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California Sharks and Rays

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FOREWORD

With the discovery of the vitamin-rich liver of the soupfin, a decade or so ago, public interest in sharks rose to an unprecedented level. Though the bonanza days are of the past, much of this interest remains, and there is considerable demand for information about these animals. It is the purpose of this bulletin to answer, insofar as it can be done, the recurring questions about our sharks and rays and the fishery for them, and to provide a guide to the species known from California. Here it should be noted that the text refers only to conditions and circumstances in California unless there is a specific statement to the contrary.

This publication succeeds Bulletin 45, "The Sharks and Rays of California," by Lionel A. Walford (1935), which is now out of print. Many of the illustrations used herein appeared in that paper. These include several taken from Garman's "The Plagiostomia" (1913) which are reproduced again by permission of the Museum of Comparative Zoology, Harvard University. Dr. W. I. Follett of the California Academy of Sciences, San Francisco, provided us with the photograph of the frill shark which was made from the Academy's specimen. The Academy also gave permission to reproduce the drawing of Carcharhinus azureus from Gilbert and Starks' "The Fishes of Panama Bay" (1904). Through the kindness of Dr. C. L. Hubbs, the Scripps Institution of Oceanography made available the photographs of the sixgill, mackerel and bramble sharks. Mr. Keith W. Cox, Bureau of Marine Fisheries, made the excellent pen and ink sketches of shark teeth, and gill nets. We greatly appreciate the courtesies extended to us by these institutions and individuals.

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1. INTRODUCTION

The sharks and the rays have certain things in common which differentiate them from other animals with backbones. For this reason the scientist places them in a subdivision of the vertebrates, called class Chondrichthyes,[1] apart from the true or bony fishes, the birds, the mammals and so on, each of which forms a group unto itself with its own particular set of general characteristics. Beside the sharks and the rays, class Chondrichthyes includes those animals called chimaeras. The California representative, the ratfish, is fairly common but is caught infrequently enough to remain unknown to most people. It is illustrated on page 82 and once seen will not be forgotten. While it is neither shark nor ray, it is more like them than it is like true fishes and enough like them to be placed in the same class with them.

Chimaeras, sharks and rays all have one particularly striking physical character which sets them apart from true fishes: their skeletons contain no true bones but are made instead of cartilage. Further, their scales are actually toothlike in structure while in the true fishes the scales have a bonelike origin, and their teeth are not firmly attached to the jaws. Finally, fertilization is always internal among the members of class Chondrichthyes, an exceptional circumstance among the bony fishes. The adult male shark or ray or ratfish can always be told by his claspers—the rodlike extensions by the pelvic fins. While the chimaeras have the same broad characters as the sharks and rays, they do differ from them in certain respects. As a result, the sharks and rays are placed in a subclass, Elasmobranchii, apart from the chimaeras which are assigned to subclass Holocephali. Sharks and rays have five to seven pairs of external gill openings. Chimaeras have but one pair and bear a superficial resemblance to the true fishes in this respect. The sharks and rays are separated into two orders. Sharks, whose gill openings are wholly or at least partly on the side of the body, belong to order Selachii, while rays, whose gill openings are entirely on the under surface of the body, belong to order Batoidei. Included among the rays are not only the typical skates and stingrays, but electric rays, guitarfishes, mobulas and mantas as well.

[1] We follow the classification and terminology of Bigelow and Schroeder (1948) where applicable. Speaking generally, the classification system breaks large groups into smaller on the basis of progressively smaller differences and greater likenesses. Thus vertebrates, which form a major division of the animal kingdom (a phylum), are divided into classes, the classes into orders, orders into families, families into genera and genera into species. Intervening stages are frequently used, such as sub-classes. The scientific name of any animal consists of the name of the genus followed by the name of the species. The man's name sometimes found after the scientific name is that of the person who first described the species in question.

Sharks are found in all the oceans of the world. Some rove the high seas but most of them live along the coasts in relatively shallow water. Some are surface dwellers; others live at or near the bottom, certain kinds at very great depths. A few species move at times far enough up great rivers to enter fresh water, and one lives in a fresh water lake, Lake Nicaragua. The skates and rays are typically bottom dwellers at shallow and moderate depths. Some South American stingrays inhabit fresh water.

We have mentioned that fertilization is always internal among sharks, rays and ratfish. The development of the embryos follows one of three paths, depending on the species. In some, for example the skates and ratfish, the female lays the eggs after they are fertilized and the embryos develop outside of her body. Development is, in biological parlance, oviparous. The eggs are enveloped in cases which are distinctive in appearance and which are a puzzle to many people who happen to find them washed up along the shore. The greatest number of species are ovoviviparous. This means simply that the eggs remain within the body of the mother, the young develop there, and are not "born" until they are large enough to fend for themselves. The embryos are not, however, connected directly to the body of the mother, and the large egg yolks provide their source of food supply. A few species are viviparous: that is, the young are connected to the mother by a placenta-like structure through which they draw nourishment from her. With development within the mother commonplace, obviously the number of eggs cannot compare with the number spawned by bony fishes. The litters are relatively small and if a population is cut far down by fishing or for any other reason it plainly will take a long time to build it back. In our soupfin, for example, an average litter contains 30 to 35 young. In some species the number runs higher, but in others it is considerably lower. The dogfish may bear as few as three young and its period of gestation is nearly two years.

In all, 29 species of sharks, 17 rays and one ratfish are on record from California. The sharks and rays represent a very muddled group as far as scientific understanding of the species is concerned. Particularly with the larger sharks, it is hard to preserve specimens in museums, and a proper comparison of similar individuals from different parts of the world is very difficult. The literature is confused and much remains to be done in determining just what kinds do exist. It may well be that some kinds which we now regard as species separate from, say, their Atlantic counterparts actually do not differ from them at all. Conversely, some of those species now credited with a world-wide distribution may prove to be divisible into several species each with a limited range.

All of the species reported from California are described in the pages which follow. Some are very common, while others are known from only one or two specimens. Anyone who catches one of the rare ones—or, as quite well can happen, one which is not even on record from the State—should make every effort to save it and to get in touch with the nearest scientific institution. What little we know of many of our rare species we owe largely to fishermen who have recognized specimens as being unusual and have seen to it that they were preserved.

Many horrible yarns have been spun about sharks and their fondness for human flesh. And many a cynic has offered rebuttal to the tune that

sharks are, if not afraid of, at least disinterested in man. Should a propounder of this school deliberately throw himself in the path of a potential man-eater to prove (or disprove) his point, the results could be disastrous. Sharks have and will attack man and there are many authentic records of such attacks which have resulted in serious injury or death. None are from the Pacific coast of the United States, where large sharks of the dangerous species are rare, but there are documented cases on file for the Atlantic seaboard (see Bigelow and Schroeder, 1948). Shark attacks in Australia are all too numerous and Whitley (1940) discusses them at length. Those who hold that sharks as a group are dangerous carry things beyond reason, but that is a safer approach than to regard them as uniformly harmless.

of the sharks known from California, the great white, the tiger and the hammerhead are unquestionably dangerous but they are so uncommon in our waters as to present a negligible hazard. Many others are catholic feeders, and any shark of sufficient size should be regarded as a potential danger to a bleeding man in the water. None of our common inshore species are large enough or voracious enough to be of concern to swimmers.

Some of the rays are dangerous to man for quite different reasons. That stingrays can inflict severe wounds on unwary waders is well known; perhaps less widely appreciated is the fact that electric rays are perfectly capable of giving one a strong shock. It has long been generally thought that the excruciating pain resulting from a stingray wound stemmed only from the puncture itself and from subsequent bacterial infection. However, poison glands are definitely present and there is to our knowledge as yet no specific treatment. Fortunately, our stingrays do not seem to be as virulent as some from other places—people have died from the stings of South American rays. Starks (1918) recommended disinfection followed by prolonged immersion of the wound in hot water. This remains perhaps as good a treatment as any, though it is recommended that epsom salt be added to the water. Gudger (1943) suggests alcohol, iodine or potassium permanganate as possible agents to destroy the venom before it enters the system, saying that it takes up to 15 minutes for poison to be absorbed. The best course is to avoid wading where stingrays are known to congregate and to slide the feet forward—not step—when you are in suspect waters. Shuffling tends to drive the rays on ahead, whereas a foot placed squarely on an unsuspecting individual can be expected to produce but one response.

COMMON AND SCIENTIFIC NAMES

Common name	*Scientific name*	*Major page reference*
THE COWSHARKS—Family Hexanchidae		
Sixgill shark	*Hexanchus griseus* (Bonnaterre)	40
Sevengill shark	*Notorynchus maculatum* Ayers	41
THE FRILL SHARKS—Family Chlamydoselachidae		
Frill shark	*Chlamydoselachus anguineus* Garman	39
THE BULLHEAD SHARKS—Family Heterodontidae		
Horned shark	*Heterodontus francisci* (Girard)	42
THE MACKEREL SHARKS—Family Isuridae		
Mackerel shark	*Lamna ditropis* Hubbs & Follett	43
Bonito shark	*Isurus glaucus* (Müller & Henle)	44
Great white shark	*Carcharodon carcharias* (Linnaeus)	45
THE BASKING SHARKS—Family Cetorhinidae		
Basking shark	*Cetorhinus maximus* (Gunnerus)	46
THE THRESHERS—Family Alopiidae		
Thresher	*Alopias vulpinus* (Bonnaterre)	47
THE CATSHARKS—Family Scyliorhinidae		
Filetail shark	*Parmaturus xaniurus* (Gilbert)	48
Brown shark	*Apristurus brunneus* (Gilbert)	49
Swell shark	*Cephaloscyllium ventriosum* (Jordan & Gilbert)	50
THE SMOOTHHOUNDS—Family Triakidae		
Leopard shark	*Triakis semifasciata* Girard	51
Brown smoothhound	*Triakis henlei* (Gill)	52
Gray smoothhound	*Mustelus californicus* Gill	53
Sicklefin smoothhound	*Mustelus lunulatus* Jordan & Gilbert	53
THE REQUIEM SHARKS—Family Carcharhinidae		
Tiger shark	*Galeocerdo cuvieri* (Lesueur)	54
Soupfin	*Galeorhinus zyopterus* Jordan & Gilbert	55
Great blue shark	*Prionace glauca* (Linnaeus)	56
Bay shark	*Carcharhinus limbatus* (Jordan & Gilbert)	57
Gambuso	*Carcharhinus azureus* (Gilbert & Starks)	58
Sharpnose shark	*Scoliodon longurio* (Jordan & Gilbert)	59
THE HAMMERHEADS—Family Sphyrnidae		
Hammerhead	*Sphyrna zygaena* (Linnaeus)	60
Hammerhead	*Sphyrna lewini* (Griffith)	60
Bonnethead	*Sphyrna tiburo* (Linnaeus)	60
THE DOGFISHES—Family Squalidae		
Dogfish	*Squalus acanthias* Linnaeus	61

COMMON AND SCIENTIFIC NAMES—Continued

Common name	*Scientific name*	*Major page reference*
THE SLEEPER SHARKS—Family Dalatiidae		
Sleeper shark	*Somniosus pacificus* Bigelow & Schroeder	62
THE BRAMBLE SHARKS—Family Echinorhinidae		
Bramble shark	*Echinorhinus brucus* (Bonnaterre)	63
THE ANGEL SHARKS—Family Squatinidae		
Angel shark	*Squatina californica* Ayres	64
THE GUITARFISHES—Family Rhinobatidae		
Shovelnose guitarfish	*Rhinobatos productus* (Ayres)	65
Mottled guitarfish	*Zapteryx exasperata* (Jordan & Gilbert)	66
THE THORNBACKS—Family Platyrhinidae		
Thornback	*Platyrhinoidis triseriata* (Jordan & Gilbert)	67
THE SKATES—Family Rajidae		
California skate	*Raja inornata* Jordan & Gilbert	69
Big skate	*Raja binoculata* Girard	70
Longnose skate	*Raja rhina* Jordan & Gilbert	71
Monterey skate	*Raja montereyensis* Gilbert	72
Starry skate	*Raja stellulata* Jordan & Gilbert	73
Roughtail skate	*Raja trachura* Gilbert	74
Black skate	*Raja kincaidii* Garman	74
THE STINGRAYS—Family Dasyatidae		
Round stingray	*Urobatis halleri* (Cooper)	75
Diamond stingray	*Dasyatis dipterurus* (Jordan & Gilbert)	76
Butterfly stingray	*Gymnura marmorata* (Cooper)	77
THE EAGLE RAYS—Family Myliobatidae		
Bat stingray	*Holorhinus californicus* (Gill)	78
THE ELECTRIC RAYS—Family Torpedinidae		
Electric ray	*Torpedo californica* Ayres	79
THE MANTAS—Family Mobulidae		
Mobula	*Mobula lucasana* Beebe & Tee-Van	80
Manta	*Manta hamiltoni* (Newman)	81
THE CHIMAERAS—Family Chimaeridae		
Ratfish	*Hydrolagus colliei* (Lay & Bennett)	82

3. THE CALIFORNIA SHARK FISHERY

3.1. INTRODUCTION

Although there are at least 29 species of shark indigenous to or visiting the California coast, only a relatively small number are of economic importance. The value of each is determined by some specific feature, such as the presence of a high potency vitamin oil, large size, or relative abundance in combination with one of the other factors. Since the discovery in 1937 of the vitamin-rich livers of the Pacific Coast soupfin and dogfish, these two species have comprised the greatest part of the landings from California waters. Individually, the soupfin is worth far more than the dogfish, but the dogfish makes up somewhat in numbers for its lesser economic value.

The outbreak of World War II in 1939 resulted in a gradual curtailment of cod liver oil production in Europe. Coastal and oceanic fishing in Europe became so hazardous that the production and exportation of vitamin A from this source fell to almost nothing. The local shark population then represented a tremendous source of raw material and before long we were supplying this commodity to Europe from our expanding industry, and the market for shark liver oils to replace the nonavailable cod liver oil improved rapidly. In a relatively short time the huge potential of the Pacific Coast soupfin and dogfish supply had been tapped, and the golden oil began to flow from this source to the four corners of the earth.

The development of the shark industry in 1936–38 was most advantageous to the fisherman and to the welfare of the Nation. The early expansion of the market was hampered because of the stigma attached to "shark." However, vitamin oil derived from this source was gradually accepted on a competitive basis with cod liver oil. Therapeutically and chemically there is no difference. As its higher potency per unit became known to the trade, the great vitamin fad of the 1940's was indirectly stimulated. Because of the large vitamin content of the soupfin oil, encapsulation was possible at a relatively low cost. This plus skillful advertising and aggressive promotion enabled the industry to grow from the "spoonful of cod liver oil" stage to the billion dollar "one a day Vitamin A to Z" status that it has attained today. The value of the product, however, in legitimate feeding and fortification practices is not to be minimized.

Although the most spectacular and lucrative field has been in the manufacture and sale of the vitamin oils, several relatively minor shark products have been marketed for some years.

Shark skins have long had a nominal value because the finished leather made from certain species is extremely tough, resistant to abrasion yet still very pliable. Skin with its shagreen intact has found use in the past as a nonslippery surface for the handles of sword hilts, although this market of late has been somewhat dormant. It also has had uses in

cabinet work as a fine abbrasive agent but has been superseded by the development of carborundum and sandpaper.

On the West Coast there is not a significant amount of trading done in shark skins, as most fishermen have found that this particular phase of merchandising is not worth the trouble. The difficulties involved in skinning and preserving the shark hide to meet market requirements involve so much labor that most fishermen are not interested. One fisherman in Southern California described a method he developed whereby skins could be removed with a minimum of effort. He hung his sharks from the boom and made a small incision near the caudal peduncle (the narrow section of the body just ahead of the tail of the fish). Into this incision he inserted a flattened piece of copper tubing to which was attached a hose from a high pressure air supply. The inserted copper tubing was tied to the tail of the fish so that it would not be forced out by the air pressure, and the exit of air through this opening was prevented by compressing the tissue on each side of the copper tubing. By gradually increasing the air pressure, the skin was forced away from the body. He stated that this method enabled him to skin the sharks completely in a very short period of time with minimum of labor and with no fleshing required. The skin is said to have separated from the subcutaneous layers leaving the epidermal layers free from subcutaneous fat.

Several other minor products derived from shark include a base for soup stock made from the dried fins of a number of species, meal from the carcass, flesh as food, and teeth sold as curios.

3.2. GILL NETS

The fishing methods developed to capture sharks have been dependent upon the particular habits of the individual species. The fishing techniques, evolved over many years of constant trial and error, are at present standardized to about five different systems of operation. The most successful are gill netting, used mainly for soupfin, and otter trawling for dogfishing. Set gill nets are particularly successful when soupfin move inshore. Drift gill nets are utilized when the sharks are actively feeding at sea.

3.2.1. Set Nets

The set or diver gill nets used in the present fishery are made of cotton webbing. A series of individual nets, each from 25 to 50 fathoms long, depending upon the ideas of the individual fisherman constructing the nets, are joined end to end and fished as a "string" of gear. A string is usually 300 to 400 fathoms in length. Each piece, called a shackle or shot, is constructed of 27- to 32-thread, medium or hard-laid cotton webbing of 10- to 11-inch stretched mesh. The nets are hung 15 to 30 meshes deep, with the web hung to the cork and lead lines by heavier hanging twine, and are usually "set in by the thirds" (i.e., three meshes occupy the lateral space of two fully stretched meshes). The cork line is made of #- to #-inch diameter sisal hemp, or, preferably, manila. The lead line is of the same material but is generally heavier in weight than the cork line to compensate for the wear it receives from chafing on the bottom. In standard practice this line varies from one-half to three-quarters of an inch in diameter. Glass floats 5 ½ to 6 inches in diameter are hung every 8

to 10 feet on the cork line and encased in a 33-thread webbing of 2-inch stretched mesh. Hanging the glass floats in the individual net bags reduces breakage, as the thick web prevents the glass from making contact when the floats come together. Sufficient weight is equally spaced on the lead line to submerge the net and floats. At the ends of each shackle the selvage is hung to an end rope of ¼- to #-inch diameter, running from the cork to the lead line. The cork and lead lines extend about six feet beyond the end of the net and are used to tie several pieces together, or to attach the end shots to the anchor bridles. The bridle consists of a 1-inch diameter rope; and when attached to the end of a net, it forms a right angle triangle with the end rope. The bottom line of the bridle is about 10 to 14 fathoms long, and the head rope (hypotenuse) is 3 to 6 fathoms longer. These are joined into an eye.

An anchor line 5 to 10 fathoms long, 1 ¼ inches in diameter is attached to the eye of the bridle. The other end is fastened to a 45- to 75-pound stock anchor. To facilitate breaking out the anchor, the anchor line is sometimes attached to the shank at the crown. A light line is used to join the anchor line to the shank or ring so that if the anchor is caught in rocks or fouled on the bottom a heavy tug will break this line. The strain is then taken at the crown which serves to place the pull in line with the fluke. Ordinarily this attachment will free the anchor from almost any entanglement.

A buoy line is fastened to the shank of the anchor at the crown and rove to the arm immediately below the fluke. This line runs from the anchor to the surface of the water and is several fathoms greater in length than the maximum depth of water where the net is set. In areas where heavy tidal currents are encountered, considerable slack is given to the buoy line to prevent the line and buoy from being pulled under water. The upper end of the anchor line is attached to a ten-gallon keg or rubber float. Some vessels have found that ten-gallon iron beer kegs are quite satisfactory for buoys, as they are rugged, and should tidal currents pull the buoy and buoy line under, they are able to withstand the pressures encountered at many fathoms depth. Five-gallon surplus oxygen tanks have also proven their worth for this purpose. Ordinary wooden kegs collapse at very shallow depths.

A marker is attached to the buoy by a small line about one-half inch in diameter. It consists of a bamboo pole about 15 feet in length to the top of which is attached a bright-colored flag. The bottom of the marker is weighted by several pounds of lead or sash weights. Several floats with sufficient buoyancy to support the entire device are placed about one-third of the distance from the bottom of the marker. These weights and floats hold the marker in a perpendicular position when in the water. Gaudy flags are chosen because of their visibility in all kinds of weather. Red or yellow has been found to show up most favorably against the blue, gray, or foggy backgrounds. The fluorescent fabrics developed during the war are also proving quite satisfactory.

Vessels employing this type of gear usually fish five to seven strings and try to pull their gear once a day when fishing is good. often when prospecting or when weather is bad, the gear is not pulled as frequently.

When used from the beaches out to 100 fathoms, set nets are often very effective. However, there is a disadvantage connected with their use. Along certain portions of the coast, particularly in Central and Northern

California, hagfish abound and cause considerable destruction to livers, the first organ attacked by the hagfish as it is a concentrated source of food. When sharks entangled in bottom nets are not removed within 12 to 14 hours, it is probable that all of the livers and a good portion of the carcasses will be gone. The loss is particularly serious when the fisherman is unable to lift his gear because of a storm. On many occasions, complete catches of sharks have been destroyed due to the predation by hagfish. A survey made in Eureka during 1945 indicated 23 percent of all shark taken by the set gill net fishery in this region was destroyed by hagfish or isopods. Almost every boat interviewed during the season had suffered some loss to these animals. Fortunately, their activities are largely confined to mud and slimy bottoms, and nets clear of these areas suffer relatively small losses.

3.2.2. Drift Nets

Drift nets differ from set gill nets in that they are considerably deeper, hanging 50 to 60 meshes deep. Their construction otherwise is similar to that of the set gill net. The shackles vary in length from 15 fathoms to as much as 50 to 60 fathoms with the present trend toward the longer shackles. Only one drift string is fished at a time. It is usually about 1,000 fathoms long, although some of the large vessels fish with 1,700 fathom strings during good weather. The web is hung-in about 50 percent, with four meshes taking the place of two. The mesh varies from 9 ½ to 10 ½ inches in length, the recent tendency being toward use of the larger mesh of 36- to 54-thread material. The horizontal top line to which the nets are attached by buoy lines is of stout construction so that when a heavy sea is running, the nets can be hauled in without damage to the net proper. The strain of hauling against the sea is taken by this line, and it permits fishing in rough weather that would be prohibitive if the nets were not attached to some such device. The fact that the nets are slack enables them to fish efficiently. The sharks do not necessarily gill but are entangled as they attempt to escape from the net after they have hit it. When attempting to turn, the shark rolls and in so doing wraps the slack web around itself so that it is tightly bound on all sides.

The drift net fishery for soupfin is carried on during the spring and summer months. In nearly all cases the net is set in the direction of the current or seaway. With the net in this manner, the vessel is either downwind or down current from the net; the net acts as a brake; and the vessel tends to pull away from the set. One end of the net is attached to the boat and the other end is attached to a lighted buoy so that other vessels in the vicinity will know a navigational hazard exists. The drifts are made overnight as far out to sea as 100 to 150 miles.

The fishermen have found that setting the gear in a school of bait or sardines is effective, as soupfin feed upon these pelagic fishes, seemingly working the bottoms of the schools. Relatively few females are said to be taken. As the mesh size limits the size of shark taken, the number of small and immature shark captured is also reported to be relatively small. Drifting grounds are located up and down the coast, and the area in which sharks are to be found is a matter of time and place in reference to their periodic movements.

The boats engaged in this type of fishing are usually larger vessels equipped to run many miles to sea and to weather the intemperate climatic conditions that occur off the coast.

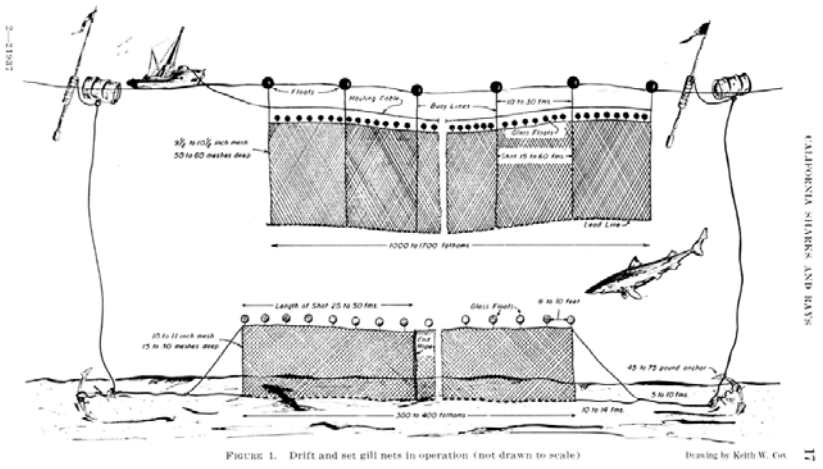


FIGURE 1. Drift and set gill nets in operation (not drawn to scale) Drawing by Keith W. Cox

FIGURE 1. Drift and set gill nets in operation (not drawn to scale)

3.2.3. Fishing Operations

The vessels used in both set gill net and drift gill net operations are on the general order of the purse seine boat, but are usually smaller than those used in the sardine purse seine fishery. These vessels are combination types and ordinarily pursue bottom fishing during the season and then change to other types of fishing, such as drift netting, halibut fishing, or otter trawling. Most of the regular shark vessels are equipped with a bin at the stern wherein the shark nets are piled ready for setting. The net is stacked with cork line to one side and lead line to the other. When a set net is payed out, the buoy line is first thrown overboard, the anchor follows, and the vessel runs ahead at about quarter speed. The net pays out over the stern setting into the water in a vertical position. This continues until all the net is "shot" and the other bridle is reached. Just before the second anchor is shot, the crew holds on to it while the vessel makes headway to stretch the net out in a tight line. If the net is not stretched when set, it often becomes entangled in the anchors as any amount of slack allows the net to work back over the anchors when tidal currents change.

When the nets are set, the skipper must ascertain his position so that he may return to them. During clear weather the location is determined by triangulation or lining up two or more known points on the shore. However, during much of the time the weather along the north coast is such that triangulation is impossible. Visibility may be only a few hundred yards. When these conditions prevail, the position of the net is

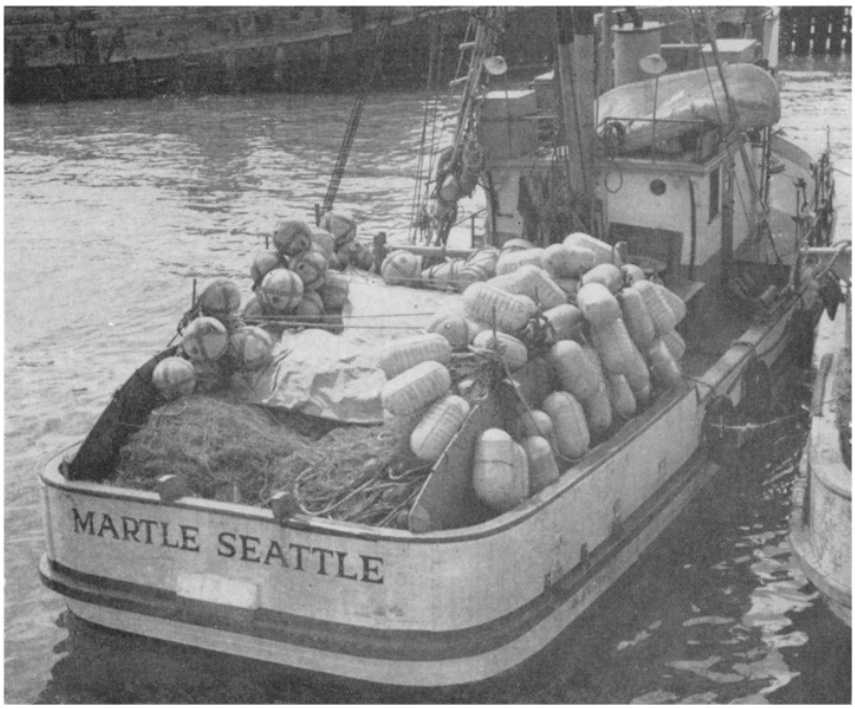


FIGURE 2. A shark vessel with a drift gill net stacked in the net bin
Photograph by W. E. Ripley, June 1949

FIGURE 2. A shark vessel with a drift gill net stacked in the net bin

usually determined by dead reckoning; i. e., running a course so many minutes from a known point on shore to the place where the net is set. The point of reference is usually a harbor mouth, jetty, or navigational aid. The tidal current at the time is taken into account, and the depth of water in which the net is set is obtained. If the vessel has no fathometer, a sounding is taken at both ends of the net, and this information either recorded or remembered. The accuracy and the rapidity with which fishermen find their nets on foggy days by this method is surprising. A few of the more elaborately equipped boats use radio direction finders to take bearings on broadcast and navigational transmitters.

Most of the regular shark fishing vessels are equipped with a sonic depth finder to enable them to spot good grounds. Some of the successful fishermen set their nets around the entrance to a submarine canyon, as it has been found that many soupfin use these as routes on their migration to the continental shelf. As the sharks seem to travel in relatively dense schools, the location of the gear is most critical. Fishing a half mile away from the particular area in which the sharks are congregated often results in virtual failure, whereas when nets are set in the proper place, rich rewards are reaped.

3.2.4. Power Net Pullers

The ability to handle large quantities of gear by both the set and drift netters has been brought about by the adoption of the power gurdy. It consists of a big horizontal sheave 18 to 36 inches in diameter and 12 inches thick. Completely encircling the rim of the sheave is a V-shaped, rubber-lined groove about six to eight inches deep at the apex. This offers an effective pulling surface to the net. Power is supplied to the sheave from a vertical axle that is attached either to the main engine of the vessel or to an auxiliary source. It is usually located forward on the after deck near the rail. On modified halibut schooners it is placed in the well deck.

In operation the buoy line is picked up and pulled around the sheave, the anchor is disengaged, and the net pulled around the sheave. A removable platform is provided which is fastened to the rail and to a support under the gurdy. This platform serves as a lead for the net as it is passing from the rail to the gurdy and also as a table to remove the gilled sharks before they are carried around the rim. The net is lead onto the table by a fairlead consisting of two upright rollers set 18 to 24 inches apart on the outside of a horizontal roller six inches or more in diameter. The horizontal roller is greater in length by several inches than the distance between the two vertical rollers. This device guides the net over the rail onto the platform and to the gurdy at a constant angle. As the net is taken from the gurdy, it is stacked on the stern of the vessel in a position ready for the next set with the lead line in one pile and the cork line in another. The stern of the vessel is boarded so that a smooth leading surface is presented to the seaward edge of the rail. The smooth surface is necessary to prevent the net from fouling while it is being set. On some vessels, mainly of the halibut schooner type, the entire aft end is formed into a chute in which the nets are stored and from which they are set. Most shark vessels have some type of bin on the stern in which to place their nets, as a heavy sea has been known to cause considerable damage to stacked gear. Each vessel presents its own problems in adapting this

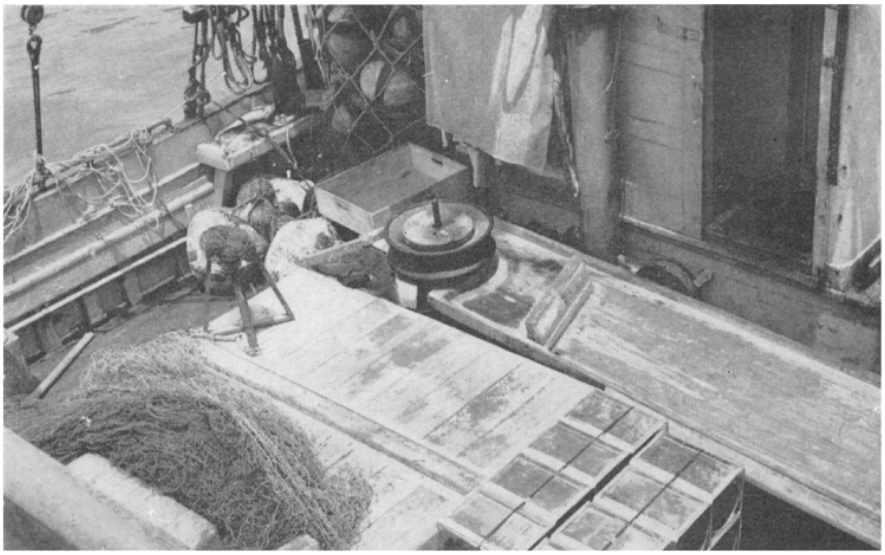


FIGURE 3. A shark gurdy and table. Note the liver cans in the foreground and the net floats in the background

Photograph by W. E. Ripley, June 1949

FIGURE 3. A shark gurdy and table. Note the liver cans in the foreground and the net floats in the background

type of gear, and modifications are evolved to fit the circumstances under which the gear is to be operated.

Because of the gurdy, the size of the crew of gill net boats can be relatively small, considering the amount of gear handled in the fishing operations. Both drift and set netters are manned by crews of three to five.

3.3. OTTER TRAWLS

Otter trawl fishing for sharks in California is limited to dogfish. This gear consists of a conical elongate sack ending in a blind pocket, which is supported by two door-like devices acting as underwater kites and extended by water pressure. Wire cables run from trawling davits on the vessels down to the kites. A line leads from each kite to the wings of the net. The wings and bag are dragged along the bottom. During the late fall and early winter months great quantities of dogfish are taken by drag boats in the northern part of the State.

The dogfish are considerably less valuable than soupfin due to their lower potency livers. However, they are sufficiently numerous to make the operation of this fishery more than worthwhile. During 1948, over a hundred thousand pounds of dogfish liver was taken by a relatively small number of boats. The dogfish fishery is an important adjunct to dragging operations for other species carried on throughout the rest of the year.

The soupfin is more successful in escaping capture by drag nets than is the dogfish though occasionally small numbers (one to seven) are taken. Fishermen interpret the capture of soupfin by drag boats as an indication that this species is present in some abundance.

3.4. HARPOON

The harpoon fishery for sharks is limited to basking sharks which are found most abundantly from October to May in Monterey Bay and from September to April off Pismo Beach and Morro Bay. The habits of the basking shark make it quite vulnerable to harpooning. It is a large inoffensive creature reaching a length of at least 45 feet, and spending considerable time floating at or near the surface of the ocean.

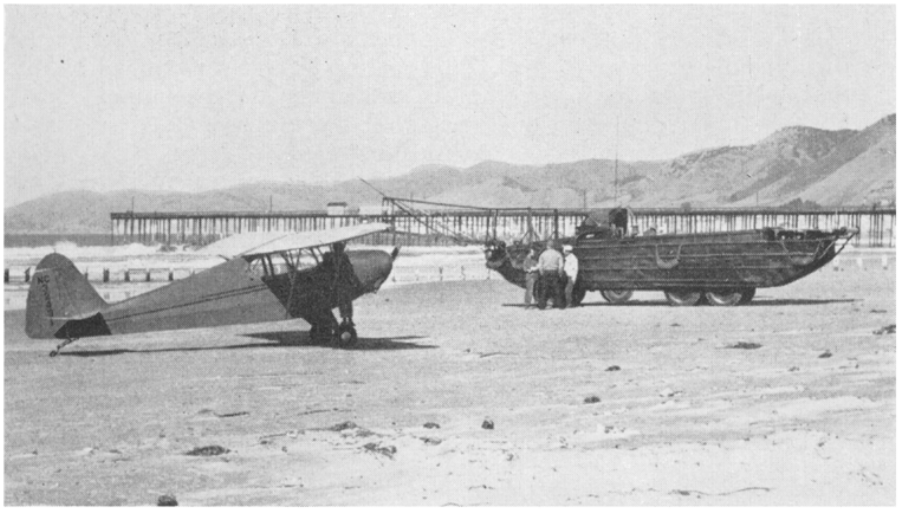


FIGURE 4. DUKW and plane used in the harpoon fishery for basking sharks at Pismo Beach
Photograph by J. F. Janssen, Jr., February, 1948

FIGURE 4. DUKW and plane used in the harpoon fishery for basking sharks at Pismo Beach

The fishery flourishes off Pismo Beach and Monterey. At Pismo Beach, the fishery is prosecuted by a unique team consisting of a surplus DUKW with a harpoon mounted on the bow and a light airplane (Figure 4). The airplane acts as a spotter. The DUKW remains ashore until the pilot notifies the skipper by radio telephone that he has sighted a shark or sharks. The skipper then drives his craft down the beach until it is opposite the reported position, plunges it through the surf and out to the floating fish. The vessel eases up to a shark and the harpoon is driven home. Current practice is to pull the harpooned animal to the side of the DUKW with a power gurdy and to kill it with a high-powered rifle. When the kill is accomplished, the shark is usually left anchored to a buoy out at sea. The DUKW comes ashore, and the skipper contacts a processing plant to sell the carcass. When the shark is sold, it is pulled ashore onto the bed of a truck and hauled to the processing plant.

3.5. HOOK AND LINE

Hook and line was commonly used in the years before 1940. Sharks, particularly soupfin, were abundant and this type of gear was very successful. The gear was set up in skates or was coiled in tubs. Each skate had a ground line 250–300 fathoms long and carried from 90 to 125 hooks per line. Most gear had rather short gangens attached approximately 2 fathoms apart. An average set of gear consisted of between

3 to 7 skates joined together. Some of the larger boats carried as many as 40 tubs of gear. This gear was set in waters where it was assumed that sharks were present. The bait was allowed to "soak" from ½ to as much as 4 ½ hours. However, the more enterprising fishermen endeavored to pick up their lines before a 1 ½-hour "soak."

Bait consisted of salted sardines, fresh sardines, sole, squid, and other fish and offal. As with the net gear, the set line fisherman in Northern California had to be careful to pull his equipment before it had soaked in the water too long as the predation by hagfish was serious.

Most of the northern boats fishing hook and line used regular halibut gurdies to pull the gear aboard. This removed some, but not all, of the manual labor from the operation. In addition, the mechanical gurdy enabled the individual boat operators to fish a much greater amount of line than could be done by hand operation.

The hooks used varied from 11/0 to 14/0. The ground line consisted of manila rope between ¼- to 3/16-inch diameter. Some of the smaller boats, particularly those in the smaller skiff fishery that operated out of the southern part of the State, used 72-thread to 210-thread ground line.

The hook and line fishery was successful until the numbers of soupfin became so reduced that the gear was no longer capturing them efficiently. Nearly all of the boats that were able to do so adapted and changed their fishing methods to that of the set gill net. Inasmuch as the gill net did not require voluntary acceptance of the bait by the shark, it was more efficient and soon supplanted the hook and line operations.

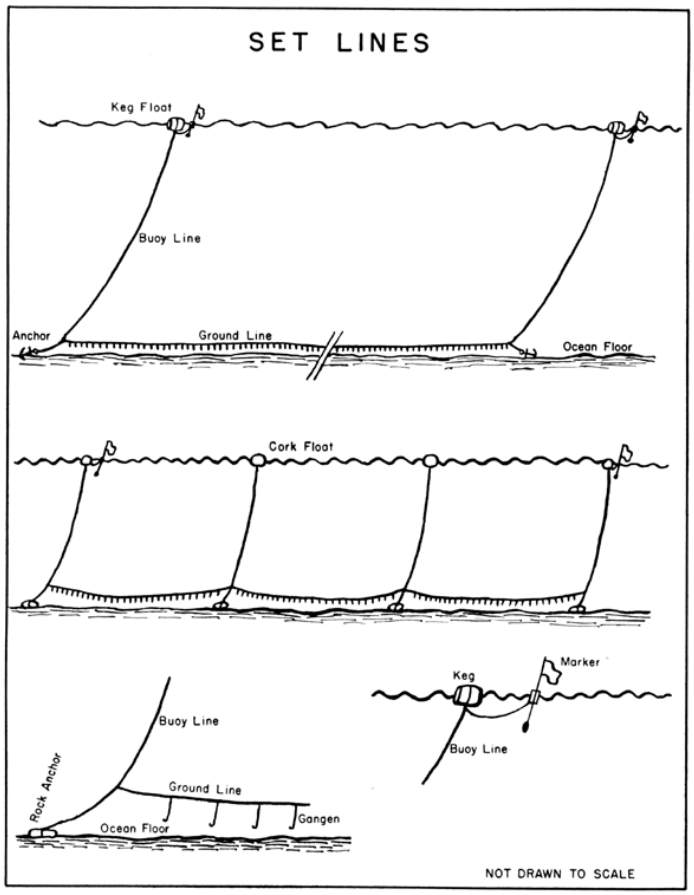


FIGURE 5. Illustrating two of the many forms of set lines
From "Fish Bulletin 66"

FIGURE 5. Illustrating two of the many forms of set lines

4. THE IMPORTANT COMMERCIAL SHARKS

4.1. SOUPFIN

By far the most important shark in California is the soupfin, Galeorhinus zyopterus. In the past it has been sufficiently abundant to constitute one of our more economically important fisheries. At one time every soupfin brought aboard was the equivalent of $50 hauled out of the sea. This condition, however, is not necessarily the case at present as all vitamin bearing livers are now sold on the basis of potency.

The soupfin ranges from Vancouver Island, British Columbia, to at least as far south as Abreojos Point, Lower California. It is most abundant in the intermediate part of its range and exhibits a somewhat peculiar sexual distribution. The catch in the northernmost part of the range consists largely of males. Relatively few mature females are taken, and the male segment of the population predominates as far south as Point Arena in Northern California. From Point Arena to about Point Buchon, just south of San Luis Obispo, the percentage of males to females is approximately equal. However, a considerable portion of the females in this region are immature, and very few of the mature females taken are carrying young. Tomales and San Francisco Bays are exceptions to this. In these bays, nursery grounds occur although their importance as spawning grounds is limited. From Point Buchon to Point Conception and southward, the character of the fishery again changes. The population of the shallow water areas of the region south of Point Conception, namely, the flats of less than 30 fathoms depth, is composed almost entirely of females. The females inhabit the shoal waters and conditions in these waters are favorable for the whelping and growth of the young. The higher average temperature of San Francisco and Tomales Bays may be an important factor in the existence of nursery grounds there. The differentiation in sexual distribution of this species is not absolute and males and females, although not of equal maturity, are to be found as far south as the lower limits of the range. The preponderance of sharks taken in the southern Mexican periphery of the range is female.

The male portion of the population shows a decrease in average size from the northernmost areas of the coast to the pupping grounds in the southern part of the State. The average size of sharks taken off Eureka and Crescent City is noticeably larger than that of those taken off Santa Barbara. Reports from the Mexican commercial fishery indicate that the males there are still smaller. Male livers from a sample lot taken in the early part of 1949 averaged 2 ½ to 3 pounds per liver. Inasmuch as the average size male liver in the northern part of the State runs in the neighborhood of 5.5 pounds, it can be inferred that males from the lower latitude are considerably smaller.

The persistent soupfin fisherman pursues this species throughout the year, typically fishing fall and winter in the northern part of the State with bottom diver nets and following the fish with drift nets during late winter, spring, and summer. However, some men fish with diver nets exclusively and yet others fish drift nets in all seasons.

The seasonal progression of the fishery along the coast may be indicative of the movements of the fish. The fishery off the northern part of the coast occurs during October, November, and December. Weather permitting, some good catches have been made during January and February. For bottom nets the greatest runs seem to occur during the full of the moon. The fishery in the south takes place during March, April, May, June, and July, with the greatest catches coming during the months of June and July.

The potency of the livers from both males and females is associated with length; that is, the longer the shark the greater the concentration of vitamin A in the liver. Because vitamin A is the important factor governing value, the greatest economic return can be obtained from harvesting large sharks. The livers of males below five feet contain so little vitamin A that it is not worth while to take them. Female sharks have a much lower potency per gram of oil than do males. This condition results in a differential price that exceeds the proportional difference in vitamin A possessed by the two sexes. Actually mature males and females contain roughly about the same total amount of vitamin A, with the males having a slightly higher average total potency. However, in males the vitamin is much more concentrated than it is in females.

The average total weight of males is in the neighborhood of 45 pounds, whereas females average approximately 67.5 pounds. The maximum weight of males is about 65 pounds; females approach close to 100 pounds. The average liver weight for males is approximately 5.5 pounds, with that for the females being 10.5 pounds. The largest male liver we have recorded weighed 8 pounds, whereas one female taken in the course of investigation by the Division of Fish and Game reached 20 pounds. Males average 117,000 international units of vitamin A per gram of oil, while females average 40,000. The greatest potency of vitamin A in males was 410,000 units of vitamin A per gram of oil, and in females 640,000 units. It must be emphasized that these very high potency livers were taken from females carrying pups close to term or recently spent. Females in this condition have very small livers, 3½ pounds or less, containing a very small amount of oil with a large amount of vitamin A. It is obvious that during the period of pregnancy, concentration of the vitamin takes place in the liver of the female. The oil contained in the liver is used but there is little or almost no utilization of vitamin by the female shark. This leads to conjecture that this substance is present as a by-product derived from ingestion of vitamin-bearing foods consumed by the soupfin.

A considerable study of the Santa Catalina Island soupfin fishery was conducted by the Division during the years 1942 and 1943. During this period approximately 5,000 sharks were taken of which only 31 were males. The fishery around Santa Catalina was conducted in shallow water mainly on the seaward side of the island.

The average amount of vitamin A per gram of oil was 86,000 units in the male sharks of this region and 43,700 units in the females. The

percentage of oil averaged 58.2 for males and 74.0 for females. Almost all of the females taken contained fertilized eggs or eggs about to be fertilized. The fact that no females were taken with pups indicated that Santa Catalina is not a pupping ground. Females approaching term migrated to other places along the coast but did not liberate their pups near the island. This same condition was true for the other Channel Islands from which data were obtained.

The total landings for soupfin have fallen from 1939 to the present. There are omissions in the catch statistics, however, which mask the true picture of what occurred in the fishery during this period. Changing marketing practices have introduced errors in the catch records that are undoubtedly serious. During the early years of the fishery the sharks were sold in the round, and the entire total weight of the fish was recorded. As time went on, however, it became known that it was to the fishermen's benefit to excise the livers. In some cases livers were sold with carcasses; some were sold without carcasses; and in still other cases the carcasses were sold separately to dealers in different ports. From this point on the records have been highly confused. The change in practice occurred about 1940–1941. Because of this the landing figures are not accurate and do not reflect conditions in the fishery during the ensuing period of time. The present landings are not large, but the fishery persists because of the value of the livers. However, the synthesization of vitamin A may seriously affect the economic future of this fishery. The market of late has been somewhat depressed because of this threat and because of competition from imports of vitamin-bearing oils and livers from other countries.

At present when a fisherman brings his catch to port the livers are placed in a public cold storage plant or in a dealer's sharp freeze box and frozen solid. A certified analytical laboratory is called in to sample and report upon the potency of the livers in the lot. The reports are issued within a very few days after the livers are sampled. On the basis of the analysis the livers are put on an auction block in San Francisco for sale, or the individual fisherman sells to a dealer at the price offered per unit of vitamin A. In 1948 over 33,000 pounds of livers were auctioned in San Francisco, of which more than 31,000 pounds was from males. The average oil content during the year ran 56.4 percent with a vitamin content of 128,700 units of vitamin A per gram of oil. The average price paid per pound of liver was $10.64. The highest price of $14.27 was offered during July and was paid for high potency liver yielding 43,000,000 units of vitamin A per pound.

Although vitamin A is the most important constituent of the soupfin shark, the carcass is sometimes valuable for sale as fresh fish. It has been customary in the past in the southern portion of the State to purchase soupfin carcasses for distribution to the Los Angeles market. In this region shark meat has a ready sale because of its low price and good flavor. At present a market for carcasses does not exist in the northern part of the State, as there are many other species of fish that are in greater demand by the consuming public. Prices paid to fishermen have varied from as little as 1 to as much as 15 cents per pound. Inasmuch as trimmed carcasses yield 25 to 30 pounds of edible meat, they are not to be ignored, and their value constitutes, in many cases, an important segment of the fisherman's income.

Some soupfin is processed into meal, mainly in Northern California. The amount that is handled in this manner is relatively small, because the shagreen on the skin is rather wearing on hammer mills, and it is reported that the skin causes difficulty by clogging the pores of the disintegrator. The carcass, however, makes a very excellent meal, which, when it is produced as a pure product, commands a premium price.

A small market exists for the fins. They are in demand particularly by the Chinese in San Francisco where they are used as the base for a unique and very palatable soup stock. The dried fins retail at about $2.50 per pound, and the extracted or processed cartilaginous rays, from which the finest oriental shark soups are made, retail from $5 to $6 per pound.

4.2. DOGFISH

The second most important shark in California is the dogfish, Squalus acanthias. Practically the entire commercial catch is made in otter trawls used ordinarily for the capture of flatfish and bottom fish. During the dogfish runs those operators who are able or desire pursue this species, and it constitutes an important segment of the drag boat landings at Eureka and Fort Bragg in the winter months, particularly November, December, and January.

A considerable gill net fishery has been developed out of British Columbia for this species. The nets have smaller size mesh than do those used for soupfin, running in the neighborhood of 5½ inches.

The vitamin A content in the dogfish is not nearly so great as that of the soupfin, but the relative abundance and numbers of the two species are such that the greater quantity of dogfish has in the past made up for the lower individual potency and value. The same increase in potency with length as shown in the soupfin has been found to be true with this species. The liver price has varied from $0.50 to more than $1.50 per pound, depending upon the potency of the material being offered. The potency of the livers of dogfish runs from 5,000 to about 35,000 units of vitamin A per gram of oil.

The fishery in Northern California during the year 1948 took over 100,000 pounds of dogfish liver. Although this is not a large quantity as compared to the amount landed along the northern part of the Pacific Coast, it still makes a significant contribution to the income of the commercial fishery in this region.

Except for the vitamin yield the dogfish has relatively little value. Occasionally, offers have been made for the carcasses for the production of meal, but in most cases they are taken purely as a matter of accommodation to the fishermen.

The dogfish ranges from northwest Alaska to Southern California but is most abundant in the middle portion of its range. The center of the fishing ground lies off Washington and in Puget Sound. The fishery in California is dependent mainly upon the numbers of individuals that migrate down the coast from the north.

The carcass of the dogfish has no particular value. The flesh when prepared for the table is somewhat mealy and like cotton in texture.

4.3. BASKING SHARK

The basking shark, Cetorhinus maximus, is probably the third most important species. No great value is placed on either the liver oil or the carcass, as the oil contains no vitamins and the recovery of meal is low. The oil is used in a leather tanning process. However, because of the great quantity of liver contained in these sharks, the mere magnitude of the products obtained makes it economically feasible for some of the smaller boats to pursue them during the season when the sharks are available. Reports for 1949 indicate that during the preceding season about 200 of these sharks from 13 to 33 feet in length were taken by the harpoon fishery in Monterey Bay. During 1947, about 100 were taken off Pismo Beach. Recent prices have ranged from 5 to 14 cents a pound for the oil. Livers weigh as much as 2,100 pounds, although the average is about 700 pounds, and contain 60 to 70 percent oil.

Occasional specimens are landed at Santa Barbara when they become entangled in the regular bottom-diver shark nets. When this occurs there is great gnashing of teeth on the part of the fishermen, as the basking shark does considerable damage to bottom gill nets. In many cases, the web has to be completely cut out to extract the shark from the net.

In Santa Barbara the facilities for handling the carcass are so limited that the market is restricted. Basking shark carcasses are reduced, at present, only at Moss Landing and a few inland cities to which the sharks are hauled by truck.

4.4. BONITO SHARK AND OTHERS

The bonito shark, Isurus glaucus, is prized in the Los Angeles and Santa Barbara region for its meat. This is a very palatable fish, and it is used to a large extent in the markets of Southern California.

In addition to the bonito, the smoothhounds, the thresher, the leopard, and the six- and sevengill sharks constitute a small proportion of the take in California. They are quite satisfactory as food and are usually freely accepted by the markets in the southern part of the State.

The great blue shark, Prionace glauca, which is of no great economic importance, is at times a considerable nuisance. This species is found ranging near the surface and becomes entangled occasionally in soupfin drift nets, barracuda nets, and other gear. It is a predacious individual and is looked upon as an unmitigated pest by commercial fishermen. The great blue shark is considered by some to be quite edible and there is a small market in the Los Angeles region for the smoked meat. The liver produces a low potency oil averaging 20,000 units of vitamin A.

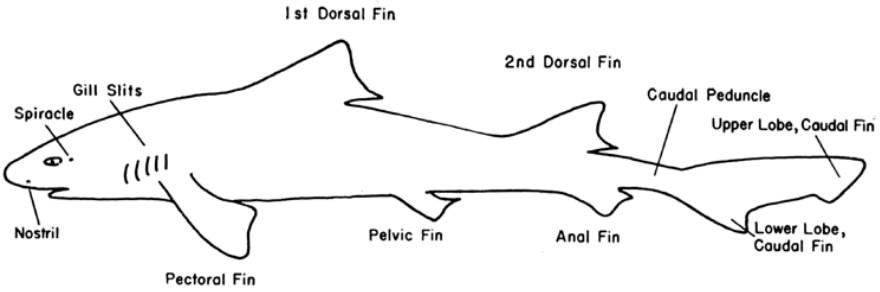


FIGURE 6. The external parts of a shark

FIGURE 6. The external parts of a shark

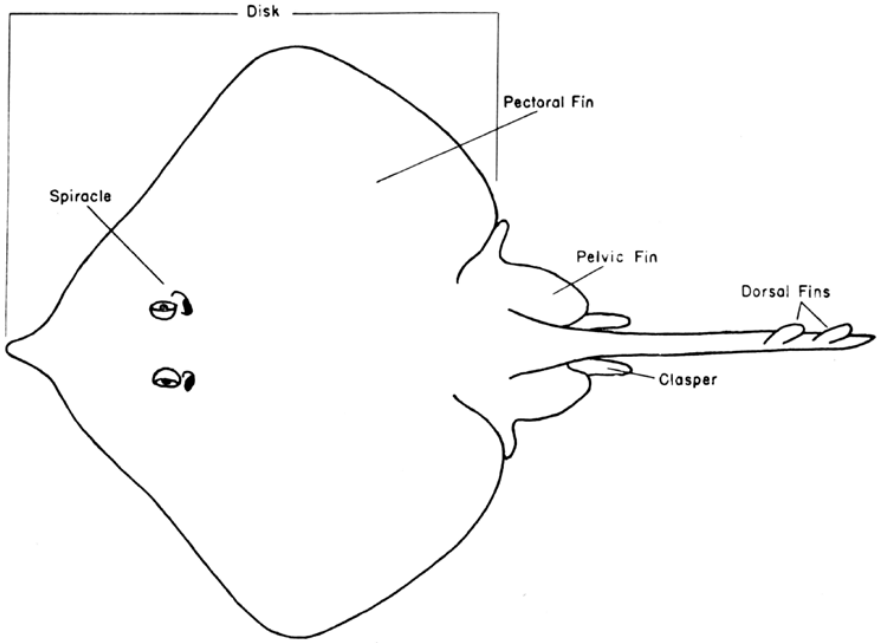


FIGURE 7. The external parts of a ray

FIGURE 7. The external parts of a ray

A KEY TO THE SPECIES KNOWN FROM CALIFORNIA

1a. Single external gill opening on each side; gill covers fleshy. Ratfish, *Hydrolagus colliei* (page 82).

1b. External gill openings 5 to 7 on each side.

2a. Gill openings wholly or at least partly on sides of body; pectoral fins not attached to sides of head.

3a. External gill openings 6 or 7 on each side.

4a. External gill openings 6 on each side.

5a. First gill opening continuous across throat; mouth terminal. Frill shark, *Chlamydoselachus anguineum* (page 39).

5b. First gill openings not meeting on throat; mouth inferior with snout projecting. Sixgill shark, *Hexanchus griseus* (page 40).

4b. External gill openings 7 on each side. Sevengill shark, *Notorynchus maculatum* (page 41).

3b. External gill openings 5 on each side.

6a. Anal fin present.

7a. A spine at front of each dorsal fin. Horned shark, *Heterodontus francisci* (page 42).

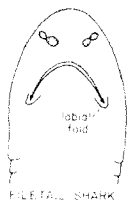
7b. Dorsal fins without spines.

8a. First dorsal fin above or behind pelvic fins.

9a. Labial fold well defined.

10a. Fold on lower jaw about twice as long as that on upper (Figure 8). Filetail shark, *Parmaturus xaniurus* (page 48).

10b. Fold on lower jaw slightly shorter than that on upper (Figure 9). Brown shark, *Apristurus brunneus* (page 49).



FILETAIL SHARK

FIGURE 8

BROWN SHARK

FIGURE 9

9b. No such labial folds. Swell shark, *Cephaloscyllium ventriosum* (page 50).

8b. First dorsal fin in front of pelvic fins.

11a. Caudal fin crescent shaped; a keel on each side of caudal peduncle.

12a. Gill openings extremely long, nearly meeting under throat; teeth small, numerous. Basking shark, *Cetorhinus maximus* (page 46).

12b. Gill openings not as above; teeth large, relatively few.

13a. Teeth, particularly in upper jaw, triangular with sawtooth edges (Figure 10). Great white shark, *Carcharodon carcharias* (page 45).

13b. Teeth without sawtooth edges.

14a. Origin of first dorsal behind pectoral base; teeth with basal cusps (Figure 11). Mackerel shark, *Lamna ditropis* (page 45).

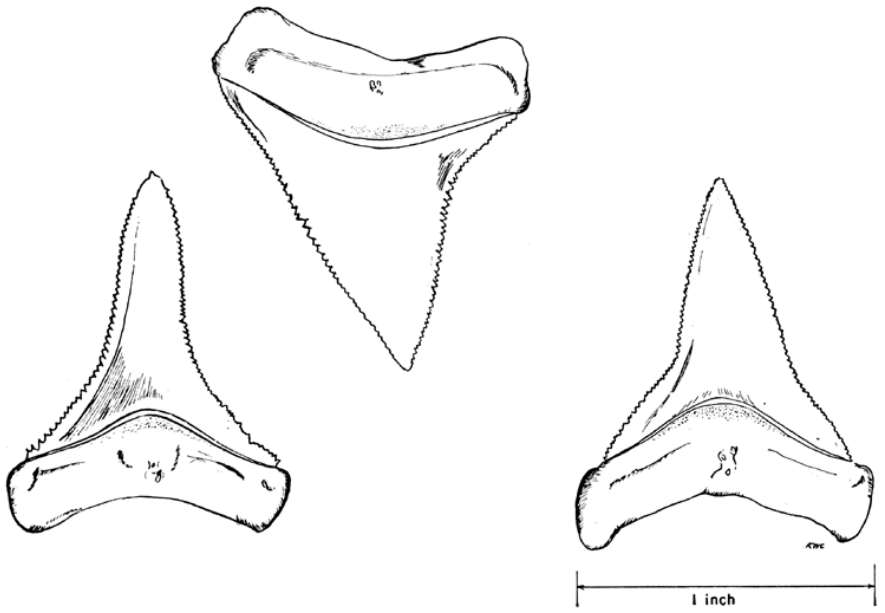


FIGURE 10. Teeth from a 23-foot great white shark, *Carcharodon carcharias*
Drawing by Keith W. Cox

FIGURE 10. Teeth from a 23-foot great white shark, Carcharodon carcharias

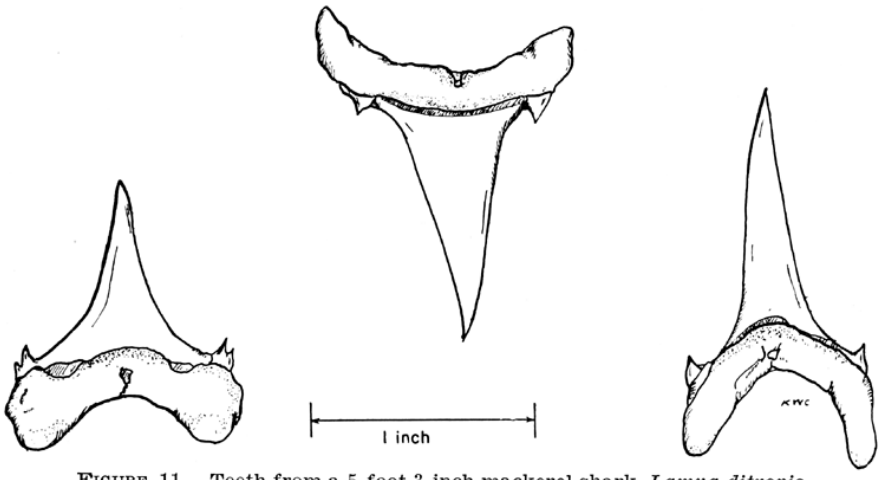


FIGURE 11. Teeth from a 5-foot 3-inch mackerel shark, *Lamna ditropis*
Drawing by Keith W. Cox

FIGURE 11. Teeth from a 5-foot 3-inch mackerel shark, Lamna ditropis

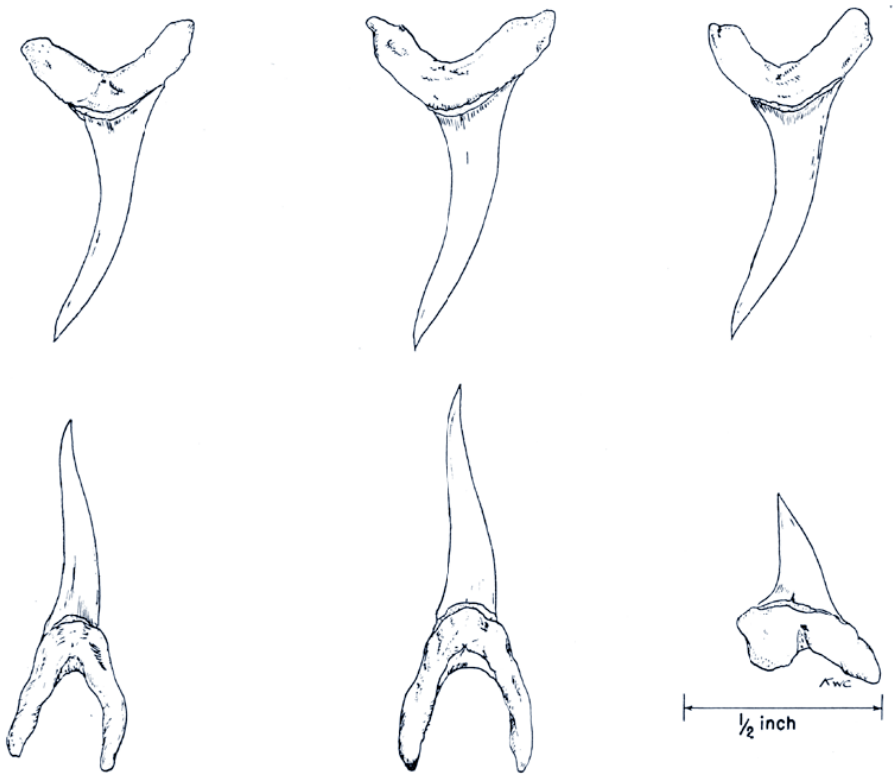


FIGURE 12. Teeth from a 5-foot bonito shark, *Isurus glaucus*
Drawing by Keith W. Cox

14b. Origin of first dorsal above hind edge of pectoral base; teeth without basal cusps (Figure 12). Bonito shark, *Isurus glaucus* (page 44).

11b. Caudal fin not crescent-shaped, the upper lobe larger; no keel on caudal peduncle except as noted under 22a.

15a. Tail about as long as rest of body. Thresher, *Alopias vulpinus* (page 47).

15b. Tail not more than $\frac{1}{3}$ of total length.

16a. Head greatly expanded laterally.

17a. Head shaped like a hammer or mallet; lobe of second dorsal about twice as long as the fin is high.

18a. Front margin of head rounded centrally. Hammerhead, *Sphyrna zygaena* (page 60).

18b. Front margin of head definitely notched centrally. Hammerhead, *Sphyrna lewini* (page 60).

17b. Head shaped like a broad spade; lobe of second dorsal little longer than height of fin. Bonnethead, *Sphyrna tiburo* (page 60).

16b. Head normally formed.

19a. Teeth blunt, pavementlike.

20a. Lower lobe of tail small, gently rounded. Gray smoothhound, *Mustelus californicus* (page 53).

20b. Lower lobe of tail expanded. Sicklefin smoothhound, *Mustelus lunulatus* (page 53).

19b. Teeth not as above, pointed or knifelike.

21a. Spiracle present.

22a. Teeth with sawtooth edges, notched on outer margin (Figure 13); a low fleshy keel on each side of caudal peduncle. Tiger shark, *Galeocerdo cuvier* (page 54).

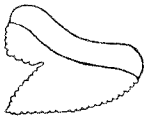


FIGURE 13

22b. Teeth not as above; no keel on caudal peduncle.

23a. Sides with blackish crossbars and spots. Leopard shark, *Triakis semifasciata* (page 51).

23b. Sides not so marked.

24a. Anal fin directly below second dorsal; the two fins about the same size (Figure 14). Soupfin, *Galeorhinus zyopterus* (page 55).

24b. Anal fin smaller than second dorsal and inserted behind it (Figure 15). Brown smoothhound, *Triakis henlei* (page 52).

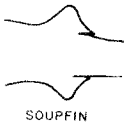


FIGURE 14

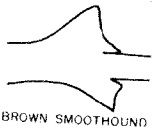


FIGURE 15

21b. No spiracle.

25a. Teeth smooth-edged; prominent labial fold on both jaws. Sharpnose shark, *Scoliodon longurio* (page 59).

25b. Teeth serrated at least in upper jaw; labial fold absent or greatly reduced on lower jaw.

26a. First dorsal fin nearer pelvics than pectorals. Great blue shark, *Prionance glauca* (page 56).

26b. First dorsal fin nearer pectorals than pelvics.

27a. Width of mouth much greater than length of snout in front of mouth (Figure 16). Gambuso, *Carcharhinus azureus* (page 58).

27b. Width of mouth about equal to length of snout in front of mouth (Figure 17). Bay shark, *Carcharhinus lamiella* (page 57).

FIGURE 16

FIGURE 17

6b. No anal fin.

28a. Body flattened, raylike; gill openings crowded in a deep notch behind head. Angel shark, *Squatina californica* (page 64).

28b. Body and gill openings not as above; appearance typically sharklike.

29a. A strong spine at the front of each dorsal fin. Dogfish, *Squalus acanthias* (page 61).

29b. Dorsal fins without spines.
30a. Dorsal fins widely separated, the first well ahead of the pelvics. Sleeper shark, *Somniosus pacificus* (page 62).
30b. Dorsal fins close together, the first over the pelvics. Bramble shark, *Echinorhinus brucus* (page 63).

2b. Gill openings entirely on under surface of body; pectoral fins attached to sides of head.
31a. Two dorsal fins.
32a. Skin entirely smooth, without spines or prickles. Electric ray, *Torpedo californica* (page 79).
32b. Skin more or less rough, with scattered spines.
33a. Tail fin well developed.
34a. Width of disk noticably less than its length; snout sharply pointed. Shovelnose guitarfish, *Rhinobatos productus* (page 65).
34b. Width of disk not less than its length; snout rounded or bluntly pointed.
35a. Snout bluntly pointed; disk about as long as wide. Mottled guitarfish, *Zapteryx exasperata* (page 66).
35b. Front of disk bluntly pointed; disk wider than long. Thornback, *Platyrhinoidis triseriata* (page 67).
33b. Tail fin absent or reduced to a slight fold of skin.
36a. A line from tip of snout to outer angle of pectoral (A to B in Figure 18) passes at least partly outside the body edge.
37a. Outer margin of pelvic fins deeply concave when held at right angles to the tail (Figure 19).

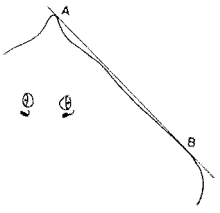


FIGURE 18

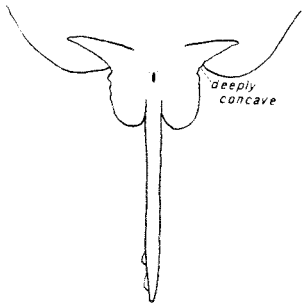


FIGURE 19

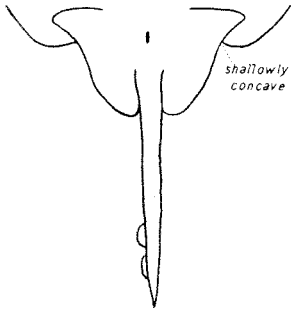


FIGURE 20

38a. Front margin of disk deeply concave; snout sharply pointed. Longnose skate, *Raja rhina* (page 71).
38b. Front margin of disk not deeply concave, line A to B about as shown in Figure 18; tip of snout projects slightly. California skate, *Raja inornata* (page 69).
37b. Outer margins of pelvic fins shallowly concave, nearly straight when held at right angles to tail (Figure 20). Big skate, *Raja binoculata* (page 70).
36b. A line from tip of snout to outer angle of pectoral passes entirely inside the body edge.
39a. Shoulders with 2 or more prominent spines.
40a. Spines around inner edges of eyes; about 6 spines on shoulders. Starry skate, *Raja stellulata* (page 73).
40b. No spines around inner edges of eyes; 2-4 spines on shoulders. Black skate, *Raja kincaidii* (page 74).
39b. Shoulders without prominent spines.
41a. Spines around inner edges of eyes (may be absent in large specimens); back somewhat mottled or spotted. Monterey skate, *Raja montereyensis* (page 72).
41b. No spines around inner edges of eyes; back plain. Roughtail skate, *Raja trachura* (page 74).

31b. Dorsal fin one or absent.
  42a. No dorsal fin.
43a. Tail fin present. Round stingray, *Urobatis halleri* (page 75).
    43b. No tail fin.
      44a. Tail longer than disk, whiplike. Diamond stingray, *Dasyatis dipterurus* (page 76).
      44b. Tail very short, less than ⅓ length of disk. Butterfly stingray, *Gymnura marmorata* (page 77).
  42b. One dorsal fin.
    45a. Hornlike forward projections on head.
      46a. Mouth on under surface; both jaws with teeth. Mobula, *Mobula lucasana* (page 80).
    46b. Mouth at front of head; no teeth in upper jaw. Manta, *Manta hamiltoni* (page 81).
45b. Head without projections. Bat ray, *Holorhinus californicus* (page 78).

6. DESCRIPTIONS AND ILLUSTRATIONS

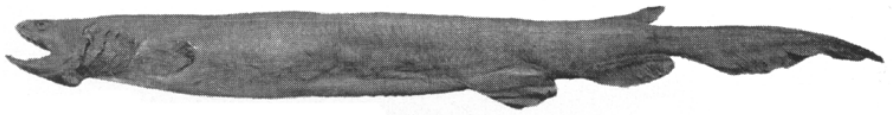


FIGURE 21

Photograph by L. T. Berryhill, Redwood City, for California Academy of Sciences

FIGURE 21

FRILL SHARK

Chlamydoselachus anguineum

Relationship: The only living member of family Chlamydoselachidae. A rare (at least to science) and primitive fish.

Range: Known from Japan, western Europe, California. A number of specimens are on record from Japan, a few from Europe and one from California. This is a deep water shark which has been caught in depths of from 100 to 600 fathoms. **California record:** The sole California specimen was caught near the surface in a gill net set some 22 miles off Pt. Arguello in June 1948. It was a female about 5 ½ feet long and is shown in the picture above.

Descriptive Characters: Six gill slits; one dorsal fin; body long, slender eellike; mouth large, terminal; teeth broad-based with 3 long slender prongs; first gill opening continuous across throat. **Color:** Brown, lighter below. **Size:** The largest specimen on record measured nearly 6 ½ feet.

Development: Bears live young (ovoviviparous). The eggs are huge and consequently few in number. The period of gestation is very long—perhaps two years.

Liver: The liver of the California specimen weighed about 5 ¼ pounds. It had an extremely low vitamin A content.

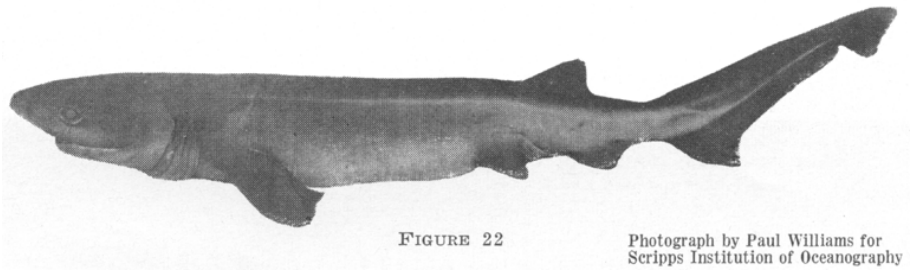


FIGURE 22 Photograph by Paul Williams for Scripps Institution of Oceanography

FIGURE 22

SIXGILL SHARK

Hexanchus griseus

Relationship: Belongs to the cowshark family, Hexanchidae, as does the sevengill shark.

Range: On our coast, from northern British Columbia to Southern California. Also known from Japan, the southeast Pacific, both coasts of the Atlantic, the Mediterranean and the south Indian Ocean. Not as common in California as the sevengill shark but reported fairly abundant off British Columbia. Caught not infrequently off San Diego county in about 50 fathoms.

Descriptive Characters: Six gill slits on each side; one dorsal fin; mouth ventral; teeth in upper jaw quite unlike those in lower (Figure 23). **Color:** Dark gray or brown to almost black; a pale streak along the side. **Length:** At least to 15 feet. There is a published account of a 26-foot specimen caught in England in 1846. **Development:** Bears a large number of live young.

Remarks: This is a bottom shark which has been caught in very deep water. It feeds on fish and crustaceans. The Pacific form has been described as a species (H. corinum) separable from the Atlantic on the basis of differences in the teeth. These are not valid according to Bigelow and Schroeder (1948).

Importance: One of the more desirable meat species but not taken in any quantity.

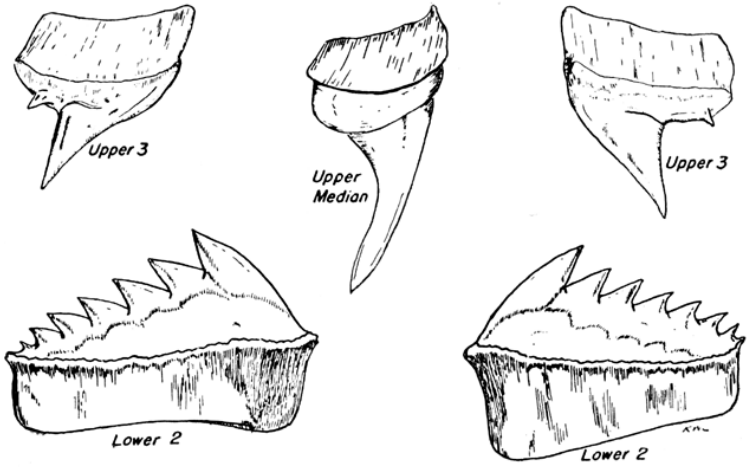


FIGURE 23 Drawing by Keith W. Cox

FIGURE 23

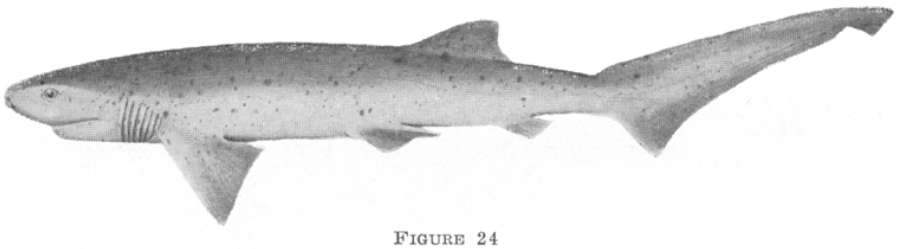


FIGURE 24

FIGURE 24

SEVENGILL SHARK

Notorynchus maculatum

Relationship: A member of the cowshark family, Hexanchidae, as is the sixgill shark. Other species of sevengill sharks are found elsewhere in the world.

Range: Northern British Columbia to Southern California. Common in San Francisco, Tomales and Monterey bays; rarely seen off Southern California where it is usually found in fairly deep water.

Descriptive Characters: Seven gill slits; one dorsal fin; teeth in upper and lower jaws unlike (Figure 25). **Color:** Sandy gray to blackish, spotted sparsely with black. **Length:** Reputed to reach 15 feet; there is record of an 8 ½-foot female caught off Washington. **Development:** Bears live young (ovoviviparous).

Remarks: Little is known of the life history and habits and of the true relationship of the several kinds of sevengill sharks usually recognized. This is a pugnacious shark and it will attempt to bite its captor if given the opportunity.

Fishery: Constitutes less than two percent of the San Francisco Bay shark catch where it is taken on bait during the fall. Two females are caught for each male.

Importance: Considered by the markets as one of the more palatable sharks.

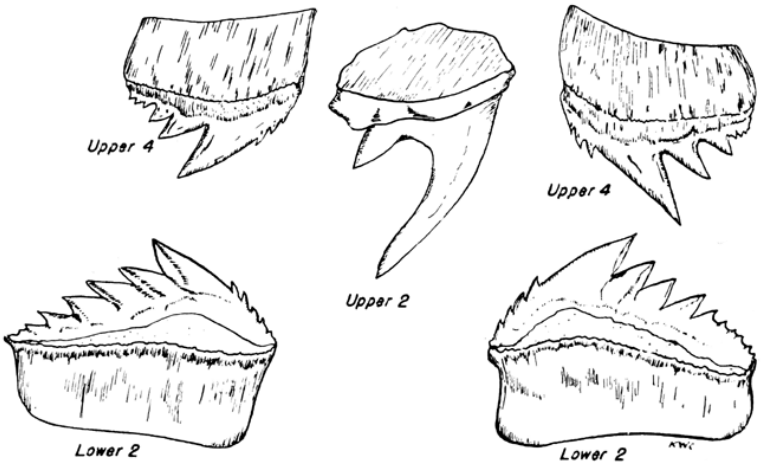


FIGURE 25

Drawing by Keith W. Cox

FIGURE 25

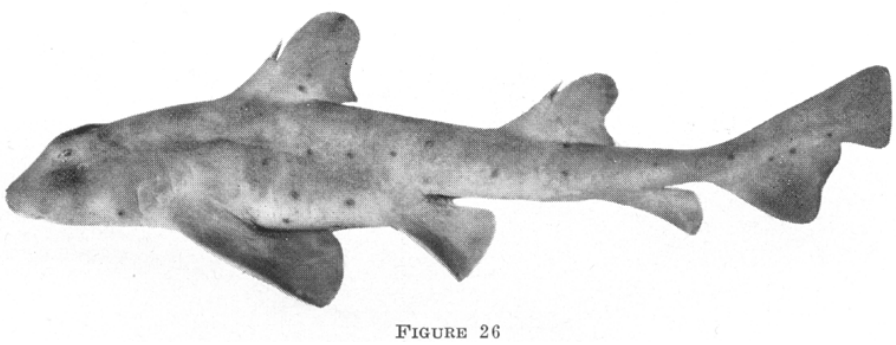


FIGURE 26

FIGURE 26

HORNED SHARK

Heterodontus francisci

Relationship: A member of the bullhead shark family, Heterodontidae. This family is of ancient lineage. It includes six living species, all from the Pacific and all belonging to the same genus.

Range: Pt. Conception to Cape San Lucas, Lower California and into the Gulf of California. Reported years ago from Monterey Bay. This is a fairly common inshore bottom form particularly around kelp. It has been caught at depths of over 500 feet and is thought to migrate from shallow to deeper water at certain times of the year.

Descriptive Characters: A spine before each dorsal fin; anal fin present. **Color:** Brownish with scattered black spots. **Length:** To about 4 feet.

Development: Lays eggs, each enclosed in a distinctively shaped horny case several inches long. The eggs are probably laid in several batches during the season and they hatch in 2 or 3 months. They may be found wedged around rocks in the lowest tide zone.

Food: Mollusks, crabs and other hard-shelled invertebrates which are crushed with ease by the molarlike teeth.

Importance: None.

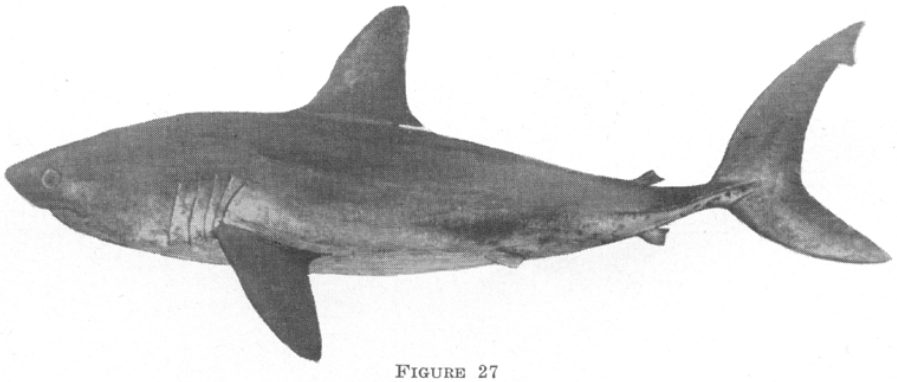


FIGURE 27

Photograph by Paul Williams for
Scripps Institution of Oceanography

FIGURE 27

MACKEREL SHARK

Lamna ditropis

Relationship: A member of the mackerel shark family, Isuridae, as are the bonito shark and the great white (pages 44 and 45). Not recognized as distinct from the Atlantic Lamna nasus until 1947.

Range: The coastal north Pacific from Southern California to Alaska and south to Japan. Apparently more abundant in the Pacific Northwest, though it is not uncommon off Northern California.

Descriptive Characters: A keel on each side of the root of the tail; a secondary keel on each side of the forepart of the tail fin; the fanglike teeth which have smooth edges and two small points at their bases (Figure 11); the first dorsal fin inserted over the back portion of the pectoral base. **Color:** Gray black or blue black above becoming abruptly white on the sides; underparts blotched with blackish in adults. **Size:** Probably reaches ten feet. British Columbia specimens of 8 ½ feet are on record. **Development:** Bears live young (ovoviviparous).

Remarks: There are no records of this shark having attacked man, though the family includes several dangerous species. It is a voracious shark, and in the Pacific Northwest, where it is reported to feed extensively on salmon, it does considerable damage to fishing gear.

Importance: Occasional specimens are taken by Northern California shark fisherman. The liver does not contain any significant amount of vitamin A and is classed as "junk."

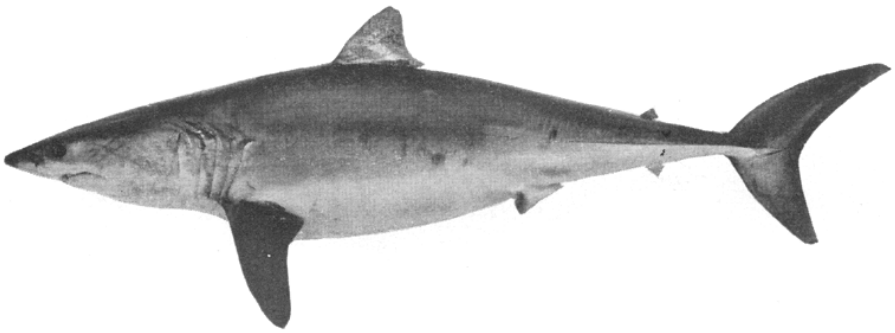


FIGURE 28

FIGURE 28

BONITO SHARK

Isurus glaucus

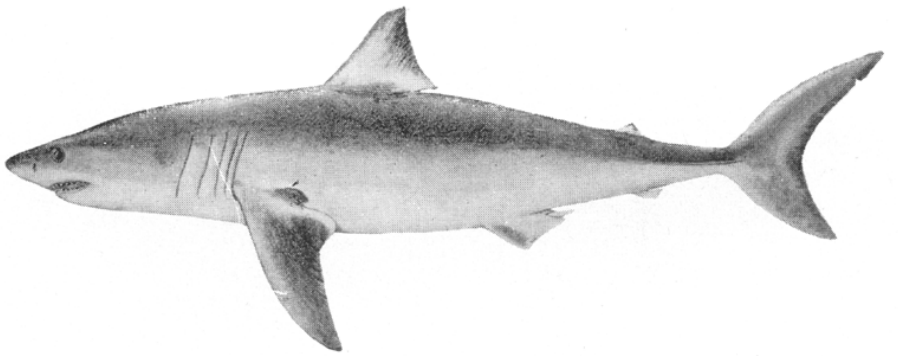
Relationship: Belongs to the mackerel shark family, Isuridae, which includes the mackerel and great white sharks. The Atlantic mako shark belongs to this genus. The mako of Australia and New Zealand may be the same as our bonito shark though it has been described as a distinct species.

Range: The coast of California from Monterey Bay south, Hawaii, Japan; the entire Indo-Pacific if there is but one species in the area. A pelagic shark common off Southern California.

Descriptive Characters: A keel on each side of the root of the tail; teeth long, sharp, with knifelike edges and without small points at their bases (Figure 12); first dorsal fin inserted behind pectoral base. **Color:** Dark blue above becoming white on the sides and belly. **Size:** South Pacific makos reach at least 13 feet; the record rod-and-reel specimen weighed 1,000 pounds. The bonito sharks commonly seen off Southern California are much smaller, usually less than 7 or 8 feet. A 7 ½-foot specimen weighed 217 pounds. **Development:** Bears live young (ovoviviparous).

Remarks: The sharks of this group are dangerous and vicious, particularly the Australia and New Zealand representatives which have been known to attack both men and boats. Bonito sharks are caught not infrequently in purse seines, along with the sardines or mackerel on which they were feeding. They are often a pest to mackerel scoop fishermen, who, however, derive some income from their sale. The Atlantic and South Pacific makos are fine game fishes, famed for their fight and spectacular leaps.

Importance: Considered an excellent food fish. The liver contains little vitamin A and is not valuable.



From Garman, 1913

FIGURE 29

FIGURE 29

GREAT WHITE SHARK

Carcharodon carcharias

Relationship: One of the mackerel sharks, family Isuridae. A single species of great white shark is generally recognized, though a number have been described. This shark is often called the man-eater.

Range: Cosmopolitan in temperate and tropical seas. Apparently rare along the Pacific coast; a few specimens have been taken in California and Washington.

Descriptive Characters: A keel on each side of the root of the tail; large triangular teeth with sawtooth edges (Figure 10). **Color:** Slate gray to blackish above, white below; under side of pectoral with a black tip. **Size:** Man-eaters over 20 feet long appear to be most exceptional, though a 36 ½-foot Australian specimen is on record and one from California was reported to be about 30 feet. Another, taken off Bodega Bay in October 1943, measured about 23 feet. The biggest individual both weighed and measured (from Cuba) was 21 feet long and weighed 7100 pounds. A 5-foot 4-inch female from Santa Catalina Island weighed 87 pounds and an 8-footer from near Morro Bay was estimated to weigh 400 pounds. A 5 ½-foot immature male caught off Ft. Bragg weighed 105 pounds and contained 16 pounds of liver. **Development:** Bears live young.

Remarks: This is a voracious fast-swimming shark usually found in the open ocean. There are authentic accounts of its killing man and attacking small boats. Since it is uncommon at best in our waters and since it rarely comes inshore, it is a negligible hazard to California swimmers. It will eat nearly anything which comes its way. Stomach contents have included a large Newfoundland dog (Australia), two sharks between 6 and 7 feet long in a 15 ½-foot female (Florida), a 100-pound sea lion (California). The 8-foot Morro Bay specimen contained a 50-pound seal, several 5- to 7-pound rockfish and the remains of other fishes.

Importance: of no commercial value.

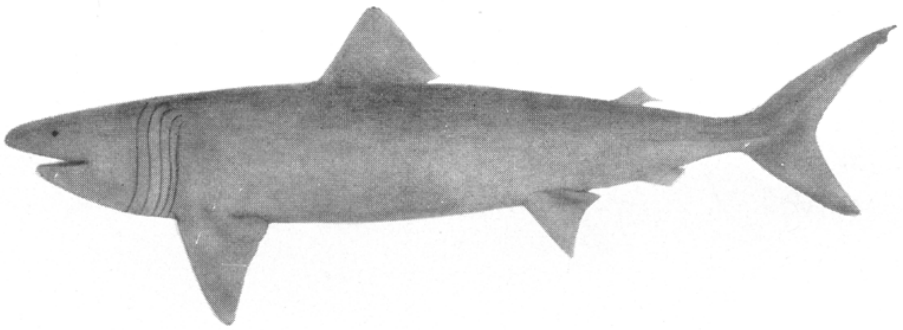


FIGURE 30

FIGURE 30

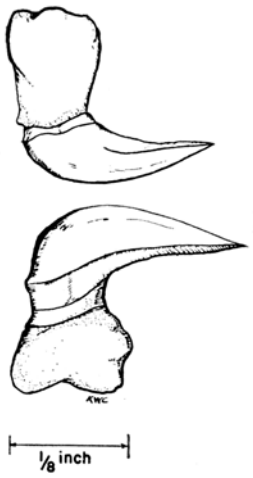
BASKING SHARK

Cetorhinus maximus

Relationship: The only member of family Cetorhinidae, if baskers from the northern and southern hemispheres, the Pacific and the Atlantic belong to the same species.

Range: Temperate and subarctic seas of both hemispheres. On the Pacific coast from Southern California northward but uncommon below Pt. Conception.

Descriptive Characters: A keel on each side of the base of the tail; gill slits extremely long, nearly meeting under the throat; numerous long, horny gill rakers; teeth small, numerous, smooth edged, those figured from a 28-foot specimen. **Color:** Lead gray above, usually becoming lighter below. **Size:** A number of specimens over 30 feet and up to 45 feet are on record. Those caught off California usually run from 15 to 30 feet, and in 1946–47 averaged about 1



TABLE

tons in weight. No specimen under 10 feet has been caught in California. **Development:** Bears live young.

Remarks: These sharks appear off the Central California coast from fall to spring where schools containing as many as 75 to 100 individuals have been observed. Despite their huge size, they are harmless to man, being somewhat sluggish creatures usually found swimming leisurely at the surface. They feed on small organisms which they strain from the water with their long, close-set gill rakers. Many tales of sea serpents can be laid to the discovery of partially decomposed remains of basking sharks washed ashore, and still others to the sight of several of them swimming one behind the other with dorsal and tail fins above the surface.

Importance: Basking sharks have been fished sporadically off Central California for many years. The latest revival of the fishery occurred in 1946.

Value: The liver oil has little medicinal value and is used chiefly for industrial purposes. Carcasses are reduced to meal and used in animal feeds, while the hides have a potential value as leather. The livers make up about a quarter of the round weight and run 60 to 70 percent oil.

Fishing method: Harpooning from small craft (see page 21).

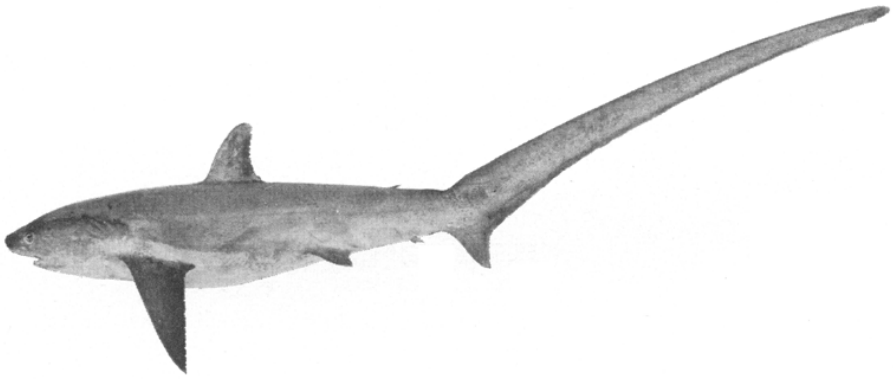


FIGURE 31
FIGURE 31

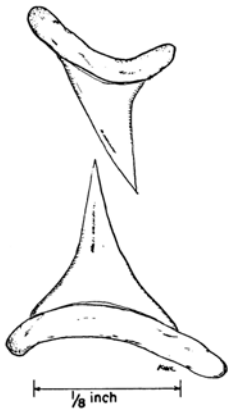


FIGURE 31

THRESHER

Alopias vulpinus

Relationship: One of the several species of threshers which comprise family Alopiidae. Whether the similar threshers of the western Pacific and the Indo-Australian region are the same as those found off our coast and in the Atlantic remains to be settled.

Range: Temperate and tropical waters of the Atlantic, the Mediterranean, the eastern Pacific from the Straits of Juan de Fuca south; the balance of the Pacific and Indian Ocean if the fish found there prove identical with the eastern Pacific form. Pelagic, but coming fairly close to shore at times. Two individuals have been taken in salmon gill nets off McNears Point, in San Pablo Bay.

Descriptive Characters: The extremely long tail which constitutes about half of the total length. Teeth small, weak, those figured from an 8-foot specimen. **Color:** Bluish or brownish gray to black above becoming white below. **Size:** Variously reported to reach 20 to 25 feet and a weight of half a ton. A New Zealand specimen (which may belong to another species) measured 18 feet and weighed 922 pounds. Reaches no great size in California. Most specimens seen run from seven to eight feet. **Development:** The young are born alive, apparently in very small litters. Those reported included two or four pups. Large females have been found carrying young about five feet long.

Feeding habits: The long tail apparently serves a good purpose in feeding. The thresher swims around or through a school of small fish, the flailing tail acting either as a scare to concentrate the school or as a weapon with which to injure or kill individual fish.

Remarks: There is a story of many generations' standing that threshers, in company with swordfish, attack whales and even kill them with their powerful tails. Like so many good stories, it is not true—these exploits can be laid to killer whales which do attack their larger relatives. The thresher is harmless to man. While it is a fast swimmer, it has a small mouth and weak teeth.

Fishery: Taken in fairly large numbers off Santa Barbara in gill nets during the summer.

Importance: Used exclusively for food; not of value as a source of vitamin A. Considered one of the most desirable food sharks.

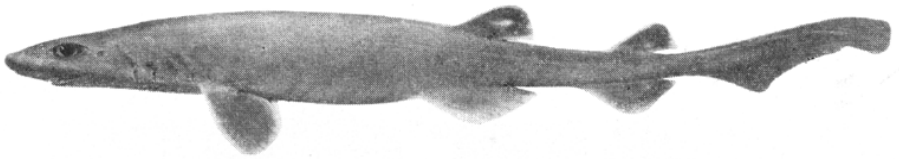


FIGURE 32 From Garman, 1913

FIGURE 32

FILETAIL SHARK

Parmaturus xaniurus

Relationship: A member of the catshark family, Scyliorhinidae, which includes the swell and brown sharks. This family includes many species of small sharks and representatives are found in most temperate and tropical seas. All are believed egg layers.

Range: Southern California south at least to San Roque Bay, Lower California. Reported fairly common in rather deep water; it has been caught in depths as great as 684 fathoms.

Descriptive Characters: Anal fin present; no keels on caudal peduncle. First dorsal fin far back, above pelvics; labial fold present, that on lower jaw about twice as long as that on upper (Figure 8); a broad band of enlarged scales on upper edge of tail in adults. **Color:** Dark slaty brown above, sometimes with small whitish spots; fins often bordered with whitish; belly pale. **Length:** To about two feet. **Development:** Lays eggs in cases.

Remarks: If not a rare shark, it is at least rarely caught and consequently is of no economic importance.

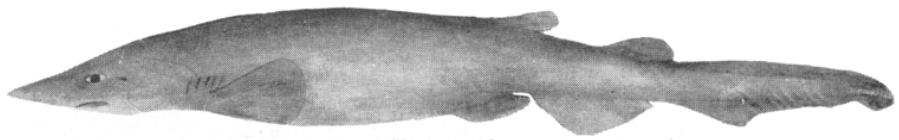


FIGURE 33

FIGURE 33

BROWN SHARK

Apristurus brunneus

Relationship: One of the three catsharks (family Scyliorhinidae) found off California. This genus includes 13 currently recognized species known from deep water in various parts of the Atlantic, Pacific, and Indian oceans.

Range: British Columbia to Southern California; a deep water form, apparently not common off California. Through an error, pointed out by Beebe and Tee-Van (1941), the range was long considered to extend into the Gulf of California. There are apparently no valid published records from south of the Mexican border.

Descriptive Characters: Anal fin present; no keel on caudal peduncle; first dorsal fin far back, over pelvics; anal fin large; labial folds present, that on lower jaw slightly shorter than on upper (Figure 9); no enlarged scales on upper edge of tail.

Color: Uniformly brown, the fins margined with black. **Length:** To about two feet.

Development: Eggs are laid in cases about two inches long shaped something like a flattened vase and with a tendril at each corner. The light brown case is transparent and the white egg can be seen inside.

Importance: None.

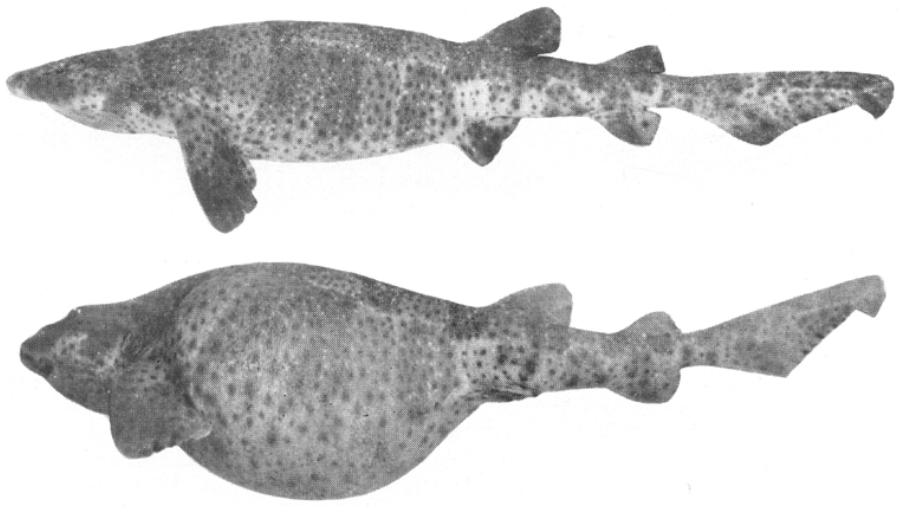


FIGURE 34

FIGURE 34

SWELL SHARK

Cephaloscyllium uter

Relationship: One of the catsharks (family Scyliorhinidae). The filetail and brown sharks are other members of the group found off California.

Range: Monterey Bay south into Lower California at least as far as San Martin Island. Reported once from Acapulco, Mexico. A common inshore form in Southern California, particularly around kelp; not common north of Pt. Conception.

Descriptive Characters: Anal fin present; no keels on caudal peduncle; first dorsal fin far back, above pelvics; labial folds absent or rudimentary; head broad, blunt, flat; skin thick; scales large, rough; ability to inflate belly. Its teeth resemble those of the mackerel shark but are very small. **Color:** Shades of brown tinged with yellowish; barred and spotted with black on back and sides; sides with small whitish spots. **Length:** To about 3 feet. **Development:** Lays eggs contained in amber colored cases.

Remarks: This shark fills its belly with air when taken from the water and can distend itself to the grotesque proportion illustrated. A fish eater, it can take surprisingly big individuals in its large mouth. It is not infrequently caught in lobster traps.

Importance: None. The liver contains no vitamin A and, according to fishermen, eating the flesh will cause diarrhea.

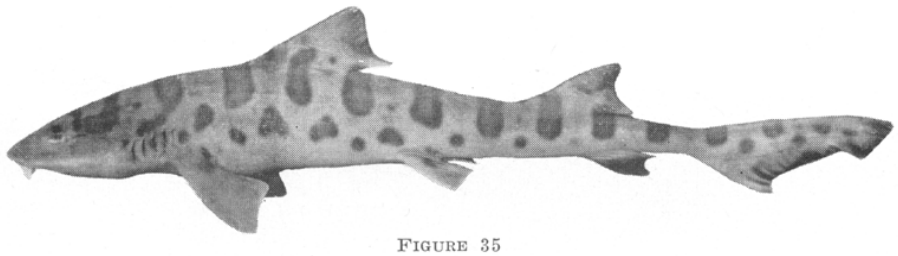


FIGURE 35

FIGURE 35

LEOPARD SHARK

Triakis semifasciata

Relationship: Belongs to the smoothhound family, Triakidae, which includes three other California species. This family has many members widespread in warmer seas. All are relatively small and are harmless to man.

Range: Oregon to Magdalena Bay, Lower California. Common in shallow water along the Southern California coast and in bays farther north.

Descriptive Characters: Anal fin present; no keel on either side of base of tail; first dorsal fin in front of pelvics; black crossbars on upper parts. **Color:** Gray with black crossbars on upper parts and black spots on sides; belly pale. **Length:** Males to three feet, females to five feet. **Development:** Bears live young. About half of the females are mature at 3½ feet.

Fishery: Caught quite frequently by Southern California fishermen. Taken throughout the year in Northern California; it comprises about 14 percent of the shark catch in San Francisco Bay during the fall.

Importance: Commonly marketed for its flesh. The liver contains no vitamins.

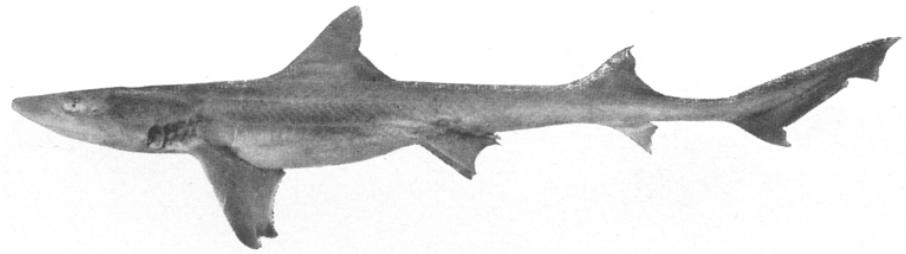


FIGURE 36

FIGURE 36

BROWN SMOOTHHOUND

Triakis henlei

Relationship: One of the smoothhounds (family Triakidae). The leopard shark belongs to the same genus.

Range: The coast of California and south into central Lower California. Common in Central California bays; it is the most abundant shark in San Francisco Bay, where it makes up over half of the total shark population.

Descriptive Characters: Anal fin present; first dorsal fin in front of pelvics; caudal peduncle without keels; teeth small, pavementlike, but with sharp points; pectoral, when held against body, reaches a point below the middle of the first dorsal; second dorsal much larger than anal. **Color:** Red brown or bronze above; sides sometimes silvery; belly white. **Length:** To 38 inches. **Development:** Bears live young. Half of the females 30 inches long are mature.

Note: This shark is quite similar in general appearance to the gray smoothhound (page 53) which, however, does not have sharp pointed teeth. It is sometimes confused with the soupfin, but is easily identified by the small anal fin (Figures 14 and 15).

Importance: Considered one of the more desirable sharks for its meat. The liver has no value.

Fishery: Taken chiefly on hook and line and offers some considerable sport to fishermen in the bay region.

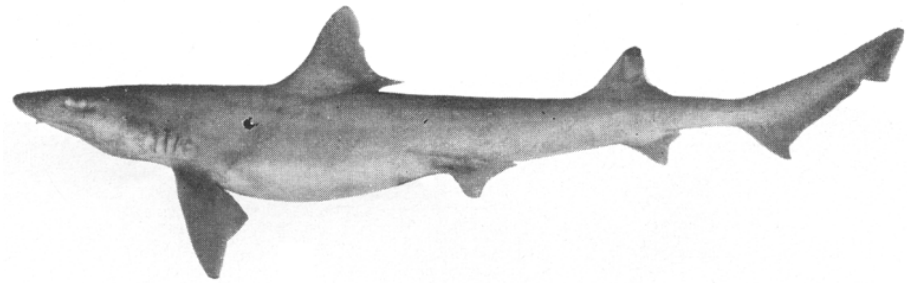


FIGURE 37

FIGURE 37

GRAY SMOOTHHOUND

Mustelus californicus

Relationship: Belongs to the smoothhound family, Triakidae. This genus includes many species found in most warm and temperate inshore waters of the world.

Range: Northern California south along Lower California and into the Gulf of California. Abundant in shallow water off Southern California but not particularly common to the north.

Descriptive Characters: Anal fin present; first dorsal fin in front of pelvics; caudal peduncle without keels; teeth flat, blunt, pavementlike, without points; pectoral fin, when held against body, does not reach past a point below the first quarter of the first dorsal; lower lobe of tail rounded. **Color:** Dark gray above becoming whitish on the belly. **Length:** To about 2½ feet. **Development:** This shark is viviparous, the young getting nourishment from the mother through a placental attachment.

SICKLEFIN SMOOTHHOUND

Mustelus lunulatus

Relationship: A member of the smoothhound family, Triakidae.

Range: San Diego south to Colombia.

Descriptive Characters: Lower lobe of caudal extended and pointed; pectoral reaches a point below the middle of the first dorsal; otherwise as for the gray smoothhound. **Color:** Grayish above, belly white. **Size:** There is record of a 5-foot 8½-inch specimen from San Diego. **Development:** Bears live young. Embryos are reported abundant in the autumn.

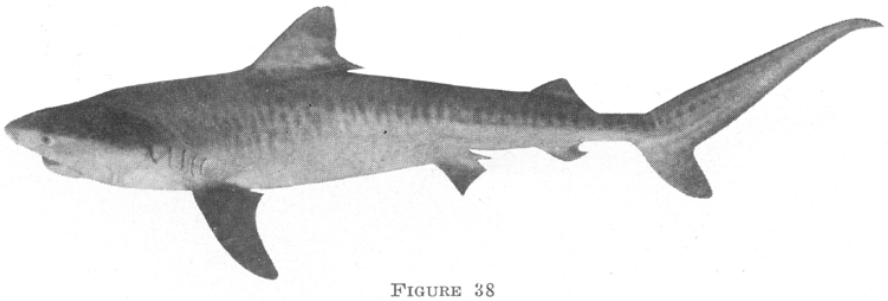


FIGURE 38

FIGURE 38

TIGER SHARK

Galeocerdo cuvier

Relationship: Belongs to the requiem shark family, Carcharhinidae (pages 54 to 59). This is the largest of the shark families, with its members widely distributed in tropical and temperate seas. Some, including the tiger shark, are definitely dangerous to man. Most, however, are harmless and a few, such as the soupfin, are extremely valuable commercially.

Range: Tropical and warm temperate seas of the world; north to Southern California on our coast and to Massachusetts on the Atlantic seaboard. **Occurrence in California:** There appear to be only two authentic records of this shark from California waters. Both were caught off San Diego County, one many years ago and the other in July 1941.

Descriptive Characters: Anal fin present; first dorsal fin in front of pelvics; tail long and pointed; caudal peduncle with a low ridge on each side; teeth large with sawtooth edges and with a deep notch at the outer margin (Figure 13); snout short, blunt; spiracles present, small; upper labial furrow long. **Color:** Gray or brownish gray above, paler below; small specimens irregularly spotted or barred with darker shades on upper parts. **Size:** Known to reach 18 feet. Reports of 25- and 30-foot specimens lack confirmation. The 1941 California specimen was 9 feet long and was estimated to weigh 200 pounds. The largest specimens weighed (Australia) were from 13 to 14½ feet long and ran from 850 to 1395 pounds. **Development:** Ovoviviparous. Usually bears from 30 to 50 young, with recorded extremes of 10 and 82.

Food: This shark is known for its varied diet. Published accounts include references to fish, other sharks, rays, marine invertebrates, birds, turtles, a young sea lion, and carrion—even tin cans and pieces of coal.

Remarks: According to Whitley (1940), this shark has been known to attack man. Bigelow and Schroeder (1948) say that ". . . Tiger Sharks, when they come into shallow water, may be a danger to bathers; in the West Indies they are said to be considered the most dangerous of sharks."

Commercial Importance: Fished for its liver and hide elsewhere. It is, of course, of no significance in California because of its extreme rarity in our waters.

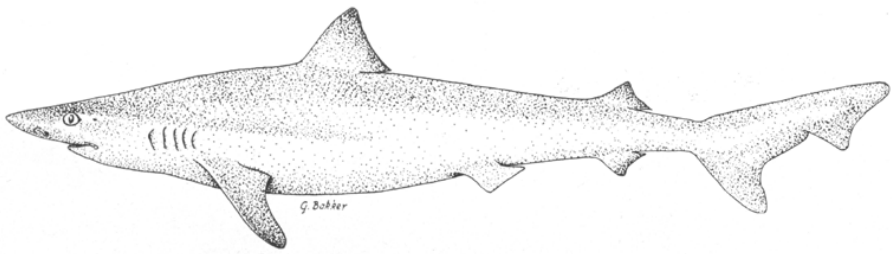


FIGURE 39

FIGURE 39

SOUPFIN

Galeorhinus zyopterus

Relationship: A member of the family Carcharhinidae. Very similar, some perhaps specifically identical, sharks are found in the eastern Atlantic and Mediterranean, on both coasts of South America, and in the central, western and south Pacific.

Range: Northern British Columbia at least to Abreojos Pt., central Lower California in inshore waters from the surface to the bottom. Soupfin have been fished in depths of up to 150 fathoms and have been caught in 225. Males predominate in the northern part of the state; females in shallow water off Southern California.

Descriptive Characters: Anal fin present; first dorsal fin in front of pelvics; caudal peduncle without keels; second dorsal fin directly above and about the same size as anal (see Figure 14; small soupfin are sometimes confused with the brown smoothhound, but in the latter the second dorsal is larger than and inserted in advance of the anal); spiracles present; teeth sharp, notched on outer edge below the point, the lower part of the notch divided into two to five points. **Color:** Dark gray or bluish above, becoming paler on the sides and whitish below. **Size:** Females reach 6½ feet and a weight of nearly 100 pounds; males, 6 feet and about 60 pounds.

Development: Ovoviviparous. Litters average 35, with known extremes of 6 and 52. The period of gestation is believed to be about a year. Most males mature at 5 feet, most females not until a few inches longer.

Food: Chiefly fishes of medium and small size. Stomach contents examined included both bottom dwelling forms (flatfish, rockfish, midshipman) and pelagic types (sardines, mackerel, barracuda, squid).

Fishery: Fishing methods and gear are described in detail on pages 13 to 20.

Importance: By far the most important of our sharks (see pages 24 to 27 for a full discussion). The liver of the soupfin is the richest known source of vitamin A. During World War II this species and the west coast dogfish were the chief factors in the production of vitamin A for the United States and the allied nations.

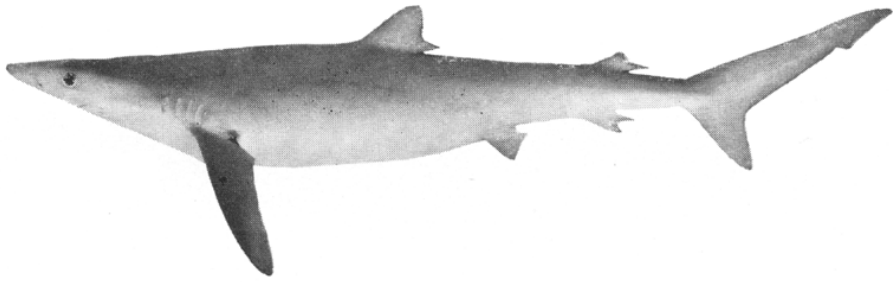


FIGURE 40

FIGURE 40

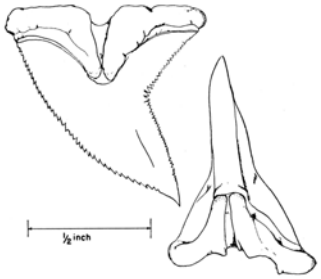


FIGURE 40

GREAT BLUE SHARK

Prionace glauca

Relationship: A member of the requiem shark family, Carcharhinidae.

Range: Tropical and temperate seas of the world. On our coast, from British Columbia to the Gulf of California, where it is found both on the high seas and in inshore waters. Common off the Southern California coast. Occasionally common in Monterey Bay and elsewhere above Pt. Conception when warm currents approach the shore.

Descriptive Characters: Anal fin present; middle of base of first dorsal nearer pelvics than pectorals; caudal peduncle without keels; upper teeth serrate; lower teeth usually finely serrate, a few sometimes smooth or nearly so (teeth figured from a 6½-foot specimen); snout long, pointed; pectorals long, pointed; no spiracles. **Color:** Indigo blue above, lighter blue on sides, belly white. **Size:** Reputed to reach 15 or 20 feet but a 12-foot 7-inch specimen is apparently the largest actually on record. A specimen some 9 feet long weighed 164 pounds; the 6 footers commonly encountered in our waters weigh 60 or 70 pounds. **Development:** Viviparous, the embryos attached to the mother with a placenta. The litters are large; a Mediterranean specimen contained 54. This shark probably does not mature until 7 or 8 feet long.

Remarks: There are no authentic records of great blue sharks attacking man, though they have unsavory reputations. Apparently they feed chiefly on small fish and squids but they are quite voracious and have an amazing vitality even when horribly mutilated.

Importance: Although this shark is not of any significant commercial importance in California, the liver oil averages 20,000 units of vitamin A per gram (Butler, 1948). Its occurrence and capture sometimes makes it quite a nuisance to drift net fishermen. It is infrequently taken by deep sea anglers. A small market exists in Southern California for the smoked meat.

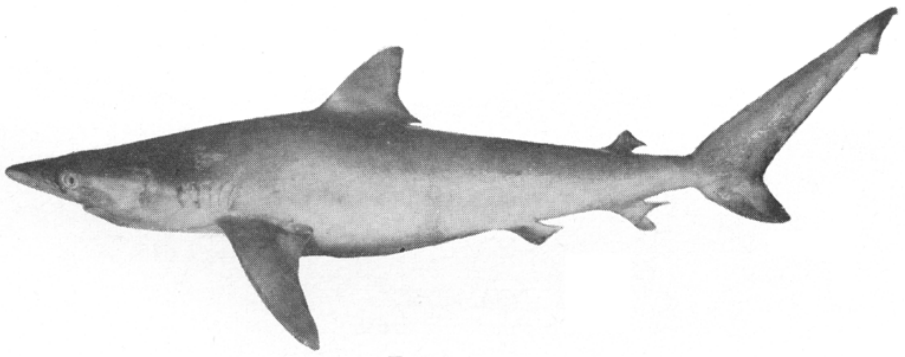


FIGURE 41

Photograph by Al Johns for
Vernon M. Haden, San Pedro

FIGURE 41

BAY SHARK

Carcharhinus Iamiella

Relationship: A requiem shark (family Carcharhinidae). Genus Carcharhinus includes many species of fairly large sharks which are found in the warm and temperate seas of the world. There is one fresh water species which lives in Lake Nicaragua. of the several species described from the eastern Pacific, only this and the gambuso reach California waters.

Range: From Southern California south at least to Mazatlan, Mexico.

Descriptive Characters: Anal fin present; middle of base of first dorsal nearer pectorals than pelvics; caudal peduncle without keels; no spiracles; edges of teeth with fine serrations; width of mouth about equal to length of snout in front of mouth; origin of anal fin slightly behind origin of second dorsal. **Color:** Golden bronze to gray above, white below. **Size:** Reported to reach 15 feet. A specimen caught years ago at Santa Catalina Island measured 12 feet. **Development:** Bears live young.

Fishery: Not a commercial species in California. It is sought in Mexican waters for its liver which is relatively rich in vitamin A. According to Walford (1944) the average potency of 16 specimens was 61,000 U. S. P. units of vitamin A per gram of oil. It is called "injerto" by the Mexicans.

Remarks: In the past, this shark has been reported as common in San Diego Bay—hence its name—but it now appears to be unusual if not rare north of Sebastian Viscaino Bay. We find no records of its capture off California in recent years. It is quite common in the southern portion of its range. It is found in relatively shallow water but is by no means confined to bays.

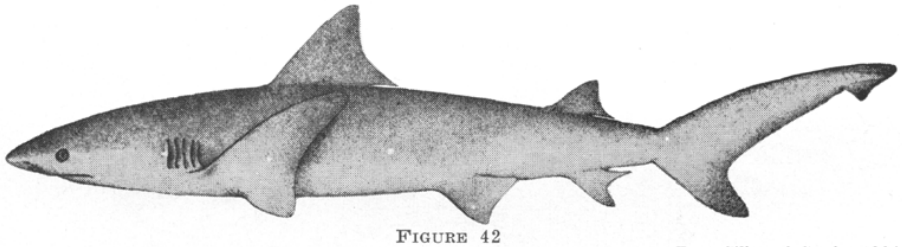


FIGURE 42 From Gilbert & Starks, 1904

FIGURE 42

GAMBUSO

Carcharhinus azureus

Relationship: A member of the requiem shark family, Carcharhinidae.

Range: Southern California to Ecuador, normally from the Gulf of California south. There is definite record of four specimens caught off Southern California. All were taken in September 1942.

Descriptive Characters: Anal fin present; middle of base of first dorsal fin nearer pectorals than pelvics; caudal peduncle without keels; no spiracles; teeth in upper jar with serrate edges, those in lower finely serrate or fairly smooth; snout short and rounded; width of mouth much greater than length of snout in front of mouth (Figure 16); origin of anal fin well behind origin of second dorsal. **Color:** Gray or blackish above becoming white below; fins tipped with dusky. **Size:** Two of the California specimens were over ten feet long.

Importance: None in California. Enters the Mexican shark catch at least to a minor degree.

Remarks: This shark has no English vernacular name. Gambuso is given by Walford (1944) as the local name in the Gulf of California.

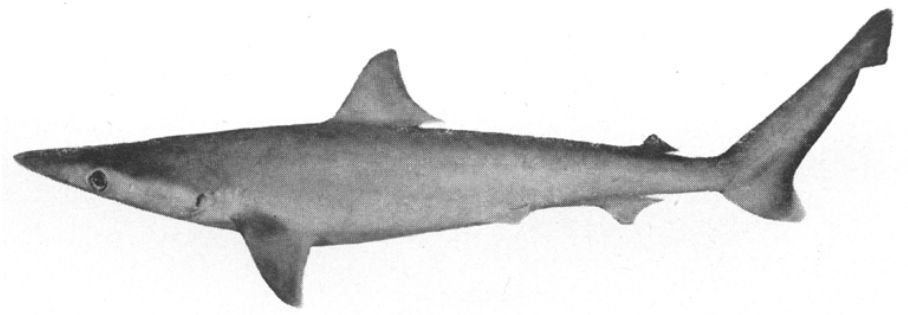


FIGURE 43

Photograph by Al Johns for
Vernon M. Haden, San Pedro

FIGURE 43

SHARPNOSE SHARK

Scoliodon longurio

Relationship: A requiem shark (family Carcharhinidae).

Range: Southern California to Panama.

Descriptive Characters: Anal fin present; first dorsal fin in front of pelvics; caudal peduncle without keels; no spiracles; teeth smooth edged in both jaws; origin of second dorsal fin behind origin of anal fin; labial folds long and conspicuous; snout pointed. **Color:** Slate to bluish gray above; belly white. **Size:** This is a small shark. A 42½-inch, 9-pound specimen is on record.

Remarks: Only one specimen of this shark—a female carrying three pups—is known from California. It was taken off San Diego County in 1948. All other records are from central Lower California south. The species is apparently a bay form, common in its normal range.

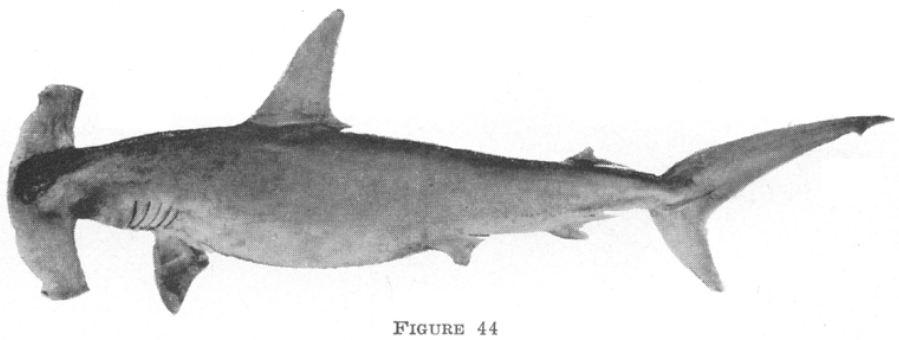


FIGURE 44

FIGURE 44

HAMMERHEAD

Sphyrna zygaena

Relationship: A member of the hammerhead family, Sphyrnidae. The status of the various kinds of hammerheads has long been confused. At present, three species are recognized as having occurred in California waters.

Range: Tropical and warm temperate seas; occasionally off Southern California on our coast. Found in surface waters both inshore and off.

Descriptive Characters: Head hammer shaped; front margin of head evenly rounded centrally, deeply scalloped by the nostrils; posterior lobe of second dorsal about twice as long as the fin is high. **Color:** Dark slate gray or brownish gray above becoming white below. **Size:** Reaches 12 or 13 feet; a 12½-foot specimen probably of this species weighed 900 pounds. There are records of larger individuals up to more than 15 feet but all are either believed or known to refer to other species. We find no record of a hammerhead even approaching 12 feet in California waters. **Development:** Bears live young; believed ovoviviparous. Females containing up to 37 embryos have been caught.

Remarks: There are authentic cases of hammerheads in the western Atlantic and in the Australian region attacking man.

Fishery: Hammerheads are far too rare in California to be sought commercially, but several kinds are taken in the Mexican shark fishery. Their livers are reported fairly rich in vitamin A though not as potent as those of the bay shark.

Other California Species: Two species, S. lewini and S. tiburo have been reported from California. S. lewini is superficially very much like S. zygaena but the central portion of the front margin of the head is notched instead of being evenly rounded. There is record of an 8-foot female caught off San Pedro in 1940 (Springer, 1941). Whether this species or S. zygaena is the one usually found off California is uncertain. The bonnethead, S. tiburo, has a head shaped more like a spade than a hammer, the front margin of which is fairly evenly rounded. The posterior lobe of the second dorsal is about as long as the fin is high. Bigelow and Schroeder (1948) report examining specimens from San Diego Bay.

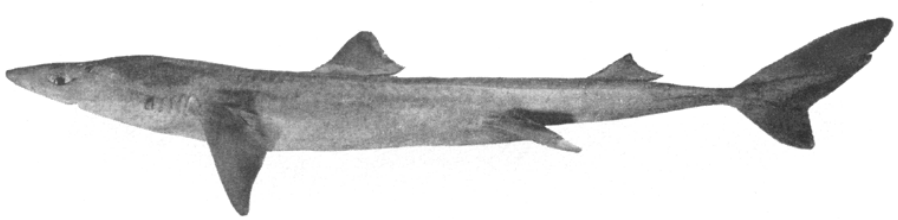


FIGURE 45

FIGURE 45

DOGFISH

Squalus acanthias

Relationship: The only member of the dogfish family, Squalidae, found on the Pacific Coast. The family is widely distributed throughout the world and the relationships of the various groups are uncertain. The north Pacific and north Atlantic dogfishes have long been regarded as separate species (S. suckleyi and S. acanthias respectively) but Bigelow and Schroeder (1948) find no difference between them. Because the Atlantic dogfish was described first, its scientific name takes precedence.

Range: Southern California to Alaska and south on the Asiatic side to north China and Japan; temperate and subarctic north Atlantic. Similar dogfishes from the southern hemisphere may belong to this species. Common, often schooling, in inshore waters along most of the Pacific Coast; in deeper water off Southern California.

Descriptive Characters: No anal fin; a spine in the forepart of each dorsal fin. **Color:** Slate gray or brownish above, becoming white below. **Size:** Length to about 5 feet, the females averaging larger than the males. **Development:** Ovoviviparous, with litters of from 3 to 14. The period of gestation is nearly 2 years.

Food: Small fishes and invertebrates, refuse.

Remarks: The spines, which are probably mildly poisonous, form a defense weapon, the fish curling like a bow before striking. often a pest to fishermen, destroying gear and taking bait designed for other species.

Fishery: See pages 20 and 27. Constitutes an important segment of the Northern California trawl catch from October through January, the months of its greatest abundance. Taken quite frequently on set lines in deep water off the Southern California coast.

Importance: Second only to the soupfin in California because of its high potency livers.

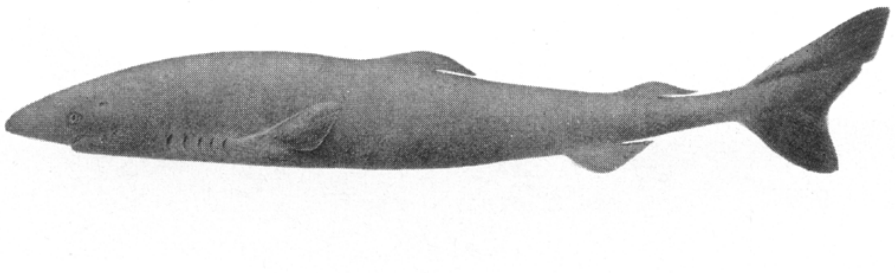


FIGURE 46 From Garman, 1913

FIGURE 46

SLEEPER SHARK

Somniosus pacificus

Relationship: A member of family Dalatiidae. This Pacific species was not recognized as distinct from the Atlantic S. microcephalus until 1944.

Range: The north Pacific; south along our coast to Southern California and on the Asiatic side to Japan. A bottom dweller, coming at times to the surface. Not common off California.

Descriptive Characters: No anal fin; dorsal fins small, without spines, well separated, about equal in length; first dorsal well ahead of pelvics. **Color:** Slate gray to black or brownish black. **Size:** Reputed to reach 25 feet; the Atlantic species is known to reach 21 feet but is unusual over 16 feet. A British Columbia specimen measured 11½ feet. **Development:** It is not known whether this shark lays eggs or bears live young.

Remarks: This is a very sluggish shark, offering little or no resistance when hooked. It feeds on almost any animal life of suitable size and on carrion. The Atlantic species, at least, favors seals highly as part of its diet.

Importance: None on our coast. The Atlantic species has long been the object of a fishery for its liver oil.

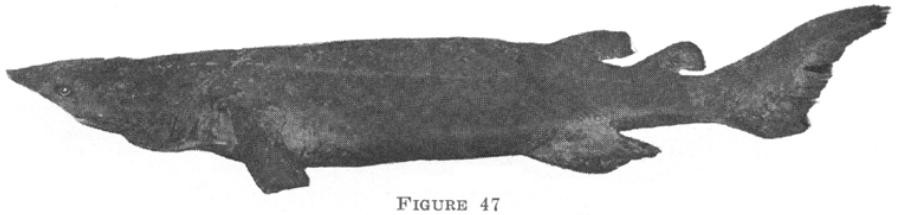


FIGURE 47

Photograph by Woody Williams, La Jolla

FIGURE 47

BRAMBLE SHARK

Echinorhinus brucus

Relationship: Considered the only member of family Echinorhinidae on the basis of present knowledge.

Range: The eastern Atlantic and Mediterranean; also known from California, Hawaii, Japan, Australia, New Zealand, New England, Argentina, South Africa, Arabia. A ground shark; it has been taken in shallow water and in depths up to 500 fathoms. **Occurrence in California:** Three specimens are known from California, one caught off Los Angeles County in 1944 and two caught off San Diego County in 1947. They were taken in from 50 to 150 fathoms. Judging from photographs, a shark caught near Santa Barbara in 1939 also belonged to this species.

Descriptive Characters: No anal fin; no spines before the small dorsal fins, which are close together with the first inserted over the pelvics; the skin armed with scattered hard plates each with one or two small spines. **Color:** The 1944 California specimen, after being frozen, was nearly uniformly dark brown. **Size:** Reaches 9 feet and at least 350 pounds. The 1944 specimen measured 6 feet 5 inches; it was a male apparently not fully mature. **Development:** Bears live young.

Liver: A 5-foot 6-inch mature male from San Diego contained a 5½-pound liver which ran 70 percent oil. The vitamin A content was negligible.

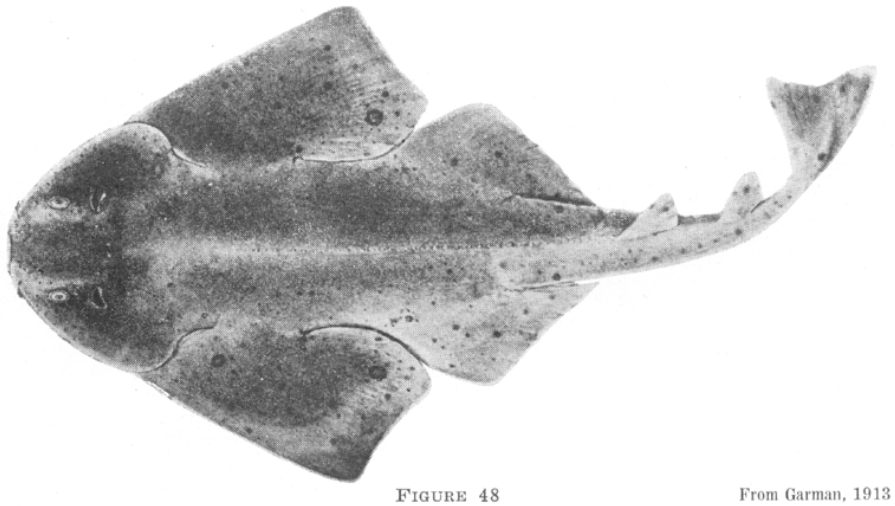


FIGURE 48 From Garman, 1913

FIGURE 48

ANGEL SHARK

Squatina californica

Relationship: The only California member of family Squatinidae. There are a number of species of angel sharks, the family being widely distributed elsewhere in the Pacific and in the Atlantic.

Range: Southern Alaska to Lower California. An inshore bottom dweller, common along the Southern California coast but rare to the north.

Descriptive Characters: Body flattened, raylike, with pectorals and pelvics expanded; pectorals not attached to sides of the head as in the rays; gill openings crowded in a deep notch behind head; no anal fin. **Color:** Red brown, darn brown, or almost black above, spotted with darker shades; fins edged with gray posteriorly; underparts white. **Size:** Average specimens are 2 or 3 feet long. Said to reach 5 feet and a weight of 60 pounds. **Development:** Bears live young (ovoviviparous).

Remarks: This shark, which has no value, is taken in drag nets along the coast. It has powerful jaws and consequently is respected by fishermen.

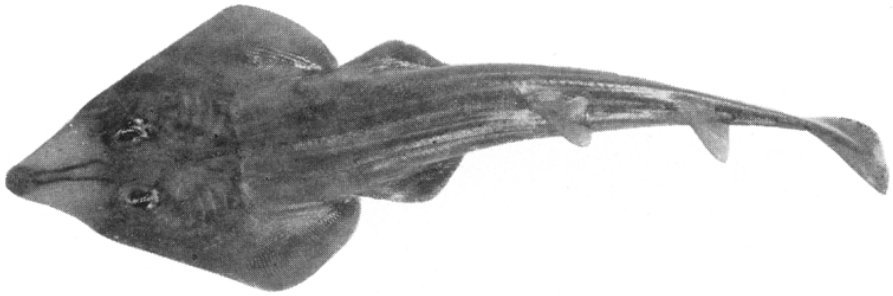


FIGURE 49

FIGURE 49

SHOVELNOSE GUITARFISH

Rhinobatos productus

Relationship: A member of the guitarfish family, Rhinobatidae. One other species is known from California, the mottled guitarfish. The family is widely distributed. Guitarfish, despite their superficial sharklike appearance, are classified with the rays in order Batoidei.

Range: Central California south to and into the Gulf of California. Rare north of Pt. Conception but common farther south in shallow water along the coast and in bays.

Descriptive Characters: Two dorsal fins; tail fin present; disk longer than wide; snout sharply pointed; hooked spines along the back and tail, on the shoulders and sometimes around the eyes; skin fairly smooth, covered with fine shagreen. **Color:** Brownish gray above becoming white below. **Length:** To about four feet.

Remarks: Bears live young (ovoviviparous). Feeds chiefly on invertebrates such as crabs and clams. It is often caught by sport fishermen who usually call it "shovelnose shark." Sometimes taken in fair numbers by gill net fishermen to whom they are quite a nuisance.

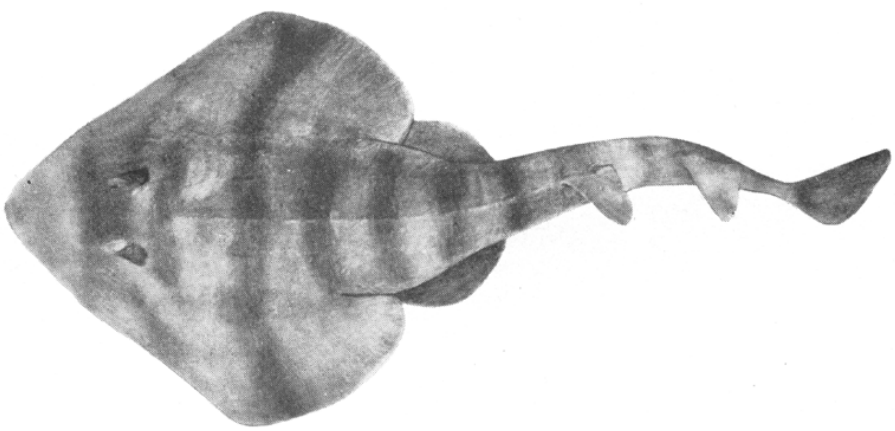


FIGURE 50

FIGURE 50

MOTTLED GUITARFISH

Zapteryx exasperata

Relationship: Belongs to the guitarfish family, Rhinobatidae.

Range: San Diego Bay south to Panama in shallow inshore waters.

Descriptive Characters: Two dorsal fins; tail fin present; snout blunt; disk about as long as wide; back covered with prickles; spines along midline of back and tail, on the shoulders and near the eyes; front of first dorsal in front of middle of tail. **Color:** Grayish brown or olive brown above; brown or blackish crossbars as illustrated, varying to yellowish spots edged with black; a black blotch on the lower rear portion of the pectoral fin; belly pale. **Length:** To about three feet.

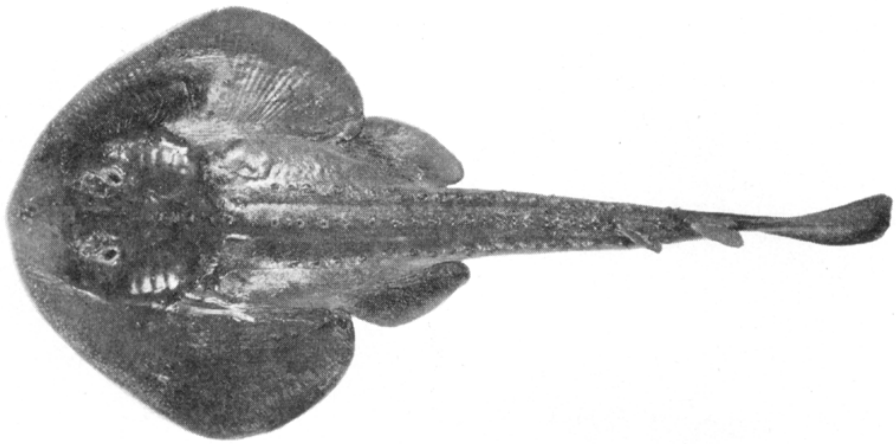


FIGURE 51

FIGURE 51

THORNBACK

Platyrhinoidis triseriata

Relationship: Belongs to family Platyrhinidae.

Range: Central California south into Lower California at least as far as San Quintin. Common on sandy bottoms in Southern California but rare north of Point Conception.

Descriptive Characters: Two dorsal fins; tail fin present; snout broadly rounded; disk wider than long; skin fairly smooth, covered with fine shagreen; three rows of strong spines along middle of back and tail; patches of spines on shoulders; smaller spines and prickles along front margin of pectoral and usually along inner edge of eye; first dorsal fin about at middle of tail. **Color:** Brown or brownish olive above; belly white or buff. **Length:** To two or three feet. **Development:** Bears live young (ovoviviparous).

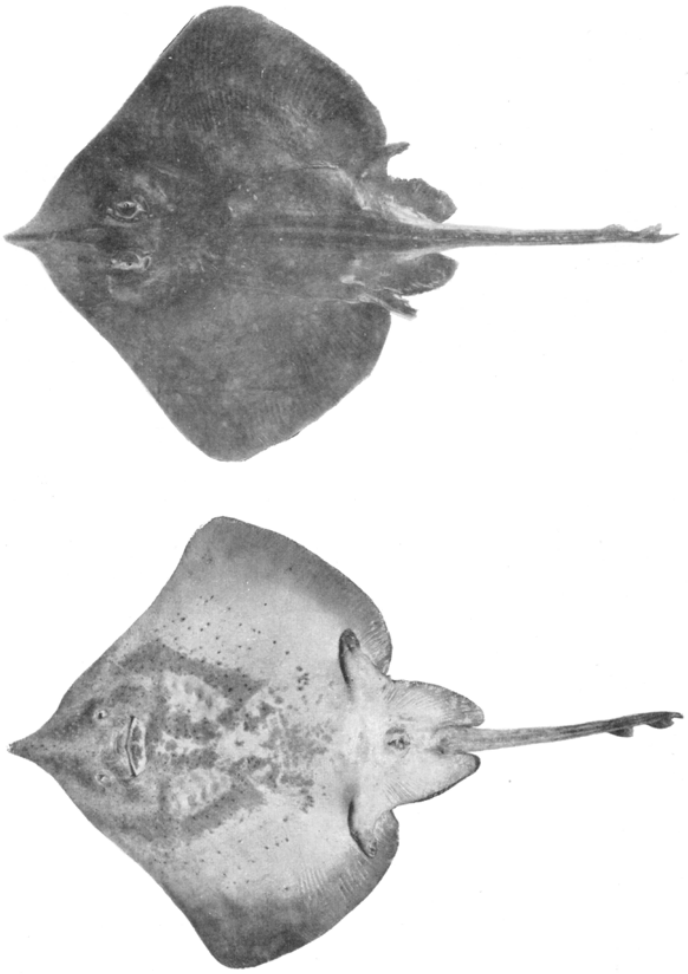


FIGURE 52

FIGURE 52

SKATES AND RAYS

Skates and rays in California, unlike many of our other species, suffer from under-exploitation. The species that make up the volume of the recorded catch are available in much greater quantity than they are used. Although almost any type of equipment that fishes the bottom may be employed to take them, the great bulk of the catch is derived from trawl boat landings at Monterey and San Francisco. Los Angeles landings are from hook and line and from gill and trammel net boats. Three species are of importance in the catch—the California skate, Raja inornata, the big skate, Raja binoculata, and the longnose skate, Raja rhina. The big skate and the California skate are considered the more desirable.

In the northern part of the State, people of Italian, French, Japanese, and Chinese descent consume most of the production. Only the trimmed wings (pectoral fins) are used from the skates, and the rays are seldom, if ever, eaten. The reduction of both skates and rays has been attempted several times, but because the price offered for the raw material was of necessity low, the ventures were never successful.

In general these animals are in a more favorable position for survival in their environment than are the flatfish which inhabit the same marine habitat. Both groups are taken in great numbers by the trawl nets, but only a very few skates are retained, these the smaller specimens up to several pounds in weight. The rest are thrown back into the sea. The skates, like weeds, are very hardy and apparently thrive when returned to the water unharmed. It is not uncommon, in areas worked for many years, to make trawl catches containing almost nothing else.

Skates have the habit, when hooked by an angler, of depressing the margin of their bodies, forming in effect an animated vacuum cup on the bottom. In this position, they are sometimes somewhat difficult to dislodge.

CALIFORNIA SKATE

Raja inornata

Relationship: A member of the skate family, Rajidae. This family includes many species from all over the world, seven of which are known from California (pages 68 to 74). Skates are oviparous, laying eggs enclosed in distinctive leathery cases. They are typically inhabitants of inshore muddy bottoms although they are also known from considerable depths.

Range: Straits of Juan de Fuca south to Cedros Island, Lower California. Common off most of the California coast; has been caught in fairly deep water.

Descriptive Characters: Two dorsal fins set far back on the tail; no tail fin; front margin of disk somewhat concave; lines drawn from tip of snout to the outer angles of the pectorals pass outside the edge of the body for all or most of their length; outer margin of pelvic fins deeply concave when held at right angles to the tail (Figure 19); prickles scattered on upper surface; spines along inner edges of eyes and in three to five rows on tail. **Color:** Dark olive brown above, usually with a small dark ring at the base of each pectoral; sometimes with two pale spots on pectorals or somewhat mottled; belly pale. **Length:** To 2 ½ feet.

Fishery: Taken for the most part incidentally by trawlers.

Importance: Perhaps the most important skate in the commercial catch.

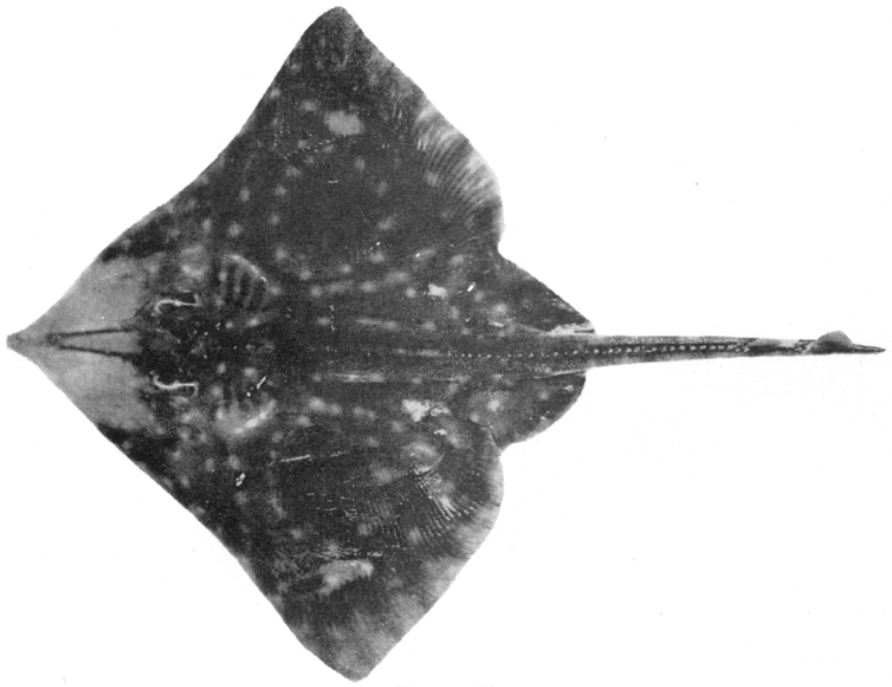


FIGURE 53

FIGURE 53

BIG SKATE

Raja binoculata

Relationship: One of the seven species of skates (family Rajidae) known from California.

Range: Northwestern Alaska to Southern California. Relatively abundant in Northern and Central California but not common south of Pt. Conception.

Descriptive Characters: Two dorsal fins far back on the tail; no tail fin; front margin of disk concave, a line drawn from tip of snout to outer angle of pectoral passing outside the edge of the body (Figure 18); outer margin of pelvic fins shallowly concave, almost straight, when held at right angles to the tail (Figure 20); upper surface covered with small prickles; spines along tail. **Color:** Brown above, usually with a large dark spot surrounded by lighter spots at the base of each pectoral fin; light spots about the size of the eye scattered over the body; belly white. **Length:** To six or eight feet. **Development:** Lays eggs. The cases in which they are contained reach a foot in length and may contain up to seven eggs each.

Fishery: Taken commonly by trawl boats along the Northern California coast, and occasionally by sportsmen, particularly in Monterey Bay.

Importance: While this is one of the three most important species, relatively few are utilized commercially.

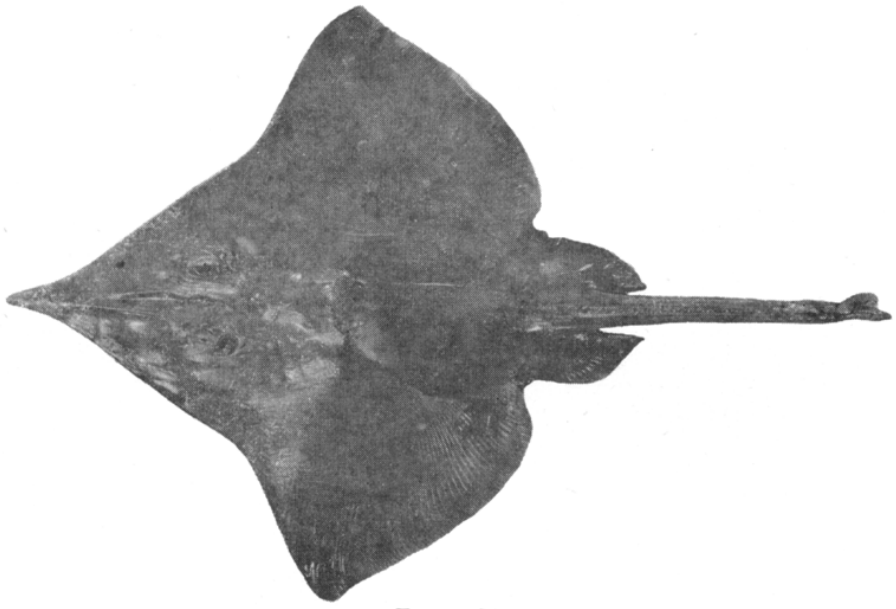


FIGURE 54

FIGURE 54

LONGNOSE SKATE

Raja rhina

Relationship: Belongs to family Rajidae.

Range: Alaska to Southern California (the range is sometimes given as extending southward into the Gulf of California, but we find no definite records south of the border, and Beebe and Tee-Van (1941) do not list it among the skates found south of Cedros Island).

Descriptive Characters: Two dorsal fins set far back on the tail; no tail fin; snout long, tapering; front margin of disk deeply concave, lines drawn from the tip of the snout to the outer angles of the pectorals passing well outside the edge of the body; outer margins of pelvic fins deeply concave when held at right angles to the tail (Figure 19). **Color:** Dark brown above with irregular spots and blotches; a more or less distinct dark ring at each pectoral base; lighter below. **Length:** Reaches four or five feet.

Development: Lays eggs in cases which generally hold one egg and are four or five inches long.

Importance: One of the more common skates. It is not considered as desirable as the California and big skates.

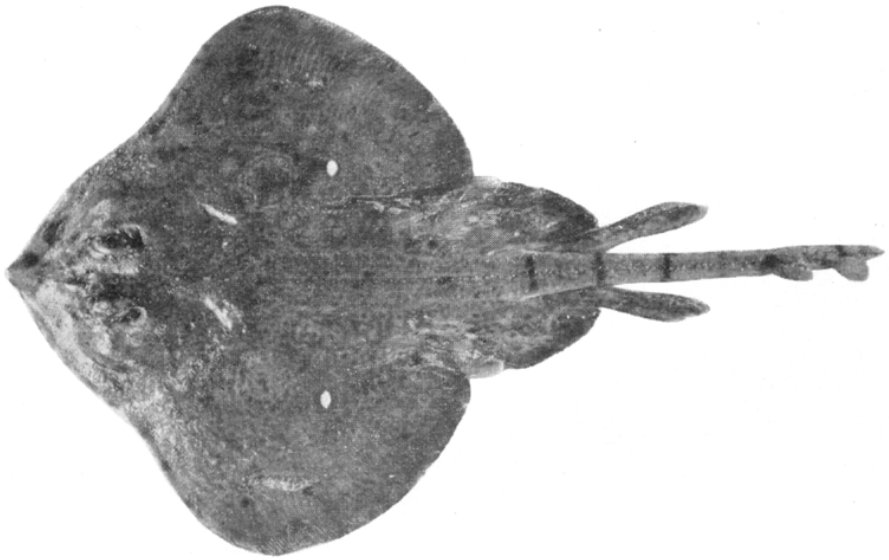


FIGURE 55

FIGURE 55

MONTEREY SKATE

Raja montereyensis

Relationship: A member of the skate family, Rajidae.

Range: Central and Southern California in moderate depths. Seems to be localized in distribution.

Descriptive Characters: Two dorsal fins set far back on tail; no well-defined tail fin; snout fairly blunt; front margin of disk convex, a line drawn from tip of snout to outer angle of pectoral passes entirely inside the body edge; prominent spines along inner edges of eyes (may be reduced or lacking in large individuals); heavily covered with prickles above; spines along the middle of back and tail; a groove with bony sides between and in front of eyes. **Color:** Brown, mottled and blotched with darker shades; base of each pectoral with a dark spot around which are small irregular dark spots and behind which is a small light spot. **Length:** To about two feet.

Remarks: of no commercial value, but sometimes found in good numbers by trawl vessels.

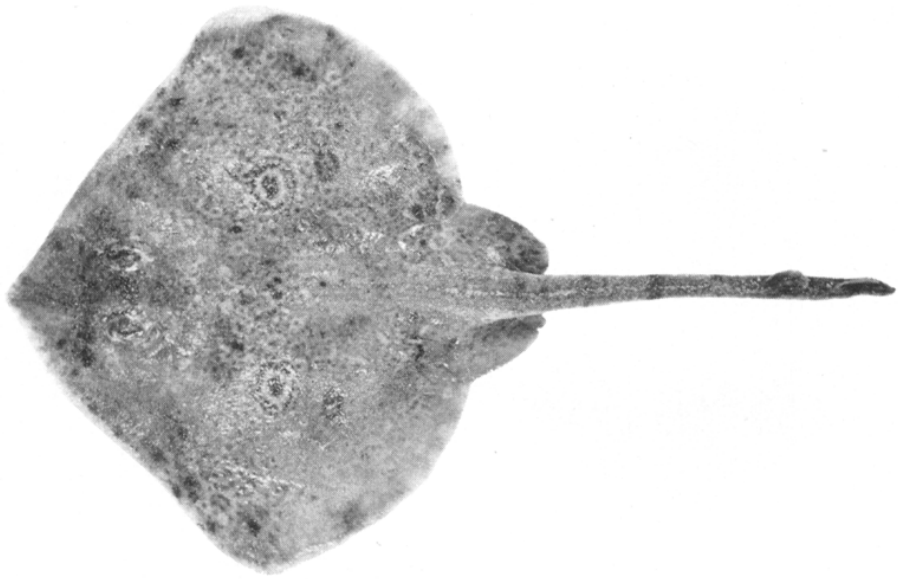


FIGURE 56

FIGURE 56

STARRY SKATE

Raja stellulata

Relationship: A member of family Rajidae.

Range: Northwest Alaska to Southern California in fairly deep water.

Descriptive Characters: Two dorsal fins set well back on tail; no well defined tail fin; snout fairly blunt; front margin of disk concave, a line drawn from tip of snout to outer angle of pectoral passes entirely inside the body edge; no groove with bony sides between and in front of eyes; heavily covered with prickles above; spines along inner edges of eyes, along middle of back and tail, and about six on shoulders. **Color:** Gray brown with small dark spots scattered on the back; spots as follows may or may not be present: a large yellow spot ringed with brown and followed by a smaller one at the base of each pectoral; a spot outward from each eye. **Length:** To about 2 ½ feet.

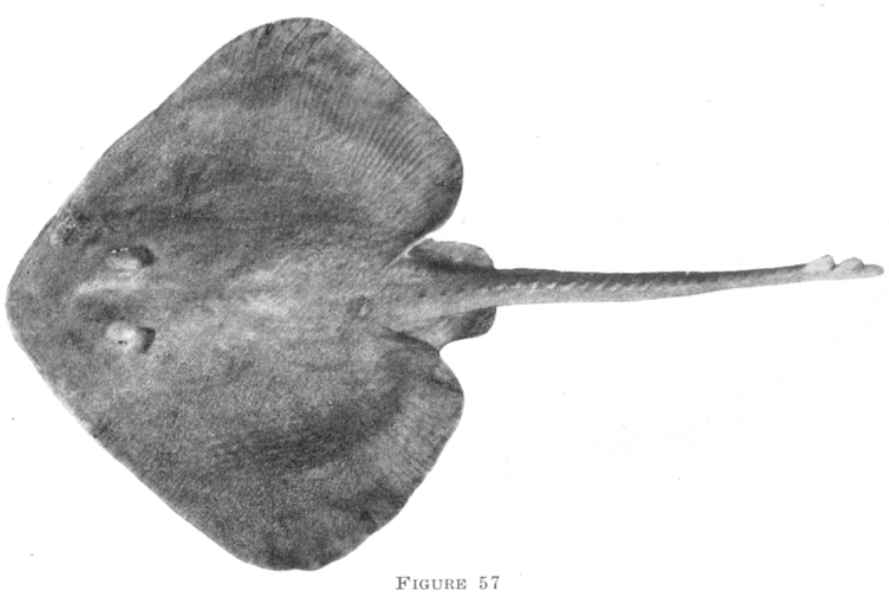


FIGURE 57

FIGURE 57

ROUGHTAIL SKATE

Raja trachura

Relationship: A member of family Rajidae.

Range: Central Alaska to Southern California in deep water; rare.

Descriptive Characters: Two dorsal fins set far back on tail; no tail fin; snout bluntly rounded; front margin of disk convex; a line drawn from tip of snout to outer pectoral angle passes entirely inside the body edge; body covered with prickles above; no spines around inner edges of eyes or on shoulders; a row of spines along middle of back and tail. **Color:** Plum or lead gray above, darker at margins; brownish below, darker on fins. **Length:** To at least 1 ½ feet.

BLACK SKATE

Raja kincaidii

Relationship: A member of family Rajidae.

Range: British Columbia to Southern California; rare off the California coast.

Descriptive Characters: Two dorsal fins set far back on the tail; no tail fin; snout blunt; front margin of disk convex so that a line drawn from tip of snout to outer angle of pectoral passes entirely inside of body edge; no spines around inner edges of eyes; two to four spines on shoulder girdle; a row of spines along middle of back and tail. **Color:** Adults, slate black, sometimes with a white spot on each side of the tail; young, lead brown with small darker brown spots which usually disappear by the time the fish is a foot long. **Length:** To about three feet.

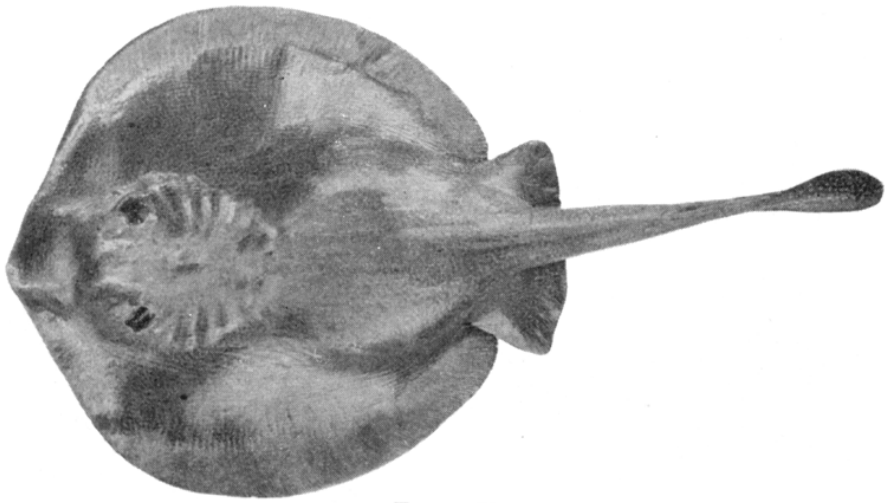


FIGURE 58

FIGURE 58

ROUND STINGRAY

Urobatis halleri

Relationship: One of the three members of the stingray family, Dasyatidae, known from California waters. There are many kinds of stingrays in the world, including such extremes as the giant Australian stingaree which reaches seven feet in width and double that length, and the fresh-water varieties found in some South American rivers.

Range: Point Conception to Panama Bay; common in Southern California bays and sloughs and along beaches.

Descriptive Characters: No dorsal fin; tail fin present; tail with a long sting; disk nearly circular; tail shorter than disk; skin smooth. **Color:** Shades of brown above, sometimes mottled and spotted; yellowish below. **Length:** Reaches about 20 inches. **Development:** Ovoviviparous, bearing up to eight young. They are reported to mate in April, the young being born in late July and August.

Danger to Man: Like all their kind, these rays can inflict extremely painful wounds, this despite their small size. They are the commonest California species and consequently the most likely to be encountered by swimmers. There is no specific to combat the poison; disinfection of the wound followed by prolonged immersion in a solution of epsom salt in hot water is perhaps as good a treatment as is known (see page 9).

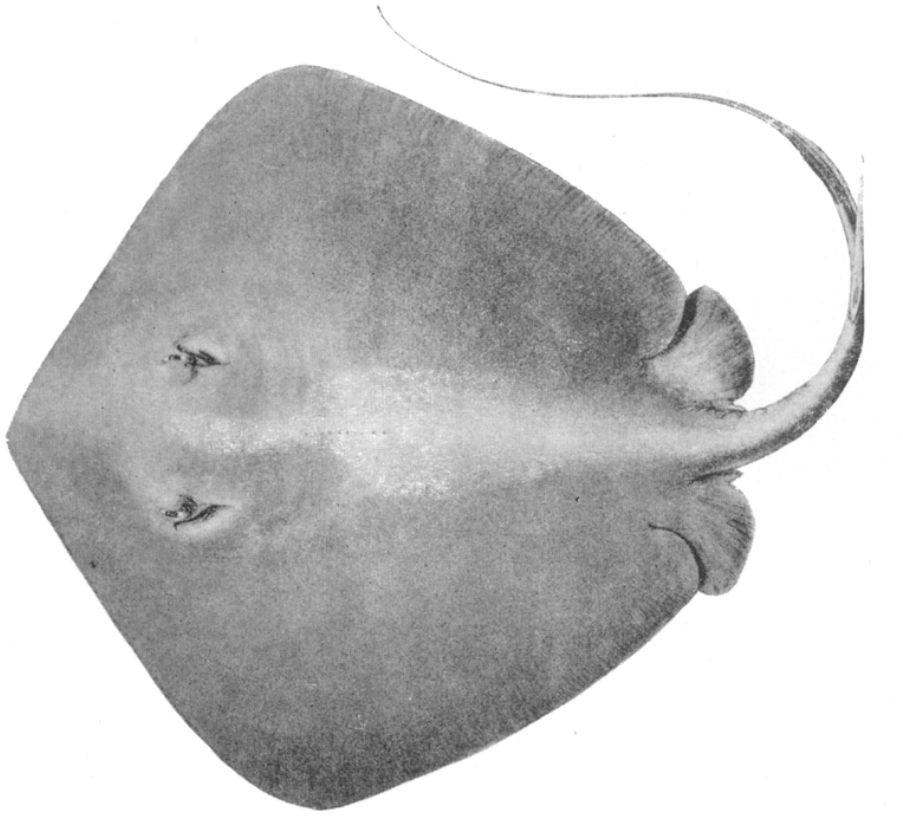


FIGURE 59 From Garman, 1913

FIGURE 59

DIAMOND STINGRAY

Dasyatis dipterurus

Relationship: A member of family Dasyatidae. Some ichthyologists consider it the same as the Peruvian D. brevis.

Range: British Columbia south into Central America; to Peru if identical with D. brevis. Common in bays and on beaches from San Diego south.

Descriptive Characters: No dorsal or tail fins; disk somewhat diamond shaped; tail whiplike, longer than disk, armed with a strong sting. **Color:** Bluish brown to blackish, without spots or blotches. **Length:** To six feet or more.

Danger to Man: Like all stingrays, it can inflict painful and dangerous wounds.

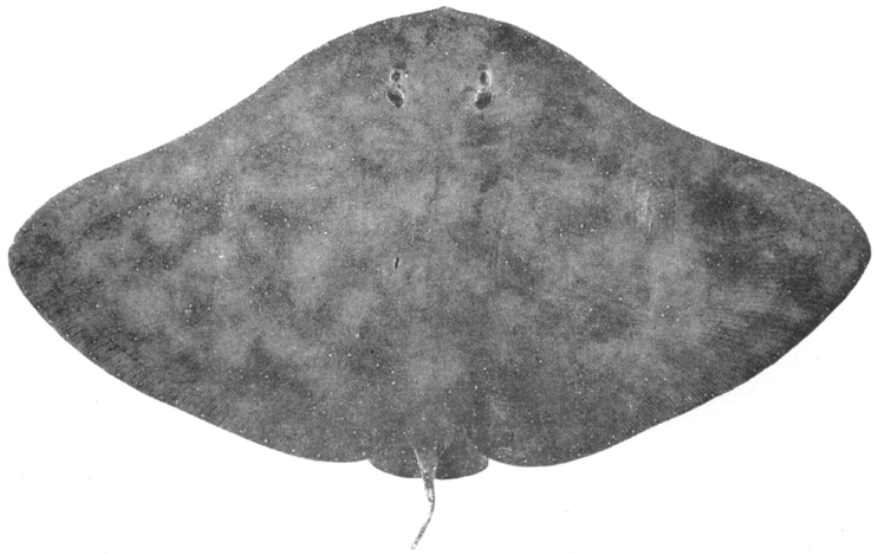


FIGURE 60

FIGURE 60

BUTTERFLY STINGRAY

Gymnura marmorata

Relationship: A member of the stingray family, Dasyatidae.

Range: Point Conception south at least to Mazatlan, Mexico. The status of a similar ray from Panama is uncertain; it may belong to the same species. Common, particularly in shallow bays and along beaches.

Descriptive Characters: No dorsal or tail fins; disk somewhat diamond shaped, nearly twice as wide as long; tail very short, less than # the length of the disk; sting small, occasionally absent; skin smooth. **Color:** Brown to gray olive above, variously mottled and spotted with darker and lighter shades; white below. **Size:** Reaches a width of four to five feet. **Development:** Bears live young.

Danger to Man: The short tail and small sting combine to make this ray one of the least dangerous.

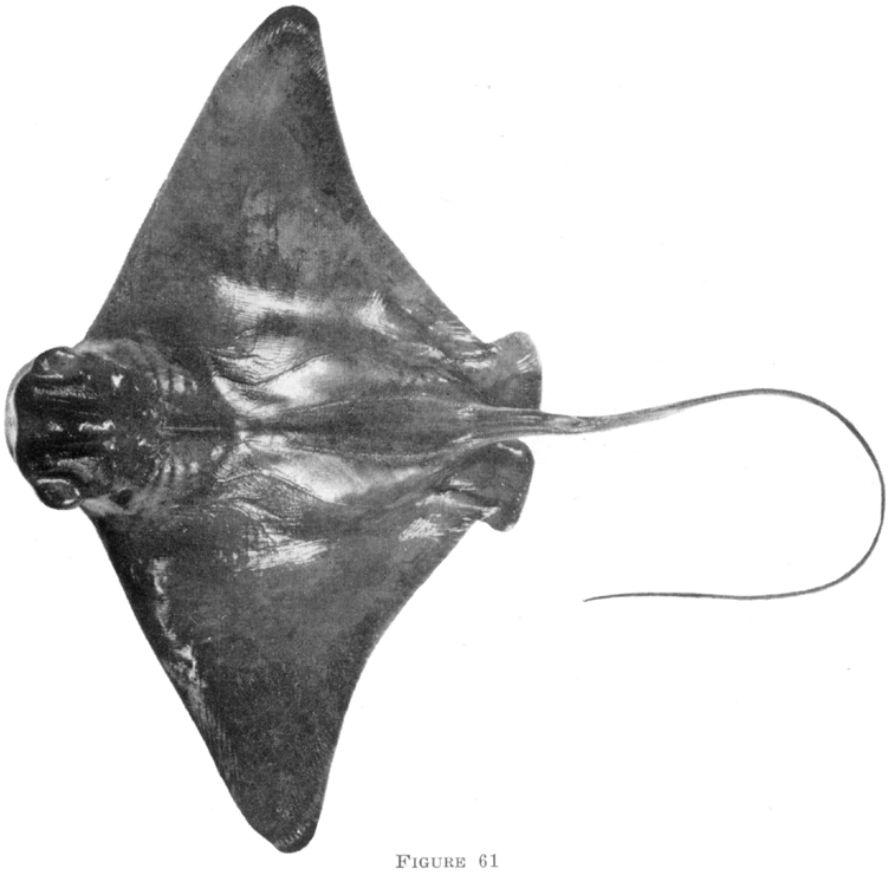


FIGURE 61

FIGURE 61

BAT STINGRAY

Holorhinus californicus

Relationship: The only California member of the eagle ray family, Myliobatidae.

Range: Oregon to Magdalena Bay, Lower California. Common inshore and in bays and sloughs.

Descriptive Characters: One dorsal fin followed by one or more long stings; tail whiplike, as long as or longer than the width of the disk; head distinct, elevated above disk; eyes on side of head; teeth flat, pavementlike; skin smooth. **Color:** Dark brown to dark olive or almost black above; white below. **Size:** Width to about four feet; reported to reach a weight of over 150 pounds.

Depradations: The teeth of this ray are particularly suited to crushing oysters, clams, crabs and the like. It is very destructive to oysters and is one reason for the fencing often seen around commercial beds. Walford (1935) describes its activities in these words, "Swims along the bottom until it meets the currents of water expelled by the siphons of clams. It then flaps its pectoral fins, creating a suction which digs out the clams. Sometimes it flaps along in this manner for considerable distances, leaving behind a barren trough."

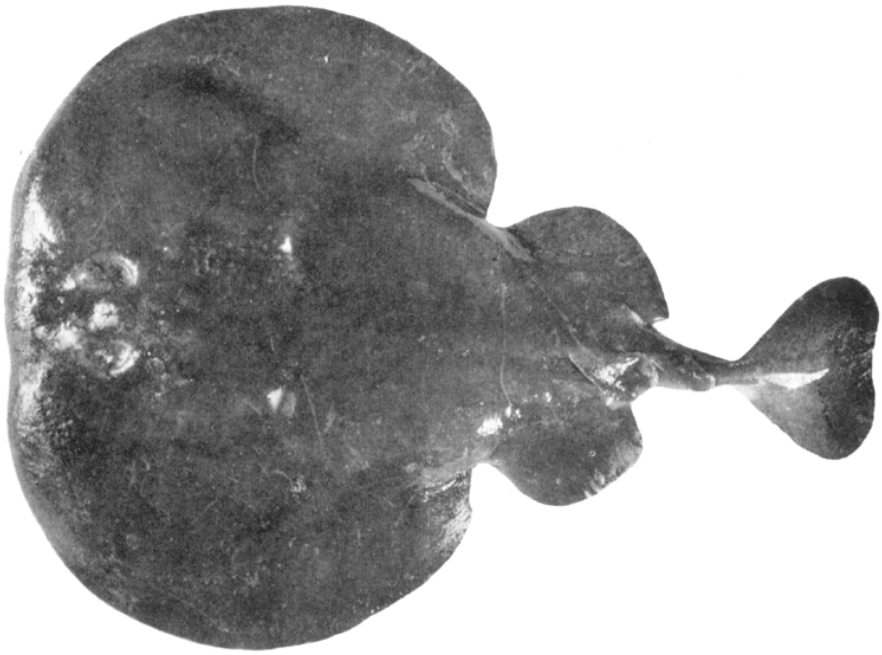


FIGURE 62

FIGURE 62

ELECTRIC RAY

Torpedo californica

Relationship: The only electric ray (family Torpedinidae) known from California.

Range: From British Columbia to Southern California in moderate depths. Locally abundant in some areas.

Descriptive Characters: Two dorsal fins; tail fin present; skin perfectly smooth with no spines or prickles; disk broad, circular. **Color:** Blue black to lead gray with scattered small black spots; gray or whitish below. **Size:** Reported to reach three feet in length and over 50 pounds in weight.

Electric Organ: These rays can deliver a powerful electric shock which is reported strongest if they are touched at two points at once. They are looked upon with great respect by commercial fishermen. The electric organs are paired, one on each side of the head. They are actually greatly modified muscles which extend from the upper to the lower surface and consist of many upright hexagonal columns.

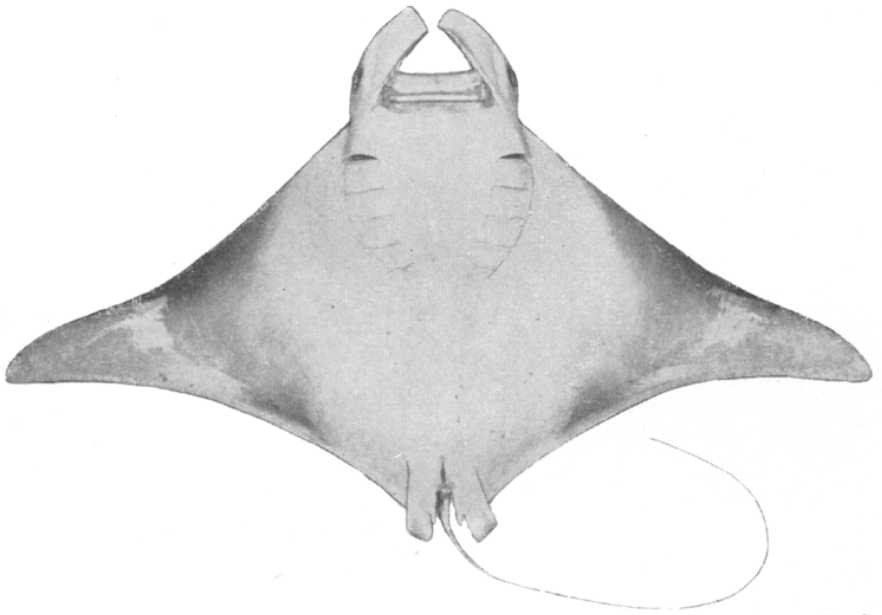


FIGURE 63 Photograph by D. H. Fry, Jr.

FIGURE 63

MOBULA

Mobula lucasana

Relationship: One of the two members of the manta family, Mobulidae, recorded from California.

Range: Vicinity of Cape San Lucas, Lower California, presumably the Gulf of California and south along Central America; north to Southern California. **California record:** Taken once (October 1946) off Laguna Beach.

Descriptive Characters: The horn- or arm-like forward projections on the head; tail long, whiplike; one dorsal fin; mouth on under surface; a narrow band of fine teeth in both jaws. **Color:** Blackish gray above, whitish below. **Size:** The California specimen was 7 feet 3 ¼ inches wide.

Habits: Like the mantas, mobulas are often seen leaping clear of the water.

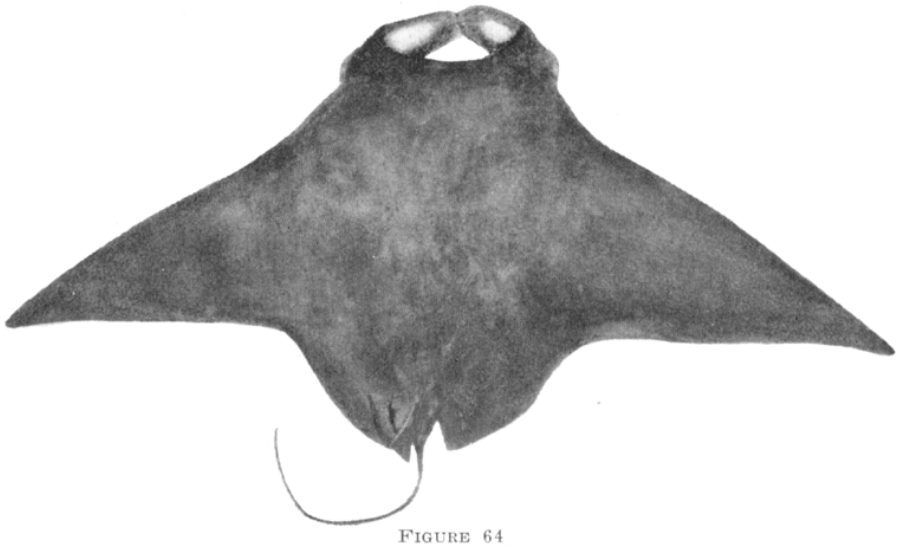


FIGURE 64

FIGURE 64

MANTA

Manta hamiltoni

Relationship: A member of family Mobulidae.

Range: Warm waters of the eastern Pacific, appearing at times off Southern California where it has been captured as far north as Redondo Beach.

Descriptive Characters: The horn- or arm-like forward projections on the head; one dorsal fin; tail whiplike; mouth at front of head with no teeth in the upper jaw. **Color:** Dull black above; white patches may or may not be evident on the shoulders; white or bluish below. **Size:** There is a record of a female 18 feet wide weighing 2,310 pounds.

Development: Bears live young. The specimen described above contained a 28-pound embryo which was 45 inches wide.

Habits: These giant rays make spectacular leaps clear out of the water, falling back with a crash like a gunshot. In feeding, to quote Walford (1935). "... the manta moves through schools of small fish, turning slowly from side to side, using the fleshy projections of the head almost like hands to fan the fish into the mouth."

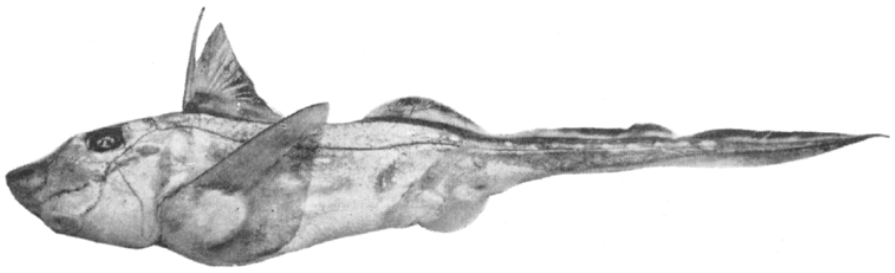


FIGURE 65

FIGURE 65

RATFISH

Hydrolagus colliei

Relationship: The only member of the chimaera family, Chimaeridae, found off California. The chimaeras are placed in the same broad classification unit (class Chondrichthyes) as are the sharks and rays, but fall in a separate division (subclass) within it.

Range: Northwest Alaska to northern Lower California. Usually found in moderately shallow water to the north and in progressively deeper water to the south. Fairly common off California, particularly in the northern part of the State.

Descriptive Characters: The fishlike shape, but with the skeleton cartilagenous as in sharks and rays rather than bony as in the true fishes; one gill opening on either side; gill cover of flesh or soft cartilage; two dorsal fins, the first preceded by a strong spine; tail tapering to a point; teeth united into bony plates; skin smooth; males with a clublike appendage between the eyes and with claspers by the pelvic fins. **Color:** Silvery with iridescent reflections of gold, blue and green; back with pale spots. **Length:** To about three feet. **Development:** Lays eggs encased in ridged capsules about five inches long.

Warning: The spine on this animal can inflict a very painful wound.

Use: Oil from the liver makes a good antioxidant lubricant for exposed machinery. The fish is not utilized commercially.

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