass. They are marked with dark greenish bars across the back and thickly spotted with small dark dots. They are closely associated with eelgrass and were never observed more than 100 feet away from it during the entire investigation.

None was observed during the spring, but this is probably due to the lack of observations in the eelgrass beds during that time of year. They prefer a sand bottom next to the eelgrass at an average observed depth of 14 feet in Newport, with an observed range of 2 to 30 feet.

Spotted bass were observed at Newport Beach and La Jolla.

The stomach contents yielded crabs and small fish, including kelpfish and klipfish.

They were observed at the following localities: Elkhorn Slough, Point Dume, Newport Beach, La Jolla, Point Loma, Bahía San Carlos, Punta Escarpa, Punta Blanca, Bahía Playa María, Bahía Santa Rosalía, San Miguel, Santa Cruz, Santa Catalina, Coronado, and San Benito Islands.

The food habits were not investigated.

The eggs are laid throughout the year in southern California, with the peak during the winter months. The eggs, the size of small BB's, are attached in large masses by long filaments to objects, especially seaweeds. The larvae are everywhere abundant inshore and are common in the surface canopy.

Jacksmelt are fished commercially with gill-nets and are sold as smelt on the fresh-fish market. There has been no decline in this fishery.

Jacksmelt have no important relationship to giant kelp, but at all ages occasionally seek cover there. They are utilized as forage by some of the larger fishes such as kelp bass and yellowtail.

Atherinops affinis littoralis Hubbs -- bay topsmelt

The length of this subspecies as observed reached 5 to 6 inches. In superficial color pattern and shape they are similar to jacksmelt.

These topsmelt inhabit the surface of bays and baylike areas at an observed average depth of 4 feet, with an observed range from the surface to 30 feet.

They are present in the bays throughout the year; outside the bays, chiefly in the summer, and chiefly along sand beaches.

They have been observed at the following localities: Newport Bay, La Jolla, Mission Bay, Catalina Island, and San Benito Islands.

The food habits were not investigated.

The spawning habits are thought to be similar to those of the kelp topsmelt. The larvae and young are found in the bays.

They have very little relationship to giant kelp, but may occasionally enter the canopy in bay areas, as at La Jolla.

Atherinops affinis cedroscensis Hubbs -- kelp topsmelt

This is a larger fish with a maximum observed size of about 11 inches. It is the mainland open-shore topsmelt of southern California, resembling closely the bay topsmelt and with overlapping characters and habitats.

Ripe adults were found in July at Newport Bay. The eggs are pelagic. The habits of the young were not investigated.

The adults often remain in small clearings, for which they are apparently responsible, in the eelgrass. On several occasions these depressions each contained one bass. Heavy spearfishing pressure during the past two years in Newport Bay has reduced the population to such an extent that further observations on this species are almost impossible.

The only observed relationship between spotted bass and the kelp was their presence in patches of eelgrass near the edges of the La Jolla kelp beds.

Leuresthes tenuis (Ayres) -- (California) grunion

The adults observed ranged in size from 5 to 8 inches. They were gray translucent blue-green above, with a bluish silver stripe along the side and silver below. They are proportionately slimmer than the topsmelt and jacksmelt.

They are rarely seen except during spawning season. During the warmer months from spring to fall they school just offshore, awaiting a series of descending night high tides to spawn. They spawn at high tide in the sand and return to the sea. The eggs incubate for two weeks until the next series of tides washes out the mature larvae.

The adults school close to shore during this period, only rarely entering the harvestable beds. The larvae, however, enter the kelp-bed canopy and all other nearshore shallow-water environments. They stay there, develop into a postlarval stage, generally swimming at the surface film, and then disappear from the kelp beds.

Grunion are collected by fishermen during regulated parts of their spawning season. The adults are collected by hand as they spawn.

The grunion have a relationship to giant kelp because it is utilized as a portion of the larval habitat. Harvesting, however, has had no noticeable effect on the larval population. They appear to be equally numerous in cut and uncut kelp beds.

Atherinopsis californiensis Girard -- jacksmelt

Jacksmelt attain a length of nearly 2 feet, although they average much smaller. They are similar in appearance to grunion, although slightly heavier proportionately.

They school in murky water, preferably over sand, at depths, where observed, averaging 14 feet, with an observed depth range from the surface to 95 feet. Most of the observed population ranged between 5 and 50 feet. They are present in southern California throughout the year.

It lives in the surface kelp and inshore over the rocky reefs and about piers. It seldom strays from these habitats except during periods of dirty or murky water, when it may move miles away. It was found at depths averaging 11 feet and has an observed range from the surface to 85 feet. It is found throughout the seasons in southern California.

Kelp topsmelt were observed in the following localities: Point Dume, Newport Beach, La Jolla, Point Loma, Punta Blanca, Punta Cono, Punta Rocosa, and Cedros Island.

They feed on the many small crustaceans that live in the canopy, as well as on the planktonic forms that drift into the kelp.

The eggs are laid during the spring, summer, and early fall. The relatively large eggs are equipped with short adhesive filaments, which tangle on bits of seaweed and rarely on the giant kelp. Spawning has been observed over shallow reefs. A female followed by a number of males made repeated passes through a clump of red seaweed suspended by the turbulence. The seaweed was collected and on examination was found to contain a number of kelp topsmelt eggs.

The larvae are particularly numerous in the upper few centimeters of the kelp, especially during the late spring and early summer. The juveniles predominate from summer through fall. In the kelp the juveniles occur chiefly in small open spaces in the canopy a foot or more below the surface. The young are particularly common in and near the intertidal area of the rocky reefs.

The adults are surface-schooling fish. They serve as forage for some of the larger fishes such as yellowtail. They will jump from the water to avoid predators.

Kelp topsmelt make up a small part of the smelt catch of California. The commercial catch is correlated with effort and not with kelp harvesting. Harvested beds appear to have a larger population of topsmelt than the unharvested beds.

Atherinops affinis insularum Gilbert -- island topsmelt

The island topsmelt grows to a somewhat larger size, of a foot or more. They are very similar to the kelp topsmelt.

They fill the same ecological niche as the kelp topsmelt, but on the offshore islands. They are surface-schooling fish; the depths of observations averaged 7 feet, and they were observed ranging from the surface to 55 feet. They live in the canopy and close inshore over rocks. They are present throughout the year in southern California.

They were observed at the following islands: San Miguel, Santa Rosa, Santa Cruz, and Santa Catalina. Smelt from Coronado Islands and Gerónimo Island may belong to this subspecies.

Island topsmelt resemble the kelp topsmelt in habits and life histories. They appear to have even less relationship to the kelp than the kelp topsmelt, for they appear to swarm more commonly in coves inside the kelp, or where there is no kelp near.

Sphyraena argentea Girard -- (California) barracuda

The observed lengths were almost 4 feet. The color is brown with a blue sheen above and silver below. They are long and slender and roughly cigar-shaped.

California barracudas are nearshore pelagic fish, observed to range from the surface to deep water. They were observed only in the summer and early fall.

They were observed at the following localities: San Pedro, La Jolla, Mission Beach, Coronado Islands, and San Martín Island.

The adults are schooling fish which may leave the water while engaged in feeding. They enter the kelp beds only rarely, although they are common along its outer edge.

They feed heavily on squid and such nearshore pelagic fishes as sardines and anchovies.

The eggs are pelagic. Ripe adults were taken throughout the summer. Young specimens were observed in shallow water (4 to 15 feet deep) at La Jolla in September. Half-grown and sub-adults are numerous during the late summer along the edges of the kelp.

They are excellent food fish and may not be netted for selling. Tons are destroyed each year as they are accidentally netted and then discarded.

They are taken by trolling, live-bait fishing, and, lately, by spearfishing.

Barracuda the world over have a bad reputation. The California skin diver has no real worry about the relatively small California barracuda, for they swallow their food whole and do not tear or cut it. They feed only on smaller animals.

They are common along the outer edges of the kelp and are fished there by live-bait boats. And although they are concentrated there, their only relationship to the giant kelp is that it forms a boundary along which they concentrate. They are reported equally abundant off the mainland and islands of Mexico in areas where no giant kelp exists.

Seriola dorsalis (Gill) -- yellowtail

The largest specimens observed were approximately 4 feet long. In the water they are metallic blue-green above with a dark stripe along the middle of the side and white below. The tail is dull yellow. They have a typical carangid shape with a forked tail.

Yellowtail are nearshore pelagic. They were observed at depths averaging 14 feet and an observed range from the surface to 50 feet, although they are known to go deeper. They are found throughout the year, but are most numerous during the summer.

They were observed at the following localities: La Jolla, Magdalena Bay, and Guaymas, on the mainland, and at Coronado Islands and Guadalupe Island.

They feed on squid and on small fishes, including sardines, anchovies, jacksmelt, and topsmelt. Sometimes their jaws can be heard from a skiff as they snap at bait.

The adults are sexually ripe during the summer months. The eggs are pelagic. No larvae, young, or half-grown were observed by me. Sub-adults were present in small schools mixed with barracuda at the inner edges of the kelp during the summer.

The adults feed and live along the edges of rocky points and kelp beds, usually swimming just below the surface. During late summer evenings it is not unusual to find them, especially pairs of large adults, close to shore.

They are extremely popular game fish. They are taken chiefly with live bait or by trolling. More recently they are being speared. Individuals who have developed the necessary skill and techniques took a considerable number in 1954. As more and more persons learn the techniques and acquire the skill, pressure from such fishing may be felt.

Live-bait fishermen do better when the water is clear. They fish the areas of clearest water, such as La Jolla and North Coronado Island. When the water is dirty the catch drops off.

Yellowtail range well south of the range of the giant kelp. They apparently do not need it. However, they do feed in and around the kelp and utilize it for cover. They were observed not to be disturbed by kelp harvesters, and they feed directly behind the harvesters, probably on food forced into the open by the harvesting operations. This circumstance is apparently becoming recognized, for many sport boats were observed fishing in the recently cut areas.

Trachurus symmetricus (Ayres) -- jackmackerel

The largest specimens observed in this investigation were estimated to be 10 inches long. The color is green to brown above and silvery to brassy below. This species also is carangid-shaped.

Jackmackerel are nearshore and offshore pelagic. The smaller individuals in particular often school under piers or in the shade of kelp. Juveniles and sub-adults are common under the Scripps Pier during the summer. They occur in dense schools. Jackmackerel were observed inshore at depths averaging 24 feet and had an observed range from the surface to 150 feet.

They were observed only during the summer and fall, but observations on the season were too few to be significant. They were observed at Guadalupe Island and San Benito Islands during the winter and at Guadalupe Island again in the summer.

They were observed at Elkhorn Slough and La Jolla; at Playa María and Santa Rosalía bays; and on Santa Cruz, Santa Catalina, Coronado, San Martín, San Benito, and Guadalupe Islands.

The food habits of this species were not investigated.

The eggs are pelagic. The young specimens (5/8 to 1 inch) are also pelagic, and often seek shelter in the mantle of the purple-striped jellyfish during the summer months. From the surface of the sea these little fish look purple. In the aquarium, they appear dusky on top and transparent below.

Since most of the sardines have become unavailable, jackmackerel has increased in importance commercially.

Jackmackerel sometimes seek cover in the kelp beds, but are equally common in areas where there are no kelp beds. Large adults and larvae are common several hundred miles from shore. The giant kelp plays no significant part in the life history of this species.

Pneumatophorus japonicus diego (Ayres) -- Pacific mackerel

Large adults observed were estimated to be 15 inches long. The color is green marked with small wavy blue lines above and is silver below. The general shape is typical of mackerels or tunas.

Pacific mackerel are nearshore pelagic and have been observed from the surface down to depths below 100 feet. They occur in California throughout the year.

The feeding habits were not investigated during this study.

They were observed at the following localities: San Pedro, La Jolla, San Diego, Bahía San Carlos, Bahía Playa María, and Catalina Island.

The eggs are pelagic. Ripe adults were taken in the early summer. No larvae were observed by me. Juveniles and half-grown specimens schooled commonly with sardines and jackmackerel.

They are fed upon by sea lions (Zalophus californicus).

They are caught commercially in large numbers with nets under lights. They have become scarce in the past few years, possibly from overfishing.

They have no important relationship to giant kelp, and rarely enter it.

Sarda lineolata (Girard) -- (California) bonito

The largest specimen collected in this investigation was 26 inches long. The color is blue above, with black stripes slanting from the back forward to the middle of the sides, and is silver below.

The bonitos are pelagic fish, extending their range from the surface to greater depths than were observed. They were observed in the summer and fall in southern California and in the winter on Guadalupe Island.

They were observed in the following localities: La Jolla, San Diego, Coronado Islands, and Guadalupe Island.

The stomach contents of a few examined revealed ocean northern anchovies.

The specimens collected in the summer were ripe. The eggs are pelagic. No larvae, young, half-grown, or sub-adults were observed by me.

Tremendous schools of this fish have been observed on several occasions. Sometimes they will leap high into the air while feeding. They are taken with live bait or by trolling.

They rarely enter the kelp beds, but often run along its outer edge. They have no important relationship to giant kelp.

Xenistius californiensis Steindachner -- (California) salema

Large adults attained an estimated length of 9 inches. They are gray-green above, striped with orange-brown, and light gray to tan below.

The salemas live over rocks in shallow water at an average observed depth of 9 feet with an observed range of 4 to 35 feet. They were observed from early spring through early fall in La Jolla. They were observed at La Jolla only.

The food habits were not investigated.

The eggs are pelagic. The young appear in late summer in shallow water. Usually they are mixed with young black croaker and sargo at depths ranging from 6 to 17 feet, and averaging 8 feet. They school 1 to 4 feet off sandy bottoms shoreward of rocks or pilings. In the aquarium they fed well on living brine shrimp and grew from 1 inch to a length of 3.5 inches in a year.

Salemas school in tightly packed groups close over rocks and among seaweeds. They are seldom caught by hook-and-line fishermen, but are commonly taken by beginning spearfishermen. They are good eating, but too small to bother with.

They have no known significant relationship to kelp and only enter the shallow inshore areas of the harvested beds.

Anisotremus davidsoni (Steindachner) -- sargo

Large adults attain a length of 14 inches. The color is dusky gray above fading to gray-white below. A single large black bar crosses the back. They are somewhat "croaker" shaped.

Sargos prefer rocky bottom or a rock-sand combination, at depths averaging 24 feet, with an observed depth range from the surface to 130 feet. Most of the observed population was concentrated between 8 and 75 feet. They are present throughout the year.

They were observed at the following localities: Point Dume, Newport Beach, La Jolla, Santa Rosalía, Bahía Magdalena, Bahía Los Angeles, San Felipe, Guaymas, Santa Catalina Island, and San Benito Islands.

Stomach contents yielded small crustaceans and mollusks, including clams and a chiton, bryozoans

The pelagic eggs are extruded in the late spring and early summer. During late summer and early fall inch-long young appear at depths averaging 10 feet, ranging from 4 to 20 feet. The young school loosely with various-sized young salema and black croaker on the shoreward side of rocks over sand bottom. They are horizontally striped as are the two associated species. As winter approaches they lose their stripes, gain a black bar and become solitary, and then live at depths averaging 20 feet, ranging from 4 to 50 feet. They retain this habit until the following winter. At a length of approximately 5 inches they join adult schools and probably spawn the following summer, when they are two years old and about 7 inches long. All through their juvenile, half-grown, sub-adult, and adult life they are capable of displaying their striped juvenile pattern.

They are good food fish and are taken by surf and skiff fishermen. Spearfishermen probably take larger numbers than do hook fishermen.

Sargos have no important relationship to giant kelp, although they often school there in the mid-kelp and bottom biotopes.

Cheilotrema saturnum (Girard) -- black croaker

The largest adult observed was estimated to be 14 inches in length. The most common color is dark brown, almost black, above, fading to a dark brassy color below. They are typically croaker-shaped.

Black croakers inhabit rocky areas and thick clumps of dark seaweeds such as ribbon kelp. They were observed over a depth range of 4 to 50 feet, averaging 21 feet. Most of the observed population lived between depths of 8 and 40 feet.

They were observed at the following localities: Point Dume, Newport Beach, Laguna, La Jolla, Ensenada, Bahía Playa María, Santa Catalina Island, and Coronado Islands. They were observed throughout the year in southern California.

They feed on rock-dwelling crabs, especially the lumpy crab.

They spawn during the spring and summer months. The eggs have been taken in plankton tows off La Jolla.

Young appear in August through October. The smallest young observed was a partially transparent 1/2-inch-long specimen taken at a depth of 10 feet over a patch of sand just inshore from a projecting rock, schooling with other black croakers, sargo, and California salema. Slightly older and larger young live in similar habitats at an average depth of 9 feet with a range of 4 to 18 feet. The majority are concentrated at a depth of 8 to 11 feet. As they approach a length of 3.5 inches they seek out crevices and caves and lead a solitary existence.

By the time they have matured, at a length of 8 inches, they are schooling together with other adults, usually in caves and dark crevices.

The adults are able to greatly modify their color patterns, sometimes reverting to juvenile patterns.

They are rarely caught by hook-and-line fishermen, but are commonly taken by spearfishermen.

They have no important direct relationship to giant kelp, but sometimes seek cover among its stipes and on the substrate below.

Roncador stearnsi (Steindachner) -- spotfin croaker

A few adults reach a length of 2 feet. The color is gray above and white below, with a large black spot at the base of the pectoral fin. They are slightly chunky, but more or less typically croaker-shaped.

The spotfins live on sand bottom. They were almost always observed in the shallow surf zone or in bays. Only rarely do they venture out as deep as the harvestable kelp beds. They were observed at depths averaging 10 feet, with an observed range of 4 to 50 feet.

They were observed at the following localities: Newport Beach, Solana Beach, La Jolla, and in Playa María and Santa Rosalía bays.

They were observed only in the late summer and early fall.

The adults feed on clams, worms, and crabs.

The eggs are pelagic. Spawning takes place in the summer. The young specimens an inch long appear in the surf during the early fall. Juveniles and sub-adults are also found in the surf zone.

The adults usually swim in small schools of 50 or less, but generally of two or three, just inside the surf, especially near rocks and breakwaters or in entrances to bays.

They are excellent sportfish and are caught by surf and pier fishermen. They are taken occasionally by spearfishermen.

They have no known relationship to giant kelp, but occasionally wander into the beds.

Umbrina roncador Jordan and Gilbert -- yellowfin croaker

These croakers were observed to reach a length estimated at 14 inches. Their color was sandy marked with many brown lines which follow the scales obliquely from the back forward and down, with the undersides white and the fins yellow.

They live in extremely shallow water close to sand bottom, especially near rocks or in bays. They were observed at depths averaging 11 feet, ranging from shore to 25 feet.

They were observed at the following localities: Santa Catalina Island, Solana Beach, La Jolla, and Bahía Santa Rosalía.

The food habits were not investigated.

The half-grown and adults were observed only from summer through midfall.

They are caught by surf-fishermen and are incidentally taken by spear-fishermen. They are excellent eating.

They have no known important relationship to giant kelp. They enter the shallow sandy portions of the kelp beds only rarely.

Menticirrhus undulatus (Girard) -- California corbina

A large adult taken in a fish trap was 28 inches long. Corbinas are gray to black above, sometimes marked with heavy distinct dark and light lines. They are more slender than the other croakers.

The corbinas usually inhabit the sandy surf zone in schools or small groups of two or three, rarely venturing as far out as the kelp beds. The average observed depth was 8 feet with a range from the surface to 25 feet, with most of the observed population concentrated between 3 and 18 feet.

They were found at Newport Beach, and La Jolla, and in Blanca, Playa María, San Rosarito, and Santa Rosalía bays.

They occur throughout the year in southern California, but were observed most commonly during the late summer and early fall.

They have been observed feeding in the surf zone, at times in water so shallow that their backs were out. They scooped up mouthfuls of sand and separated the food by sending the sand through the gills. The food they were eating was not examined but was probably sand crabs.

The eggs are pelagic, and are spawned during the summer. Inch-long young were observed at depths of 4 to 8 feet outside the surf during August. Larger young were seen in very shallow water inside the surf.

The adults are often observed meandering over the bottom in aggregations of two to five, occasionally in schools of hundreds. At times they appear to play and to ride small waves.

They are an important sportfish and are taken by surf-fishermen and spear-fishermen. They are excellent eating. They are the most highly prized of the surf fishes.

They have no important relationship to giant kelp, but enter the shallower sandy portions occasionally.

Seriphus politus Ayres -- queenfish

The largest adults examined were less than 10 inches in length. The color is brown above and silvery below. The fins are dusty yellow.

Queenfish school in tightly packed aggregations over sandy bottom. They were observed at depths averaging 11 feet, ranging from 2 to 40 feet, with the greatest concentration between 4 and 27 feet.

They were observed at the following localities: Sunset Beach, Newport Beach, La Jolla, Bahía San Carlos, Bahía Playa María, and Santa Catalina Island.

They were observed from May through October in southern California.

They feed on small free-swimming crustaceans and fish.

Ripe adults were collected in the summer. The eggs are pelagic. The tiny young, less than an inch long, appear first at a depth of 20 to 30 feet and gradually move shoreward until they enter into the surf zone at sizes ranging from 1 to 3 inches. The young appear in late summer and fall.

They are taken commercially in small quantities and sold on the fresh fish market.

They probably represent an important forage fish to certain other fishes, such as California halibut.

Occasionally a dense school of adults seeks cover in the shade of the kelp, usually at mid-depths or near the bottom. They have no other known relationship to giant kelp.

Cynoscion nobilis (Ayres) -- white seabass

Large adults observed were less than 4 feet long. The color is gray marked with irregular bars across the back and white below. Occasionally they lack the bars, especially when caught.

The adults school over rocky bottoms and among the giant kelp just below the canopy. They were observed at depths averaging 17 feet, with an observed depth range of 4 to 50 feet. Most of the observed population was between 10 and 40 feet.

They were observed at the following localities: Newport Beach, Abalone Point, La Jolla, Mission Bay, San Felipe, and Coronado Islands.

They were observed during the summer through midfall in southern California. They are occasionally caught in the winter and were seen in the kelp through the winter of 1954-55.

They feed on squid and small fish such as anchovies and sardines.

The pelagic eggs are spawned during the summer. The young appear in the bays and surf during the late summer and fall. One young specimen was collected at San Felipe in the Gulf of California.

Adults are taken commercially with gill-nets set in the kelp. Gill-net fishermen follow the kelp cutters around, fishing for some time after the harvesters have cleared away the heavy canopy.

Live-bait fishermen occasionally catch this species in the kelp, usually on the inner edge. The best fishing is usually between the kelp beds and shore over rocky bottoms.

Kelp is not a necessary requirement in the life cycle of the white seabass. They do utilize it for cover, but the harvesting of the kelp does not interfere with the habit, as they seek cover at the lower levels.

Caulolatilus princeps anomalus (Cooper) -- (California) ocean-whitefish

The largest specimens collected were less than 22 inches long. The color is brown above, shading to light gray-brown below.

The ocean-whitefish live over rocky bottom and in the kelp, at depths where observed, averaging 42 feet, and over an observed range from the surface to 160 feet. They probably go much deeper, since those observed in the submarine canyons appeared to come from considerably deeper than the 160-foot observation depth of the diver. The majority of those observed were between the 10-and 65-foot levels.

They were observed at the following localities: La Jolla, Santo Tomás, Coronado Islands, San Martín Island, San Benito Islands, and Guadalupe Island.

They were observed throughout the year at La Jolla.

They feed heavily on abalone scraps and pieces of lobster thrown from boats.

The eggs are pelagic. Ripe adults were collected in May. A solitary half-grown specimen was observed in February. No other young stages were observed.

The adults are loosely gregarious and wander almost continuously 4 to 15 feet above the substrate, rarely dropping to the bottom to feed.

They are excellent food fish, and fair game fish. They were formerly reported as abundant in California waters, but they appear to be rather rare now, although they are abundant south of California.

The adults are found at mid-depths in southern California kelp beds, but appear over rocks at similar depths in areas to the south where there is no kelp. They appear to have no important relationship to giant kelp.

Hyperprosopon ellipticum (Gibbons)-- silver surfperch

This is a small fish; the largest observed was 4 inches long.

The color is olive along the back and silver along the sides and below. The sides may have darker bars of pink. It is thinner than the other surfperches.

Silver surfperch were observed over sandy bottom, usually 2 to 8 feet above the substrate, at an average depth of 6 feet, with a range from the surface to 16 feet. They were usually seen near attached or free seaweeds.

They were observed in March, July, and September on Santa Rosa Island, and in October at Point Arguello.

The food habits were not investigated.

Silver surfperch school in loose aggregations, usually inshore from seaweeds or rocks over sand. They were observed at the inner edge of the kelp at Point Arguello.

Adults were observed mating in October at Point Arguello at depths of 4 to 10 feet over a bottom 10 to 25 feet deep. The male approached the female from below and the two swam together with their vents close together for 2 or 3 seconds, then separated and repeated the process.

The young are probably born in the spring and summer. They were noted at Santa Rosa in July and September.

This species is too small to be of much significance to sportfishermen but may serve as forage for other fishes. It lives in the area of the more northerly of the harvested kelp beds, but rarely enters the beds, except on the extreme inshore edge. It has no significant relationship to giant kelp.

Hyperprosopon argenteum Gibbons -- walleye surfperch

The largest specimens observed were less than 7 inches in length. The color is silver on the bottom and sides, darker above, and marked with black or brown crossbars in life.

Walleye surfperch live over sand patches among rocks or over sand shoreward of projecting rocks. They school in an aggregate cloud as deep as 6 to 8 feet, coming to within 2 feet of the surface. They were seen over a depth range from the surface to 40 feet, with the average depth at 13 feet. Most of the population was within the 5-to 22-foot range.

add Crossochir koelzi
Amphistichus argenteus

They were observed at the following localities: Elkhorn Slough, Monterey, Santa Barbara, Point Dume, Rocky Cove, Newport Beach, La Jolla, Santo Tomás, Bahía San Carlos, Punta Escarpa, Punta Blanca, Bahía Playa María, Santa Rosalía, Santa Rosa, Santa Cruz, Santa Catalina, Coronado, and San Martín Islands.

They are found throughout the year in southern California.

They feed on small crustaceans.

Breeding takes place in October, November, and December in southern California. The young are born in the spring and breed the following fall and winter. The largest proportion of the breeding adults are young of the year. Young and adults have similar habitats, except that the young tend to seek slightly shallower water than the adults.

They serve as forage for kelp bass, scorpionfish, and halibut.

They are caught and eaten by surf-fishermen. They are seldom bothered by spearfishermen because of their small size. They are extremely abundant, probably the most abundant surfperch on the open rocky coasts.

They enter the inner edges of the kelp beds along sand patches, but they have no significant relationship to kelp.

Embiotoca jacksoni Agassiz -- bay blackperch

The largest adult observed was estimated to be 10 inches long. The color is usually brown or olive marked with darker bars.

Bay blackperch inhabit the eelgrass beds of bays, but occasionally may be found among seaweeds along the coast. In general they prefer shallow water at depths less than 25 feet. Only on rare occasions are they found in the kelp beds.

They were observed at the following localities: Elkhorn Slough, Monterey, Morro Bay, Newport Bay, La Jolla, and Catalina Island.

They are found throughout the year in California

They feed on crustaceans and mollusks. They also feed on the external parasites of other fishes.

They breed during the summer months and possibly throughout the year. During the mating activity large numbers aggregate in rather tight schools. These will split up into pairs, with the males swimming close beside the females.

During the breeding season a nipple-like structure projects forward from each side of the anal fin. These structures are in reality intromittent organs, for they are connected to the testes and carry the sperm. The young seem to be present throughout the year but are most numerous in the spring.

Bay blackperch are excellent eating and are caught by fishermen, especially over eelgrass in shallow-water bays.

They have no relationship to giant kelp, rarely entering the inner edge near bays or semi-bays.

Embiotoca sp. -- ocean blackperch

The largest specimens observed were only 11 inches long. The color pattern is similar to that of the bay blackperch, but usually contains more orange and red.

Ocean blackperch inhabit seaweed-covered bottoms at depths averaging 23 feet, but range from the tide-pools to depths of 110 feet. Most of the population is concentrated between 2 and 80 feet.

They were observed at the following localities: Pacific Grove, Point Arguello, Goleta, Santa Barbara, Point Dume, El Segundo, Rocky Cove, Long Point, Portuguese Bend, Cabrillo Beach, Newport Beach, Laguna Beach, Dana Point, San Clemente, La Jolla, Santo Tomás, Punta San Rosarito, Punta Rocosa, Bahía Playa María, Punta Cono, Punta Blanca, Punta Escarpa, Bahía San Carlos, and Santa Rosa, Santa Cruz, Santa Catalina, Coronado, San Martín, San Gerónimo, and San Benito Islands.

They are present in extreme abundance throughout the year in southern California. They are probably the most abundant of all southern California surfperches.

They feed on crustaceans, mollusks, bryozoans, and worms. The stomach contents yielded external parasitic fish crustaceans. They have been observed removing parasites from members of their own species.

The breeding habits are similar to those of the bay blackperch. Mating was observed in both winters and summers, often at mid-depths in the inshore portions of the kelp beds. Young appear predominantly in the spring and summer, less commonly in the other seasons.

Ocean surfperch swim close along the bottom between and over rocks, through tunnels and caves, and through seaweeds, usually as solitary individuals or groups of three or four. The heavy aggregations in the kelp beds and inshore among the rocks always contain ripe males, which are easily recognized by the peculiar genital structures on the anal fin.

They are an important portion of the rocky shore fisherman's catch and they make up the largest portion of the average novice spearfisherman's catch.

For cover, during breeding activities, they utilize the lower levels of the giant kelp as well as rocks and caves, and are not disturbed by harvesting. A very few adults are rarely taken in the canopy by kelp harvesters. They have no important relationship to giant kelp and are not affected by present cutting methods.

Taeniotoca lateralis (Agassiz) -- striped seaperch

All specimens observed were less than 12 inches long. The color is brown above, with fine blue and orange stripes along the sides, becoming lighter below. The tail is orange in life.

Striped seaperch live in the cold-water rocky bottoms, deeper in southern California and shallower in northern California. They were observed at depths averaging 40 feet near La Jolla; 17 feet in the Santa Barbara region; and 12 feet in northern California. The observed depth range for southern California was 15 to 55 feet, and from the surface to 35 feet in northern California.

They were observed at the following localities: Trinidad Head, Point Lobos, Yankee Point, Morro Bay, Point Arguello, Goleta, Point Dume, La Jolla, and San Miguel, Santa Rosa, and Santa Cruz Islands.

They are found throughout the year in southern California, but not in any abundance south of Point Dume.

The food habits were not investigated.

The young were not observed south of Point Dume. They were observed in May, June, August, and September.

The adults are more or less solitary, but probably aggregate during the breeding season.

They are commonly caught by sportfishermen above Santa Barbara.

This seaperch has no apparent relationship to kelp, except that it occasionally seeks cover in its lower levels.

Hypsurus caryi (Agassiz) -- rainbow seaperch

The largest adults observed were less than 10 inches in length. The color is fine stripes of red, orange, and blue along the sides and bottom. On the back the stripes are less apparent and a red-brown pattern of irregular bars is superimposed.

Rainbow seaperch live in the colder waters in southern California, going deeper in the warmer areas to get the proper temperature. During the past four years there has been a noticeable buildup in the population of this

fish at La Jolla and at Newport, possibly because of the lower ocean temperatures in winter and spring. They were observed at depths averaging 31 feet and over a depth range from tide-pools to over 100 feet. Most of the population lives below the 10-foot depth.

They were observed at the following localities: Pacific Grove, Yankee Point, Goleta, Santa Barbara, Point Dume, Rocky Cove, Long Point, Portuguese Bend, Newport, San Clemente, La Jolla, Bahía San Carlos, and Santa Rosa Island.

They are present in southern California throughout the year, seeking deeper water below the thermocline in the summer, ranging almost to the tide-pools in winter.

Young were collected in September. They are probably born through the entire summer. Clusters of rainbow seaperch in the fall are thought to be breeding aggregations. During the rest of the year they are solitary, occasionally forming groups of two or three.

Rainbow seaperch are occasionally taken by hook-and-line in "deep" water in the kelp beds of southern California. They are good food fish.

This species has no significant relationship to giant kelp, but usually occurs over a rocky substrate. Kelp on an otherwise barren sand bottom sometimes attracts a small number of rainbow seaperch.

Phanerodon furcatus Girard -- white seaperch

The largest adults reach 1 foot in length. The color is olive above to white below.

White seaperch live in quiet waters, preferring bays and deeper water, especially around combinations of rocks and fine sand. They were observed at depths averaging 24 feet, but range from 1 to 120 feet. Most of the population was between 8 and 110 feet.

They have been observed at the following localities: Elkhorn Slough, Monterey, Pacific Grove, Point Arguello, Santa Barbara, Newport Beach, La Jolla, Bahía San Carlos, and Santa Rosa, Santa Cruz, and Santa Catalina Islands.

They are present throughout the year in southern California. They are quite common and tend to form loose schools throughout the year.

The breeding habits were not observed, but are probably similar to those of other surfperches. Young were observed in September.

The food habits were not investigated.

White seaperch are taken commercially in the northern part of the state. They are generally passed up by spearfishermen because of their small average size.

They have no important direct relationship with giant kelp. They do utilize it as cover in the lower regions near the holdfasts.

Phanerodon atripes (Jordan and Gilbert) -- sharpnose seaperch

This is a smaller species. The largest observed was about 6 inches in length. Flecked with red, it is more colorful than the white seaperch.

Sharpnose seaperch are relatively rare. The few observed came from depths ranging from 4 to 150 feet.

They were observed at Elkhorn Slough, Santa Rosa Island, La Jolla, and San Benito Islands.

Their food habits were not investigated.

They were observed in July, August, and September in southern California, and in February at the San Benito Islands. They are probably more abundant than formerly suspected, and are not uncommonly taken in deeper water collections.

Their breeding habits are probably similar to those of other surfperches. Young were observed in September.

They serve as forage for larger fishes and some were found in the stomach of a cormorant.

They have no important relationship to giant kelp, but were once found (at San Benito Islands) near a holdfast in a kelp bed.

Damalichthys vacca Girard -- pileperch

Large adults observed reached a length of 15 inches. In life they are dusky above, silvery on the sides and bottom, with one black or dusky bar across the back.

Pileperch prefer rocky habitats near sand, living at depths averaging 26 feet, with a range from the surface to 150 feet. Most of the population is concentrated at a depth of 5 to 115 feet.

They were observed at the following localities: Elkhorn Slough, Monterey, Point Arguello, Goleta, Point Dume, Malibu, El Segundo, Long Point, Portuguese Bend, Whites Point, Newport Beach, Solana Beach, La Jolla, Santo Tomás, San Carlos, Punta Blanca, Punta Cono, Bahía Playa María; and about Santa Rosa, Santa Cruz, Santa Catalina, Coronado, San Martín, and San Gerónimo Islands.

They are found abundantly throughout the year in southern California. They feed on clams (such as mussels and bean clams), gastropods (including limpets, dove shells, cones, and smooth tops), chitons, decapods, other crustaceans, ophiuroids, and sand dollars. They are commonly observed around pilings pulling small mussels free, crushing them in their throats as they swallow them. A half-grown specimen was observed being forced into eating external fish parasites by a group of blacksmith. The blacksmith would crowd in front and around the pileperch until it was unable to proceed. It would pick at a parasite and then move on until blocked by another blacksmith.

They were observed breeding in October and November. Mating pairs in large schools were observed in depths ranging from 4 to 30 feet over sand bottom near rocks or pier pilings. The male and female involved in mating press their ventral surfaces together and swim slowly on their sides, in the same direction. The particular incident takes place in just a few seconds but the entire procedure is repeated many times. Schools of breeding adults remained at the Scripps Pier tip for several days.

Young appear in June through October.

The adults tend to school throughout the year, but the sub-adults tend to be solitary.

They are good food fish and are commonly taken by pier fishermen and spearfishermen.

They occur frequently in the kelp beds at mid-depths and near the bottom. They are not affected by kelp harvesting. They have no important association with giant kelp.

Rhacochilus toxotes Agassiz -- rubberlip seaperch

The larger adults observed reached an estimated 15 inches in length. The color is olive above, fading to brassy below. The darker bar across the upper sides disappears when the fish are frightened.

The rubberlips live among the giant kelps at mid-depths and near the bottom. They also inhabit submarine canyons and other rocky areas. They were observed at depths averaging 33 feet, with an observed range of 6 to 150 feet. The majority are concentrated between 10 and 100 feet.

They were observed in the following localities: Elkhorn Slough, Goleta, Point Dume, Long Point, La Jolla, Bahía San Carlos, and Santa Rosa, Santa Cruz, Santa Catalina, and Coronado Islands.

They occur throughout the year in southern California and are an abundant sportfish. They are primarily taken by spearfishermen in the kelp beds, with small fish spears.

They feed on crustaceans.

The actual breeding was not observed but the seasonally developed intromittent organs on the anal fin are still present in late December. Small embryos were observed in September. The life history pattern seems to be almost identical with that of the pileperch.

They are often concentrated in dense schools throughtout the year. They are one of the few fishes that prefer the mid-kelp biotope in southern California. They are not disturbed by kelp harvesting and seem to be equally abundant in cut and uncut kelp.

Cymatogaster aggregata Gibbons -- shiner seaperch

The largest adults observed were estimated to be 5 inches in length. The color is olive-gray above, with black and yellow bands along the sides.

Shiner seaperch prefer bays and eelgrass, but are not too uncommon along the open coast in calm, deeper water, or around patches of ribbon kelp in turbid water. In the bays they live at depths ranging from the surface to 22 feet. Along the open coast they were observed to range from depths of 4 to 120 feet.

They were observed at the following localities: Pájaro River (mixed with fresh-water forms), Elkhorn Slough, Monterey, Pacific Grove, Santa Barbara, Newport Beach, La Jolla, and Santo Tomás.

They occur in southern California throughout the year. They are extremely abundant in the bays.

The food habits were not investigated.

Mating pairs and young seem to occur through all the seasons. Breeding pairs are a common sight in nature and sometimes can be observed in the aquarium. The male turns dark, almost black, and follows the female closely, bringing his vent close to hers for a second or two. He then leaves to chase off other fishes, some of which would be normally quite unconcerned with the whole procedure.

They are extremely abundant in bays and in places are the predominant fish. They are caught on small hooks.

They are bay fishes and normally have no relationship to giant kelp, except where it grows inside the entrances. They do, however, seek cover there at mid-depths and near the bottom. The portion of the population found

outside the bays is infinitely small as compared with the portion remaining in the bays. Kelp harvesting has no effect on the population of this species.

Cymatogaster gracilis Tarp -- island seaperch

This is a smaller, more slender species, attaining a length of slightly over 4 inches. It is similar in color pattern to C. aggregata, but is brassy above.

Island seaperch swim over the entire inshore areas of the islands, over sand, among rocks, eelgrass, giant kelp, and in bays. It has an observed depth range from the surface to 30 feet.

They were observed at Santa Rosa and Santa Cruz Islands. A similar form occurs around Santa Catalina Island.

They are abundant everywhere in the shallow waters. Observations in these localities were not made throughout the year, but they are presumed to remain there throughout the year.

The food habits were not investigated.

Young were observed during June, July, and September, but because of their close relationship to the shiner seaperch, and their similar habits, they are presumed to be present throughout the year.

This seaperch utilizes the kelp freely as cover, but is equally common in rocky and sandy areas. Kelp harvesting apparently does not affect its habits.

Brachyistius frenatus Gill -- kelpperch

The largest adults observed were estimated to reach a length of 6 inches. The color is yellow-copper to olive above to red-copper below. In life a silver bridle runs through the eye and is broken along the middle of the body, and then continues in splotches.

Kelpperch are common inhabitants of the giant kelp and are seldom found any distance from growing plants. They definitely prefer the canopy and the region just below it, although their depth range extends from the surface to 100 feet.

They have been observed at the following localities: Monterey, Goleta, Gaviota, Point Dume, Rocky Cove, Long Point, Portuguese Bend, Newport Beach, San Clemente, La Jolla, Point Loma, Bahía San Carlos, and San Miguel, Santa Rosa, Santa Cruz, Santa Catalina, Coronado, San Geronimo, San Martín, and San Benito Islands.

They are present throughout the year and are common everywhere in the giant kelp beds and around scattered plants.

They feed on small crustaceans, particularly those found on giant kelp, and on the external parasites that dwell on other fishes. This peculiar habit, which is shared by fishes in many other families in different oceans, has modified the behavior of the parasitized species so that they will seek out a kelpperch to remove a particular parasite. Blacksmith will crowd around a solitary kelpperch until the kelpperch is completely hidden. Other fishes that benefit and cooperate with the kelpperch are kelp bass, walleye surfperch, garibaldi, opaleye, and halfmoon. Other fishes in southern California which share this habit of parasite-picking are ocean blackperch, pileperch, and señorita.

Breeding takes place in September and October, and probably continues through December, with pairs swimming side-to-side among seaweed. The young are born the following spring and summer, from early May to late August. The young breed the following fall or winter. Large aggregations of these fish occur in the late summer, possibly in preparation for mating.

They are too small to be of any direct economic importance, but their habit of devouring parasites may be beneficial to the kelp-dwelling fishes.

Some are taken aboard the kelp harvesters along with the canopy. An estimated 10 to 20 are taken on each load. However, the numbers are insignificant, especially to an unfished population. Sufficient food is always available at lower levels even after the harvester has passed. Kelp harvesting has not had any noticeable effect on the population of this species.

Micrometrus minimus (Gibbons) -- dwarfperch

Large adults observed were estimated to reach a maximum length of 4 inches. The back is mottled brownish olive, lighter on the sides and bottom, with an irregular longitudinal stripe down the side and a darker irregular bar extending down from the spines dorsally.

Dwarfperch inhabit all the shallow eelgrass and surfgrass beds, swimming over these searching for food and swimming into them in search of cover. They were observed at depths averaging 11 feet, ranging from the tidepools to 30 feet. Most of the population is concentrated between 3 and 20 feet.

They were observed at the following localities: Elkhorn Slough, Point Arguello, Newport Beach, Solana Beach, La Jolla, Santo Tomás, Punta Escarpa, Bahía Blanca, Punta Cono, Bahía Playa María, Punta Rocosa, Punta San Rosarito, and Santa Rosa, Santa Cruz, and San Martín Islands.

They occur throughout the year and are scattered throughout the shallow waters, nowhere in heavy schools.

They feed primarily on small crustaceans and mollusks, especially amphipods.

The breeding habits were not investigated. The young are born alive and appear in April and May.

This fish has almost no economic importance.

Only on rare occasions are they observed in the harvestable portions of the kelp beds. Occasionally they enter the shallower parts of the kelp beds.

Chromis punctipinnis (Cooper) -- blacksmith

The largest adults observed were estimated to be 10 inches in length. They are blue-gray, spotted with small black dots. They have heavy scales and a rather blunt head.

They live over and among rock or seaweeds. They were observed at depths averaging 30 feet, with an observed range from the surface to 150 feet, and they probably go deeper.

They were observed at the following localities: Point Dume, Rocky Cove, Long Point, Newport Beach, La Jolla, and Santa Cruz, Santa Catalina, Coronado and Guadalupe Islands.

They are present throughout the year in southern California in extreme abundance.

They feed on particulate plankton such as small fish, squid and crustaceans. Screens of these fish filter the incoming current in the kelp beds.

Ripe adults were collected in June and July. The eggs are relatively large and cherry red. The breeding habits were not observed, although an exhaustive search was made each year during the spawning season. I believe the only possibility left is that they spawn in deep rocky crevices at considerable depth, probably between 200 and 300 feet. If their habits are typical, the male will clear part of a rock and a female will deposit eggs there. He will fertilize and guard them for a number of weeks and they will hatch and fend for themselves. The inch-long young appear in large semi-pelagic schools in August, September, and October. By November only a few inch-long specimens remain. By June of the following year they will be between 2 and 3 inches in length. They are mature at 5.5 inches, at an age of probably two years.

The young of the year have gray-blue anterior and yellow-orange posterior halves. They school densely in the open ocean, sometimes entering the kelp beds. As they grow larger, they settle down with the schools remaining over shallow sandy patches protected by large rocks.

The yearling blacksmith is somewhat more solitary, seeking refuge in small caves and crevices.

Sub-adults seek out fishes that feed on parasites. Clumps of blacksmith completely hiding their benefactor are common sights over shallow rocky reefs. While having their parasites removed, they will remain in almost any position: on their sides, head up, head down, or even upside down. They keep the affected side toward their benefactor. If the benefactor should try to leave, they will follow it, crowd in front of it, and prevent its escape.

They are excellent eating, but are seldom caught on a hook-and-line because of their small mouth size.

Sub-adults may materially affect the amount of plankton entering kelp beds because they eat it as it enters. They themselves are not affected by harvesting. The population still remains quite high.

Hypsypops rubicunda (Girard) -- garibaldi

The largest adult collected in this investigation measured 11.5 inches in length. The adults are bright orange with green eyes. The scales are heavy and the general shape of the body is quite heavy.

Garibaldi occur chiefly on rocky reefs that afford plenty of crevices and small caves for cover. They were observed to range from tide-pools to 85 feet, with an average depth of 21 feet. Most of the population is concentrated between 4 and 42 feet.

They were observed at the following localities: Point Dume, Malibu, Rocky Cove, Palos Verdes Cove, Long Point, Newport Beach, Laguna Beach, Dana Point, Solana Beach, Del Mar, La Jolla, Bahia San Carlos, Punta Blanca, Bahía Playa María, and Punta San Rosarito; and at Santa Cruz, Santa Catalina, Coronado, San Martín, and San Benito Islands.

They are present throughout the year and probably remain in a restricted territory during most of their life. They are common although less abundant than before spearfishing started. They are now protected by law and the population will probably recover.

Garibaldis probably prefer bryozoans to other organisms. Other organisms found in their stomachs include sea anemones, worms, tiny crustaceans (crabs, shrimps, etc.), clams, snail eggs, gooseneck barnacles, and even eggs of their own species.

Their spawning habits are typical of the family (the pomacentrids or damselfishes). The slightly larger and more red-orange male prepares a nest, beginning as early as March. He clears a shaded rock surface in shallow water, tearing off all but the more calcareous invertebrates. In the center

of the cleared area he cultivates a patch of velvety red seaweeds, which he guards and cleans continually. In April, some females spawn. The female must force her way past the pugnacious male to deposit her eggs. During this process, the male may join her, spewing sperm on the eggs as they are laid.

After she has departed, he may go over them again. The tiny, capsule-shaped eggs are attached by one end to the seaweed. Several weeks later, the larvae hatch and may be collected in nearshore plankton hauls. Spawning continues through July.

The half-inch young appear from August through November. They are brilliantly marked with iridescent butterfly-blue over an otherwise transparent orange body. As they grow older they become a deeper orange and lose their blue markings a little at a time. These brightly colored young seek shelter in the tiny crevices afforded by the epibiose. As they enter the shade of a crevice, the bright blue turns to black (because it is a reflected color), and the fish disappears from sight. The half-grown pass through a dull orange stage, when they are much less conspicuous than either the young or the adults.

Garibaldis mature at a length of about 8 inches. As they reach maturity the last of the bright blue markings (the edges of their fins) disappear. Studies of aquarium-grown fish and of size groups in nature, indicate that the age of maturity is about three years. Approximately one out of 12 fish 2.5 years old and older, observed in nature, is an immature fish ready to begin its third year of life. If the recruitment of three year-olds is only a little over 8 percent and has been that low for several years, the average life span is at least 13 years.

The garibaldi is a pugnacious fish, challenging fishes ten times its own weight to protect the nest, biting them and making thumping noises. A nest left unguarded is quickly attacked by other male garibaldis, which devour the eggs. The resident on returning will cause the outsider to beat a hasty retreat.

Foreign objects such as shells, stones, crabs, and starfish are removed if they settle on the nest. If the summer waves raise the sand level in shallow water until it covers the nest, the male will continue to clean the sand away. Some holes as deep as 8 inches are found around nests.

The garibaldi is a good food fish. However, it is now protected by law and wisely so, because it is easy to spear and the population might stand a real danger of being exterminated. It is, furthermore, a considerable tourist attraction.

Garibaldis have little relation to giant kelp. Occasionally they bite off a chunk with a bryozoan colony and they often seek shelter in the rocks below. Only on rare occasions have they been observed high on the columns, apparently searching for food.

Pimelometopon pulchrum (Ayres) -- sheephead

Large adult males were estimated to be slightly over 3 feet in length. The male has a black body with a very wide pink band running around it just behind the head. The female is more uniform in color, red or purplish above, fading to pink below.

Sheephead live in rocky areas at depths averaging 26 feet, over an observed range from the surface to 150 feet, and they probably go deeper. Most of the population occurs below 10 feet.

They have been observed at the following localities: Monterey, Goleta, Point Dume, Rocky Cove, Long Point, Whites Point, Cabrillo Beach, Newport Beach, Dana Point, San Clemente, Solana Beach, Del Mar, La Jolla, Point Loma, Santo Tomás, Bahía San Carlos, Punta Blanca, Bahía Playa María, Punta Rocosa, and San Rosarito Point on the mainland, and on Santa Cruz, Santa Catalina, San Martín, Coronado, San Gerónimo, San Benito, and Guadalupe Islands.

They were very abundant throughout the year. The numbers of extremely large ones seems to have been reduced in heavily spearfished areas.

The adults feed on sea urchins, mussels, crabs, large and small snails, squid, bryozoans, sand dollars, and sea cucumbers. They crush the food in their throats as they swallow it. On several occasions large adults were observed above water hanging onto mussels after a wave had retreated. Those found around mussel beds seem to attain the largest size.

Spawning occurs during the early spring and summer. The eggs are pelagic. Young appear in late May and continue to appear through late December. The young are light red with black spots in their fins. They usually live at depths of 20 to 50 feet, particularly about beds of gorgonians (sea fans). One young specimen was observed during a summer at Pacific Grove.

The females mature at a length of 10 to 11 inches. They live to be quite old. An adult male held in the Steinhart Aquarium has been reported to have attained the age of 29 years.

Sheephead are solitary wanderers, never remaining long in one place. They sleep at night resting on the bottom. Sometimes they may be caught napping during the day, lying on their sides in crevices or caves.

They commonly live on rocky bottoms below giant kelp and leave the bottom a greater distance where this plant is present, but apparently have no important relationship with the kelp.

Halichoeres semicinctus (Ayres) -- (rock) wrasse

A large male collected at Newport Beach measured 15 inches in length. The color of the male is greenish brown above with a blue-black band behind the yellow pectoral. Blue-green wavy lines radiate from the red eye. The general shape is that of a laterally flattened cigar.

These wrasses live very close to the rocky bottom, preferring areas with small patches of coarse sand. They were observed at depths averaging 22 feet, with a range from tide-pools to 60 feet. Most of the population lived between 10 and 50 feet.

They were observed at the following localities: Rocky Cove, Long Point, Newport Beach, Laguna Beach, San Clemente, Bahía Playa María, and Punta San Rosarito; and on Santa Cruz, Santa Catalina, Coronado, San Martín, San Gerónimo, San Benito, and Guadalupe Islands.

Adults are present throughout the year in California, but never in extreme abundance.

The stomachs of two individuals included amphipods, small decapods, dove shells, and one slipper shell. They have small mouths with protruding sharp canine teeth which are suitable for picking small organisms from their substrate.

Ripe adults were collected in the summer. The eggs are probably pelagic. Inch-long young, brown with cream stripe and black spots in their fins, appear from September through November, over flat rocky areas interspersed with sand, at a depth of about 8 to 20 feet. When frightened or disturbed, they dart into the sand. During the night they sleep buried with the head protruding. Juveniles and half-grown are found throughout the year. The minimum age for maturity is probably 2 or 3 years.

The adults are solitary nomads, wandering over the reefs foraging by day and burrowing between or under rocks to escape predators or to sleep.

They are occasionally caught by hook-and-line fishermen or spearfishermen. Their beautiful colors attract considerable attention.

This species has no relationship to giant kelp other than utilizing, in part, the same rocky substrate.

Oxyjulis californica (Günther) -- señorita

The largest adults collected in this investigation were 8.5 inches long. The color is brown above, orange on the sides, and lighter below, with a large black spot on the caudal peduncle. In general shape and size they resemble a cigar.

In their range the señoritas are found almost everywhere among seaweeds and over rocks. Even broken seaweed and eelgrass are utilized as habitats. They have been observed from tide-pools to depths of 140 feet. They prefer an average depth of 27 feet, with most of the population between 5 and 75 feet.

They were observed at the following localities: Pacific Grove, Point Dume, Malibu, El Segundo, Rocky Cove, Long Point, Portuguese Bend, Newport Beach, Laguna Beach, San Clemente, Del Mar, La Jolla, Santo Tomás, Bahía Playa Maria, Punta Rocosa, and Punta Rosarito; and on San Miguel, Santa Rosa, Santa Cruz, Santa Catalina, Coronado, San Martín, San Gerónimo, San Benito, and Guadalupe Islands.

They occur throughout the year, either in more or less dense schools, or scattered and solitary. Some very large schools have been seen.

The pelagic eggs are spawned from May through the summer. Postlarval young less than an inch long appear from June to early November. They are transparent with single black spots in the soft dorsal and anal fins. The caudal peduncle has two spots, which later fuse into one. At this early age, they school with slightly larger young which have attained the color pattern of the adult. Schools of these small fish occur throughout the seaweeds of the inshore region, including the eelgrass of the bays, and into the kelp beds sometimes as high as the canopy region.

When frightened, the young make no attempt to go around the seaweeds, but go right through them, piercing the leaflike structures with their sharp snout. Like rock wrasse, they often burrow when frightened near the bottom. Half-grown young and sub-adults are present from August through April. Maturity is attained at a length of 5.5 inches, at a probable age of one year.

Señoritas are omnivorous carnivores, feeding on almost any animal protein, continually picking at small objects on the bottom, on plants, other fishes, or from the water itself. When plankton is heavy with larval fish, squid, or small crustaceans, large schools of señoritas, along with blacksmith and topsmelt, often intercept the inflowing current in a kelp bed or in a bay entrance. As a characteristic habit, señoritas pick the parasites from other fishes, some of which seek them out for this purpose. Fishes which have been observed thus to seek out the señoritas are the bat ray, black sea bass, kelp bass, jacksmelt, bay topsmelt, kelp topsmelt, island topsmelt, sargo, walleye surfperch, pileperch, blacksmith, garibaldi, opaleye, halfmoon, and the common mola. Often the fishes will put themselves in awkward positions in order to place the parasite in front of the señorita. Garibaldis will even hold their gill slits open so that the parasites inside may be removed. Blacksmith crowd around a señorita so tightly as to obscure it completely. If it should try to move on they will swim in front of it, blocking its path. The opaleye, a wary fish in almost constant motion, will stop by a señorita to allow its parasites to be removed. The kelp bass, which normally feeds on

señorita-sized fish, will remain motionless while the parasites are removed from its lips. Large numbers of señoritas will tend a single black sea bass or common mola.

In addition to these parasites, which consist of bacteria, copepods, and isopods, they feed on non-parasitic sessile benthic forms such as worms, bryozoans, dove snails, limpets, decapods, and other crustaceans.

They are taken by cut-bait fishermen, who exude great volumes of profanity in describing the bait-stealing qualities of this small-mouthed fish. They are not considered good food fish and are probably never used as forage by other fishes except by accident. They have been found in the stomach of cormorants.

They utilize the entire kelp bed as part of their very extensive habitat. They are almost never taken by harvesters. Their population remains at an extremely high level in both cut and uncut kelp beds.

Girella nigricans (Ayres) -- (California) opaleye

A large specimen collected in Pacific Grove was 20 inches in length. Opaleyes are olive gray-green above with a white spot (occasionally doubled) on either side of the dorsal fin, grading to dusty white or gray below. Their eyes are blue and the general body pattern is heavy.

Adults live among seaweeds at shallow depths, ranging from the tide-pools and canopy to depths of 100 feet. They prefer depths averaging about 20 feet, with most of the population concentrated between 5 and 65 feet.

Opaleyes have been observed at the following localities: Pacific Grove, Point Dume, Malibu, El Segundo, Rocky Cove, Long Point, Portuguese Bend, Whites Point, Newport Beach, Solana Beach, La Jolla, Santo Tomás, Punto Escarpa, Punta Blanca, Punta Cono, Bahía Playa María, Punta Rocosa, San Rosarito, and Santa Rosalía; and on Santa Cruz, Santa Catalina, Coronado, San Martín, San Benito, and Guadalupe Islands.

They are present throughout the year in southern California. They are extremely abundant and might make a suitable fishery if better fishing methods could be devised.

Adults feed primarily on organisms attached to seaweed. They often eat pieces of seaweed encrusted with organisms, or tender pieces of seaweed without such encrustation. Their gut is long and convoluted, typical of vegetarian vertebrates. They will take hooks baited with flesh, but a fisherman using bits of green moss will have better luck.

Among the organisms found in their stomach are ribbon kelp, giant kelp, sea lettuce, gelidium, coralline algae, bryozoans, and sinistral worms.

Observed

The eggs and larvae are pelagic. Ripe adults were taken in April, May, and June. During this period, dense schools of large adult opaleye aggregate in the shallower part of the kelp beds or inshore among the patches of ribbon kelp. Those taken from such aggregations were heavy with roe or milt. Spawning probably also takes place much earlier, for young appear in the tide-pools as early as March and are found into October. The postlarval and pelagic juveniles are nearshore pelagic. They may be found a number of miles to sea around jellyfish or bits of drifting seaweed. They are bright green above and silver along the sides and below. They school in typical anchovy fashion, the whole group turning in a synchronized movement. The schools are small, usually containing fewer than two dozen fish. Scattered individuals rest in a curled position just beneath the surface, resembling a wet feather.

The pelagic young enter the tide-pools at a length estimated at about an inch. Within a few days or even overnight, they lose their pelagic colors and habits, becoming olive on top with a white dot at either side of the dorsal, and gray below. They lose their synchronized schooling habits and form the typical loose aggregation of the tide-pools.

As they grow into juveniles and sub-adults, they seek deeper and deeper water. They mature at a length of 8 to 9 inches, probably at an age of two or three years.

Spawning probably does not occur in the Monterey region as no young, half-grown, or even small adults were observed during an entire summer in that area. The large adults probably are stragglers which have wandered from successful spawning areas in the south or they may be the result of successful spawnings in the Monterey region in warmer past years.

The adults browse through the seaweeds continually, usually at lower levels and in shallow waters, but occasionally high along the kelp columns through the mid-kelp biotope and even to the canopy. They are rarely taken in the kelp during harvesting operations.

The fish is edible, prized by some fishermen who deliberately fish for this species. They are despised by others as food and are discarded as they are caught.

Kelp harvesting appears to have had no effect on the population of this fish. It is equally abundant in harvested and unharvested beds.

Hermosilla azurea Jenkins and Evermann -- zebraperch

The largest adults observed in California were estimated to be 10 inches in length. They are brown to olive, barred with lighter bands.

Zebraperch live in the extreme shallow waters of southern Califronia and only one was observed in the kelp beds. It was in the canopy off Corona del Mar. They were observed at an average depth of 7 feet and over a depth range from the surface to 25 feet.

They were observed at the following localities: Newport Beach, La Jolla, Bahía Playa María, Punta Rocosa, and Guaymas, and at the San Benito Islands.

They were observed in July, August, and September in southern California. In San Diego County they are common close inshore, and often school with opaleyes and halfmoons.

The food habits were not investigated, but I suspect that their feeding habits are similar to those of the opaleye and halfmoon.

The eggs and larvae are probably pelagic. The young, schooling with young opaleye in August, are not uncommon inshore and in tide-pools.

The adults are almost always in fast, constant motion, swimming back and forth over the same areas, utilizing the same paths around ledges and boulders.

They are occasionally taken by spearfishermen and although they are edible, they are not rated high as food fish.

Only one specimen was observed in the kelp at harvestable depths in southern California.

Medialuna californiensis (Steindachner) -- (California) halfmoon

The largest adult collected in this investigation was 11 inches long. The color is slaty gray-blue, darker above than below. Halfmoons caught on the offshore islands are much bluer.

Adults usually swim high over the rocks and at mid-depths in the kelp. Occasionally they seek cover in crevices and swim close among the boulders inshore. They have a depth range from the surface to 100 feet, with the average depth of observation 27 feet. Most of the population is between 8 and 65 feet.

Halfmoons have been observed at the following localities: Point Dume, Rocky Cove, Palos Verdes Cove, Long Point, Newport Beach, Laguna Beach, Del Mar, La Jolla, and Punta San Rosarito, and about Santa Cruz, Santa Catalina, Coronado, San Martín, San Benito, and Guadalupe Islands.

They are present throughout the year in southern California. They are abundant but do not aggregate in large compact schools. Sometimes they school loosely; often they are solitary.

observed nibbling at squid pen

They feed on red, green, and brown algae, and on bryozoans and sponges. Bits of giant kelp are included, perhaps inadvertently, with other brown seaweeds in their diet. In the more turbulent areas of the rocky coasts individuals have been seen catching bits of upsurging seaweed.

Ripe adults were found in July, August, September, and October. The eggs are thought to be pelagic. The pelagic young (1 to 2.5 inches long) were observed and collected beyond the outer edges of the kelp beds off Santa Cruz Island in August. The young are similar in appearance to pelagic opaleye and have the same pelagic habit of curling which makes them look like a wet feather. Mature specimens as small as 7.5 inches were collected.

They are good eating and are taken by hook and by spear.

They are extremely abundant everywhere among the seaweed, often outside the range of giant kelp. They do not appear to have any very significant dependence on the kelp.

Scorpaena guttata Girard -- California scorpionfish ("sculpin")

The largest adults observed were estimated to reach a length of 15 inches. The general color is reddish, usually mottled with cream and brown. The spines of this fish are mildly to rather violently, but not fatally, poisonous. On three occasions divers stuck by these spines during deep dives in cold water noticed no poison effects until they neared the surface.

Scorpionfish are common throughout the year in southern California. They prefer relatively bare, rocky bottoms. In the shallower areas they seek caves and crevices. In the deeper areas they remain in the open. Where a certain rocky area was inundated slowly with sand, the scorpionfish that had inhabited the rocks remained for a number of months on the sand bottom. They were observed to range from tide-pools to 180 feet, and undoubtedly live deeper. They appear to increase in abundance with depth.

They have been observed at the following localities: El Segundo, Whites Point, Newport Beach, Dana Point, San Clemente, Solana Beach, Del Mar, La Jolla, Mission Beach, Point Loma, Bahía San Carlos, Punta Blanca, Bahía Playa María, Punta Rocosa, and Punta San Rosarito; and on Santa Cruz, Santa Catalina, Coronado, San Martín, San Gerónimo, San Benito, and Guadalupe Islands.

The food consists of crabs, shrimp, fish, octopus, and squid.

The eggs are laid in the summer and fall. Floating bilobed masses of these transparent, almost invisible eggs are sometimes observed just below the surface in the nearshore open water. Inch-long young have been taken in the tide-pools during the winter. Half-grown and sub-adults prefer slightly deeper waters. The smallest mature adult examined was 7.5 inches long.

Adults are usually solitary, but are gregarious to the extent that in suitable habitats four or five of them may seek shelter in the same cave or on the same ledge. They are generally sluggish and not easily disturbed. Often when prodded, they will do no more than raise their spines.

They are excellent eating and are sought by hook and spear fishermen.

Scorpionfish have no relationship to the kelp beds except that they utilize the same type of substrate, where their depth range overlaps that of the giant kelp.

Sebastodes paucispinis (Ayres) -- bocaccio

The largest adult observed was estimated at 26 inches. The general color is tan, mottled with brown, sometimes pink along the sides.

The larger specimens were all observed at depths of 90 feet and below, normally over a rocky substrate such as the submarine canyon walls at La Jolla.

This species was observed at the following localities: Pacific Grove, Santa Barbara, Whites Point, Newport Beach, and La Jolla; and on Santa Rosa, Santa Cruz, and Santa Catalina Islands.

The young are abundant from April through September in the shallow water. They feed on small crustaceans and fish, sometimes on the smaller members of their own species.

The larvae are probably born in the winter months. The young begin to school in the spring and usually mix with schools of olive rockfish. Their growth rate is extremely rapid in the aquarium. They may grow to a length of 5 inches during their first year.

The dense schools of 1- to 3-inch young enter the kelp beds commonly. Usually, however, they seek shallower water, often in the entrances of bays or behind protecting points.

The older the young become, the deeper the water they seek. The adults are commonly taken from deep water by hook fishermen.

The appearance of the young in the kelp beds is only incidental in the life cycle of this species.

Sebastodes mystinus (Jordan and Gilbert) -- blue rockfish

The largest adults observed were estimated to be 15 inches long. The color is blue-gray above to white on the underside.

Blue rockfish inhabit the rocky cold-water areas, deep in southern California and shallower in central California. They are common in the mid-kelp and canopy biotopes of Monterey County kelp beds. They were observed at depths ranging from the surface at Pacific Grove to 130 feet at La Jolla.

They were observed at the following localities: Pacific Grove, Yankee Point, Morro Bay, Goleta, Point Dume, Newport Beach, La Jolla, and Santo Tomás; and on San Miguel, Santa Rosa, Santa Cruz, and Santa Catalina Islands.

They are present throughout the year in southern California but usually are uncommon there. They are abundant in central California, and during the last few years have markedly increased in abundance at Newport.

The food habits were not investigated.

The young are particularly abundant in Pacific Grove and Morro Bay during the summer. In southern California the young, though scarce and occurring in the deeper water, are much more often encountered than the adults.

This good food fish is commonly taken by hook and spear in central California.

This species is not disturbed by kelp harvesters.

Sebastodes serranoides Eigenmann and Eigenmann -- olive rockfish

Large adults observed at Naples Reef above Santa Barbara were estimated to have attained a length of 2 feet. The color is olive, spotted with white. The general shape and color resemble that of the kelp bass. The distinctly different evasive movements of the two species (pp. 68, 69) may make this similarity a distinct advantage, through the confusion of predators.

Olive rockfish are common inhabitants of the kelp and of rocky bottoms, especially in the Santa Barbara region. They have been observed at depths from the surface to 100 feet, with an average of 25 feet.

They were observed at the following localities: Gaviota, Goleta, Point Dume, Whites Point, Newport Beach, Laguna Beach, La Jolla, and Mission Beach; and on San Miguel, Santa Rosa, Santa Cruz, Santa Catalina, and Coronado Islands.

They are present throughout the year, scarce in most of southern California, but abundant in the region of Santa Barbara.

They feed on crustaceans and smaller fish.

The larvae are probably born in the winter. Possible sexual activity was observed in February at the Coronado Islands. Two adults swam close together, one seemingly trying to get its vent region next to that of the other.

The young appear in large schools, from May through September. The schools form behind protective reefs, in bay entrances, and in the lee of islands. Maturity is reached between 7 and 8.5 inches.

Olive rockfish are usually solitary, but occasionally aggregate around favorable reefs or clumps of kelp. They are less easily frightened than kelp bass and make a slow descent toward cover in the rocks when disturbed.

They are excellent food fish and are common in the sport catch of the Santa Barbara region, where they are often mistakenly identified as kelp bass.

Although they are common throughout the kelp, there is no indication that harvesting interferes with the life cycle of this species.

Sebastodes "miniatus (Jordan and Gilbert)" -- vermilion rockfish

The largest adults observed reached an estimated 2.5 feet in length. The color varies with the depth at which they occur. Those at the shallower depths of 85 feet are a reddish brown; those at 150 feet are brick-red, and those taken by hook-and-line at even greater depths are vermilion.

Vermilion rockfish live over and among rocks where cover, in the form of caves or crevices, is available. The adults were observed at depths of 85 to 170 feet. Young ones were observed as shallow as 25 feet.

This species was observed at the following localities: Goleta, El Segundo, and La Jolla; and at Santa Rosa and Santa Catalina Islands. It is present throughout the year and is abundant in deep rocky areas.

The larvae are probably born in the winter. The smallest young, less than an inch in length, appear at depths of 40 to 90 feet in March and April. Later, during June and July, when between 2 and 3 inches in length, and living at depths of 25 to 100 feet, the dark brown to blackish young are beginning to turn rusty brown.

The adults are excellent food fish and are fished with heavy lines in the deep water. Spearfishermen equipped with breathing devices are beginning to spear this species. The spines of this species are mildly poisonous.

Vermilion rockfish are occasionally found among the rocks along the outer edges of the kelp beds. They are therefore not adversely affected by the kelp cutting.

Sebastodes atrovirens (Jordan and Gilbert) -- kelp rockfish

The largest adult of this species collected in this investigation was 13 inches in length. In life the color is quite variable, usually light tan to brown.

Kelp rockfish live in the lower levels of the kelp and among rocks at depths averaging 34 feet, with an observed range from the surface to 140 feet.

They were observed at the following localities: Goleta, Point Dume, Rocky Cove, Long Point, Whites Point, San Clemente, La Jolla, Point Loma, and Bahía San Carlos; and at San Miguel, Santa Catalina, Santa Rosa, Santa Cruz, Coronado, and San Martín Islands.

They are abundant throughout the year, and feed on crustaceans and small fish.

Ripe adults were observed in December. Females ready to give birth to larvae were speared at Newport and La Jolla in March.

Inch-long young appeared in large numbers along the scattered rocks on the open sand bottom in April through August. Fish 2 to 3 inches long were taken in August and September.

Fishermen commonly catch kelp rockfish in the kelp beds and spearfishermen take fair numbers. They are good food fish but should be handled with care, as the fins are mildly poisonous.

This is the rockfish that is most commonly brought aboard the kelp cutters during harvesting operations, but the average weight taken is less than two pounds per day per harvester. This destruction is inconsequential in comparison with the sport and commercial catches. Harvesting has no other known effect on the species.

Sebastodes saxicola (Gilbert) -- popeye rockfish

Small adults taken from the La Jolla canyon were estimated to be 7 inches in length. They are grayish above to silver below.

They live over rocky bottoms in deep water; only the young enter the kelp beds.

This rockfish was observed at La Jolla and on Santa Cruz and Anacapa Islands.

The food habits were not investigated.

The very small young, an inch or less long, appear in March, April, and May in the surface kelp, especially in the inshore kelp close to rocks. Larger young are found in the deeper water below 100 feet during June and July. This is an abundant but very small deep-water species, not taken by sport or commercial fishermen. Kelp harvesting does not significantly interfere with the life cycle of this species.

Sebastodes semicinctus Gilbert -- halfbanded rockfish

No adults were taken in this investigation. Young were taken at mid-depths in the kelp in May and juveniles were taken at mid-depths in June.

Observations were made at Long Point and La Jolla.

This small species is not important in the sport or commercial catch. In inshore waters it occurs too rarely to be significantly disturbed by harvesting methods.

Sebastodes auriculatus (Girard) -- brown rockfish

The largest adults observed by diving were estimated to be 14 inches long. The colors vary considerably; in general, however, they are dark brown, mottled with light brown, with a dark "ear" spot.

Brown rockfish were observed in the shallow-water rocks at depths of 15 to 40 feet. The species is also caught in deeper water.

Specimens were observed at the following localities: Monterey, Rocky Cove, Newport Beach, La Jolla, and Bahía San Carlos.

This species feeds on crabs and small fish. It is common but not exceedingly abundant.

Nothing is known of the early life history, but it is presumed to follow the pattern of the genus.

This fish lives low in crevices and is not easily seen. Numbers are caught in lobster traps, few by hook and by spear.

Brown rockfish are not disturbed by kelp harvesting as they inhabit only the lower parts of the beds.

Sebastodes rastrelliger (Jordan and Gilbert) -- grass rockfish

The largest specimen observed was estimated to be 16 inches long. The color is a mottled blackish brown. The pectoral fins usually have a pink edge.

Grass rockfish live among the seaweeds of the shallower depths. They were observed at an average depth of 17 feet, with a range from the surface to 60 feet. Most are concentrated between 3 and 30 feet.

They were observed at the following localities: Yankee Point, Goleta, Portuguese Bend, Newport Beach, La Jolla, Punta Escarpa, Punta Blanca, Punta Cono, and Bahía Playa María; and on San Miguel, Santa Rosa, Santa Cruz, and Coronado Islands.

They were observed throughout the spring, summer, and fall, but were missing in my observations during the winter months. Although the observations are few, it seems probable that during the spawning season, which coincides with the seasonal winter storms, the species moves either into deeper or into intertidal waters.

Young were observed from March to September, in the same areas as the adults.

This species feeds on crabs and small fish.

It is taken along the rocky shore by hook fishermen and by skin divers. It is a fair food fish.

Since it merely enters the rocky-bottom inshore edges of the kelp beds, this rockfish is presumably not affected by kelp harvesting.

Sebastodes chrysomelas (Jordan and Gilbert) -- black-and-yellow rockfish

The largest adults taken in this investigation were estimated to be 10 inches in length. The color is dark brown or black above, spotted with orange or yellow.

This rockfish lives in rocky areas in shallow water, especially around the large sea urchin. It was observed at an overall depth range from the surface to 35 feet, at Yankee Point, and at San Miguel, Santa Rosa, and Santa Cruz Islands. There was no opportunity to examine the range during the winter. The observations were made through spring to early fall.

The food habits were not investigated.

Young were found in shallow water in June, July, and September.

This is an important sport fish in the central and northern California areas. It is a shallow cold-water species, but some enter the rocky bottoms below the kelp in the more northerly harvested areas. It is highly improbable that the species is affected by kelp harvesting.

Sebastodes carnatus (Jordan and Gilbert) -- gopher rockfish

The larger adults observed do not exceed 10 inches. They are dark brown to tan, spotted with yellowish pink.

Gopher rockfish live among the rocks in the kelp beds and deeper. They have an observed range of 5 to 130 feet. In the warmer La Jolla area adults are never observed at less than 30 feet.

Specimens were observed at Monterey, Newport Beach, and La Jolla, and at Santa Cruz and Coronado Islands.

This is usually the most abundant rockfish at depths of 65 to 100 feet. It lives in areas with much rocky cover, especially where boulders are covered with sea urchins.

The food is crabs, small fish, and squid.

Young were observed in July. The breeding habits are probably similar to those of other species of the genus.

Gopher rockfish are taken commonly by hook-and-line fishermen in the kelp beds and occasionally by spearfishermen.

At no stage in its life cycle does this bottom species appear to be disturbed by kelp harvesting.

Sebastodes serriceps (Jordan and Gilbert) -- treefish

Large adults observed in shallow water were estimated to be 12 inches long. They are olive, fading to yellow on the sides, and are heavily banded with black. The chin is red.

Treefish inhabit rocky crevices, especially those with sea urchins in the shallower waters. They were observed at depths averaging 45 feet, with a depth range of 8 to 140 feet.

They were observed at the following localities: Goleta, Point Dume, Newport Beach, La Jolla, and Mission Beach; and at San Miguel, Santa Cruz, Santa Catalina, and Coronado Islands.

They are common throughout the year, though never abundant.

The food habits were not investigated.

In its breeding habits this species is thought to be similar to others of the genus. The young, appearing in late summer and early fall, seek shelter among sea urchin-filled crevices at depths of 35 to 130 feet.

Specimens from deeper water seem to have longer spines and the color less olive, brighter yellow.

Treefish are taken occasionally by hook and by spear.

Harvesting surely has no effect on this rock-dwelling form.

Hexagrammos decagrammus (Pallas) -- kelp greenling

The largest specimens observed were estimated to be 14 inches in length. The color of the male is brown with light blue spots. The females are brown with fine brown spots.

Kelp greenling were observed around rocks at depths averaging 32 feet in southern California and 7 feet in northern California. The observed depth range varies from 4 to 75 feet in southern California and from the surface to 20 feet in northern California.

They were observed at the following localities: Trinidad Head, Goleta, Elkhorn Slough, Yankee Point, El Segundo, Whites Point, and Newport Beach; and at Santa Rosa and Santa Cruz Islands. They were observed from March through September in southern California. They are still scarce in the more southern localities, although they are apparently rapidly increasing in abundance there. They are much more abundant in northern California.

No study was made of the food habits or the breeding habits.

Larvae and young were collected in March and slightly larger young in June. Spawning must occur during the winter.

These greenlings are bottom dwellers that seldom leave the bottom except when disturbed.

They are prized as sportfish in the central and northern parts of California.

At least in southern California this species has no direct relationship to giant kelp, but sometimes lives among rocks that support the holdfasts.

Ophiodon elongatus Girard -- lingcod

The largest adults observed were estimated to be 3.5 feet in length. The general color in life is brown with dark spots.

Lingcod occur in deep water in southern California, but penetrate into shallow water in northern California. Those observed in La Jolla were at depths below 65 feet. In central California they were observed in shallow water, even in the tide-pools.

They were observed at Morro Bay, Goleta, Point Dume, El Segundo, and La Jolla, and at Santa Rosa and Santa Cruz Islands.

They are found in southern California from March to September and probably throughout the winter. The eggs are laid in the winter; larvae appear in March.

This good food fish is sought by anglers and skin divers. It has no apparent relationship to kelp, other than to live about the rocks below the kelp.

Oxylebius pictus Gill -- convictfish

Large adults were estimated to reach a length of 10 inches. The color is gray marked with black or red bars.

Convictfish occur in the rocky areas, preferring those with little growth. The depths of observations average 45 feet, with an observed range from the surface to 160 feet. Most of the population was observed between 4 and 120 feet.

Specimens were observed at the following localities: Yankee Point, Goleta, Point Dume, El Segundo, Long Point, Whites Point, Newport Beach, San Clemente, La Jolla, Santo Tomás, and Bahía San Carlos; and at San Miguel, Santa Rosa, Santa Cruz, Anacapa, Santa Catalina, and Coronado Islands.

They are present throughout the year. Though not gregarious, they often concentrate in favorable habitats.

The food habits were not investigated.

The eggs are probably produced in winter. Off La Jolla in December, at a depth of 50 feet, an individual was observed to attack a sheephead almost a hundred times its own weight, apparently as a territorial display in defense of a nest. Young only an inch long, with an ocellus on the dorsal fin, were collected on the Newport breakwater during February. A slightly larger specimen was observed at Whites Point in April. The young seek cover among gorgonians.

Convictfish sometimes live on and among rocks below the kelp beds. Harvesting has no apparent effect on the population of this species, which is not taken by fishermen.

Scorpaenichthys marmoratus marmoratus (Ayres) -- reef cabezon

The largest adults observed are estimated to be 2 feet in length. The color is generally olive, mottled with irregular patches of brown or brownish red.

Reef cabezons were observed on almost all rocky bottoms at depths ranging from tide-pools to 150 feet. Depths observed in southern California averaged about 35 feet.

They were observed at the following localities: Trinidad Head, Elkhorn Slough, Monterey, Yankee Point, Goleta, Point Dume, El Segundo, Whites Point, Newport Beach, San Clemente, La Jolla, Bahía San Carlos, Punta Escarpa, Punta Blanca, Bahía Playa María, and Punta Rocosa; and on San Miguel, Santa Rosa, Santa Cruz, Coronado, San Martín, and San Geronimo Islands.

They are present throughout the year in southern California. They appear to be especially common in the Santa Barbara region.

They feed on crabs, small lobsters, squid, octopus, abalone, fish eggs, and small fishes. Often their own eggs are found in their stomachs. The abalone are swallowed whole and the shells are apparently regurgitated after some digestion has taken place. These shells are sometimes beautifully polished by the stomach acids.

Ripe males were found as early as October. In southern California the eggs are laid in December, January, February, and March. The eggs are laid in large masses on cleared, usually steeply slanting, rocks at depths ranging from the tide-pools to 65 feet. Those observed in the tide-pools were under rocks or in deep crevices. Nesting sites are located close together in restricted areas. The same nesting sites are used each year. An adult male remains to drive away intruders which threaten the nests and to fertilize further spawnings. The eggs occur in three different colors -- white, pink, and blue-green. They turn olive as they mature. The larvae and young are pelagic. The pelagic young are silver-sided and have the typical pelagic color patterns. Young enter the tide-pools and lower levels in March, April, May, and June, at a length of 1.5 inches. They quickly lose their pelagic color patterns and develop a mottled pattern suitable for rocky bottoms heavy with plant and animal growths. Isolated objects at depths of 30 to 90 feet attracted many young cabezons to an otherwise bare bottom.

Cabezons are considered excellent food and are highly prized by anglers and spearfishermen. With the increased use of self-contained diving apparatus, the nesting adults may be severely threatened.

Cabezons live primarily on the bottom. However, occasional specimens enter the canopy and may be taken aboard the kelp harvesters. Such incidents are rare. The kelp harvesting does not affect the life of this species.

Icelinus cavifrons Gilbert -- pit-head sculpin

Specimens collected were as long as 3.5 inches. They were mottled olive with dark bars.

This species was observed at La Jolla and on Santa Rosa, Santa Cruz, and Anacapa Islands.

The feeding and breeding habits were not investigated.

This is a small fish of no direct economic importance. It enters the outer rocky areas of the kelp beds.

Artedius creaseri (Hubbs) -- roughcheek sculpin

This small species, mottled tan in color, lives in rocky crevices where the epibiose is heavy. The observed depth range is from the surface to 50 feet.

Roughcheek sculpins were observed at the following localities: La Jolla, Bahía San Carlos, Punta Blanca, Bahía Playa María, and Punta Rocosa; and at San Miguel, Santa Cruz, Santa Catalina, Coronado, and San Martín Islands.

They were observed through most of the year. They seem to be quite common.

The food habits were not investigated. The stomachs of poisoned specimens contained freshly poisoned fishes.

Young 0.5 inch long occur in June and July.

This sculpin has no economic value and is not affected by kelp harvesting.

Artedius corallinus (Hubbs) -- coralline sculpin

This small bottom fish is mottled with pink, brown, and white.

It prefers crevices, but does not require a heavy epibiose. It is especially common in encrusting coralline algae. The observed range is from the surface to 130 feet.

Coralline sculpins were observed at the following localities: Portuguese Bend, La Jolla, Punta Blanca, Punta Cono, Bahía Playa María, and Punta Rocosa; and at San Miguel, Santa Rosa, Santa Cruz, Santa Catalina, and Coronado Islands.

The food and breeding habits were not investigated. The young, 0.5 inch long and smaller, were collected in June, juveniles in August, and half-grown in September.

This species has no apparent economic value, and is not closely associated with kelp.

Artedius lateralis (Girard) -- smoothhead sculpin

This small tan-mottled fish inhabits the shallow waters, especially under rocks. It was observed to range from the tide-pools to 35 feet.

It was observed at the following localities: Yankee Point, Newport Beach, La Jolla, Punta Blanca, and Bahía Playa María; and at San Miguel, Santa Rosa, Santa Cruz, and Coronado Islands.

The breeding and food habits were not observed. Young were observed in July and September, juveniles in September.

This is another species of no economic importance, and not closely associated with kelp.

Orthonopias triacis Starks and Mann -- snubnose sculpin

The largest specimens observed were 3.5 inches in length. The general color is reddish brown, with a series of dark blotches along the back.

Snubnose sculpins were found living among the short seaweeds at an average depth of 42 feet, with a depth range from the surface to 130 feet. Most of the population is concentrated between 15 and 70 feet.

They were observed at the following localities: Newport Beach, La Jolla, and Bahía San Carlos; and at San Miguel, Santa Rosa, Santa Cruz, Santa Catalina, Coronado, San Martín, and San Gerónimo Islands.

They occur throughout the year in southern California. They are common though not extremely abundant.

The food habits were not investigated.

Mating behavior was observed in the aquarium in April. A relatively large male which had been in the aquarium for some time swam over to a newly introduced female, followed her for some time, and then tried to or possibly mated with her. He would move in beside and partially on top of her, curling his ventral section toward her.

Young less than 1 inch long were found in June, July, August, and September. They were at depths of 20 to 100 feet, on sparsely covered rocks and among broken bits of seaweeds and other detritus.

Adults were usually found in pairs during the winter and spring.

Its small size and relatively small numbers render this species economically unimportant, either directly or indirectly. It is common everywhere along the bottom in the kelp beds, but apparently never ventures into the mid-kelp or canopy biotopes.

Clinocottus analis (Girard) -- wooly sculpin

The largest adults observed were estimated to have a length of 6 inches. The color is usually dull mottled greenish black, with specklings resembling salt and pepper.

This sculpin is primarily a shallow-water fish. Even the large adults live in the deeper tide-pools and just below the low-tide line. The species was observed from the tide-pools to depths of 18 feet.

The postlarvae were taken during the winter months at the surface inshore and in the canopy. In February and March the young were found in the shallow, higher tide-pools.

Wooly sculpins were observed at Yankee Point, Portuguese Bend, Newport Beach, La Jolla, Punta Blanca, Punta Cono, Bahía Playa María, and Punta Rocosa on the mainland; and at San Miguel, Santa Rosa, Santa Cruz, Anacapa, Santa Catalina, San Martín, and San Benito Islands.

They are present in the tide-pools throughout the year, and are one of the dominant tide-pool fishes.

Leiocottus hirundo Girard -- lavender sculpin

The largest adults were estimated to attain a maximum length of 10 inches. The general color is light gray or pinkish, marked with a darker saddle.

Lavender sculpins live on the sand near rocks at moderate depths. The observed depths averaged 30 feet, and ranged from 7 to 72 feet.

They were observed at Newport Beach, San Clemente, and La Jolla on the mainland; and on Santa Rosa, Santa Cruz, and Santa Catalina Islands.

Though they are present throughout the year, they are never abundant or even common.

A single young was taken on Santa Rosa Island in March at a depth of 72 feet. A solitary half-grown specimen was taken on Santa Catalina in June at a depth of 15 feet.

This sculpin is rarely taken by lobster fishermen. It occurs in the kelp beds only incidentally.

Leptocottus armatus Girard -- staghorn sculpin

The largest adults observed in this investigation were estimated to be 8 inches long. The color is mottled olive-gray on the back, fading to white below.

Staghorn sculpins are sand dwellers, chiefly of shallow water. They were observed at depths ranging from tide-line to 30 feet.

They were observed at the following localities: Pájaro River, Elkhorn Slough, Monterey, Point Dume, Newport Beach, and San Clemente. They occur more abundantly in the bays, where they burrow in the sand.

They are taken occasionally by fishermen, but are too small to be of any considerable value. They are utilized as forage by several fishes, including halibut and scorpionfish.

They occur commonly in the sand-bottom kelp-bed biotope.

Odontopyxis trispinosa Lockington -- pit-head poacher

The largest specimens were estimated to be only 3.5 inches long. They are brown. The general shape is angular, tapering from the head. The scales are relatively large and platelike.

These poachers occur in deep waters and were observed at depths of 40 to 290 feet, and probably occur deeper.

They were observed at the following localities: La Jolla, off the Tijuana River, and in Bahía San Carlos; and on Santa Cruz, Anacapa, Santa Catalina, and San Martín Islands.

They feed on small crustaceans.

Half-grown specimens were taken at a depth of 140 feet in June, at Santa Catalina Island.

This species is too small to be economically significant. It enters only the deeper parts of the kelp beds, especially in areas where the epibiose is sparse.

Liparis mucosus Ayres -- slimy snailfish

This fish is usually less than 2 inches in length. The color varies from olive to pink or red; the pattern is either plain or finely striped.

It is closely associated with the inshore seaweeds, but on rare occasions occurs in the lower parts of the kelp beds, down to depths of 35 feet.

Specimens were observed at La Jolla and in Playa María and San Carlos bays; and on San Miguel, Santa Rosa, Santa Cruz, Santa Catalina, and San Martín Islands.

Half-grown specimens were collected with the adults in summer and late fall, in shallow water.

The species is rare in the kelp beds and has not been collected among the harvested kelp.

Aulorhynchus flavidum Gill -- tube-nose

The tube-nose is a small, very slender fish, closely related to the sticklebacks (Gasterosteidae). The largest specimen measured was less than 6.5 inches.

Tube-noses are found over rocky areas in shallow water in northern California, but often in deeper water in southern California. They were observed at depths estimated to average 36 feet, with a range from the surface to 100 feet.

They were observed at the following localities: Van Dam State Park, Morro Bay, La Jolla, Point Loma, and Punta Rocosa; and on San Miguel, Santa Rosa, Santa Cruz, and Coronado Islands.

They are present throughout the year in southern California. At times they are extremely abundant.

They feed primarily on small free-swimming organisms which include amphipods, mysids, fish larvae, and crab zoeae.

The life history was observed in detail. Spawning takes place throughout the year. The male binds seaweed together with a very thin thread which is extruded from the urogenital region. The seaweed chosen is often the new growths in the lower parts of the giant kelp. The eggs are deposited around the seaweed by the females and are closely guarded by the male, who drives off intruders by dashing at them. The translucent orange eggs hatch in about two to three weeks, and the larvae form schools near the bottom, usually in quiet water near rocks or seaweeds. Schooling behavior continues throughout life and is broken up only during spawning, when the male must remain to guard the nest. The young probably take less than one year to mature.

This fish is extremely abundant and serves as an important forage item. They have been found in the stomachs of kelp bass and sand bass. The eggs have been taken from the stomachs of sand bass, scorpionfish, and cabezons.

This species is not taken by fishermen because of its small size and feeding habits. The lower parts of the giant kelp that are used for spawning are not disturbed by kelp harvesting.

Syngnathus arcta (Jenkins and Evermann) -- snubnose pipefish

This small pipefish was estimated to reach a maximum length of only 5 inches. The general color is brown, olive, or black, often flecked or marked with white.

Snubnose pipefish live among the short coralline algae or in the broken bits of eelgrass among the rocks, usually in shallow water, but were observed to range from the tide-pools to depths of 60 feet.

They were observed at La Jolla, Bahía Playa María, and Punta San Rosarito; and at Santa Catalina, San Martín, and San Gerónimo Islands.

This very small and relatively uncommon fish has no economic importance. It occurs in the kelp beds close to the bottom among the short seaweeds, and is not affected by kelp harvesting.

Syngnathus sp. -- slimnose pipefish

This small species seldom exceeds 8 inches. The color is green to dark olive.

It was usually observed at the surface among bits of drifting surf-grass. None was observed deeper than 18 feet.

Specimens were observed at La Jolla.

They are relatively uncommon in the kelp beds. They do occur in the region of the canopy among the broken bits of surf-grass trapped there. None was collected on board the kelp harvesters.

Syngnathus californiensis Storer -- kelp pipefish

The largest measured individual was slightly under 18 inches in total length. The color of those found in the kelp beds varies from olive to yellow.

This pipefish lives among seaweeds, but is particularly fond of the giant kelp, especially in the canopy and mid-kelp biotopes. The average depth of the observations was 10 feet, with an observed depth range from the surface to 48 feet.

Specimens were observed at the following localities: Monterey, Goleta, San Clemente, La Jolla, Point Loma, Cabo Colnett; and on San Miguel, Santa Rosa, Santa Cruz, and Santa Catalina Islands.

The kelp pipefish is common throughout the year. It feeds chiefly on mysids and small amphipods.

The females lay their eggs in a pouch in the male. The eggs hatch and are retained in the pouch for a short time, and then released as miniature, thread-sized adults. Spawning occurs throughout the year.

The young live among the seaweeds with the adults and some probably spend their entire life in the kelp beds.

Kelp pipefish are not significantly important to man. They are occasionally preserved and sold as curios. They serve, to a small extent, as forage for kelp bass and gulls.

They are quite common in the harvested kelp, but the numbers thus taken are infinitesimal in comparison with the numbers that remain in the kelp beds.

Coryphopterus nicholsi (Bean) -- crested goby

The largest specimen observed was estimated to have reached the maximum size of 4.5 inches. The color in life is gray-white to pale yellow, with black eyes.

Crested gobies live in the deep quiet waters along the bottom, entering the intertidal regions of bays and penetrating into deeper water in the open sea. They were observed at depths ranging from the intertidal regions to more than 200 feet.

They were observed at the following localities: Pacific Grove, Yankee Point, Goleta, Point Dume, El Segundo, Rocky Cove, Newport Beach, San Clemente, and La Jolla; and at San Miguel, Santa Rosa, Santa Cruz, Anacapa, Santa Catalina, Coronado, and San Martin Islands.

This goby occurs throughout the year and is extremely abundant, especially on fine sand among or near rocks.

The breeding habits were not discovered, although intensive searches were made for their eggs. The definite territorial habits of the adults indicate a strong possibility that they may guard a nest of eggs, as is the common practice of other members of the same family. Half-grown and sub-adult specimens are common throughout the year.

When disturbed, these fish seek shelter in crevices or burrow in the sand or mud.

They penetrate the kelp beds only along the substrate. They have no direct relationship to kelp and are not affected by harvesting operations.

Lythrypnus zebra (Gilbert) -- zebra goby

Zebra gobies are usually less than 2 inches in length. They are dull red with numerous fine blue bars.

They live in rocky areas where there is a heavy shell epibiose, usually inside crevices or caves where the light is not strong.

They were observed at depths ranging from tide-pools to 110 feet, averaging 27 feet.

They were observed at Newport Beach and La Jolla; and at San Miguel, Santa Cruz, Santa Catalina, Coronado, and Guadalupe Islands. In general they are much commoner around the islands than on the mainland.

This species is extremely abundant throughout the year in southern California.

Because of its habit of living in dark crevices or caves, it is seldom observed. However, it is almost always found when the rocky environments are intensively collected.

Zebra gobies are insignificant in the economy of the kelp beds, owing to their very small size. They are not affected by kelp harvesting.

Lythrypnus dalli (Gilbert) -- bluebanded goby

Bluebanded gobies reach an estimated total length of 2.5 inches. The color is orange-red, with a few iridescent blue crossbars.

They live on rocks that are not heavily covered with seaweeds or mosslike animals. They occur at depths from the surface to 100 feet, with the average depth of observation at about 30 feet.

They were observed at Newport Beach and La Jolla; and at Santa Catalina, Coronado, and Guadalupe Islands.

This species occurs throughout the year in southern California and is especially abundant on the offshore islands.

It feeds on small crustaceans, including amphipods.

The eggs are spawned in empty shells, especially the empty shells of attached mollusks such as the scaly worm mollusk and the rock scallop. The eggs are protected by the male, who remains until the eggs are hatched. The oblong eggs are attached at their base by threads to the inner surfaces of the shells.

Eggs were collected in nature in August and some were spawned in the aquarium in May. The young and postlarvae were collected in March.

The scarcity of specimens on the mainland may be due to its parasitization there by a parasitic isopod. Almost all specimens collected on the mainland were infected, but none of those collected on the islands was.

This fish is small and economically insignificant. Its bottom habits prevent it from being adversely affected by kelp harvesting.

Lethops connectens Hubbs -- halfblind goby

Halfblind gobies reach an estimated length of about 2.5 inches. They are pale olive-tan in life.

They live around rocks, probably among the gravel between boulders. They were collected at depths from the surface to 50 feet.

They were observed at Gaviota, Newport Beach, and La Jolla; and at Santa Cruz, Santa Catalina, and Coronado Islands.

This species was collected from March through September, mostly as postlarvae, which are extremely abundant under the kelp canopy.

It feeds on small crustaceans.

The postlarvae occur in extremely large schools beneath the kelp canopy in the mid-kelp biotope, sometimes extending into the bottom biotope. Because of their extreme abundance, I suspect that the young may be utilized as forage for young or small fishes. They settle to the bottom as they change into sub-adults and seek out crevices. The postlarvae prefer heavy canopy and may be disturbed to a small extent by kelp harvesting. However, they seem equally numerous in cut and uncut kelp beds.

Typhlogobius californiensis Steindachner -- blind goby

The largest blind gobies observed were slightly less than 2.5 inches in length. They are almost uniformly translucent pink.

They live in association with a ghost shrimp (Callianassa sp.) in sand burrows, usually under rocks. They were observed at depths ranging from intertidal regions to 50 feet and probably occur deeper.

They were observed at Portuguese Bend, Newport Beach, La Jolla, and Santa Cruz Island.

Their life habits were not investigated, but have been described in detail by MacGinitie.

They do occur in the sand patches among rocks in the kelp beds.

They are of no economic significance and are not disturbed by kelp harvesting.

Porichthys notatus Girard -- northern midshipman

The largest adults observed were estimated to be 11 inches in length. The color is purplish brown above to yellow below. The sides are beaded with small silver luminous organs.

This common deep-water fish enters the tide-pools of northern and central California to spawn. Specimens were collected at depths ranging from low tide to 280 feet.

They were observed or collected at the following localities: Pájaro River (entrance to sea), Monterey, Goleta, Bahía San Carlos, and Punta Canoas; and at San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands.

They are present throughout the year, especially in deeper waters.

They spawn on the sides and undersides of rocks, ranging from the intertidal region to depths of at least 265 feet. The parents guard the nest of rather large eggs.

The young seek cover by burrowing in the mud or sand. Young were found at depths ranging from shore to 35 feet.

The adults are occasionally caught by bottom fishermen, but because of their ugly appearance I seriously doubt that many are eaten. They have sharp, mildly poisonous spines.

They were observed only once in harvestable kelp beds during this investigation.

Porichthys myriaster Hubbs and Schultz -- slim midshipman

The largest adults observed were an estimated 15 inches in length. The color is rather similar to that of the northern midshipman, except that the fins are more definitely bordered with dark.

Slim midshipman were observed at depths ranging from 6 to 130 feet. They seem to prefer sandy mud near rocks.

They were observed at the following localities: La Jolla, San Carlos Bay, Punta Canoas, Bahía Playa María, and Santa Rosalía; and about Santa Rosa and Santa Catalina Islands.

They were scarce and only sporadically observed.

Young were collected in September on Santa Catalina and Santa Rosa Islands at depths ranging from 6 to 20 feet.

A single adult specimen was observed in the La Jolla kelp beds in March. No others were observed in the kelp beds during the entire investigation.

Rimicola muscarum (Meek and Pierson) -- kelp clingfish

These tiny fish measure less than 1.5 inches. The color is generally that of the kelp. Some of them are banded with light orange.

They cling tenaciously to the kelp with a sucker composed chiefly of their pelvic fins. They are more common in the canopy than elsewhere, but do occur at the lower levels, even to the region of the holdfasts.

They have been observed at Goleta, Newport Beach, San Clemente, La Jolla, and Point Loma.

They are abundant in the canopy throughout the year. They feed primarily on small crustaceans.

The relatively large eggs are laid in groups of two dozen or more on the leaflike blades of the giant kelp. Usually the eggs are laid in between the corrugations. The eggs have been found throughout the year. The young are similar to the adults and probably spend their entire life in the kelp beds.

They cling to the kelp, moving occasionally to feed or seek cover. Their coloration makes them almost invisible.

They serve in a small way as forage for kelp bass, kelp rockfish, and olive rockfish.

Many of those living in the canopy are brought aboard the kelp harvesters. Most escape, however, and return to lower levels. They are abundant in both harvested and unharvested kelp beds.

Gobiesox rhessodon Smith -- California clingfish

These small brown fish, which are shaped like a frying pan, seldom reach a length of 2 inches. They rarely enter the shallower portions of the kelp beds, but have been taken as deep as 35 feet. They are, however, a typical tide-pool fish, which lives under stones and boulders of the tide-pools.

A single specimen was collected in the kelp off the Coronado Islands. Others have been observed in tide-pools at Portuguese Bend, Newport Beach, La Jolla, and the San Benito Islands.

They have no economic importance and are not affected by kelp harvesting.

Paraclinus integripinnis integripinnis (Smith) -- California reef finspot

Most of the adults observed were less than 2 inches in length. The color in life varies from a mottled dark, almost blackish brown, through pink to creamy white.

This species was found to live among the short coralline algae at depths ranging from tide-pools to 60 feet. The average depth of observation was 13 feet. Most of the observed population was concentrated between 2 and 25 feet.

Specimens were observed at the following localities: Newport Beach, La Jolla, Bahía Playa María, and Punta San Rosarito; and at Santa Cruz, Santa Catalina, Coronado, San Martín, and San Benito Islands.

They occur throughout the year, but are never extremely abundant.

Half-grown specimens were collected in January at La Jolla.

They are insignificant fish of no economic value. They are not affected by kelp harvesting.

Alloclinus holderi (Lauderbach) -- island klipfish

The larger adults are estimated to reach a length of 4.5 inches. The color in life is a pinkish gray with a dark stripe running from the eye along the sides of the body.

The island klipfish lives among boulders and ledges with much cover. It was observed at depths ranging from tide-pools to 70 feet, averaging 20 feet.

It occurs more commonly on the offshore islands than on the mainland. Specimens were observed at the following localities: La Jolla, Punta San Rosarito, and Bahía Playa María, on the mainland; and on Santa Cruz, Santa Catalina, Coronado, and Guadalupe Islands.

Island klipfish are solitary, somewhat territorial bottom fish. They are too small to be of direct value to fishermen, but may play a small role as forage for game fishes. They are not affected by kelp harvesting.

Heterostichus rostratus rostratus Girard -- California kelpfish

The larger adults are estimated to attain a length of 20 inches. The color varies with the habitat, from bright green with silver stripes in eelgrass and in surf-grass to yellow-brown in the giant kelp.

Kelpfish live among seaweeds from low tide to depths of 100 feet. The average depth of observation was 15 feet.

They were observed at the following localities: Monterey, Morro Bay, Goleta, Point Dume, Newport Beach, Laguna Beach, San Clemente, Solana Beach, La Jolla, Point Loma, Bahía San Carlos, Punta Escarpa, Punta Cono, Bahía Playa María, Punta Rocosa, Bahía San Rosarito, and Bahía Magdalena; and at San Miguel, Santa Rosa, Santa Cruz, Santa Catalina, Coronado, San Martín, San Gerónimo, and San Benito Islands.

They occur throughout the year and are extremely abundant in and among all seaweeds. They feed predominantly on small crustaceans, but do feed on small fish and mollusks too.

The spawning occurs from March through July. The pink to greenish eggs are laid on seaweeds and are held there by entangling threads which are part of the egg covering. The male remains to guard the eggs.

During the spawning, which occurs in the territory of the male, the female places the eggs on the seaweed while she shimmies with the male next to her, sometimes parallel and sometimes head to tail. The activity often takes place in strong surges.

The eggs have been found on sargassum, ribbon kelp, giant kelp, and surf-grass.

The transparent postlarvae appear from April through August, usually in shallow water at depths of 5 to 30 feet. They school until they are approximately 2.5 inches long. At this stage of development they begin to assume their adult colors and become solitary in habit, living close among the seaweeds.

They are despised by most sportfishermen as food, although they can be eaten.

Numbers of juveniles and adults are taken on board the kelp cutters during harvesting. The majority of the population, however, lives inshore and is not disturbed by harvesting. The population remains at a high level.

Gibbonsia metzi Hubbs -- weed klipfish

Large adults reach a length of 7 inches. The color varies somewhat with the background, but is much less variable than that of the ocellated klip-fish. Those found in the kelp are kelp-colored, sometimes barred with brown.

Weed klipfish live among the seaweeds of shallow waters and in the canopy and mid-depths of the kelp beds. They have an observed depth range from the surface to 30 feet, with an average of 8 feet.

They were observed at Portuguese Bend, Newport Beach, La Jolla, Point Loma, and Bahía Playa María; and at Santa Rosa, Santa Cruz, Anacapa, Santa Catalina, and Coronado Islands.

They are found throughout the year in southern California. They are quite numerous in certain specific localities.

They feed on small crustaceans in the canopy biotope.

The spawning habits were not observed although an intensive search was made for their eggs. They probably do not spawn in the canopy.

Schooling young were observed from April through July. The transparent young appear under the kelp and inshore. As the fish become opaque, they move into the seaweeds.

Weed klipfish are of no significant economic importance, but are probably utilized incidentally as forage by game fishes. They are brought aboard the kelp cutters in considerable numbers, when the kelp is being cut over rocky bottoms. The numbers brought aboard, however, are small in comparison with the numbers in the beds and the kelp harvesting presumably has little effect on the total population.

Gibbonsia elegans (Cooper) -- ocellated klipfish

The largest adults observed were estimated to be 4.5 inches long. The color varies with the seaweed background, from gray-brown through yellow-brown to red or greenish. Usually the body is barred or mottled and has one to three ocelli (eye spots).

Ocellated klipfish inhabit the seaweeds from shore down to observed depths of 70 feet. Gibbonsia elegans elegans lives in the tide-pool region and just below. Gibbonsia elegans velifera, a longer-finned, usually mottled red fish, lives in the deeper portion of the habitat.

Ocellated klipfish have been observed at the following localities: Portuguese Bend, Newport Beach, La Jolla, San Carlos Bay, Punta Escarpa, Punta Blanca, Punta Cono, Bahía Playa María, and Punta San Rosarito; and at Santa Rosa, Santa Cruz, Anacapa, Santa Catalina, Coronado, San Martín, and San Benito Islands.

This species occurs throughout the year and is extremely abundant close among the short seaweeds. Because of their ability to blend with their background, they are not easily observed, even by divers.

They feed on small crustaceans and mollusks.

They were observed spawning in January, May, and June. The eggs are laid among short seaweeds. The female lays her eggs periodically, getting astride the egg mass and undulating her body stiffly as she adds to the egg mass. Occasionally she gets off the egg mass and pushes seaweed into it with her head.

The male brings his vent as close to the female as possible without pushing her. Then he quivers, becomes rigid, and falls back as if spent (and probably is). The male takes time out to drive away intruders, such as larger fish.

The egg mass is white and the total mass less than 1 inch in diameter. The male remains and guards the nest.

This is an economically insignificant fish except that it is utilized as forage to a small extent by certain of the game fishes. It occurs along the bottom of kelp beds and in areas of short seaweeds. It is not affected by kelp harvesting.

Gibbonsia erythra Hubbs -- scarlet klipfish

This close relative to the preceding species was taken during this investigation on one occasion in the kelp beds, at La Jolla in a depth of 60 feet.

It is too rare and too small to be important economically.

Neoclinus stephensae Hubbs -- yellowfin fringehead

This species attains an estimated length of only 5 inches. It is dark olive, spotted with green. One specimen was bright orange (perhaps an erythric specimen).

Yellowfin fringeheads live in empty shells or in holes in rocks, at depths ranging from 10 to 90 feet. Four of the five specimens taken were at depths less than 20 feet. A single specimen was taken at a depth of 90 feet at the outer edge of a kelp bed.

They were observed at the following localities: Newport Beach, and La Jolla; and at San Martín and San Gerónimo Islands.

A young one was taken in August and a juvenile in September. The eggs of others in the genus were taken in the spring and early summer.

This is a relatively rare fish, not economically significant in the fauna of southern California.

Neoclinus blanchardi Girard -- sarcastic fringehead

Large adult males may attain a length of up to a foot. The head is large with exaggerated jaws brightly marked with yellow. The general body color is a mottled warm brown to gray.

They live on sandy bottoms usually in a discarded can or bottle. In a few instances they have been found in sea shells and under rocks.

The orange eggs are laid in the "home" of the male. The eggs are attached by means of threads which protrude from the base of each egg. The male guards the eggs and fans them with an undulating motion of his body.

The adults occur at depths of 25 to 90 feet, preferring a depth of about 60 feet at La Jolla. The were observed at Catalina Island, Point Dume, and La Jolla.

They are not used as food and have no relationship to kelp occurring together only where the bottom is predominantly sand.

Rathbunella hypoplectus (Gilbert) -- smooth ronquil

The large adults were estimated to be 8 inches in length. In life they appear olive-brown above to gray below, sometimes blotched.

Smooth ronquils prefer deeper water combinations of rock and sand. They were observed at depths ranging from 20 to 175 feet. with the largest population at a depth of 130 to 150 feet.

They were observed at La Jolla and in San Carlos Bay.

They are bottom fishes which seek shelter in rocky crevices. They seem to have no special territory as do most rock-bottom dwellers, but wander somewhat. When frightened, they will "play possum."

They are an uncommon fish in the deeper range of the giant kelp, but do occur there in small numbers.

(Unnamed prickleback)

This small fish attains an estimated length of about 8 inches. It varies in color from cream through red to black.

It lives among rocks and in seaweed holdfasts at observed depths of 15 to 100 feet.

Specimens were observed at La Jolla and at San Miguel and Santa Cruz Islands.

They were found in all seasons. They are common in the holdfasts of the La Jolla kelp. Often the head projects from the holdfasts as if waiting for food.

These fish are relatively rare. Their numbers are insignificant in relation to other fishes. Kelp harvesting has no detrimental effect on them.

Xererpes fucorum (Jordan and Gilbert) -- rockweed gunnel

The largest adults observed were 5 inches in length. Those that live in the kelp are yellow-brown and match the background of the giant kelp. Others are green or red.

Rockweed gunnels are primarily inshore weed fishes and probably live only in shallow water. The observed depth range of this species was from the surface to 30 feet, with the average depth of 6 feet.

They were observed at the following localities: Yankee Point, Portuguese Bend, La Jolla, Point Loma, and Punta Escarpa; and at San Miguel, Santa Rosa, Santa Cruz, and San Martín Islands.

They are common throughout the year. They live among the red and green seaweeds inshore, taking on the colors of the inshore plants. Those that live in the canopy are yellowish-brown and entwine with the stipes.

Young occur in March in southern California and in August and September north of Point Conception.

Rockweed gunnels are insignificant in the ecology of the kelp, although small numbers from the canopy are brought on board kelp cutters.

Ulvicola sanctaerosae Gilbert and Starks -- kelp gunnel

Large adults measure about 9.5 inches. They are kelp-colored and blend with their background in color, texture, shape, and diameter.

They live entwined in the canopy kelp at shallow depths, although they have been observed from the surface to depths of 40 feet. The majority live in the canopy.

Specimens were observed at the following localities: Goleta, Gaviota, La Jolla, and Point Loma; and at Santa Cruz, Santa Catalina, Coronado, San Martín, and Guadalupe Islands.

They occur throughout the seasons in the canopy. They are common, although not extremely abundant.

They feed on the mysids and amphipods of the canopy.

Ripe adult females were taken in January. Young were collected in March and June.

This species probably spawns in rocky crevices or holes. No eggs were found in the canopy although intensive searches were conducted.

The species is probably not an important forage fish and has no other economic significance. A portion of the population is taken on board the kelp harvesters, but is no doubt small in proportion to those that escape as the kelp is brought on board.

Mola mola Linnaeus -- common mola

The largest observed were less than 3 feet in total length. They are dark gray above and silver on the sides and below.

Molas (or "ocean sunfish") are pelagic, but at times are common along the edges of the kelp beds, especially at the surface.

They were observed at the following localities: Pacific Grove, Yankee Point, Newport Beach, and La Jolla; and about Santa Rosa, Santa Cruz, Santa Catalina, and Coronado Islands.

They occur sporadically throughout the year, usually in large numbers when present.

They feed upon jellyfish, by-the-wind sailers (Velella), and gooseneck barnacles.

No adults or young were observed and spawning is believed to take place farther south.

Molas come into the kelp beds and allow señoritas to flock around them and eat the external parasites. They seem to congregate purposely at the edges of the kelp beds, where the supply of jellyfishes is larger and where the señoritas will eat their parasites.

At times the common mola may leap clear of the water. The fish leaves the water on its side and at an angle, and falls back into the water on its side.

Molas are edible, but are seldom sought by fishermen.

Kelp harvesting does not interfere with the life cycle of this fish.

INVERTEBRATES OF THE KELP BED CANOPY BIOTOPE

Hydrozoa

Hydrozoans (mosslike animals) are found attached to the fronds in the canopy. The two most common are probably Sertularella sp. (Fig. 16), and Campanularia sp. The two species form similar appearing colonies of hair-size projections from the kelp fronds. The projecting portions of the colonies are connected by runners, with the runners radiating from a central point. The colonies are seldom more than 0.5 inch high, but may cover a circular area 2 to 3 inches in diameter (see Fig. 16). They are plantlike in appearance to a casual observer, but under the microscope they are extremely beautiful little yellow-brown colonies of animals.

The hydrozoans feed on plankton and other small organisms that come within their grasp. They are so small that their feeding effect on other organisms in the canopy must be insignificant. I have observed no organisms feeding on kelp hydrozoans, but suspect that several of the small nudibranchs may. Hydrozoans are so few and so small that they probably have no significant effect on the total ecology of the canopy, even if they are utilized as food by other animals.

Coelenterata

A small (0.5 inch in diameter) anemone, Epiactis (prolifera?) occurs sporadically throughout the canopy, usually attached to the pneumatocysts. Normally it may be found intertidally, especially at the extreme low tides. It is common, but less abundant, in the deeper water, sometimes invading holdfasts in rather large numbers. It is also quite common, at times, on the lower stipes. Its feeding habits are probably similar to those of other anemones, which wait for small organisms to brush against their tentacles. They sting their prey and fold it into their centrally located mouth.

This small anemone occurs in a variety of colors in its rocky habitats, but those found attached to kelp are the color of their background and are not easily observed. Anemones of other species have been found in the stomachs of garibaldi (Hypsypops rubicunda), a reef-dwelling fish, but it is highly unlikely that individuals of this species found in the canopy are utilized as forage to a large extent by any fishes.

Annulata

A number of worms inhabit the surface canopy, but only the tiny shell-dwelling serpulid worm, Spirorbis, is sufficiently abundant to be worthy of special note.

It attaches its tiny sinistrally spiraled shells to the fronds of kelp, most abundantly in the deeper portions of the beds, but commonly in the surface kelp. The white shell is usually less than one-eighth inch in diameter. These tiny worms filter their food from the passing sea water and may materially reduce plankton when they are sufficiently concentrated.

Three species of fish, kelp perch (Brachyistius frenatus), pileperch (Damalichthys vacca), and señorita (Oxyjulis californica) occasionally feed on this worm. The pileperch rarely enters the canopy region, but feeds upon this worm in the lower regions.

Bryozoa

Certain colonies of bryozoans found on the kelp fronds are sometimes mistaken by fishermen for fish eggs. Others are mistaken for plants.

Membranipora serrilamella (Fig. 8), an encrusting calcareous form, sometimes covers more than 90 percent of an entire plant. The additional density may even sink some of the stipes. It is more abundant along the lower portions of the plants, but is not at all uncommon in the canopy. In old unharvested beds it is particularly noticeable. Because of its abundance it may cause a significant reduction in the amount of plankton in the kelp bed as it feeds partially on plankton. Small amounts of this species have been taken from the stomachs of the following fishes: kelpperch (Brachyistius frenatus), garibaldi (Hypsypops rubicunda), señorita (Oxyjulis californica), opaleye (Girella nigricans), and halfmoon (Medialuna californica).

Both the garibaldi and the opaleye are known to feed on plants and the occurrence of this bryozoan may be entirely accidental, although once in the stomach of a fish it is probably digested and utilized. The predominant food of the kelpperch and the señorita is small crustaceans (often parasites on other fishes), although they will pick on almost any small object attached to the kelp and in this way take in bryozoans.

The amount of bryozoans left after harvesting is always at a high level, for most of them live in the deeper water.

Bugula neritina, a purple bushlike colony, less than an inch high, is extremely common on the older leaflike blades of the kelp (Fig. 17). Associated with these are several small crustaceans, especially Caprella sp., a peculiar elongate amphipod. Bugula is rarely so abundant that it could have a noticeable effect on plankton. It apparently is not utilized as food by fishes, but may act as food and cover for small crustaceans.

Many other encrusting forms occur uncommonly in the surface canopy, but are common below.

Crustacea

The crustaceans are by far the most important invertebrates of the canopy, so far as fish are concerned. They are utilized as food by most of the canopy fishes. The classification of these organisms is difficult. Although many species occur in the surface area of the kelp beds, only the more important and conspicuous forms will be dealt with.

The barnacles are limited to those attached to the Norris top snail Norrisia norrisae, or to the kelp crab Pugettia producta. The predominant species is Balanus tintinnabulum, commonly found attached to boats, floats, and pilings. It is small, pink, and roughly cylindrical or conical. Barnacles feed on plankton and are themselves utilized only incidentally as forage by fishes. Their limited numbers could have little effect on other organisms in the kelp. They are mentioned only because they are relatively large and conspicuous.

The opossum shrimp Mysidopsis californica is extremely abundant in the canopy region and is probably the dominant organism in the upper 10 cm. They are small, less than three-fourth inch in length, and very slender. They spend much of their time darting through the water among the fronds. They will seldom leave the cover of the fronds and will remain with them even when they are submerged by storms. Because they have a tendency to aggregate and because their evasive darting movements resemble those of small fishes, many fishermen mistake them for larval fish.

The color of this shrimp varies from a dark, almost black, brown to a yellow-ochre. While resting on a kelp frond they are almost impossible to see. The young are carried in a brood pouch on the underside of the female.

Almost all of the common canopy fishes utilize these mysids for food. They have been found in the stomachs of the following fishes: kelp bass (Paralabrax clathratus), kelp topsmelt (Atherinops affinis cedroscensis), señorita (Oxyjulis californica), kelpperch (Brachyistius frenatus), blacksmith (Chromis punctipinnis), kelp rockfish (Sebastodes atrovirens), olive rockfish (Sebastodes serranoides), kelp pipefish (Syngnathus californiensis), kelp clingfish (Rimicola muscarum), kelpfish (Heterostichus rostratus), weed klipfish (Gibbonsia metzi), rockweed gunnel (Xererpes fucorum), and kelp gunnel (Ulvicola sanctaerosae). This long list of fishes feeding on this mysid illustrates its importance as forage.

It is seldom brought on board the kelp harvesters in any numbers because it falls through the screen.

A kelp-colored isopod Iodothea (Pentidotea) resecata, sometimes more than 2 inches long, is common throughout the kelp bed, but especially in the canopy. It clings tenaciously to the kelp, occasionally swimming from one stipe to another. Young as small as one-sixteenth inch in length are miniatures of the adult. This species is found inshore among other seaweeds

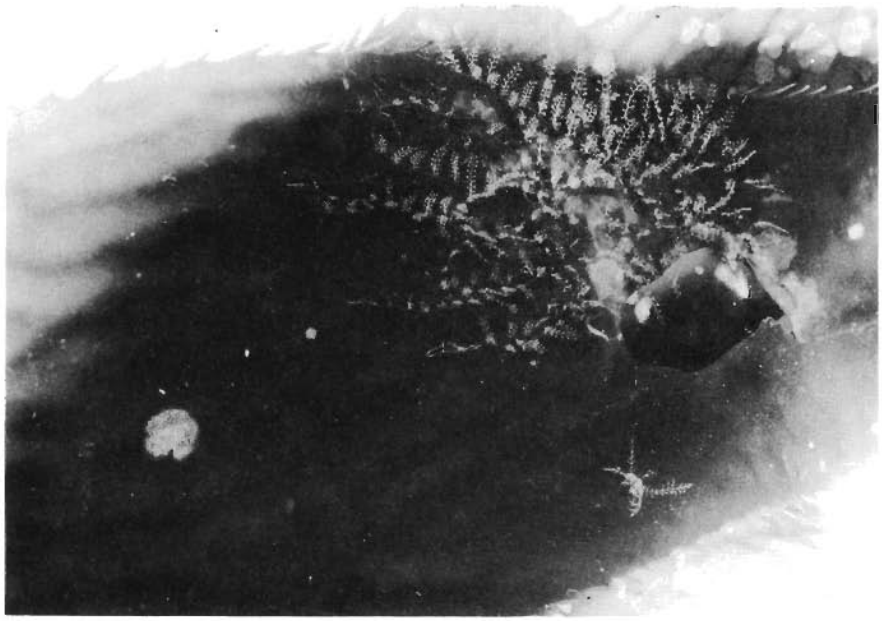


FIGURE 16. Sertularella sp., a moss-like animal, a hydroid, that grows on the leaflike fronds of the giant kelp.

FIGURE 17. Bugula neritina, a purple bushlike bryozoan less than an inch high which attaches to giant kelp fronds.

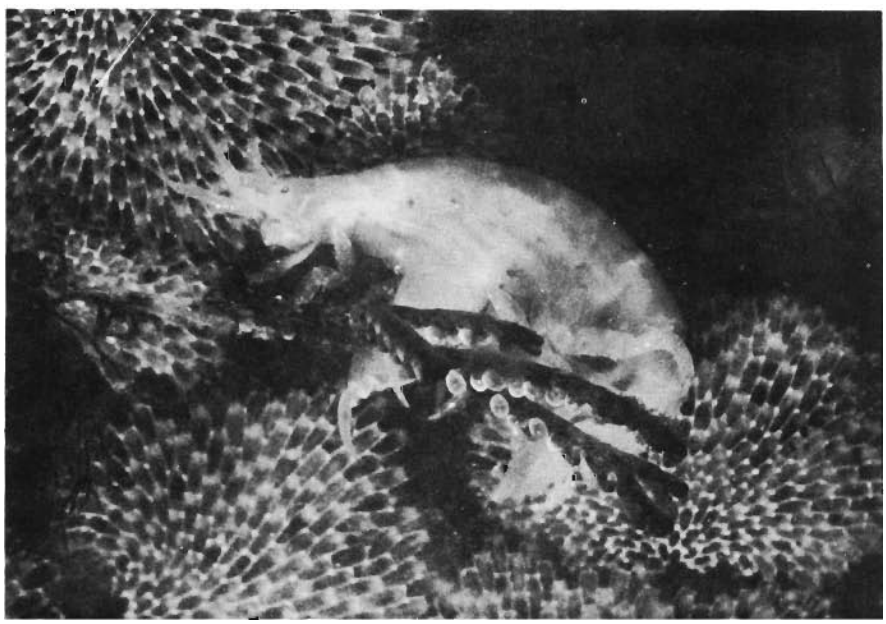


FIGURE 18. Hyale frequens, a small, but extremely abundant amphipod of the canopy region. Frequently mistaken for young lobster.

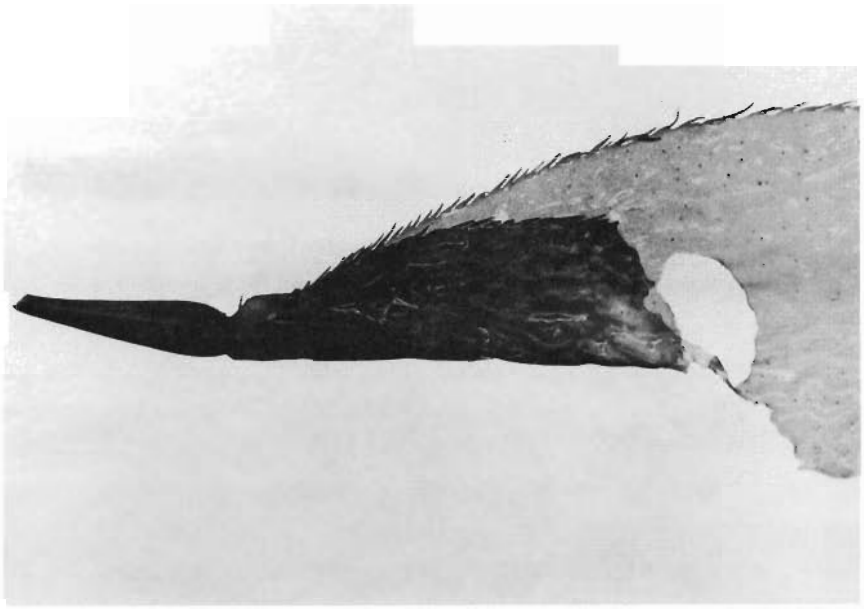


FIGURE 19. The tubular nest of the amphipod Ampithoe humeralis. The kelp frond has been curled and held together by mucus threads.

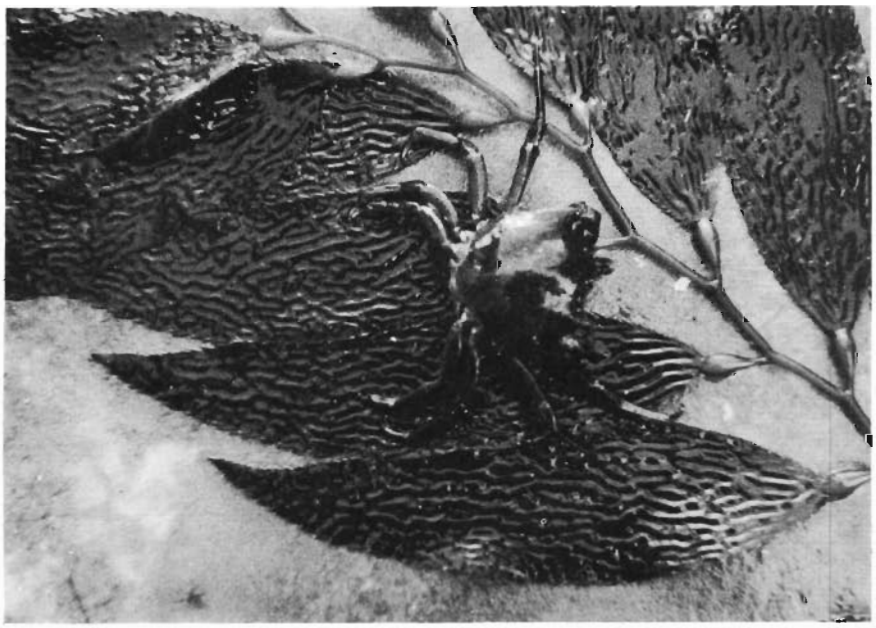


FIGURE 20. The common kelp crab Pugettia producta, a common inhabitant of the kelp.

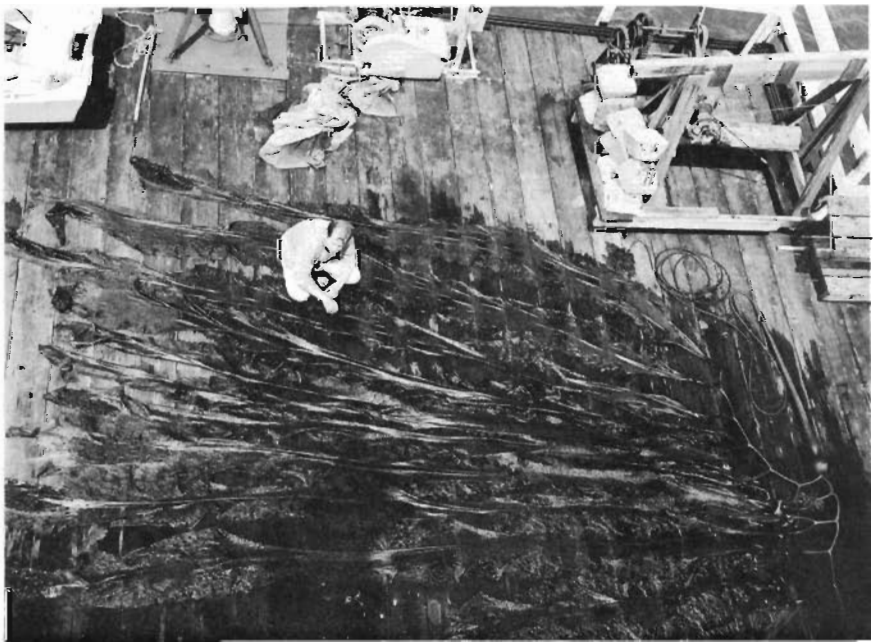


FIGURE 21. Pelagophycus porra, elk kelp. An entire plant taken from the La Jolla beds. Note the small holdfast and the slender basal portion of the stipe.

and serves as food for many fishes, especially the surfperches (Embiotocidae). Among the common canopy fishes it may serve as food for kelp bass, señorita, kelp rockfish, bass rockfish, and kelpfish.

Another less important isopod is Paracerceis sp. Usually this is less then three-eighths inch in length and almost as wide. It is found throughout the kelp and to a lesser degree in the canopy. It is a light gray and blends well with the encrusting bryozoans. It too clings tenaciously to the kelp and is almost never seen swimming. It is relatively rare as compared to Iodothea resecata and I have not found it in any of the fish stomachs. It is relatively large and its conspicuous shape makes it worthy of mention.

Another tiny shrimp, an amphipod Hyale frequens (Fig. 18), only one-fourth inch long, is extremely common throughout the kelp. Large numbers of these may be taken by shaking a dip net among the fronds. They usually remain attached to the fronds of the kelp, occasionally swimming short distances to alight on a new frond. The smaller ruby-spotted female is carried beneath the male. They serve as food for the same fishes that eat the mysid Mysidopsis californica. They are not quite as common in the stomachs as are mysids, probably because they are slightly less abundant.

Another much larger amphipod, Ampithoë humeralis, sometimes 1.5 inches in length, is much less common and has not been identified from the stomachs of the kelp fishes. However, dead specimens fed to señoritas and kelp bass were quickly eaten. This amphipod, which carries a brood of one-eighth inch young on its underside, has the peculiar habit of curling a kelp frond into a tube and then gluing it together with mucus (Fig. 19). Holes on the same frond, obviously cut by the builder, may be made during construction of the nest, or this amphipod may utilize the kelp as food.

Two species of crabs are found in the surface canopy, the southern kelp crab Taliepus nuttalli, and the common kelp crab Pugettia producta (Fig. 20). The former is rather rare in the canopy but is extremely common in the rocky crevices below and inshore, usually associated with spiny lobster, Panulirus interruptus. The common kelp crab is abundant throughout the kelp, but unlike the bright red southern kelp crab, it blends well with the kelp. Mating pairs and females with eggs have been observed in the winter and early spring months. Their food habits were not observed in nature, but in the aquarium they feed on almost any flesh.

These crabs do not form a large portion of the diet of any one species of fish, but may occasionally be found in the stomachs of kelp bass, sheephead, olive rockfish, scorpionfish, and the cabezon.

Mollusca

A common squid, Loligo opalescens, more typical of the nearshore open waters, is a common nocturnal visitor in the kelp and forms a large portion of the diet of the larger kelp fishes. Young squid are often found in the stomachs of the smaller kelp-dwelling fishes.

Norrisia norrisae, the smooth turban shell, is abundant on most of the brown seaweeds, and extends its habitat into the surface canopy. It is not nearly so common at the surface as in the lower layers. The bright red and black body of this relatively large snail makes this mollusk one of the most conspicuous of the canopy animals. The food habits are unknown. They have been observed in the stomachs of the bat ray, pileperch, and sheephead. The shell serves as a substrate for the acorn barnacle and the onyx slipper shell Crepidula norrissorum.

The gilded top snail Tegula aureotincta, although less common and less conspicuous than the smooth turban, is common in the canopy. It has not been observed in the stomachs of any of the fishes.

A very beautiful shell, the ring top Calliostoma arincolor, found in abundance in certain deeper cold areas of southern California, is common in the surface canopy above Point Conception.

The many smaller snails of the canopy have similar habitats and are utilized as food by a number of fishes. Included in this list are: small kelp bass, ocean blackfish, pileperch, kelpperch, sheephead, and señorita.

The two most common forms of small snails are the red- to kelp-colored Lacuna unifasciata, which lives in the canopy and mid-kelp region, and the brightly colored keeled dove snail Mitrella carinata, which lives in large concentrations in all three regions of the kelp as well as inshore.

Nudibranchs of small size are common inhabitants of all littoral marine environments of southern California. Classification of these organisms is extremely difficult, if not impossible. The kelp canopy has a variety of these tiny nudibranchs of various shapes and colors. Because of their small size and comparatively insignificant numbers, they cannot play an important part in kelp ecology.

One of the larger nudibranchs, Melibe leonina, is kelp-colored and feeds on the small crustaceans of the kelp, casting a netlike mouth around its prey. It is not extremely abundant and is of no significant importance. However, its eggs, along with the rosettes of cream-colored to yellow eggs of other nudibranchs, are often mistaken for fish eggs by fishermen.

The tiny kelp scallop, Pecten latiuratus, sometimes covers the kelp fronds in enormous numbers. It prefers the mid-kelp region and has a special liking for the elkhorn kelp which grows at mid-depths. Although they were not observed in this study in the stomachs of fishes, I suspect that they must serve as food for some.

Echinodermata

A number of young starfish, usually less than three-fourths inch, may be found scattered throughout the canopy down into the mid-kelp, and more abundantly in the region of the holdfasts. The more common canopy forms are Leptasterias aequalis, Linckia, and Pisaster giganteus.

Smaller Organisms

In addition to the obvious invertebrate forms mentioned above, there are hundreds of smaller forms too small to observe easily. They serve as food for some larval fishes and for a number of other animals, especially the filter feeders.

Populations

The relative numbers of the more common forms will vary from place to place, and from time to time, especially with the seasons. Although not many of them are gregarious, they often are concentrated because of the particular biological and physical conditions at a particular area. Forms not mentioned above may be temporarily abundant for a short period of time or new forms which were not common during this investigation may become established for longer periods at some later date. The ecology of the littoral ocean is more dynamic than that of the land. Drastic changes in organic communities may take place in a relatively short time. We can expect none of the biological populations to remain at a constant level.

INVERTEBRATES OF THE KELP-BED SAND-BOTTOM BIOTOPE

Corymorpha palma, the palm hydroid, reaching a length of 1 to 2 inches, is a slender, stalked, anemone-like, tan to pale orange hydroid, which anchors itself into mud or fine sand in quiet water. It is not uncommon in the kelp beds, but is more common along steep sloping sand banks where little or no sand movement occurs. It was observed at depths of 10 to 90 feet.

Renilla koletzi, the sea pansy, a 1.5 to 3.5 inch pansy-colored alcyonarian, shaped like a geranium leaf, anchors into its sandy environment with a short peduncle. It lives at depths from the surface to 60 feet in slightly turbulent water. The pansy nudibranch, Pleurophyllidia californica, often occurs on the sea pansy, and may feed on it. The sea pansy is less common in the kelp beds than on the open sand.

Edwardsiella californica, a small sand anemone, is sand-colored and 0.5 inch in diameter, with a stalk anchored several inches into the sandy mud. The disk lies flush with the surface of the sandy mud at depths from the surface to 45 feet. These anemones are common in bays and in the deeper but slightly turbulent ocean waters. They are about equally common in the kelp beds and on the open sand bottom. They tend to aggregate in colonies of a few to hundreds of individuals.

A tube-dwelling anemone, Cerianthus sp., varies from gray to fluorescent orange-red, and reaches 6 inches in diameter. It builds a leathery tube, which is buried for several feet in the substrate, and most frequently wedges itself around or between solid objects buried in mud or fine to

medium sand at depths of 8 to over 200 feet. It is rare on open sandy bottoms, but may be found in the sand-bottom holdfast area in the region of the holdfast, utilizing the buried portion of the solid substrate for its own stability.

Purple-striped jellyfish, Pelagia sp., are translucent white with purple markings. They grow to 20 feet in length and several feet in diameter. They inhabit the nearshore waters of California and the Pacific side of Baja California. They are common throughout the nearshore waters and are thus included in the sandy bottom fauna. They tend to avoid the kelp by swimming against the current and in this manner they are concentrated on the edges of the kelp beds. Half-dead and injured individuals are common on the bottom in the kelp beds, especially during certain summers when the population is extremely large. A number of fishes, including the opaleye, helfmoon, and common mola, feed freely on these jellyfish.

Scrippsia sp., a smaller, transparent, red-marked jellyfish, is common in southern California in some years. It is semi-pelagic, being found at depths ranging from the surface to 150 feet. However, it is more common close to the bottom or at the thermocline. It is especially fond of the sandy bottom areas in the kelp, where it may possibly feed on detritus obtained by dropping its tentacles to the bottom.

Sea walnuts, Pleurobrachia sp., are transparent, spherical, marble-sized jellies. They concentrate at the thermocline, and although pelagic, are often carried by currents into the kelp bottom area. They feed on plankton by means of two trailing tentacles. They are more numerous nearshore than in the open sea, but are no more abundant in the kelp than elsewhere nearshore.

Membranipora serrilamella, the encrusting bryozoan of the canopy region, is more abundant at the lower levels, especially the mid-kelp region.

Phidolopora pacifica, the lace coralline bryozoan, resembles a miniature orange- to pink-tinged coral. It lives in protected crevices of the holdfasts, where the colonies may reach diameters of 5 inches.

Idmonea and other common coralline bryozoans of similar appearance are more arboreal than the lace coralline bryozoans, but resemble them in color and habitat. The minutely branched colonies may reach diameters of 18 inches and a height of 6 inches. The colonies are utilized as cover by a great variety of small organisms.

Featherduster worms, Eudistylia polymorpha, usually wedge their thin leathery tubes in a rocky substrate, but often occur along the sandy bottom where a suitable solid substrate exists below the sand. Their tubes, averaging less than an inch in diameter, project several inches above the substrate. The yellow-orange to purplish black gills may expand, like a featherduster, to several inches in diameter. When disturbed by a change in current or light the gills are quickly withdrawn and only timidly reappear.

Tiny worms of the genus Spirorbis form calcareous coiled tubes on solid substrates such as rock, shells, and blades of kelp. In the sand-bottom holdfast biotope they attach to the holdfasts and stipes of the kelp. They are extremely abundant and are occasionally eaten by kelpperch, pileperch, and señoritas. They are more abundant in the mid-kelp and less abundant in the canopy biotope.

The sticky pinkish threadlike tentacles of the terebellid worms radiate from a hole in the sand. They attach to detritus and living organisms which they withdraw to the hole to feed on. They are more common in rocky areas, buried in the sand at the bottoms of crevices, but are not uncommon in the sand-bottom kelp biotope. They have been observed from low tide to depths as great as 150 feet.

The yellowish parchment-like tubes of Chaetopterus variopedatus, the parchment tube worm, are extremely abundant in certain areas. They are commonest on a solid substrate, partially buried in fine to coarse sediments. Colonies are sometimes attached to the half-buried holdfasts. They are filter feeders which often occur in sufficient numbers to have a material affect on the concentration of plankton. Many smaller organisms utilize the spaces between the tubes as cover. This worm is able to produce light when disturbed.

Diapatra ornata, the gray tube worm, is a small species that forms irregular gray tubes to which it attaches bits of shell and bits of dead seaweeds. It occurs on the open sand bottom, but is commoner on some solid substrates, which other individuals keep attaching themselves to on a solid bottom, often forming colonies of considerable size. These substrates may be a pebble or consolidated sediments. This worm is particularly common on old half-buried holdfasts. It is the predominant organism around the sewer outlets in Los Angeles County.

Astropecten armata, the common sand star, of purple color and ranging from 2 to 11 inches in diameter, lives on mud to medium-coarse sand at depths ranging from low tide in bays and estuaries to 90 feet in the open ocean. It may occasionally be found buried or partially buried, especially while feeding or when threatened by strong currents. It is particularly common in calm water, free from even moderate surge. It is equally common in the sand-bottom kelp beds and in the nearby sandy areas.

Luidia foliolata, the soft sand star, tan or gray and ranging in size from 2 to 13 inches, has a similar habitat, but is found at depths of 50 to 180 feet. It is rather uncommon in the depth range of Macrocystis.

A sand-burrowing brittle star is one of the most peculiar of the sand dwellers inhabiting the holdfast sand-bottom area. It ranges in depth from 30 to over 180 feet. The brittle star remains buried some 8 to 10 inches below the surface with each of its five arms, which may attain a length of 16 inches, protruding several inches through the sand from individual holes.

The individual arms are often mistaken for small sea pens by divers making casual observations and biologists interpreting bottom photographs often make the same mistake. It is very common, equally so inside the kelp beds and in nearby sand areas.

Sand dollars, Dendraster excentricus, are very abundant in certain areas. Concentrations of hundreds or even thousands per square yard are not unusual. Living adults are purple, roughly circular, flat, and 1 to 3 inches in diameter. Usually they stand on edge, half-buried in the sand. By far the largest portion of the population along the open coast is located in sand, outside the kelp beds at depths of 30 to 50 feet. Only scattered individuals have been observed in the kelp beds. These sand dollars have been found in the stomachs of pileperch, Damalichthys vacca, and occasionally in sheephead, Pimelometopon pulchrum.

Purple, heart-shaped, thin-spined heart urchins, Lovenia cordiforma, burrow in fine to medium sand at observed depths from the surface to 95 feet. They plough through the sand an inch or slightly more beneath the surface, leaving an indistinct furrow. They are seldom extremely numerous in any one area, but are common throughout the sand-bottom areas of quiet water. They are utilized as food by sand bass, Paralabrax nebulifer, señoritas, Oxyjulis californica, and the sanddab, Citharichthys stigmaeus.

Leptosynapta inhaerens, the transparent sea cucumber, lives beneath the sand, usually near buried solid substrates such as rocks or old holdfasts. It is particularly abundant in the shallow, rocky areas buried in the sand between and under rocks. It is not abundant in the sand-bottom kelp-bed areas.

Giant, yellow-ochre to red-brown, warty California sea cucumbers, Stichopus Californicus, are common in sandy and rocky areas where the water is cold. They prefer rocky areas and are found intertidally among rocks above Point Conception. In southern California they are more abundant in deeper water at observed depths of 60 to 190 feet. They are most common at depths below 100 feet in southern California, but small concentrations occur in the kelp beds. They feed continually on the mud, digesting organic particles and leaving sand casts behind.

Malpodia arenicola, known as "sweet potato," is yellow-tan, mottled with rusty red. It is smooth and resembles a sweet potato in size and shape. These sea cucumbers burrow in medium-grained sand to depths of 6 to 8 inches, in water from the surface to 60 feet deep. They usually occur near buried solid substrates and are common within the sandy-bottom kelp-bed biotopes.

A sand-dwelling hermit crab, Holopagurus pilosus, often carries dead moonsnail shells, in the shallower waters of California at depths from the surface to 35 feet, commonly entering the shallow parts of the kelp beds, but nowhere in great abundance.

A sand-burrowing hermit crab, which has been identified as Pagurus ochotensis, lives in southern California at depths of 18 to 65 feet. It utilizes the shells of many species of gastropods. When buried, only the stalked eyes and antennae are exposed; even the shell is buried. It prefers fine to medium sand and is nowhere abundant, although it is not uncommon throughout the sandy areas in cold water. It is somewhat more common in the kelp than on the open bottom.

The giant sand crab, Blepharipoda occidentalis, has a shiny gray elongate carapace approximately 2.5 to 4 inches in length. Aggregations of these burrowing crabs may reach 40 per square yard. They prefer a fine to medium sand and were observed in southern California at depths of 8 to 45 feet. They are more abundant in the kelp beds than in the surrounding areas, but are even more numerous at the heads of canyons. During certain seasons of the year the cast shells of these animals are extremely numerous. Like the sand hermit crab they often go unnoticed by the casual observer, because only their antennae and eyes protrude above the surface of the sand. They have been found in the stomach of the fantail sole, Xystreurys liolepis.

Cancer gracilis, the agile cancer crab, is purplish gray to gray-tan and relatively smooth and free of growth. They are more agile than any of the other southern California cancer crabs. They burrow into the sand and mud, usually near solid objects, but commonly in the open sand. Their presence may be detected by the protruding hydroid Clytia bakeri, which is sometimes attached to the carapace. They are the most common of the cancers found in the sand-bottom kelp beds. They have been taken from the stomachs of cabezon, Scorpaenichthys marmoratus. In southern California they prefer depths of 18 to 65 feet.

Heterocrypta occidentalis, the elbow crab, is purple, rather small (2.5 inches from elbow to elbow), with the two pincer arms together almost as large as the rest of the animal. They are most common in and around beds of sand dollars, with which they may share some biological relationship. They prefer medium sand from depths of 10 to 45 feet.

Randallia ornata, the purple globe crab, lives in habitats similar to that of the elbow crab, ranging slightly deeper, from depths of 15 to 55 feet on the open coast and into shore in bays. It too may have some relationship to sand dollars.

Loxorhynchus crispatus, the moss-covered crab, grows to a width of 20 inches with its legs spread. Scattered individuals may be observed crawling over the sandy or rocky bottom depths of 15 to 165 feet. It is one of the most conspicuous inhabitants of the sandy bottom kelp beds. Young specimens have been taken from the stomach of black croaker, Cheilotrema saturnum, and the cabezon, Scorpaenichthys marmoratus.

Pansy nudibranchs, Pleurophyllidia californica, are white-and-brown striped "sea slugs" which are closely associated with sea pansies. They occur in fine to medium sand from shore to depths of 60 feet. Their close association with sea pansies leads me to suspect that they feed on them.

The barrel snails, Actaeon punctocoelata, about 0.5 inch long and white with fine black bands, live on mud to rocky bottoms and in southern California are most commonly observed at depths of 65 to 120 feet, although they have been seen from shore to depths approximating 200 feet.

Conus californicus, the California cone, is probably one of the most abundant snails in southern California. However, its small size (1 inch) and its dull brown color make it inconspicuous. It is especially common on solid substrates near sand or mud. The sand-bottom kelp beds provide ideal habitats. It is found from the intertidal areas to observed depths of 180 feet. It is eaten by the sheephead, Pimelometopon pulchrum.

(Cryptoconus) carpenterianus, the Carpenter's turret snail, has a peach-colored shell marked with fine black bands. Large adults may reach a length of 4 inches, although the average size is less than 2 inches. This snail is very common throughout the fine sand to gravel bottom, especially around the heads of submarine canyons. They live at observed depths of 45 to 130 feet.

The purple olives, Olivella biplicata, are extremely common in the shallow waters, especially in the surf zone where they aggregate in thousands. Usually they remain buried in medium sand several yards inshore from submerged or partly submerged reefs. They do range, however, to depths of 50 feet and commonly occur in the kelp beds. They have been found in the stomachs of small adult pileperch, Damalichthys vacca.

Kellettia kelletti, the Kellett's welk, is a large spindle-shaped snail ranging in length from 4 to 6 inches. The shell is white with fine brown bands. However, the shell is usually covered with other organisms or stained. It prefers a rocky habitat, but does occur in the sand-bottom kelp beds and occasionally on the open sand or mud bottom. The gray-white, relatively large egg capsules of this snail are attached in large masses to rocks. The snail itself feeds on dead flesh or other organisms and is often captured in lobster traps. It occurs from shore to depths of 100 feet.

Nassarius fossatus, the channeled basket shell, a small orange to gray-black snail plows a small furrow over the open sand bottom from low tide to depths of 45 feet. It is a common inhabitant of the shallower portions of the sand-bottom kelp beds and the open sand bottom.

Polonices draconis, the fat moonsnail, is a tan-brown snail found in the fine to medium sand at depths from the surface to 45 feet. It may reach a size of 3 inches. Occasionally closely related species, P. lewisii and P. recluziana, occupy the same habitat.

Norrisia norrisae, the smooth turban, is a top shell, which also occurs in the canopy region, and lives on almost all of the larger brown seaweeds and probably lives wherever these seaweeds are found from low tide down to depths of 100 feet or more.

Common Marine Plants of the Kelp Bed Rock-Bottom Biotope

Codium cuneatum, spinach weed, replaces the pickleweed of shallower depths. It grows scattered, especially on the sides of rocks. It is a loose, floppy plant, sometimes 14 to 16 inches in height.

Petrospongium rugosum, sponge algae, covers the rocks with a spongy growth to depths of several inches. It inhabits the shallow calm waters, and penetrates only the shallower portions of the kelp beds.

Desmarestia munda, a brown alga of the deeper portion of the kelp bed, often grows in aggregations. It is several feet in length and attaches to the tops of rocks. It prefers a light surge.

Laminaria andersoni, palm streamer kelp, lives only in the deeper, colder portions of the kelp beds. It attaches to the surfaces of the rocks and provides part of the understory cover for the reef and bottom fishes.

Laminaria farlowi, giant streamer kelp, lives along the bottom like giant streamers, sometimes 12 feet in length and 2 feet wide. It is the most conspicuous and common of the streamer kelps. It serves as food for the red abalone, Haliotis rufescens, and the pink abalone, Haliotis corrugatus. It also serves as a substrate for the worm Spirorbis, the broad-eared scallop Pecten latiuratus, and a number of hydrozoans and small crustaceans.

Dictyoneuropsis reticulata, one-ribbed streamer kelp, is smaller and less common than the giant streamer kelp, but fills a similar ecological niche.

Costaria costata, three-ribbed streamer kelp, is almost identical with the one-ribbed streamer kelp in its habits and its habitat.

Pelagophycus porra, elkhorn kelp (Fig. 21), forms a loose subsurface kelp bed on the outer edges of the beds of the giant kelp. The fronds do not reach the surface except when the plant is torn loose from the bottom. The plants are never concentrated enough to form a subsurface canopy but the individual plants have extremely large leaflike blades which may serve as cover for yellowtail (Seriola dorsalis). Single plants often provide as much as 700 square feet of leaf surface. The single cordlike stipe arises from a small holdfast, usually less than 8 inches in diameter, and rises unbranched 30 to 40 feet, where it thickens into a hollow tube filled with gas and terminates in a cantaloupe-sized bulb. Attached to the bulb are antler-like branches from which the huge leaflike blades grow. These blades are often covered by thousands of broad-eared scallops, hydroids, and bryozoans. The pneumatocysts often bear the tooth marks of fishes which apparently scrape the surface for food. In the aquarium the opaleye (Girella nigricans) has been observed to make similar marks, and even to consume whole bulbs quickly. The holdfasts are utilized as cover for many small organisms and the eggs of the tube-nose, Aulorhynchus flavidum, are often found in these holdfasts. Live-bait anglers fish these beds, without realizing their existence, for barracuda, yellowtail, and other nearshore pelagic fishes. Beds of this kelp occur at Dana Point, La Jolla, Point Loma, and the Coronado Islands.

Pterygophora californica, smooth palm kelp, forms part of the deep-water understory. It is not exceedingly common.

Eisenia arborea, the southern California palm kelp (or a related species) forms much of the inshore "scrub forest" and most of the understory of the kelp beds. Along with Macrocystis and Egregia laevigata, it forms the principal food of the commercial abalones in southern California.

Egregia laevigata, ribbon kelp, lives in shallow water, including the inshore edge of the habitat of the giant kelp. It is one of the favorite habitats of the young kelp bass, 1 to 4.5 inches long. It is often covered with the worm Spirorbis and the central stem of the stipe is almost always infested with the kelp limpet, Acmaea incesa. It is less buoyant than giant kelp and does not always reach the surface. It often grows in sprawling, tangled, dark, at times almost black, masses that look forbidding to the sport diver and often have entangled those who choose to probe these masses. Fishes that commonly seek cover there are kelp bass, black croaker, white seabass, walleye surfperch, ocean blackperch, white seaperch, pileperch, shiner seaperch, rock wrasse, señorita, opaleye, kelp rockfish, and kelpfish.

Cystoseira setchelli is a sargassum which seems to retain its juvenile growth in deeper water in southern California, where it produces only a minimum of the more filamentous growth. It is common at moderate depths in the kelp beds and forms part of the cover for bottom fishes and some of the food for abalones.

Porphyra perforata, red sea lettuce, is an extremely thin red algae, reminding one of the placental tissues in its thinness and texture. It prefers the calm deep water on rocks close to the sand.

Species of Lithothamnium, ~~color~~ coralline algae, form encrusting calcareous growths that bear little resemblance to other seaweeds or to terrestrial plants. They grow from low tide to depths of 150 feet.

Bossea is a typical member of the coralline algae that form the pink mats in which many klipfish seek cover.

Botryocladia pseudodichotoma, sea grape, is a relatively common red seaweed that bears a striking resemblance to a bunch of grapes. It occurs at moderate depths of 10 to 75 feet. It forms part of the epibiose. It usually does not exceed a height of 10 inches.

Rhodymenia pacifica is a short, red, dichotomously branched red alga that forms a lawn-high covering on rocks of deeper water. Its habitat extends into the outer edge of kelp beds.

Phyllospadix torreyi, Torrey's surfgrass, lives from low tide to depths of 40 feet, barely entering the inner edge of the kelp. It is the common sea grass often called "eelgrass" by sportsmen and swimmers. It attaches to flat rocks, where it serves as cover for the least perch, opaleye, and kelpfish.

Invertebrates of the Kelp Bed Rocky-Bottom Biotope

Geodia mesotriaena, geode sponge, is found in the deeper portions of the kelp beds, usually on the upper surfaces of flat rocks, although it may occur on the sides. It is dirty cream colored and usually resembles a portion of the rocky substrate. It has a much flattened spherical shape, often 8 inches in diameter. When split open its centrally oriented crystal-like spicules give it the appearance of a goede.

Tethya aurantia, puffball sponge, inhabits the deeper parts of the kelp beds. It is often attached to the edges and sides, as well as the tops, of rocks. It is orange and resembles puffballs in size and shape. The maximum diameter observed was less than 5 inches.

Hemecton hyle, leaf sponge, grows in the deeper waters, on the vertical or nearly vertical sides of rocks. It is orange, up to 6 inches long, and quite foliose. It is not extremely common in the kelp beds, but occurs in spotty concentrations along the outer edges.

Rhabdodermella nuttingi, urn sponge, resembles a miniature white urn, and is seldom more than an inch high. It lives on solid substrates, usually on a vertical surface. It is extremely abundant inshore, but is less common in the deeper portions of the kelp beds.

Leuconia heathi, thistle sponge, is small (less than 2 inches in diameter), white, and slightly prickly. It attaches to sides and undersides of rocks. It is extremely abundant, especially where the epibiose is heavy.

Sphecospongia confoederata, the liver sponge, is the largest of the California sponges. Colonies 5 feet long have been observed. It has the color of cooked liver, except in a portion of its southern range where it is yellow. It prefers habitats which include accelerated current velocities, especially rock tunnels. In southern California it lives in the shallow waters, entering only the inner edge of the kelp beds.

Ferangia thiona, sulphur sponge, is attached to the sides and undersides of rocks. The amorphous shape is none the less conspicuous because of the sulphur color. It is extremely common and is probably the most abundant of the sponges living throughout the rocky parts of the littoral zone.

Chora celata, burrowing sponge, is a tiny sponge that burrows into the shells of abalone and rock scallops. It was observed commonly at depths of 60 to 130 feet.

Aglaophenia struthionides, ostrich plume hydroid, grows in the colder waters of southern California, becoming increasingly abundant at depths of 40 to 100 feet. It is attached to solid substrates near the edges of

rocks and holdfasts and is often found in stranded holdfasts, especially those of Pelagophycus porra. The colonies resemble the antennae of the wild male silk moths. They are brown and often 4 to 5 inches in length.

Scrippsia sp., the Scripps jellyfish, has already been mentioned in the discussion of the sand-bottom biotope. Its habits over the rocky areas are similar. It contracts a few times to lift itself off the bottom and drift a few inches with the current, then drops slowly to the bottom, allowing its tentacles to sprawl on the bottom a second, then it pumps itself back into the current and repeats this cycle. In the upper waters similar actions were observed, as the organism apparently picked up food by falling against it.

Pelagia sp., purple-striped jellyfish, is only an accidental inhabitant of the kelp beds, for those found there are almost always badly torn or dead. However, they do serve as forage for some fishes including the opaleye, halfmoon, and common mola.

Muricea fructosa, the rust gorgonian, is the most abundant gorgonian of southern California. Its rust-colored colonies with yellow polyps form gardens sometimes 3 feet deep on the relatively flat parts of the rocky bottoms. It serves as cover for many small fishes, especially young sheephead and convictfish. It grows from the low tide line to depths of 120 feet, with most of the colonies between 30 and 65 feet.

Muricea californica, the California gorgonian, is similar but smaller. Its polyps are white and the colonies are somewhat more bushlike, less fanlike. It often lives with the rust gorgonian in mixed colonies, but prefers somewhat shallower depths.

Lophogorgia chilensis, the pink gorgonian, prefers the colder waters, living somewhat deeper than the previously mentioned species. It is coral pink and grows to a height of 2 feet at depths of 35 to 150 feet in southern California. In places its colonies are sufficiently numerous to add cover for bottom fishes. It is harvested commercially by divers, to be utilized as ornaments in window displays and homes.

Eugorgia rubens, purple sea fan, a fuchsia-colored gorgonian, is more fanlike than the other species on our coast. It is comparatively small, rarely a foot high. It prefers deeper water and penetrates only the outer edges of the kelp beds. It too is harvested commercially and sold as an ornament, but to a lesser extent.

Balanophyllia elegans, cup coral, lives in large numbers, especially where the epibiose is thin or relatively hard. The cups are 0.5 inch in diameter. The fleshy part of the animal is orange. It prefers the sides and undersides of rocks.

Astrangea sp., colonial cup coral, appears on the sides of rocks in soft-appearing colonies and retracts when disturbed, exposing the sharp-edged cups.

Epiactis prolifera, prolific anemone (or a related species) is common in the canopy, mid-kelp, and holdfast regions. It is also common inshore among the rocks. It is small, less than an inch in diameter, and when found attached to kelp, it blends with its background. It is particularly fond of holdfasts and may be found on almost all large holdfasts.

Corynactis californica, the pink anemone, carpets the entire upper and lateral sides of rocks in certain areas of colder water at depths of 10 to 180 feet. Probably the most beautiful reefs on the California coast are those at Naples, California, which are covered with colonies of these colorful anemones ranging from a blue-purple through red, orange, yellow, brown, tan, pink, to almost white.

Cerianthus sp., tube anemone, is common in sandy patches among the rocks.

Turbellids are free-living flatworms that live in the dark crevices and under rocks. Most of them are less than an inch long, extremely thin, and very agile. They are usually dull-colored.

Membranipora serrilamella, the encrusting bryozoan, Phidolopora pacifica, the lace coralline bryozoan, and Idmonea sp., the common coralline bryozoan, are mentioned in the discussion of the sand-bottom biotopes.

Terebratulina unguicula, snake-head lampshell, is pea-sized, white-ribbed, and is usually well protected from strong currents. It lives on the sides and undersides of rocks at depths of 30 to 190 feet.

Terebratulia transversa, red lampshell, prune-sized, orange-red, strongly ribbed, lives on the sides of rocks. It is quite common, especially in the areas of colder water. The animals remain with their shells slightly open, but closing at slight disturbances. The shells are often heavily encrusted with other organisms.

Spirorbis sp., serpulid worm, encrusts many of the seaweeds at the lower levels. It is particularly common on the streamer kelps.

Serpula columbiana, red flower worm, is a small, 1 to 2 inch, worm which forms a calcareous shell attached to the tops and sides of rocks. It prefers the shallower depths but may occur as deep as the center of the kelp beds. Its bright red flower-like gills are withdrawn almost instantaneously when disturbed by differences in light intensity or turbulence.

Eudistylia polymorpha, featherduster worm, lives wedged against solid substrates. It is a common worm in the calmer, deeper waters and in the calm waters of bays. The feathery yellow-orange to purple-brown gill structures are quickly withdrawn when disturbed. The leathery tube may be over a foot and a half long. Most of it is wedged deep in crevices or sediments.

Sabellaria californica, honeycomb worm, forms large colonies up to 3.5 feet by 18 inches. They are formed in rocky crevices near sandy bottoms in shallow water. These brown honeycomb-like structures are made with sand grains. They are found only in the shallow portion of the kelp beds, but are often quite numerous if sand is available.

Sipunculoids, peanut worms, are slender gourd-shaped worms usually less than 2 inches in length. They live in the coarse sand under and near rocks and wedged among other animals, when the epibiose is particularly heavy.

Linckia columbiae, the irregular starfish, is small, usually less than 3 inches in diameter, blue-gray, and heavily mottled with dull purplish red. The arms are almost always of unequal length, owing to its habit of losing its arms and regenerating new ones. It lives among the heavy growth of other organisms which cover rocks. It prefers a flat rocky bottom.

Pycnopodia helianthoides, sun star, lives in the deeper cold water and is closely associated with the large sea urchin, Strongylocentrotus franciscanus, on which it feeds. This many-rayed star may reach a diameter of 3 feet.

Evasterias troschelli, colorful star, is a soft, rather variable starfish inhabiting the deeper water on rocky substrates. A diameter of 15 inches is not unusual for this species.

Leptasterias hexactis, six-rayed star, is seldom observed except as tiny individuals on kelp plants or in the holdfasts. It is usually less than an inch in greatest diameter. It is white. It undoubtedly feeds on organisms on the kelp.

Astrometis sertulifera, soft star, is common throughout the rocky areas. This brown, relatively soft, but quite spiny, 6 to 8 inch starfish, feeds on many organisms including other starfish.

Henricea sp., little red starfish, is a bright orange-red starfish which inhabits the deeper cold water. It is extremely abundant at depths of 65 to 90 feet. It may reach a diameter of 15 inches.

Henricea sp., little tan starfish, is a tan to buff starfish, slightly larger than the little red starfish. It reaches a diameter of 6 inches. It inhabits slightly deeper water than the preceding species. Young Henricea are common within the kelp holdfasts.

Asterina miniata, bat star, inhabits the shallower water from low tide to depths of 60 feet. It reaches a diameter of about 8 inches. Red, orange, cream-tan, blue-purple, purple, red-purple, rust-brown, and combinations of these colors are some of the varying colorations that have been observed. They often occur in tremendous numbers, especially where sea urchins abound.

Dermasterias imbricata, the leather star, is a common starfish, similar in size and shape to the bat star. It is the color of cooked liver marked with dull orange to red. The surface has a slimy texture. It inhabits the deeper waters of southern California and never occurs in large concentrations.

Mediaster aequalis, the vermilion star, is a small, very symmetrical, bright red starfish found in the deeper cold water at the outer edges of the kelp beds among the rocks.

Ophiothrix spiculata, the spiny brittlestar, occurs in almost unbelievable numbers in certain areas. The bottom in deeper water may be covered to depths of an inch or more by millions of these active animals. Holdfasts often have a hairy or mossy appearance owing to the projecting and wavy arms of these animals.

Strongylocentrotus purpuratus, the purple sea urchin, and Strongylocentrotus franciscanus, the large sea urchin, live in close association throughout their southern California range. The purple sea urchin ventures a little higher into the intertidal region and is less numerous at lower levels although both species are found to depths of 110 feet. They were both observed throughout the length of the state and on all the California islands visited. They were observed as far south as Magdalena Bay along Baja California and on all the islands visited between Magdalena Bay and California, including Guadalupe Island. They are omnivorous animals feeding on both plant and animal matter. They may even destroy sections of kelp beds and the disappearance of three square miles of kelp off the Tijuana River might be explained by the presence of large numbers of sea urchins, as has been mentioned. Along the breakwater at Newport Beach the presence of sea urchins could be noted by the absence of seaweeds. In sea urchin beds the rock surfaces have a barren appearance and are not able to support plant growth, except the encrusting coralline algae.

During the past two years there has been a noticeable decline in the numbers of these animals in the shallow waters down to 35 feet in the La Jolla area. This I attribute to the increased popularity as a food for skin divers. The many acres of these animals that live in the deeper waters remain untouched except by the occasional abalone diver who may collect a dozen or so for himself or an Italian friend.

The rock-cutting power of generations of the purple sea urchin has been common knowledge for many years. In their intertidal habitat each urchin sits half-buried in rock. The large sea urchin burrows into rock too in the sub-intertidal regions. At Yankee Point huge reefs are deeply perforated by thousands of large sea urchin-cut depressions. At La Jolla the sandstone boulders may be deeply cut or carved by sea urchins so that only a light skeleton of a rock remains.

Because of their seaweed-eating habits, the sea urchins are direct competitors with the abalone and their presence means a reduced number of abalone.

Almost all reef-dwelling fishes will feed upon sea urchins, but only the sheephead is properly equipped for eating them. The stomach contents of individual sheephead may contain nothing but crushed sea urchins, spines and all.

Sea urchins are a common diving hazard, for divers may bump or kick them and although the spines are blunt, they may enter the wet skin rather easily. The spines of the two species here discussed, though not poisonous, are brittle and hard to extract.

Cucumaria sp., the little sea cucumber, is pinkish orange, between 1 and 2 inches long, and literally covers the bottom in large areas around Santa Rosa Island. It has been found in lesser numbers along the mainland.

Stichopus parvimensis, the southern sea cucumber, is the most abundant form in the shallower and warmer waters. It prefers the rocky bottom and is extremely abundant in certain areas, and although it is considered good food it has not been accepted as a steady diet by many skin divers, probably because of the difficulty of preparing it. It serves as forage for some sheephead. It is seldom more than a foot long, and is usually orangish brown, but an occasional snow-white individual or ones with patches of white are observed. When sufficient food is unavailable, as in the aquarium, it becomes smaller and smaller, over a period of months, sometimes reducing to one-half its normal size.

Stichopus californica, the California sea cucumber, replaces the southern sea cucumber in the deeper colder waters, and over the calm sandy bottoms. It is a larger animal, sometimes over 2 feet long. It has larger and less numerous warts and will die when roughly handled.

Barnacles (Balanida) of several species form an insignificant portion of the biota. They are incidentally utilized as forage by sheephead and are heavily preyed upon by starfish. They occur at all depths in the littoral zone.

Amphipoda (flea shrimps) are probably the most important forage animals of the smaller reef fishes. These tiny creatures, some of which reach a length of one and three-quarter inches, are found throughout the seaweeds and the plantlike animal growth. They have been found in the stomachs of the following fishes: Paralabrax clathratus, kelp bass (juveniles); Paralabrax nebulifer, sand bass (juveniles); Atherinopsis californiensis, jacksmelt; Atherinops affinis cedroscensis, kelp topsmelt; Xenistius californiensis, salema (juveniles); Anisotremus davidsoni, sargo (juveniles); Cheilotrema saturnum, black croaker (juveniles); Seriphus politus, queenfish; Hyperprosopon argenteum, walleye surfperch; Embiotoca sp., ocean blackperch; Phanerodon furcatus, white seaperch; Damalichthys vacca, pileperch (juveniles); Cymatogaster aggregata, shiner seaperch; Brachyistius frenatus, kelpperch; Micrometrus minimus, dwarfperch; Chromis punctipinnis, blacksmith; Hypsypops rubicunda, garibaldi (juveniles); Pimelometopon pulchrum, sheephead (juveniles); Oxyjulis californica, señorita; Girella nigricans, opaleye (juveniles); Scorpaena guttata, scorpionfish (juveniles);

Sebastodes atrovirens, kelp rockfish; Oxylebius pictus, redbanded convictfish (Juveniles); Artedius corallinus, coralline sculpin; Odontopyxis trispinosus, pit-head poacher; Aulorhynchus flavidum, tube-nose; Syngnathus californiensis, kelp pipefish; Rimicola muscarum, kelp clingfish; Heterostichus rostratus, (California) kelpfish; Gibbonsia metzi, weed klipfish; Gibbonsia elegans, ocellated klipfish; Hypsoblennius sp., mussel-blenny; Xererpes fucorum, rockweed gunnel; Ulvicola sanctaerosae, kelp gunnel. The large number of fishes that feed on this group of animals is an indication of its importance in the biota. Unfortunately the taxonomy of this group has been neglected, making it difficult to separate and identify the more important species.

Caprellidae, ghost shrimp, are tiny mantis-like shrimp that live in hydroids and gorgonians in tremendous numbers. They blend with the color of their background, even on the pink gorgonians. They too make up a large portion of the diet of many of the reef- or rock-dwelling fishes.

Iodothea resecata, kelp isopods, are not too common in the lower portions of the kelp beds, preferring the canopy and mid-kelp regions. They are utilized by the canopy fishes but seldom appear in the stomachs of the bottom dwellers.

Limnoria sp., kelp-burrowing isopods, burrow into the haptera of the holdfast and weaken it. This tiny isopod may be, in part, responsible for the destruction of some kelp beds.

Hippolysmata californica, the red-and-white shrimp, is a small shrimp that lives gregariously in the darker crevices and caves, venturing out at night. It reaches a length of less than 3 inches. It serves as forage for the larger fishes which dwell in caves and deep crevices, such as California moray (Gymnothorax mordax), the black croaker, scorpionfish, and various rockfishes. It is being caught in increasing numbers and sold as live bait, as which it is reportedly very effective.

Balaeus harfordi, the abalone shrimp, is found living in the abalone and closely associated with the large sea urchin. It is purple-blue and only 1 inch long. It is found at all depths with the abalone and large sea urchins. It is quite common.

Spirontocaris species, bent-back shrimps, comprise a relatively large group of shrimps almost as important as the amphipods in the diet of the reef fishes. The species and individuals vary with their background from red through brown, olive to green.

Panulirus interruptus, California spiny lobster, is the commercial lobster of southern California and Baja California. It is very abundant, but seems to be rapidly declining in numbers and in size. The increased fishing pressure is probably responsible for the decline in lobsters. A small boy sitting in a boat over a rocky area during lobster season could throw rocks to a dozen floats without moving his own boat. In addition there is increased pressure from sportsmen in shallow water. Although

their catch is infinitely smaller than the commercial catch the sportfishing pressure has just begun to grow and may in the future be more important than the commercial catch.

Lobsters are not dependent upon kelp at any stage during their life. The eggs are carried by the female. The newly hatched young are pelagic, and the successive stages are also pelagic until the young lobster (1.5 inches long) enters the tide pools in the winter. After a few more stages, the lobster is a miniature adult seeking out rocky crevices during the day and foraging at night. Maturity is reached at about 8 inches. The legal size limit, somewhat larger, is designed to allow sufficient time for reproduction.

Crangon species, snapping shrimps, are everywhere abundant in the shallow-water rocky bottom. They seek out tiny holes which they protect aggressively with their huge snapping claw. A snap of the claw can injure a small fish. The sound they emit is a sharp click, but when thousands click at once they sound like static to divers. They serve as food for the reef-dwelling fishes.

Paguristes turgidus, the hairy hermit crab, is the predominant large hermit crab of the kelp beds. It inhabits the old shells of the wavy top snail and the Kellett's spindle mollusk. The hairy or bristly appearance of this animal is a good protective texture for the projecting legs in an environment of short seaweeds, hydroids, and bryozoans.

Porcelain crabs are small, flat, large-clawed crustaceans which cling closely to the undersides of rocks. They are utilized as food by the many small, large-mouthed sculpins, such as Artedius.

Pugettia productus, kelp crab, lives on the various kelps. More numerous inshore and in the canopy than elsewhere, it is utilized as food by several fishes, as is mentioned in the section on the canopy organisms.

Taliepus nuttalli, southern kelp crab, lives in the cracks and crevices along the bottom, occasionally venturing up the kelp into the canopy region. It lives in close association with the California spiny lobster.

Small spider and decorator crabs of many species inhabit the rocky bottoms. Usually they are so covered with plants and animals that they are not easily observed. They serve as food for the larger rock-dwelling fishes.

Loxorhynchus crispatus, moss-covered crab, is a common inhabitant of the rocky bottoms, but prefers the sand-rock combination.

Loxorhynchus grandi, the sheep crab, is one of our largest crabs. The extended legs of the male crab may reach a width of over 4 feet. A noticeable decline in the numbers of these crabs has been observed in the Newport and San Diego areas. Skin divers collect them and although some are utilized as food, most of them are collected as perishable trophies which end up in the garbage. They feed on other crabs, starfish, and rotting flesh.

Cancer productus, red crab, and Cancer antennarius, rock crab, are common inhabitants of the rock-sand bottoms. They are taken in large numbers in lobster traps, but are usually discarded as they have little market value. Lately, however, they are appearing more commonly in the markets and may be utilized to a larger extent in the future.

Paraxanthias taylori, lumpy crab, is a small crab with beadwork-like pincers. It is one of the favorite foods of the black croaker and is eaten occasionally by scorpionfish and cabezon. It is one of the most abundant crabs of the rocky bottoms.

Hinnites multirugosus, the rock scallop, is an abundant clam which wedges itself into protected crevices. It is quite edible and has become a popular food item of the skin diver, requiring legislation to protect it by restricting the number to 10 scallops per diver per day. The scallop attaches to rocks and must be pried loose with a heavy prying tool. The shells may reach a length of 9 inches. They are readily eaten by almost all reef fishes when broken open, but probably do not constitute a normal diet for any of them, although they are eaten by octopi. The empty shells serve as cover for tiny fish, such as gobies, clinids, and blennies.

Pecten latiuratis, broad-eared scallop, a small species, seldom over 1 inch long, most commonly lives attached to seaweeds such as the streamer kelps, elkhorn kelp, and giant kelp. It is common at lower depths on the streamer kelps.

Lima dehiscens, file shell, is a small white clam with a red animal. Although it is capable of swimming freely, it is usually found wedged in holdfasts or among soft worm tubes.

Pododesmus macroschisma, jingle, is a fair-sized edible clam. It has a very thin shell and a very compressed body. It lies so close to the rocks and its shell blends so well with the background, that even close inspection may miss entire colonies of these animals. Dead shells in large concentrations jingle with the surge and can be heard by divers several hundred feet away.

Botula falcata, pea-pod borer, burrows into rocks, especially soft shales. It is extremely numerous in the Palos Verdes area. The shells may reach a length of 4 inches. Their burrows are often used as cover for many small organisms.

Lithophaga plumulata, date mussel, burrows into rocks and shells and even the thicker basal parts of gorgonians. It is small, usually less than 2 inches long. It is common throughout rocky areas in the littoral region. Their burrows are often mistakenly referred to as pholad burrows by geologists.

Semele decisa, rock semele, lives in the shallow water in sand patches between rocks. It grows to a diameter of 3 inches. It is one of the favorite foods of the octopus and shells with chips in their edges are common in front of octopus "nests."

Pholadidea penita, the common pholad, burrows into the soft mud of shallow waters. Its black-and-white siphons lie flush with the rock surface. The shells may grow to 3.5 inches, although the animal may be much larger.

Tethys californica, California sea hare, lives from the low-tide line into the middle of the kelp beds. It is associated with seaweeds. During the mating period enormous mats of yellow eggs in long strings are laid entangled with the kelplike piles of sticky yarn.

Nudibranchs of varying shapes, designs and color are found throughout the rocky areas. Most of them feed on hydroids and small sessile organisms. They are extremely colorful, but are not sufficiently numerous to be important in the ecology of the kelp.

Mitra idae, Ida miter, is a slender black-shelled snail with a white-bodied animal. It is numerous, although scattered throughout the rocky areas of the kelp beds.

Kellettia kelletti, Kellett's spindle, is a large carnivorous snail often trapped by lobster fishermen. It sometimes attains a length of 5 inches. It is one of the two most numerous snails of the kelp beds. It prefers the flat rocky bottoms. Young specimens have been taken from the stomachs of young pileperch.

Columbella carinata, the keeled dove shell, is a small (one-fourth inch), brightly colored snail. Thousands may congregate in a single holdfast. They occur in the stomachs of señoritas, kelpperch, and pileperch.

Cypraea spadicea, nut-brown cowry, is an extremely common snail which lives among the sea urchins and under rocks. It is gregarious and as many as 70 individuals have been found grouped together on a small rock. The beautiful polished shells are about 2 inches long. They are sold commercially at curio stores.

Bursa californica, the California frog shell, appears in the deeper sections of the kelp beds, especially in areas of low flat rock and fine sand. It is taken commonly in lobster traps.

Aletes squamigerus, the scalyworm mollusk, lives as large colonies in rocky crevices. The calcareous tubes are quite irregular. They may attain a length of over 6 inches. The razor-sharp edges of the tubes have caused severe cuts on the bodies of skin divers and other swimmers.

Spiroglyphis lituellus, the crooked worm mollusk, is a more or less solitary animal which prefers to attach its coiled shell to flat rocks. It is more common than the scalyworm mollusks in the kelp beds.

Acmaea mitra, white cap limpet, lives on relatively barren rocks in the deeper cold water, especially in areas of coralling algae.

Norrisia norrisae, smooth turban, a common inhabitant of the canopy, is more numerous in the bottom kelp.

Astraea undosa, the wavy top snail, is by far the most abundant of the large snails. It is a vegetarian and occurs in the shallower water. Shells 5.5 inches high are not uncommon. These snails serve as forage for bat rays and sheephead, and were eaten by the Indians.

Astraea inaequalis, red top snail, is a cold-water inhabitant. It is smaller and far less common than the wavy top snail. It is encountered only in the deeper portions of the kelp beds.

Tegula aureotincta, the gilded top, is another canopy inhabitant that is extremely common in the lower levels of the shallower portions of the kelp beds. It has been found in the stomachs of sheephead.

Calliostoma canaliculatum, channeled top, occurs in the colder portions of the kelp beds, often climbing the stipes as far as the thermocline. It seldom reaches a height of over 1 inch.

Haliotis fulgens, green abalone, grows abundantly from low tide to depths of 35 feet and occurs occasionally as deep as 65 feet. It feeds on brown seaweeds, including giant kelp. It is a large species, attaining a maximum diameter of 11 inches. It is taken as a small portion of the commercial catch and as a major portion of the sport catch. An obvious decline in the numbers of abalone has been noticed in southern California.

Haliotis rufescens, the red abalone, is one of the most important commercial species. In the southern portion of its range it lives in the deeper colder water. Because it does live deep it is rarely taken by sportsmen in southern California.

Haliotis corrugata, pink abalone, lives at intermediate depths and is taken by both commercial and sports divers. It appears to be less abundant than it was five years ago. It often lives on the tops of rocks, where it is more available to the bat rays than other abalones. I strongly suspect that the hosts of the abalone worm may include the bat ray, Holorhinus californicus.

Megathura crenulata, the giant keyhole limpet, is a large meaty gastropod which almost obscures its shell with a mantle. The animal is black to mottled brown with an orange foot. The flattened volcano-shaped shell is brown to white and often 4 inches long. It lives among the seaweeds at all depths.

Several species of Octopus inhabit the rocky bottoms of the kelp beds. Most of them are small, seldom reaching an arm spread of over 3 feet. They feed heavily on mollusks, crabs and small fishes. They are in turn preyed upon by the many larger reef fishes, especially kelp bass, rockfishes, scorpionfish, and cabezon. Octopi remain in crevices and under rocks during the day and forage by night. The female is a good

mother, tending her eggs for weeks, caressing and cleaning them constantly with her tentacles. A crevice occupied by an octopus can easily be detected by the piles of discarded shells in front of it.

Styela montereyensis, the common ascidian, is a wrinkled, long-stalked, dull red to orangish brown, simple tunicate. It is a solitary animal, although it is often found in large numbers where conditions are favorable. The tunic and stalk are often utilized as substrates for other smaller animals. The common ascidians occasionally attach to sheepcrabs. It is a filter feeder. It is common in the shallower parts of the kelp beds.

Metandrocarpa dura, jelly ascidians, attach to short algae. They are bright orange-red and have a glistening firm texture. They live throughout the shallower portions of the kelp beds.