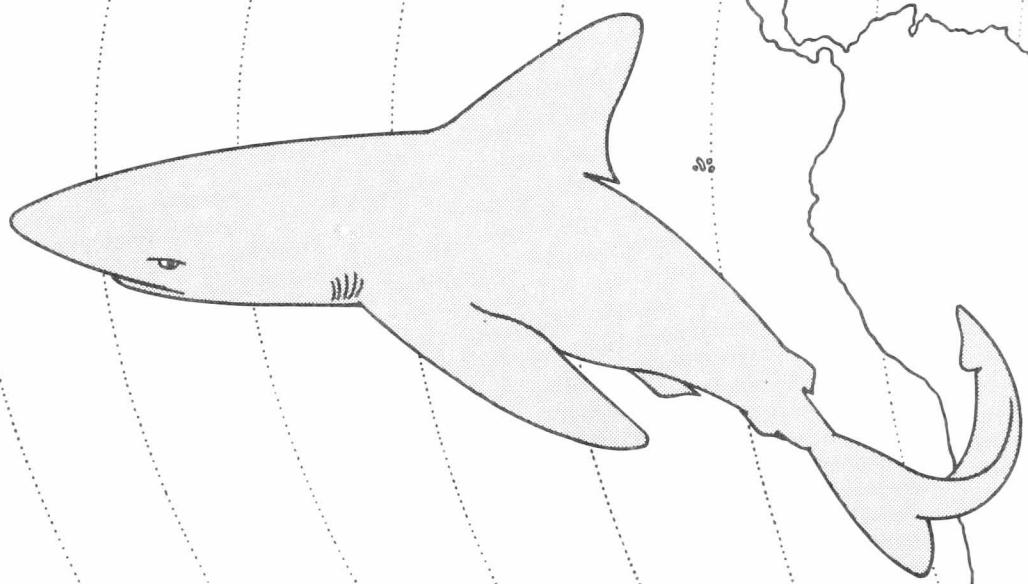
Field Guide to Eastern Pacific and Hawaiian Sharks



UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

Circular 271

UNITED STATES DEPARTMENT OF THE INTERIOR
Stewart L. Udall, *Secretary*
David S. Black, *Under Secretary*
Stanley A. Cain, *Assistant Secretary for Fish and Wildlife and Parks*
FISH AND WILDLIFE SERVICE, Clarence F. Pautzke, *Commissioner*
BUREAU OF COMMERCIAL FISHERIES, H. E. Crowther, *Director*

Field Guide to Eastern Pacific and Hawaiian Sharks

By

SUSUMU KATO, STEWART SPRINGER, and MARY H. WAGNER

Circular 271

Washington, D.C.

December 1967

CONTENTS

Field Guide to Eastern Pacific and Hawaiian Sharks

By

SUSUMU KATO, Fishery Biologist[1]

and STEWART SPRINGER and MARY H. WAGNER, Biologists[2]

ABSTRACT

Illustrations, descriptions, and keys to the identification of more than 70 species of sharks are presented.

INTRODUCTION

Our purpose is to provide a useful field guide to the identification of all the sharks known to occur in the vast seas of the eastern Pacific from Alaska to Cape Horn, and in the waters surrounding the Hawaiian Islands. An illustrated two-stage key is used to separate the species.

Nearly all of the species are illustrated; specimens collected especially for the preparation of this guide were the main source of material, but some specimens were also borrowed from museums. Drawings of a few rare species of which specimens were unavailable were based on published or unpublished photographs. The reader should refer to the illustrations for verification of identification from the key, but it should be remembered that many sharks change in body and fin proportions with growth, and that color patterns of some sharks are variable. Notes and descriptions which are given for each species also serve as additional criteria for verifying identification.

The scientific name is given for each species, and, for many, common names in English or Spanish are also given. Usage of common names varies greatly, especially from country to country. We have used common names recognized by the American Fisheries Society checklist (1960) whenever applicable, but new names have been selected for a few species, e.g., "peppered shark" for Galeus piperatus.

We have tried to retain the scientific names now in general use but at the same time have attempted to keep names in line with current studies. Some of these studies are still unpublished.

We have neither included synonymies nor stated our reasons for the inclusion or exclusion of certain species that have been recorded from the eastern Pacific and Hawaii. For example, we have used the name Cephaloscyllium ventriosum Garman, 1880, for the swell sharks of both North and South America, excluding the name C. uter Jordan and Evermann, 1896, which has customarily been used for the northern form; our decision here was based on descriptions given in published accounts, in which we did not find differences between the two forms.

HOW TO USE THE KEY

Although many of the species listed in this guide are found in other parts of the world, the keys will not be suitable for identification of sharks outside the eastern Pacific or the vicinity of the Hawaiian Islands.

Diagrams of the shark's external features (figs. 1 and 2) are included to define terms used in the keys and to indicate methods of measurement.

With the unidentified shark specimen at hand, refer first to the key to families and begin by reading both 1a and 1b (both phrases in each couplet should be read during the entire identification procedure). Select the phrase that describes the specimen and continue to the next appropriate couplet until the family is determined. The succeeding couplet is indicated by the

[1] Bureau of Commercial Fisheries Tuna Resources Laboratory, La Jolla, Calif. 92037.
[2] Bureau of Commercial Fisheries Ichthyological Laboratory, Stanford, Calif. 94305.

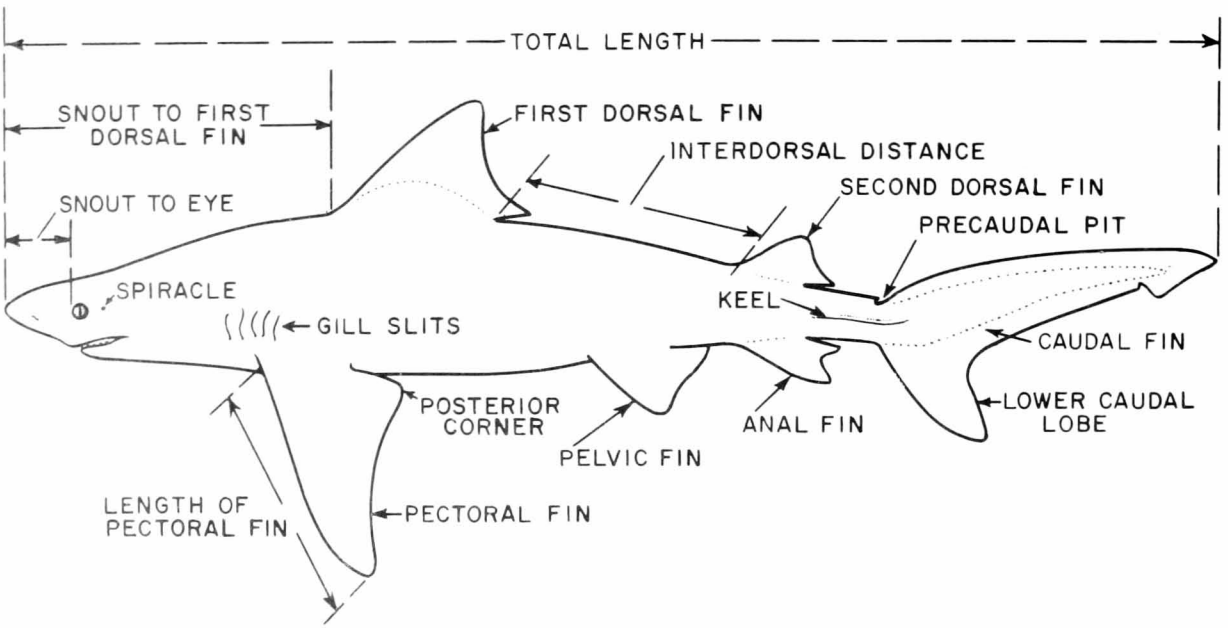


Figure 1.--Outline drawing of a shark showing external features and methods of measurement; no single shark possesses all the features shown.

figures on the right side of the page. For example: if the specimen has six or seven gill slits instead of five, go to couplet 2a-2b; if it has five gill slits, go to 3a-3b. For the several species that are the sole members of their families, identification is complete at this point. Descriptions and illustrations of these species are given in their respective family sections. If the family is represented by more than one eastern Pacific species, the next step is to turn to the appropriate family section and again begin the process of selection until the species is determined.

KEY TO FAMILIES OF EASTERN PACIFIC AND HAWAIIAN SHARKS

1a. Sharks with six or seven pairs of gill slits . . . . . 2a or 2b

1b. Sharks with five pairs of gill slits . . . . . 3a or 3b

2a. First gill slits unusually well developed, first pair continuous in a fold across midventral line; teeth of upper and lower jaws similar in shape . . . . . Frill shark, Family Chlamydoselachidae, p. 5 .

2b. First gill slits not unusually well developed, first pair not continuous across midventral line; teeth of upper and lower jaws dissimilar in shape . . . . . Sixgill and sevengill sharks, Family Hexanchidae, p. 5 .

3a. Anal fin absent . . . . . 4a or 4b

3b. Anal fin present . . . . . 5a or 5b

4a. Trunk flattened, raylike; eyes on top head . . . . . Angel sharks, Family Squatinidae, p. 14 .

4b. Trunk cylindrical or nearly so; eyes on sides of head . . . . . Squaloid sharks, Family Squalidae, p. 8 .

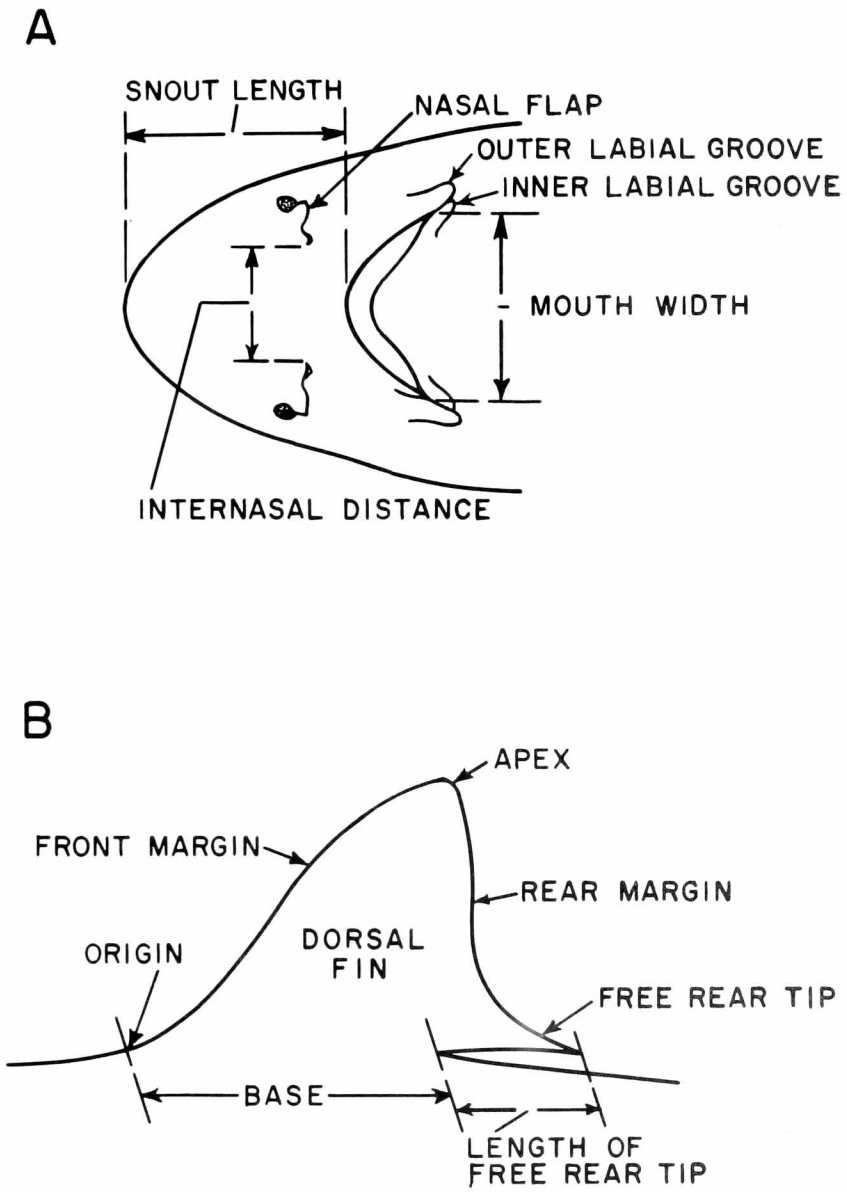


Figure 2.--Outline drawings of parts of a shark showing terminology and methods of measurement: A - Underside of head; B - Dorsal fin; C - Tooth.

5a. A hard spine in front of each dorsal fin . . . . . Bullhead sharks, Family Heterodontidae, p. 7.

5b. No spines in front of dorsal fins . . . . . 6a or 6b

6a. Mouth nearly at forward end of head with tip of snout only slightly overhanging mouth . . . . . Whaleshark, Family Rhincodontidae, p. 18.

6b. Mouth on lower side of head with snout extending well in front of mouth . . . . . 7a or 7b

---

7a. Origin of first dorsal fin ahead of origin of pelvic fins; rear end of base of first dorsal fin never reaches to a point above the rear end of base of pelvic fins . . . . . 9a or 9b

7b. Origin of first dorsal fin directly over or behind origin of pelvic fins, or, if origin of first dorsal is ahead of pelvics (one species only, Cephalurus cephalus), rear end of base of first dorsal fin reaches to a point above rear end of base of pelvic fins. . . . . 8a or 8b

---

8a. Fleshy barbel present on inner side of each nostril . . . . . Nurse sharks, Family Orectolobidae, p. 15.

8b. No fleshy barbels near nostrils . . . . . Cat sharks, Family Scyliorhinidae, p. 22.

9a. Length of caudal fin about equal to length of body . . . . . Thresher sharks, Family Alopiidae, p. 17.

9b. Length of caudal fin much shorter than length of body. . . . . 10a or 10b

---

10a. Caudal fin crescentic, upper lobe never more than 1.5 times greater than lower lobe . . . . . 11a or 11b

10b. Upper lobe of caudal fin more than twice as long as lower lobe, or lower lobe indistinct . . . . . 12a or 12b

---

11a. Teeth minute, about 200 in front series of upper jaw; gill slits very long, extending from high on dorsal side to near the midline on ventral side . . . . . Basking sharks, Family Cetorhinidae, p. 15.

11b. Teeth large, about 25 to 35 in front series of upper jaw; gill slits long, but confined to sides of head. . . . . Mackerel sharks, Family Lamnidae, p. 19.

12a. Origin of pectoral fin posterior to 5th gill slit. . . . . Sand sharks, Family Odontaspidae, p. 16.

12b. Origin of pectoral fin under 4th or 5th gill slit, never posterior to 5th gill slit . . . . . 13a or 13b

---

13a. Head flattened and expanded laterally to form a spade-shaped or hammer-shaped structure . . . . . Hammerhead sharks, Family Sphyrnidae, p. 27.

13b. Head not flattened or expanded . . . . . 14a or 14b

14a. Three or more series of teeth upright at sides and corners of jaws; upper precaudal pit absent (the soupfin shark, Galeorhinus zyopterus, is an exception; it lacks an upper precaudal pit but belongs in family Carcharhinidae) . . . . . Smoothhounds, Family Triakidae, p. 30.

14b. One or two series of teeth upright at sides and corners of jaws (more than two series may be upright at center of jaws); upper precaudal pit present, except in Galeorhinus . . . . . Requiem sharks, Family Carcharhinidae, p. 35 .

FRILL SHARK, FAMILY CHLAMYDOSELACHIDAE

The frill shark, Chlamydoselachus anguineus, is the sole representative of Chlamydoselachidae. It is easily recognized by its elongate eellike body, the anterior position of its mouth, and the unusually well-developed gill covers that give this shark a frilled appearance in the throat region.

The frill shark has been reported chiefly from depths greater than 500 m. (meters) or 275 fm. (fathoms); one collected off Point Arguello, Calif., however, was taken in a gill net set at the surface.

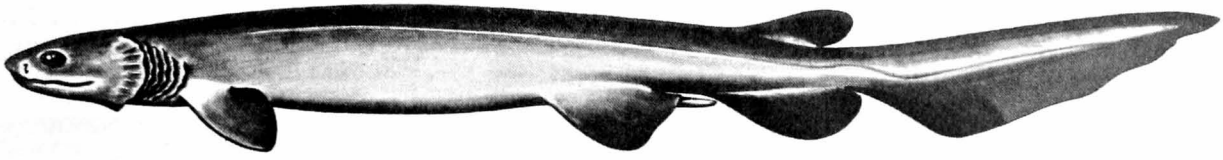


Figure 3.--Chlamydoselachus anguineus, 54 cm. (1.8 ft.) male, Japan, adapted from Gudger and Smith (1933).

Descriptive notes: Teeth similar in upper and lower jaws, each tooth made up of three curved cusps arranged like a pitchfork, sometimes with small denticles at the base.
Size: Reaches a length of about 2.0 m. (6.5 ft.).
Distribution: In the eastern Pacific only one or two specimens known, from off southern California.

SIXGILL AND SEVENGILL SHARKS, FAMILY HEXANCHIDAE

The Hexanchidae are characterized by having six or seven pairs of gill slits and a single dorsal fin. The frill shark, which also has these characteristics, is separated from the Hexanchidae by the terminal position of its mouth and the unusual first gill-slit covers, which are continuous in a fold across the midventral line.

Family Hexanchidae contains two genera of seven-gilled sharks, Heptranchias and Notorynchus, and one genus of six-gilled sharks, Hexanchus. Notorynchus and Hexanchus are present in the eastern Pacific; Heptranchias is probably present also but has not been definitely reported.

Identification of sixgill and sevengill sharks is complicated by changes with growth in proportional sizes of various parts of the body. Tooth shape may also vary slightly in sharks of different sizes.

Key to Sixgill and Sevengill Sharks, Family Hexanchidae

1a. Sharks with six pairs of gill slits . . . . . Sixgill shark, Hexanchus griseus.

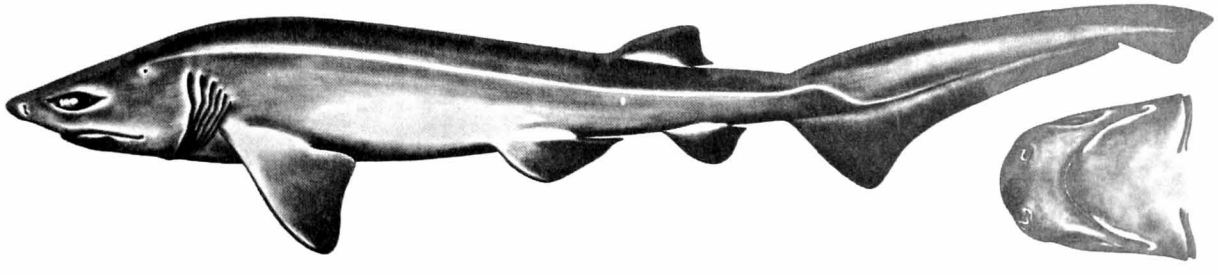


Figure 4.--Hexanchus griseus, 75 cm. (2.4 ft.) male, Washington State.

Descriptive notes: Single dorsal fin; mouth on underside of head; upper teeth narrow and pointed, lower teeth broad and sawlike.

Size: Although sixgill sharks from about 70 cm. to 335 cm. (2.3 to 11.0 ft.) are commonly taken in the eastern Pacific, sexually mature individuals have not been recorded. The smallest sexually mature female recorded from the Atlantic was 4.5 m. (14.8 ft.).

Distribution: In cool waters from British Columbia to southern California; coast of Chile; vicinity of Hawaiian Islands. Young and intermediate sizes enter Puget Sound and San Francisco Bay; principal habitat thought to be continental slopes and island terraces deeper than 300 m. (160 fm.).

Remarks: We are unable to find differences between young sixgill sharks of the northeastern or southeastern Pacific and small specimens of H. griseus from the eastern Atlantic, and provisionally regard H. corinus of the northeastern Pacific and H. vulgaris of the southeastern Pacific as synonymous of H. griseus.

1b. Sharks with seven pairs of gill slits . . . . . 2a or 2b

2a. Snout broadly rounded; head somewhat flattened; dorsal surface of body usually marked with dark or light, or both dark and light, spots smaller than the eye . . . . . Sevengill shark, Notorynchus maculatus.

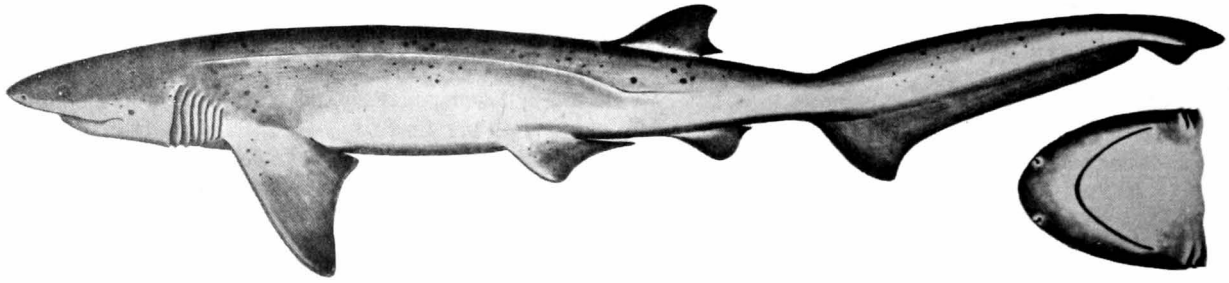


Figure 5.--Notorynchus maculatus, 160 cm. (5.2 ft.) male, California.

Descriptive notes: Single dorsal fin; mouth on underside of head; upper teeth narrow and pointed, lower teeth broad and sawlike; snout tip rounded.

Size: Grows to at least 2.6 m. (8.5 ft.). A dry jaw (USNM 110926) taken many years ago from a large specimen at Port Ludlow, Wash., originally labeled Notorynchus maculatus, is in fact a jaw of Hexanchus and is comparable in size to the jaw of a 433 cm. (14.2 ft.) H. griseus from the Gulf of Mexico. The mislabeled jaw may have been the source of repeated reports that Notorynchus attains a length of 15 ft.

Distribution: In cooler waters, from British Columbia to Chile; not yet reported from the tropics.

Remarks: We are unable to determine whether there are several species of Notorynchus or only one, and our use of N. maculatus is provisional.

2b. Snout pointed, tapering; head not flattened; dorsal surface uniformly dark . . . . . Heptranchias perlo.

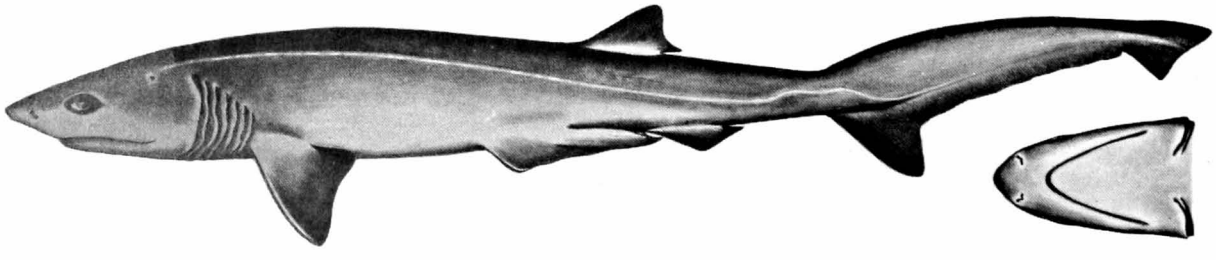


Figure 6.--Heptranchias perlo, 90 cm. (3.0 ft.) male, Indian Ocean.

Descriptive notes: The snout, tapering to a blunt point from a cylindrical body, serves to distinguish Heptranchias from other sevengill sharks.

Size: A small shark; grows to about 1.0 m. (3.3 ft.).
Distribution: Recorded from Chile but identification uncertain; may be present in eastern Pacific, for it is found in nearly all seas.

BULLHEAD SHARKS, FAMILY HETERODONTIDAE

Bullhead sharks are small sharks commonly found in inshore waters. The family is represented by a single genus, Heterodontus. The scientific name of the family and genus refers to the striking difference in the shape of the front and rear teeth: the front teeth have three to five sharp cusps, whereas the lateral and posterior teeth are rectangular with sharp cutting edges or rounded crushing cusps.

Other characters of bullhead sharks are: large spines in front of each dorsal fin; body short, very stout in front of pelvic fins and slender behind; mouth small; labial grooves conspicuous; nostrils connected to corners of mouth by a short groove; spiracles small, located under and slightly posterior to eyes.

Instead of bearing live young as do many other sharks, bullhead sharks lay egg cases from which the young hatch out in several months. The egg cases have leathery flanges arranged in a spiral, and some species have cases with two long curled tendrils on one end.

The taxonomy of eastern Pacific bullhead sharks is now in a state of confusion. Although only two species are generally recognized, at least three, and possibly more species are present here. In the Southern Hemisphere, H. quoyi was originally described from the Galapagos Islands. Heterodontus peruanus, subsequently described from offshore islands near Peru, is considered to be identical with H. quoyi. In the Northern Hemisphere the horn shark, H. francisci, is common from California to the Gulf of California. One specimen of a second species, not positively identified but similar in general appearance to H. quoyi, has been recorded from Mexican waters. In addition, specimens of still another unidentified species have been found in the Gulf of California; these specimens probably represent a new species. Egg cases with tendrils, and characteristics different in other ways from those of H. francisci, have also been found in Gulf waters.

The following key is limited to the two recognized species, H. francisci and H. quoyi.

Key to Bullhead Sharks, Family Heterodontidae

1a. Origin of first dorsal fin ahead of rear end of base of pectoral fins . . . . . Horn shark, Heterodontus francisci.

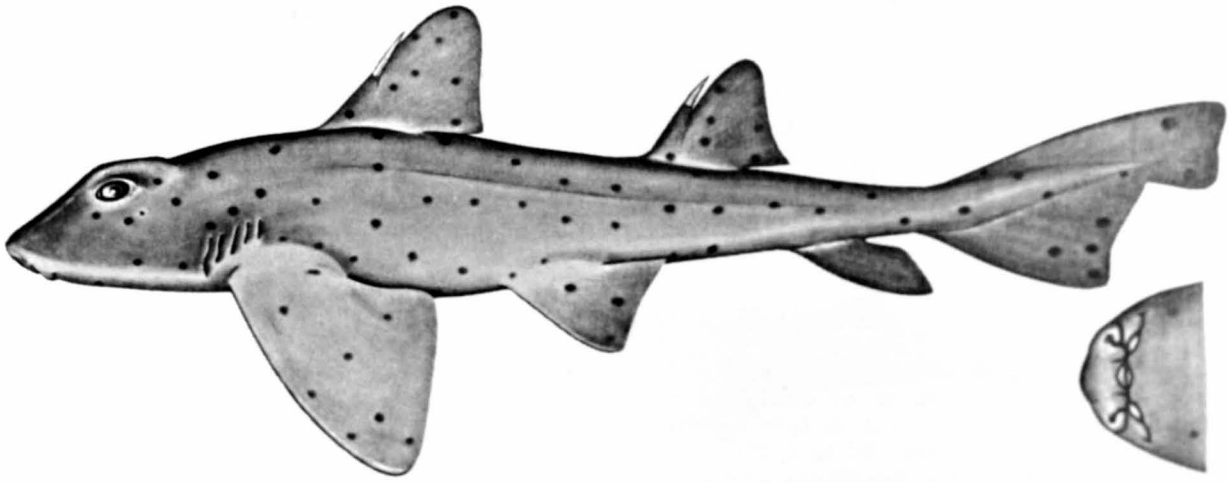


Figure 7.--Heterodontus francisci, 44 cm. (1.4 ft.) female, probably from central California.

Descriptive notes: Body usually with small isolated dark spots, very few or none of which are larger than the eye (spots sometimes faded or absent in adults; some individuals of all ages may have transverse dark bands on the head and body); dorsal fins and spines high; supraorbital crests prominent and high (may be weaker in adults); anal fin reaches to base of caudal fin; egg case without tendrils.

Size: Grows to about 90 cm. (3.0 ft.).
Distribution: In shallow and deep waters (at least to 150 m. or 82 fm.) from central California to the Gulf of California.
Remarks: An unidentified species which occurs in the Gulf of California will fall in the key here. This species differs from H. francisci in having larger dark markings, larger eyes, and larger denticles; it is also a smaller species.

1b. Origin of first dorsal fin over or behind rear end of base of pectoral fins . . . . . Gato, Heterodontus quoyi.

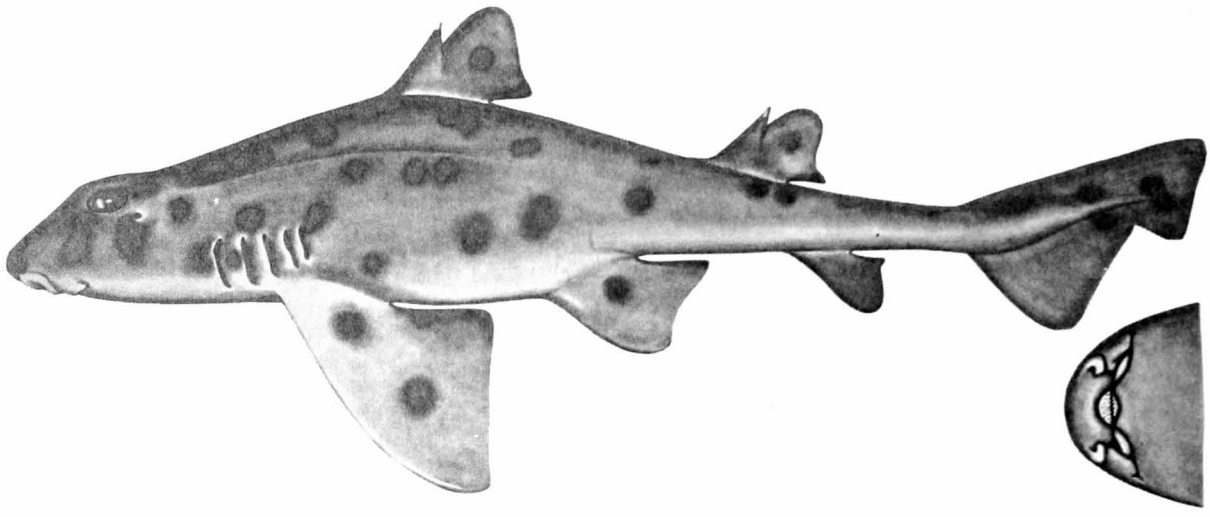


Figure 8.--Heterodontus quoyi, 46 cm. (1.5 ft.) female, Peru.

Descriptive notes: Body marked with numerous dark spots that are often in groups of two to four, some spots coalesced to form spots larger than the eye; dorsal fins and spines low; supraorbital crests low; anal fin may or may not reach to base of caudal fin; egg case with tendrils.
Size: Not sufficiently known; males from the Galapagos Islands were mature at 430 mm. (15 in.).
Distribution: Known from Ecuador, Peru, and the Galapagos Islands; possibly present in the Gulf of California.
Remarks: Our figure was drawn from a Peruvian specimen. Five specimens from the Galapagos Islands showed the following differences: spots more numerous; anal fin reaches to base of caudal fin; rear margin of dorsal fins convex rather than concave; second dorsal fin relatively larger; supraorbital ridge stronger; denticles smaller. If the two forms are different species, the Peruvian form would probably take the name H. peruanus Evermann and Radcliffe; the specimen on which that description is based, however, appears to be closer to those from the Galapagos Islands than to the specimen figured here.

SQUALOID SHARKS, FAMILY SQUALIDAE

Family Squalidae includes spiny dogfishes and a varied assortment of small and large species, chiefly inhabitants of cool and moderately deep water; in the higher latitudes and where surface waters are cool a few species occur over the Continental Shelf but most species are found at depths of from 500 to 2,000 m. (275-1,100 fm).

Sharks of family Squalidae and sharks of two other families, Squatinidae (angel sharks) and Pristiophoridae (sawsharks), all lack an anal fin. The flattened raylike form of angel sharks distinguishes them from the Squalidae, and sawsharks possess a sawlike extension of the rostrum. Sawsharks have not been reported from the eastern Pacific or near Hawaii.

Of the 55 known species of Squaloid sharks, 10 have been reported from the eastern Pacific or Hawaiian Islands. Possibly more species are present in these areas, especially in deep water.

Key to Squaloid Sharks, Family Squalidae

1a. A spine present at front margins of both first and second dorsal fins (broken or hidden spines can be detected by pinching the lower anterior margin of the fin) . . . . . 2a or 2b

1b, No spine at front margin of either dorsal fin . . . . . 8a or 8b

2a. Teeth of upper jaw with only one cusp . . . . . 3a or 3b

2b. Teeth of upper jaw with several cusps . . . . . 7a or 7b

3a. Shape of teeth similar in upper and lower jaws . . . . . 4a or 4b

3b. Shape of teeth dissimilar, upper teeth needlelike, lower teeth broad with oblique cusps arranged like a saw . . . . . 6a or 6b

4a. All teeth small, needlelike, with cusps directed perpendicularly to jaws. . . . Aculeola nigra.

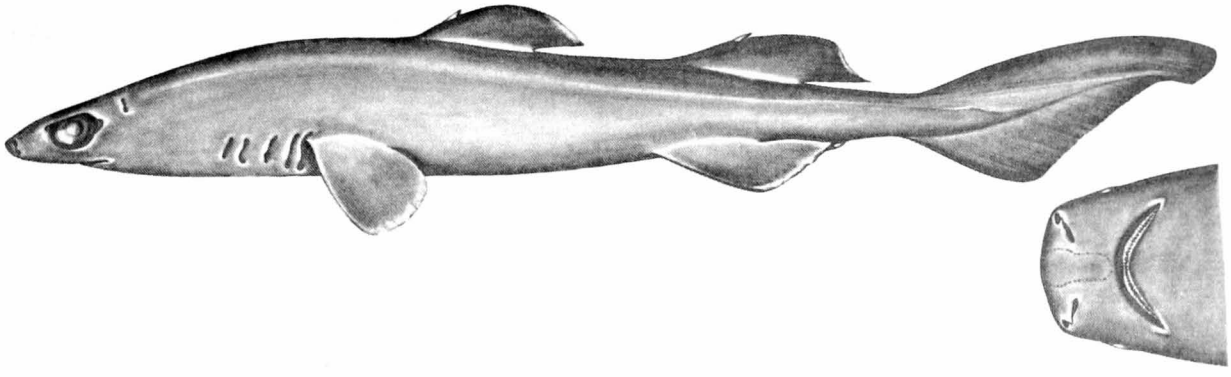


Figure 9.--Aculeola nigra, 41 cm. (1.3 ft.) male, central Chile.

Descriptive notes: Body uniformly black; tips of fins white, the amount of white greater in young specimens; body rather soft; upper caudal lobe with a terminal notch, sometimes only faintly indicated.
Size: Females grow to about 60 cm. (2.0 ft.); males somewhat smaller.
Distribution: Deep water off Peru and Chile.

4b. All teeth wide, with tips directed obliquely toward corners of jaws . . . . . 5a or 5b

5a. Nasal flap at anterior margin of nostril without a small secondary lobe; origin of first dorsal fin usually posterior to inner rear corner of pectoral fin, but occasionally over it; body usually marked with white spots irregularly distributed or arranged in lines on upper and lateral surfaces; some individuals plain, without white spots . . . . . Spiny dogfish, Squalus acanthias.

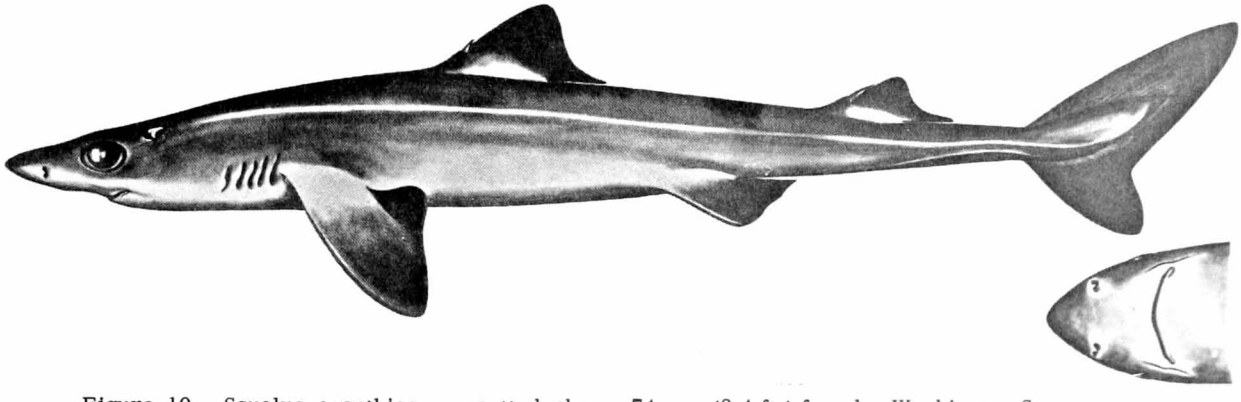


Figure 10.--Squalus acanthias, unspotted phase, 74 cm. (2.4 ft.) female, Washington State.

Descriptive notes: Upper lobe of caudal without a notch near the tip; most individuals with white spots.

Size: Reported to reach a length of 1.6 m. (5.2 ft.), but adults are commonly about 1.0 m. (3.3 ft.).
Distribution: From British Columbia to southern Baja California and off Chile.
Remarks: The spiny dogfish of the eastern North Pacific has been considered a distinct species, Squalus suckleyi. The form taken off southern Chile has been given the name Squalus lebruni. Recent studies have indicated that the three forms are difficult to separate morphologically but are easily separated on the basis of numbers of vertebrae. It seems clear that the forms are distinct at the sub-specific level, but we have chosen to retain the older name here until a definitive study is made.

5b. Nasal flap at anterior margin of nostril with a small secondary lobe; origin of first dorsal fin usually anterior to inner rear corner of pectoral fin, but occasionally over it; body never marked with white spots . . . . . Squalus blainvillei.

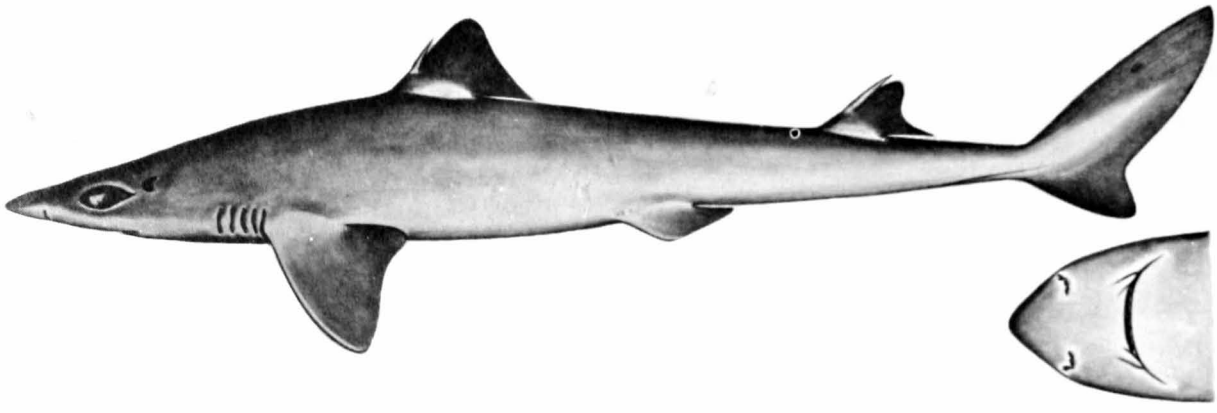


Figure 11.--Squalus blainvillei, 46 cm. (1.5 ft.) female, Gulf of Mexico.

Descriptive notes: Upper lobe of caudal without a notch near the tip; body plain gray or brown, occasionally with dark markings, but never with white spots.
Size: Grows to about 1.2 m. (4.0 ft.).
Distribution: Probably occurs at offshore islands off Chile and at the Hawaiian Islands.
Remarks: This species has usually been called Squalus fernandinus. The identity of S. blainvillei has been so confused that we are uncertain whether reports of its presence off Chile actually refer to this species. Some reports of S. fernandinus from Chile actually referred to specimens of S. acanthias. Our figure was drawn from a specimen from the Gulf of Mexico. A detailed account of the taxonomy of Squalus is given in Garrick (1960).

6a. Length of first dorsal fin, from exposed part of spine to rear end of fin base, about three times greater than its height (measured from rear end of base perpendicularly to highest point); anterior ends of furrows in front of mouth widely separated from each other . . . . . Deania calcea.

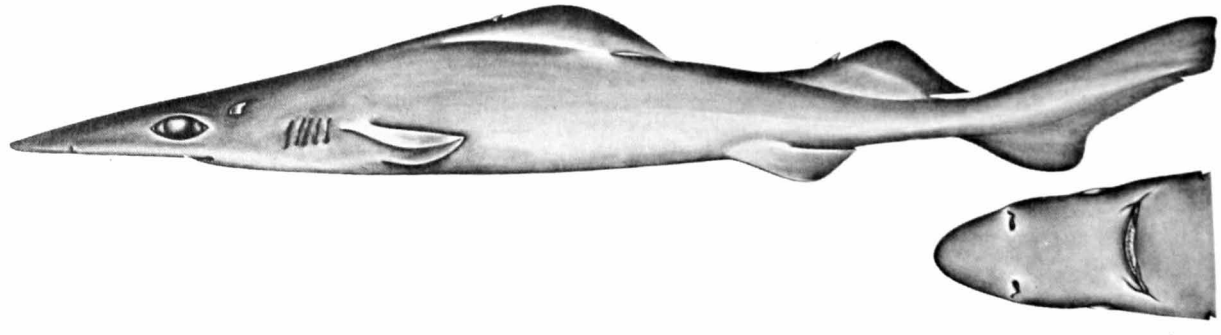


Figure 12.--Deania calcea, 80 cm. (2.7 ft.) female, central Chile.

Descriptive notes: Snout flattened, extremely long; distance between snout tip and front of mouth greater than width of trunk at pectoral origins; all upper teeth more or less narrowly triangular; cusps of lower teeth wider, usually inclined, tips directed toward corners

of jaws; scales on back with high pedicels, tips with three slender points resembling a pitchfork, or with four points.
Size: Grows to about 1.0 m. (3.3 ft.).
Distribution: Central Chile.
Remarks: This species has been reported from Chile under the name Deania eglantina.

6b. Length of first dorsal fin, from exposed part of spine to rear end of fin base, about equal to its height (measured from rear end of base perpendicularly to highest point); anterior ends of furrows in front of mouth almost meet at midline in front of mouth. . . . . Centroscymnus crepidater.

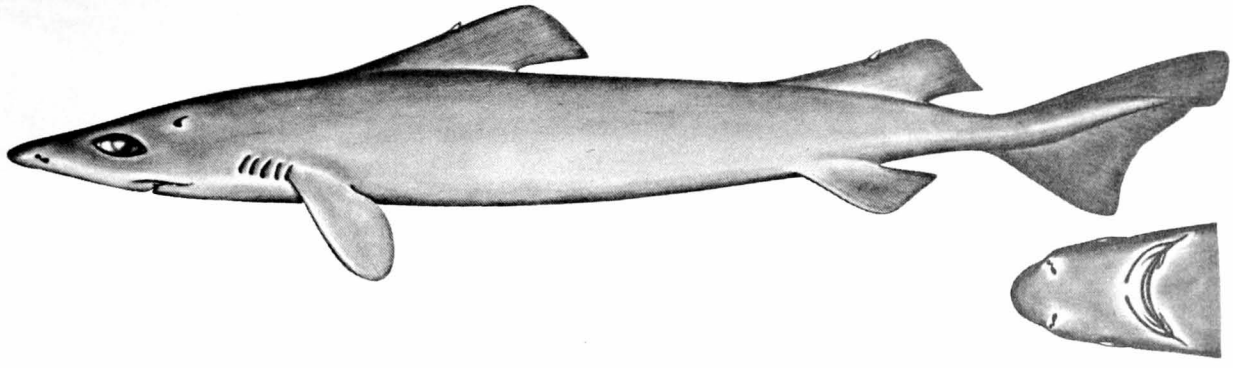


Figure 13.--Centroscymnus crepidater, 90 cm. (3.0 ft.) male, New Zealand, adapted from Garrick (1959).

Descriptive notes: Snout flattened, long; distance between snout tip and front of mouth about equal to trunk width at pectoral origin; teeth in center of upper jaw needlelike; teeth on sides broader, with small pointed cusps on large bases; teeth on lower jaw broad, cusps usually oblique, arranged like a saw; scales on back rounded, usually with three points at the rear margin.
Size: Grows to about 1.0 m. (3.3 ft.).
Distribution: Central Chile.
Remarks: We regard the Chilean Centroscymnus furvescens de Buen a synonym of C. crepidater; only a single specimen has been reported from the eastern Pacific.

7a. Shape of teeth in upper and lower jaws similar, with three or more narrow cusps . . . . . Centroscyllium granulosum.

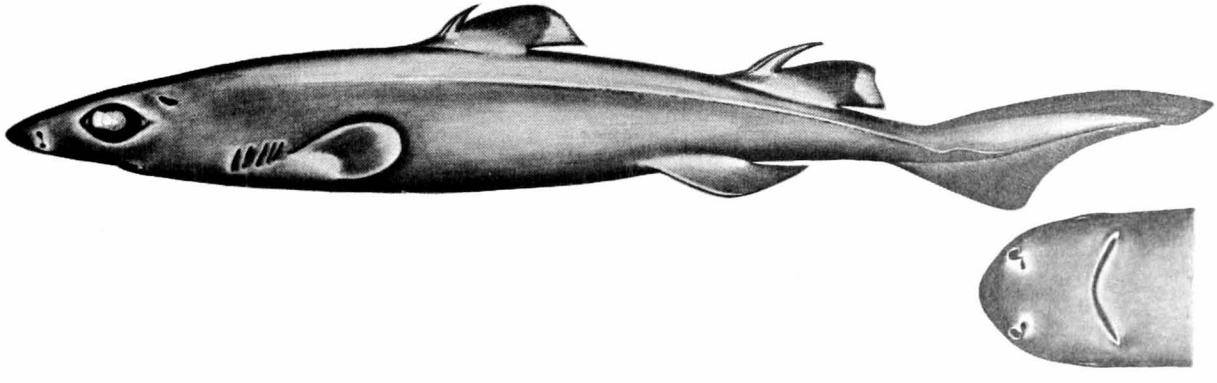


Figure 14.--Centroscyllium granulosum, 21 cm. (8.2 in.) female, Cocos Island, Costa Rica.

Descriptive notes: Body black except for bands of white along margins or tips of fins; scales on head as well as on body with stellate bases, points nearly erect, needlelike, not close together.
Size: Grows to about 40 cm. (1.3 ft.).
Distribution: Recorded from depths over 700 m. (400 fm.) off Hawaii, Cocos Island, Colombia, and central Chile, but from depths of only 220 m. (120 fm.) off southern Chile; also occurs near the Galapagos Islands.

Remarks: We regard both Centroscyllium nigrum Garman, 1899, from near Cocos Island and C. ruscosum Gilbert, 1905--referred to also as C. nigrum--from near Kauai Island, Hawaii, as synonyms of Centroscyllium granulosum (Spinax granulosus Günther, 1880).

7b. Shape of teeth dissimilar in upper and lower jaws; upper teeth with three or more cusps, lower teeth flattened and broad, with a single inclined cusp . . . . . Genus Etmopterus.

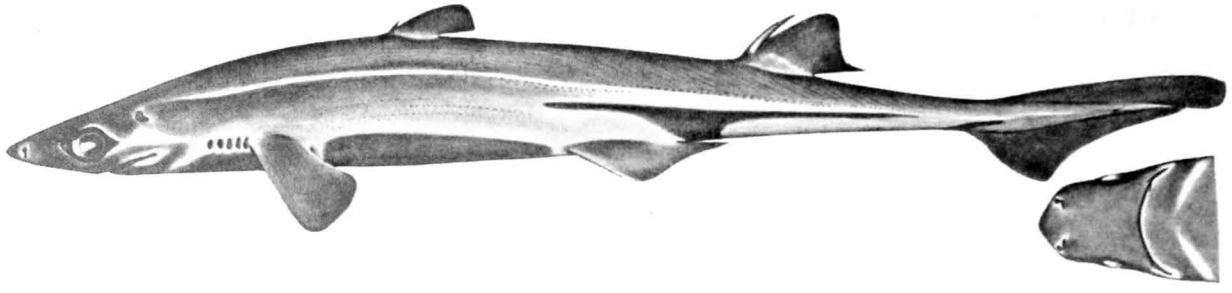


Figure 15.--Etmopterus lucifer, 35 cm. (1.1 ft.) female, Japan.

Descriptive notes, genus Etmopterus: Body either all black or with a variegated pattern of light and dark areas, especially in pelvic region; some species with patches of vivid green, deep blue, or purple; color patterns variable in some species; perhaps all species luminescent.
Size: One species of Etmopterus reaches a length of 75 cm. (2.4 ft.), but most species are much smaller.
Distribution: Widely distributed at depths from 350 to 750 m. (200 - 400 fm.).
Remarks: Genus Etmopterus is represented in the eastern Pacific by one described species, Etmopterus villosus, known from a single specimen 17 cm. (6.7 in.) long, taken off the south coast of Molokai, Hawaii, in 405 to 910 m. (222-498 fm.). The color of this specimen was described as follows: warm brown; lower side of head, breast, and abdomen purplish black; dorsals black on basal and anterior portions, broadly tipped with white; caudal lobes black, the intermediate portion light margined; pectorals and ventrals dusky with white posterior edges. Unidentified species of Etmopterus have been collected off Panama and Baja California. In the absence of available identified specimens for illustration we have included a drawing of a specimen of Etmopterus lucifer from Japan. E. lucifer apparently has a wide distribution and is one of the better-known species.

8a. Shape of teeth similar in upper and lower jaws, cusps inclined, with long cutting edges . . . . . Prickly shark, Echinorhinus cookei.

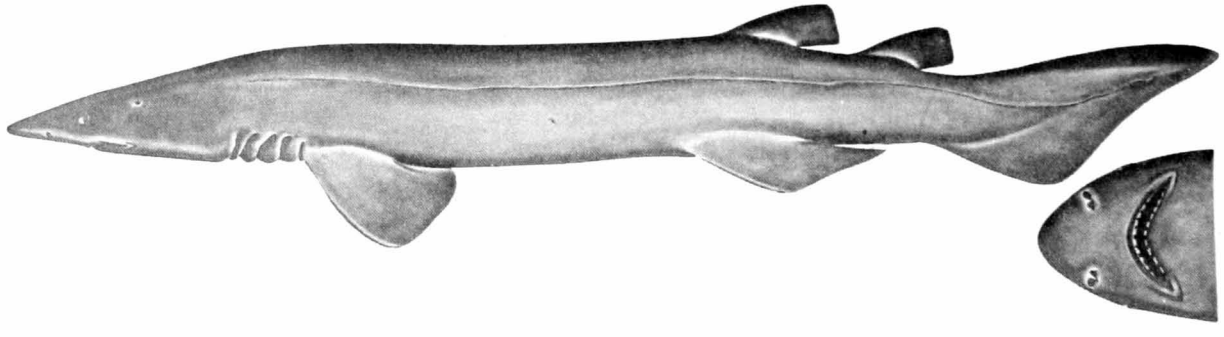


Figure 16.--Echinorhinus cookei, 155 cm. (5.1 ft.) male, California.

Descriptive notes: First dorsal fin located far back; pelvic fins large; scales spiny with large stellate bases; rear portion of trunk rather deep.
Size: Grows to about 4.0 m. (13.1 ft.).
Distribution: Rather uncommon, recorded from Hawaiian Islands, southern California, Guadalupe Island (off Baja California), and Peru.

Remarks: A second species of Echinorhinus, the common bramble shark (E. brucus), has a widespread distribution but has not been found yet in our area. E. brucus can be distinguished from E. cookei by its large, sparsely spaced scales; the bases of the scales on one E. brucus 2.0 m. (6.6 ft.) long are about 15 mm. (0.59 in.) wide, whereas those of E. cookei of the same size are about 4 mm. (0.16 in.) wide.

8b. Shape of teeth dissimilar in upper and lower jaws, upper teeth narrow and spikelike, lower teeth wider with either triangular or inclined cusps . . . . . 9a or 9b

9a. First dorsal fin about midway between pectoral fin and second dorsal fin; a large species, reaching lengths of 4.0 m. (13 ft.) or more . . . . . Pacific sleeper shark, Somniosus pacificus.

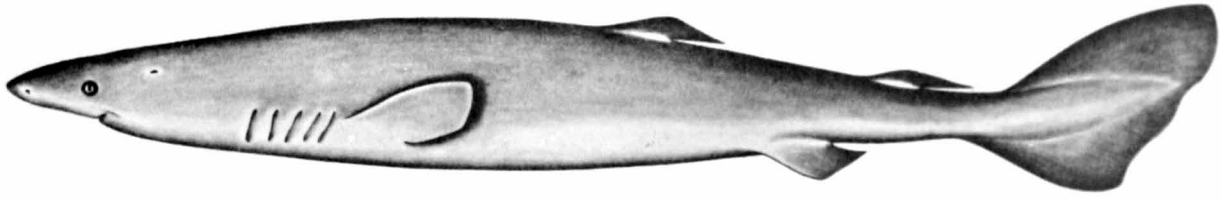


Figure 17.--Somniosus pacificus, 104 cm. (3.4 ft.) female, California.

Descriptive notes: Body ash-gray above, sometimes mottled with white, undersides not much lighter; eyes small; all fins small; upper teeth spikelike, lower teeth with wide cutting edges, cusps oblique and directed toward the corners of the jaw.
Size: Grows to at least 4.0 m. (13 ft.), probably much larger. The related Atlantic species Somniosus microcephalus is said to reach lengths of over 6.0 m. (20 ft.).
Distribution: Arctic waters, occasionally straying southward to northern California, and probably to southern California.
Remarks: The specimen figured here is small; larger individuals are much stouter, and the lower caudal lobe is well formed.

9b. First dorsal fin far back, closer to second dorsal fin than to pectoral fins; a small species with lengths not over 50 cm. (1.6 ft.). . . . . 10a or 10b

10a. Base of second doral fin more than twice as long as base of first dorsal fin. . . . . Slime shark, Euprotomicrus bispinatus.

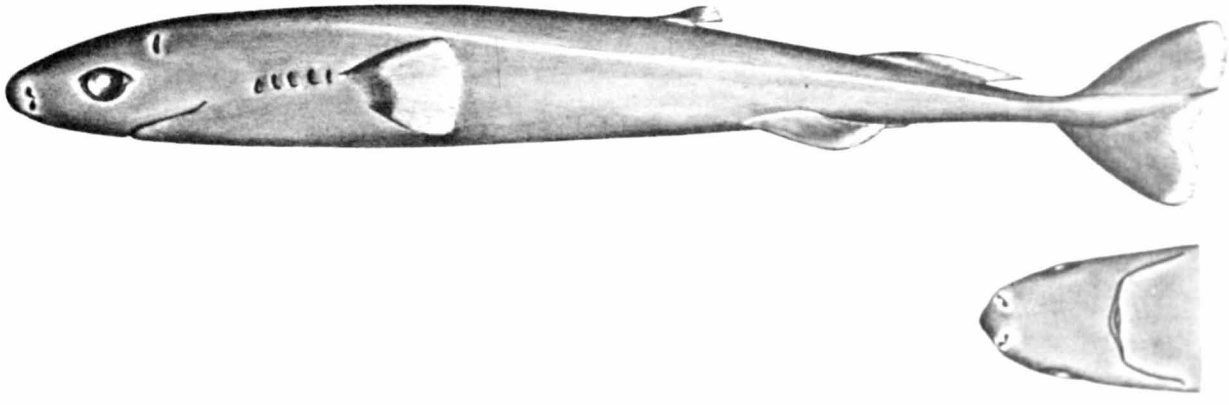


Figure 18.--Euprotomicrus bispinatus, 17 cm. (6.7 in.) male, offshore California.

Descriptive notes: Body fusiform, uniformly brown or black; margins of fins unpigmented, clear; upper teeth spikelike; lower teeth wider, with sharp, slightly oblique cusps.
Size: Probably does not reach 30 cm. (1.0 ft.).
Distribution: A midwater oceanic species; reported from Hawaiian Islands and California.

10b. Base of second dorsal fin only slightly longer than base of first dorsal fin. . . . . Cigar shark, Isistius brasiliensis.

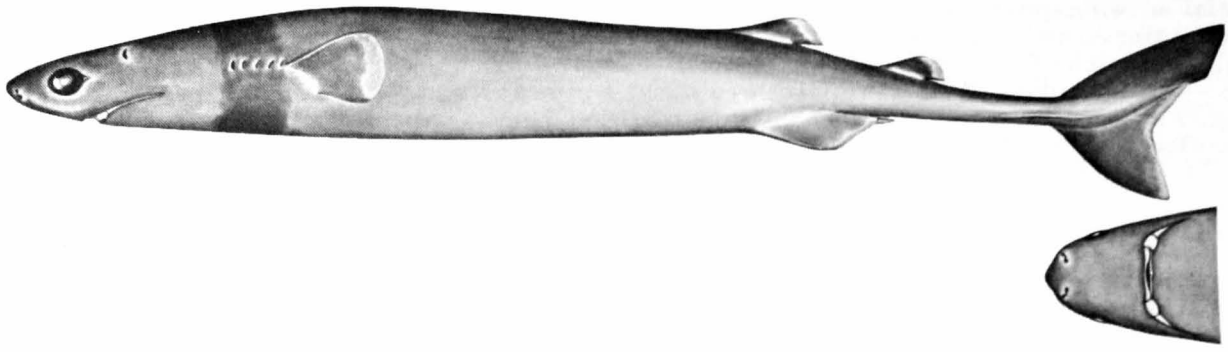


Figure 19.--Isistius brasiliensis, 37 cm. (1.2 ft.) male, offshore Galapagos Islands.

Descriptive notes: Body elongate, cigar-shaped; dark collar around neck near gill slits; upper teeth spikelike, lower teeth triangular.
Size: Grows to about 50 cm. (1.6 ft.).
Distribution: A midwater oceanic species; reported from well offshore of the Hawaiian Islands, and near the Galapagos Islands.

ANGEL SHARKS, FAMILY SQUATINIDAE

Angel sharks are easily distinguished from all other sharks by their raylike appearance and their lack of an anal fin. Unlike rays, however, the expanded pectoral fins of angel sharks are not attached to the head.

There are 11 species of angel sharks, all belonging to a single genus, Squatina. Two species are usually recognized in the eastern Pacific; others occur in the Atlantic, Mediterranean, and western Pacific, and off Australia and South Africa. In the eastern Pacific, angel sharks are found in cooler waters northward from the Gulf of California and southward from Peru. Characteristics used to distinguish the two species are: shape of the inner nasal lobe; presence or absence of denticles on the ventral surface; presence or absence of a series of enlarged denticles along the middle of the back; shapes of the pectoral and caudal fins; and number of teeth. Using these criteria, we were unable to distinguish between series of small and large specimens from the north and south.

The specimen illustrated here is the northern angel shark, Squatina californica. The southern species, if it is distinct, is the angelote, S. armata. Although our study of a number of specimens from both areas indicated that the two species are probably identical, we hesitate to lump them into a single species until a more thorough study is made of the two forms and of the family.

Figure 20.--Squatina californica, 30 cm. (1.0 ft.) female, central California.

Descriptive notes: Body flattened; anal fin absent; pectoral fin expanded; teeth small, needlelike.
Size: Grows to about 1.5 m. (5.0 ft.).
Distribution: Gulf of California to southern Alaska, and Peru to southern Chile (see remarks).
Remarks: The southern form, Squatina armata or angelote, is usually considered a distinct species.

NURSE SHARKS, FAMILY ORECTOLOBIDAE

Sharks of family Orectolobidae are generally sluggish bottom dwellers with the following characteristics: a fleshy barbel in front of each nostril; spiracle present; teeth small; first dorsal fin far back, over pelvic fins.

The family has 11 genera, but only 1 of these is represented in the eastern Pacific, by the nurse shark, Ginglymostoma cirratum.

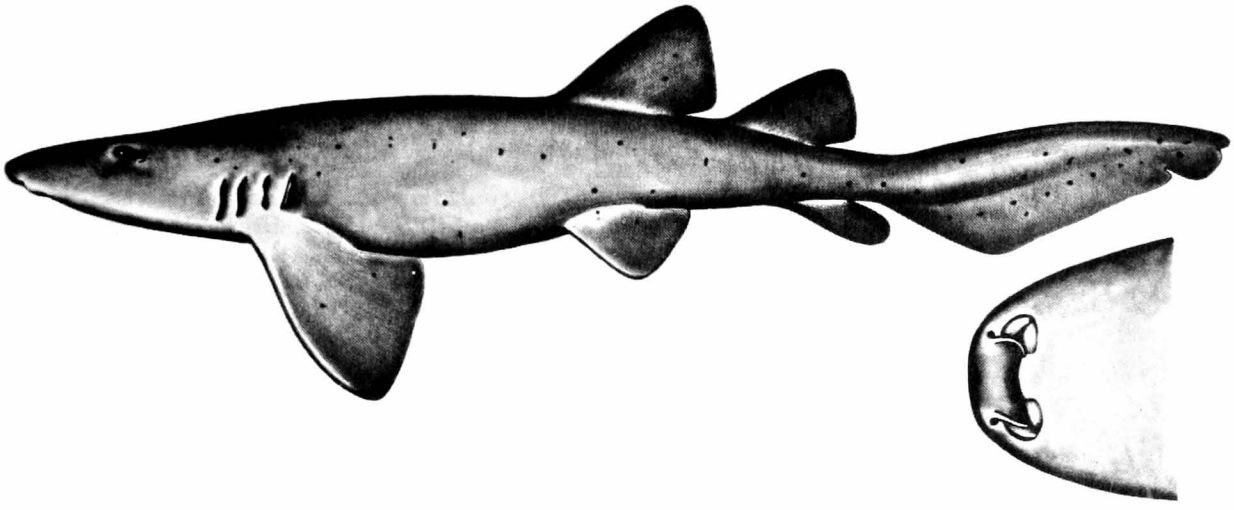


Figure 21.--Ginglymostoma cirratum, 27 cm. (10.5 in.) female, Nayarit, Mexico.

Descriptive notes: Fleshy barbels in front of nostrils; eyes small; spiracles minute; fourth and fifth gill slits close together; scales without points, skin smooth to touch when rubbed in any direction; young often with black spots scattered sparsely and irregularly.
Size: Reported to attain 4.0 m. (13 ft.), but the largest specimen on record from the eastern Pacific measured less than 3.0 m. (10 ft.).
Distribution: Inshore, from the Gulf of California to Peru; a record from Oregon (Garrick and Schultz, 1963) was erroneous.

BASKING SHARKS, FAMILY CETORHINIDAE

Basking sharks are similar to mackerel sharks in having a keel near the tail, a pointed snout, and a crescentic tail. The gill slits of basking sharks, however, are extraordinarily long, extending from high on top of the head to near the midline on the ventral side. Only the whale shark is larger than the basking sharks; the whale shark differs in that it has a rounded snout, ridges along the back, and white spots on the body (basking sharks lack ridges and are plain brownish-gray). Despite their large size, basking sharks are harmless; they feed on minute organisms.

Basking sharks are widely distributed in cooler waters of the Northern and Southern Hemispheres, only occasionally venturing into warm waters. All are usually considered to belong to a single species, Cetorhinus maximus, but it is possible that more than one species exists; a recent publication differentiates two species in the Northern Hemisphere and two others in the Southern Hemisphere.

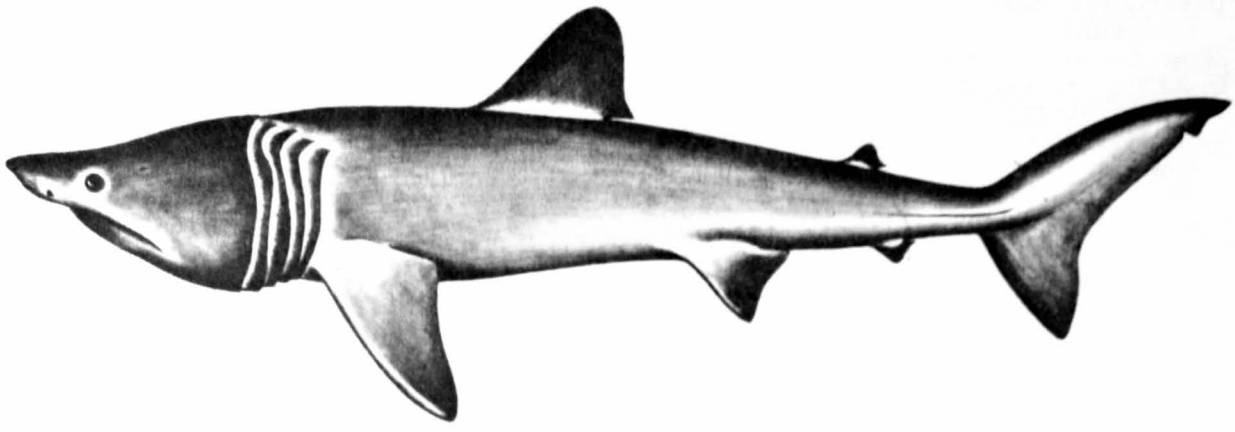


Figure 22.--Cetorhinus maximus, 820 cm. (26.9 ft.) female, central California.

Descriptive notes: Caudal fin crescentic, upper caudal lobe not much greater than the lower; a keel on the sides of the trunk near the tail; gill slits long; teeth small, numerous, with several series functional; gill rakers sievelike; young with a rounded snout.
Size: Grows to at least 9.8 m. (32 ft.); individuals as large as 14 m. (45 ft.) have been reported, but the reliability of such records is questionable.
Distribution: In the Northern Hemisphere, from southern California to British Columbia, and rarely to Alaska and the Gulf of California; in the Southern Hemisphere, from Peru to central Chile, and probably to the tip of South America; probably occurs occasionally near the Galapagos Islands.

SAND SHARKS, FAMILY ODONTASPIDAE

The family of sand sharks contains a single genus, Odontaspis, with six or seven recognized species. Sand sharks have the following characteristics: fifth gill opening anterior to origin of pectoral fins; second dorsal and anal fins nearly as large as first dorsal fin (in most species); teeth slender, usually with one or more small denticles on each side of the base; upper precaudal pit present but lower absent; spiracles present, small; eye without nictitating fold or membrane.

Odontaspis ferox, the single species present in the eastern Pacific, was reported from southern California, but only two specimens from the area have been identified with certainty.

Sand sharks have sometimes been referred to the family Carchariidae, genus Carcharias.

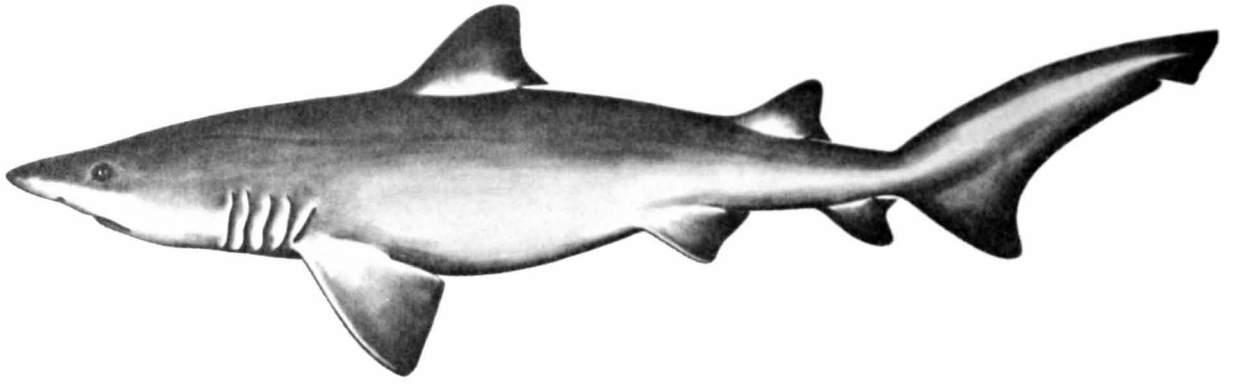


Figure 23.--Odontaspis ferox, 150 cm. (4.9 ft.) female, southern California.

Descriptive notes: Teeth narrow, main cusps fanglike, with two or more small pointed denticles on each side of the base; first upper tooth from the midline small, second and third teeth much larger, fourth through seventh teeth small; body stout, belly rounded; snout pointed.
Size: Only two specimens recorded in the eastern Pacific, one about 1.7 m. (5.5 ft.), the other about 3.0 m. (10 ft.).

Distribution: Southern California; possibly present in the Gulf of California where a set of jaws of O. ferox has been found at La Paz, Baja California.

Remarks: A second species of Odontaspis occurs offshore and is occasionally taken on longlines by Japanese tuna fishermen. This species, Odontaspis kamoharai, is small, attaining a total length of about 1.0 m. (3.3 ft.), and is easily distinguished from O. ferox by its large eyes (horizontal diameter about twice as long as the largest tooth), non-denticulated teeth, and small second dorsal and anal fins.

THRESHER SHARKS, FAMILY ALOPIIDAE

The elongate tail distinguishes thresher sharks from all others. Four species of threshers are now recognized, all belonging to a single genus, Alopias. Two have been reported only from the western and central Pacific; the other two are in most warm and cool seas, including the eastern Pacific. Although fairly common in cool inshore waters, thresher sharks are more frequently caught by longline fishermen far out at sea.

The following key distinguishes between the bigeye thresher and the common thresher, both of which are found in the eastern Pacific.

Key to Thresher Sharks, Family Alopiidae

1a. Head with a prominent crest, extending from over eyes backward and downward to a point behind gill slits; first dorsal fin far back, its rear tip about over, or just in front of, origin of the pelvic fins . . . . . Bigeye thresher, Alopias superciliosus.

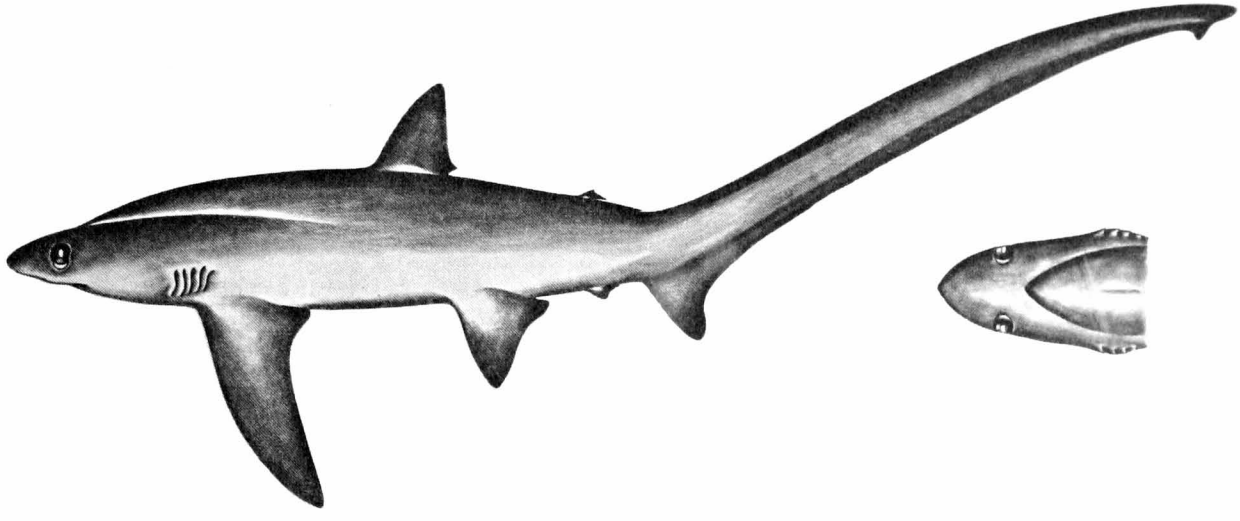


Figure 24.--Alopias superciliosus, 287 cm. (9.4 ft.) female, offshore eastern Pacific (dorsal view of head).

Descriptive notes: About 10 or 11 teeth on each side of upper jaw; third tooth (from the middle) equal in size to second and fourth teeth; vertical diameter of eye much greater than horizontal diameter; lower precaudal pit probably absent; rear tip of second dorsal fin located well in front of origin of anal fin; pelvic and first dorsal fins about equal in size.

Size: Grows to about 5.5 m. (18 ft.).

Distribution: Probably a deep-living species; eastern Pacific specimens were caught in 150 to 180 m. (85 - 100 fm.) with gill nets; commonly caught by longline fishermen on the high seas; in the eastern Pacific, recorded only from southern California but probably present elsewhere.

Remarks: A closely related species, Alopias profundus, thus far known only from the western Pacific, may be confused with the bigeye thresher. The two species are similar and may be identical. Characteristics of A. profundus that allegedly separate it from A. superciliosus are: lower precaudal pit present; rear tip of second dorsal fin about over origin of anal fin; first dorsal fin about twice as large as pelvic fins.

1b. Head without a prominent crest, at most a slight indentation running from over eyes to gill slits; first dorsal fin well in front of pelvic fins . . . . . Common thresher, Alopias vulpinus.

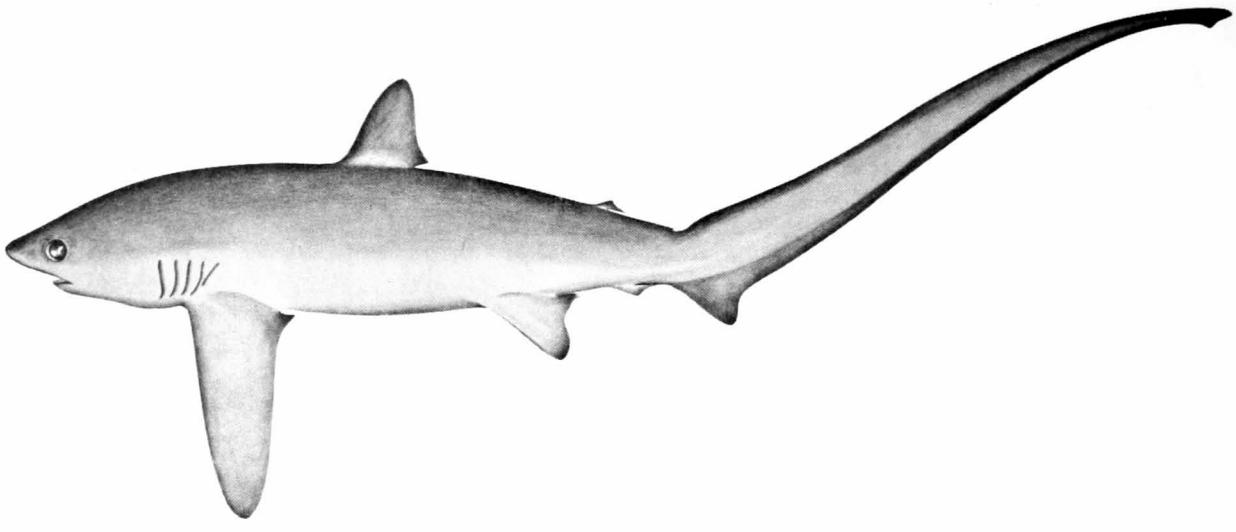


Figure 25.--Alopias vulpinus, 191 cm. (6.2 ft.) male, offshore eastern Pacific.

Descriptive notes: Teeth erect or only slightly oblique, some with tiny denticles on each side of the base; usually about 21 to 22 teeth in each side of upper jaw; third tooth (from the middle) distinctly smaller than second and fourth teeth; vertical diameter of eye not much greater than horizontal diameter; lower precaudal pit absent in some specimens, present in others; pelvic and first dorsal fins about equal in size.

Size: Grows to about 6.0 m. (18 ft.).

Distribution: Inshore and offshore, from Canada to southern Chile, and near the Hawaiian Islands.

Remarks: The common thresher has a close relative, Alopias pelagicus, which has been reported from the central and western Pacific. As in the bigeye threshers, the differences between the common thresher and A. pelagicus are slight and may be merely individual, population, or developmental differences. The following characteristics of A. pelagicus are thought to be different from those of A. vulpinus: teeth oriented obliquely, with denticles present on one side of the base; lower precaudal pit present; pelvic fins somewhat smaller than the first dorsal fin.

We have found that the orientation and shape of teeth, and the presence of a lower precaudal pit are variable characters; the alleged differences (taken from published accounts) do not appear to be consistent. This group needs further study to ascertain whether one, two, or even four species of "common" threshers exist.

WHALE SHARK, FAMILY RHINCODONTIDAE

The whale shark, Rhincodon typus, is the only member of family Rhincodontidae. It is easily identified by its large size, terminal mouth, and the longitudinal ridges and white spots along its back and sides. Whale sharks feed at the surface on small crustaceans (shrimps, crabs, etc.), small schooling fishes, and occasionally on larger fishes. Schools of huge whale sharks may sometimes be seen feeding while maintaining a vertical position in the water. Their emergent heads resemble dark oil drums slowly moving up and down in the swell.

Little is known about the early life history of whale sharks. An egg case 30 cm. by 14 cm. by 8 cm. (12 in. by 5.5 in. by 3 in.) contained an embryo apparently close to hatching. It was 35 cm. (13.5 in.) in total length, and resembled the adult in general form and coloration.

Whale sharks are found in warm water throughout the world and occasionally in cold water. They are considered inoffensive, but are large and powerful enough to be dangerous when feeding or if annoyed.

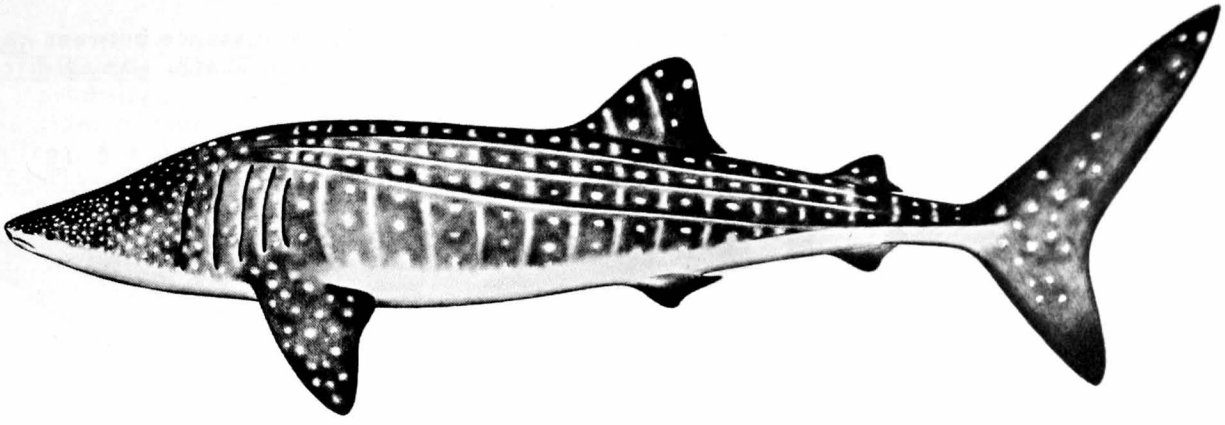


Figure 26.--Rhincodon typus, 550 cm. (18.0 ft.) female, South Africa, drawn from photographs.

Descriptive notes: Body with longitudinal ridges, spotted with white; mouth at extreme end of head.
Size: Grows to at least 14 m. (45 ft.) and perhaps to 18 m. (60 ft.).
Distribution: From northern Baja California to northern Chile, but rare near the limits of the range; reported from the Galapagos Islands; and probably present near the Hawaiian Islands.

MACKEREL SHARKS, FAMILY LAMNIDAE

Mackerel sharks are large, streamlined sharks found in all oceans, both close to shore and far out at sea. Because of their large size, all species are potentially dangerous, and one species, the great white shark, has earned the reputation and the common name of maneater.

Three genera are included in family Lamnidae, which is often referred to as family Isuridae. One of these genera, Carcharodon, is represented by a single species, the great white shark. The other two genera, Isurus and Lamna, are composed of at least two species each. All species of mackerel sharks are probably present in the eastern Pacific or near the Hawaiian Islands.

Characteristics shared by all sharks of family Lamnidae are: trunk depressed near tail, with a prominent keel on each side extending from rear portion of body into the tail; tail crescentic, upper lobe not markedly longer than lower lobe; gill slits long; second dorsal and anal fins much smaller than first dorsal fin; snout pointed.

Key to Mackerel Sharks, Family Lamnidae

1a. Caudal fin with a short secondary keel located under posterior end of main keel (fig. 27A). . . . . 2a or 2b

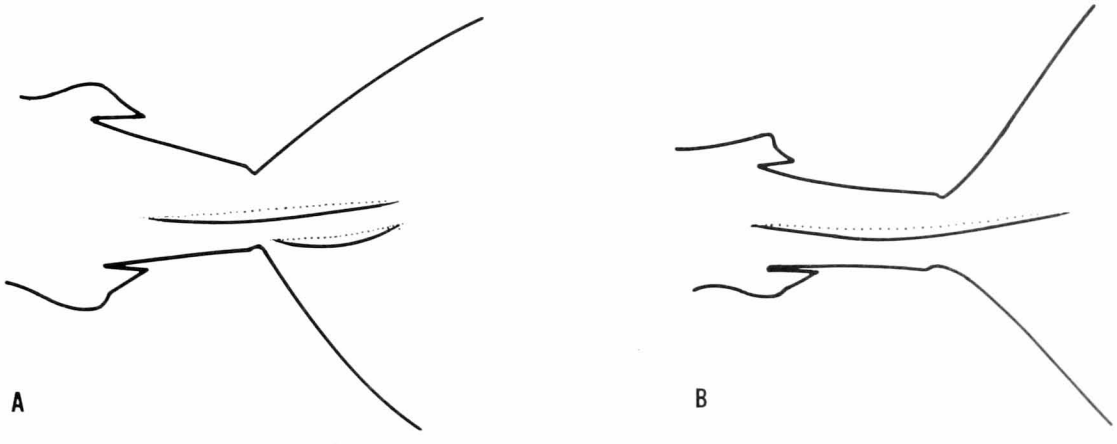


Figure 27.--Caudal fins of mackerel sharks: A - Shark with secondary keel; B - Shark without secondary keel.

1b. Caudal fin without a secondary keel under posterior end of main keel (fig. 27B). . . . . 3a or 3b

2a. Distance between snout tip and front of eye less than one-half the distance between back of eye and first gill slit. . . . . Salmon shark, Lamna ditropis.

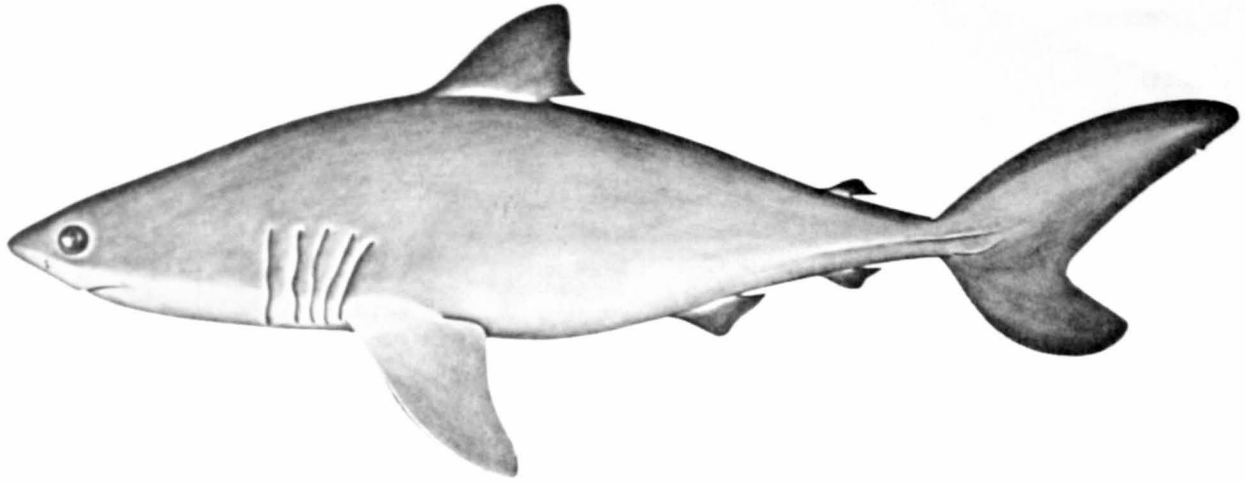


Figure 28.--Lamna ditropis, 74 cm. (2.4 ft.) female embryo, California.

Descriptive notes: Main cusps of teeth somewhat slender, without serrations, but usually with a small secondary cusp at the base (the secondary cusps may be absent or difficult to see in small specimens); first dorsal fin located somewhat forward; most individuals over 1.5 m. (5.0 ft.) with dark blotches on the undersides; smaller individuals usually without such blotches.

Size: A stout shark, probably grows to about 3.0 m. (10 ft.).

Distribution: Found far out at sea and inshore, reported from the north Pacific only, from Alaska to southern California; commonly caught in gill nets in the high-seas salmon fishery.

Remarks: The specimen figured above is an embryo; some differences should be expected in proportional dimensions and shapes of parts of the body of larger individuals.

2b. Distance between snout tip and front of eye more than one-half the distance between back of eye and first gill slit. . . . . Porbeagle, Lamna nasus.

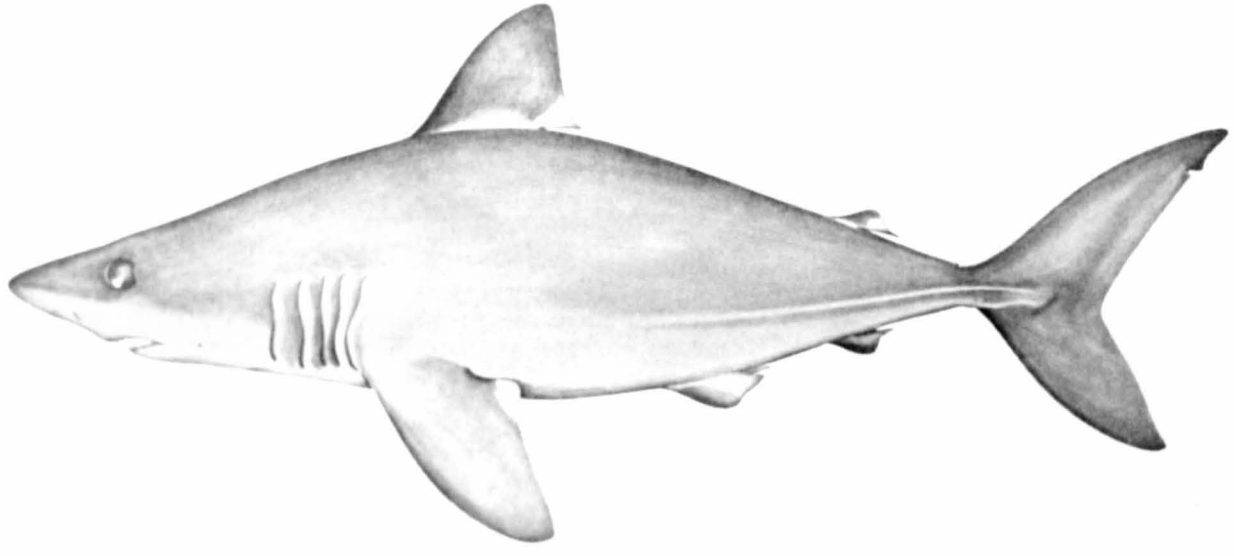


Figure 29.--Lamna nasus, 81 cm. (2.7 ft.) male, offshore Chile.

Descriptive notes: Main cusps of teeth somewhat slender, without serrations, but usually with a small secondary cusp on each side of the base (the secondary cusps may be absent or difficult to see in small specimens); first dorsal fin located somewhat forward; undersides of both juveniles and adults white, without dark blotches.

Size: A stout shark; grows to at least 3.0 m. (10 ft.).

Distribution: Found in cold waters of the Southern Hemisphere; in the eastern Pacific probably near Chile only.

Remarks: The specimen figured above is a small juvenile; adults have more streamlined bodies and fins which are more pointed and relatively longer; the first dorsal fin may also be slightly farther back in adults.

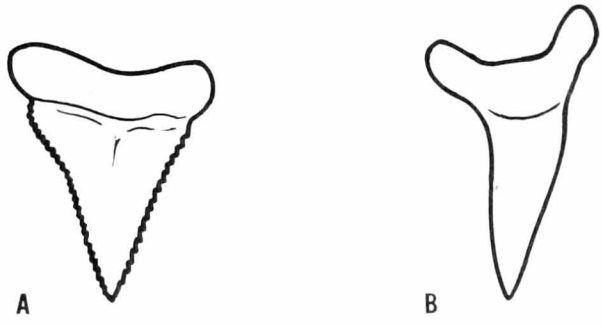


Figure 30.--Types of teeth: A - Broad, triangular, margins serrated (from great white shark); B - Slender, margins not serrated (from mako shark).

3a. Teeth broad, triangular, with coarse serrations on the margins from base to tip (fig. 30A). . . . . Great white shark, Carcharodon carcharias.

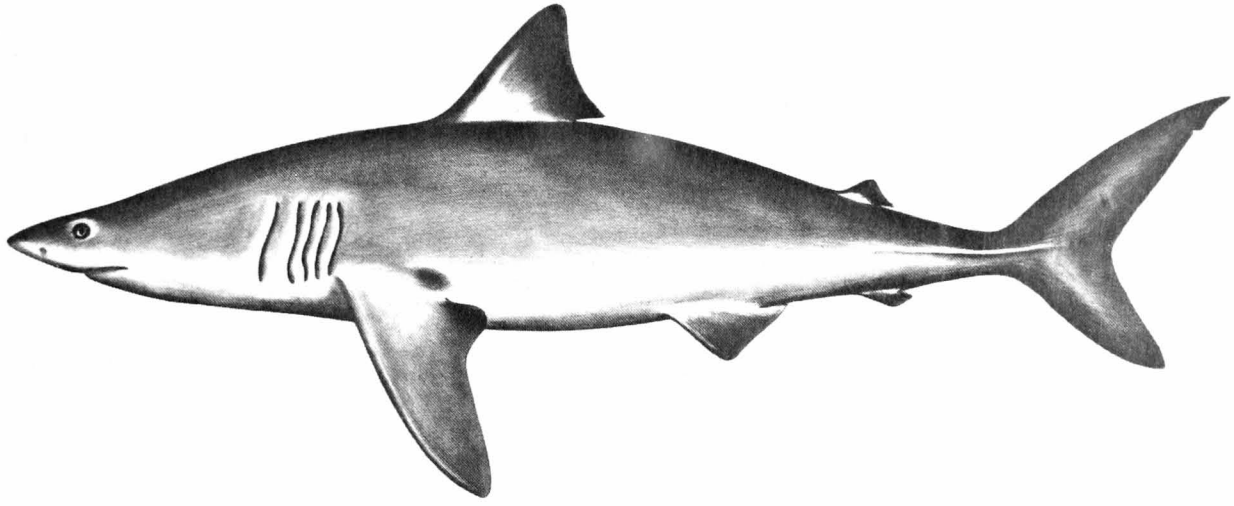


Figure 31.--Carcharodon carcharias, female, from photographs.

Descriptive notes: Teeth in both jaws triangular and heavily serrated in adults, but serrations may be lacking in some lower teeth of juveniles under 1.5 m. (5.0 ft.); origin of anal fin distinctly behind origin of second dorsal fin; a dark spot usually present near the bases of the pectoral fins.

Size: Individuals of 6.0 m. (20 ft.) not rare; reported to grow larger than 9.0 m. (30 ft.), but such reports are unverifiable.

Distribution: Found far out at sea as well as inshore, reported from Alaska to the Gulf of California, and from Panama to Chile; also found at the Hawaiian Islands; probably occurs near other offshore islands.

3b. Teeth narrow and long, not serrated (fig. 30B). . . . . Mako (Bonito shark), Isurus oxyrinchus.

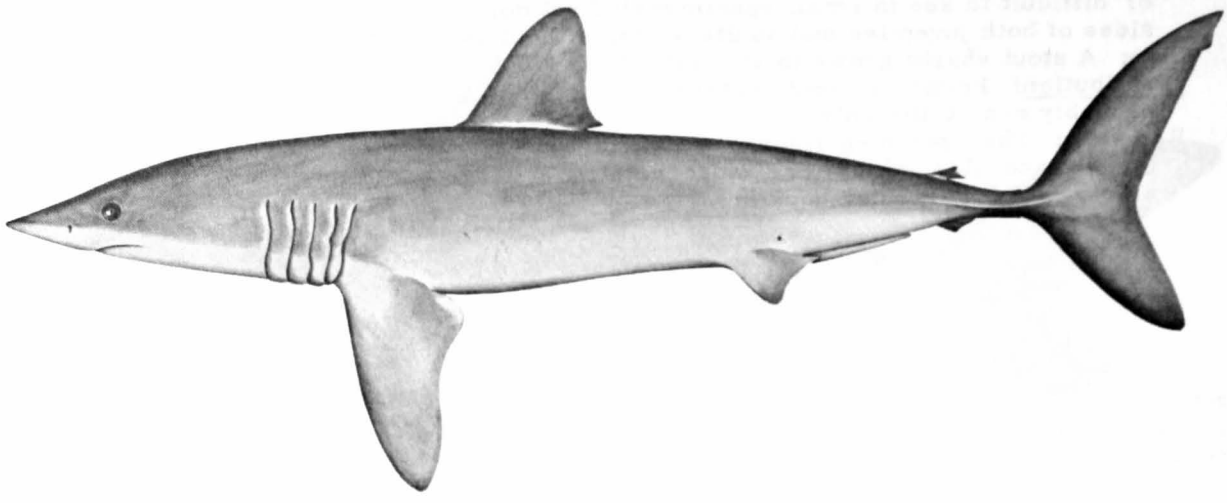


Figure 32.--Isurus oxyrinchus, 180 cm. (5.9 ft.) male, offshore eastern Pacific.

Descriptive notes: Teeth without serrations or secondary cusps, highly curved inward near the center of the lower jaw where three rows are usually upright; first dorsal fin far back in relation to pectoral fins.

Size: Grows to about 3.6 m. (12 ft.).

Distribution: Found far out at sea and inshore, reported from central California to the Gulf of California, and from Ecuador to Chile; occurs at the Hawaiian Islands, and no doubt also at offshore islands in the eastern Pacific.

Remarks: The eastern Pacific bonito shark has usually been referred to as Isurus glaucus, but a recent study by Garrick (1967) shows that the bonito shark is identical with the widely distributed mako shark, Isurus oxyrinchus. A second species of Isurus is taken by fishermen in the western and central Pacific. This species, Isurus paucus, has only recently been shown to be different from Isurus oxyrinchus, from which it can be distinguished by its extremely long pectoral fins. Individuals of Isurus paucus over about 1.5 m. (5.0 ft.) long are marked with dark blotches on the undersides of the head and body, in contrast with the mako shark which has white undersides. The common name "long-finned mako" has been appended for the new species, which is probably present near Hawaii, and possibly occurs in the eastern Pacific.

CAT SHARKS, FAMILY SCYLIORHINIDAE

Cat sharks are small bottom-dwellers restricted to moderately cool waters. Many species live at depths of more than 200 m. (110 fm.), but a few species enter shallower waters in areas where the temperature is sufficiently low, as along the coast of southern Chile.

Of the 50 or more species of cat sharks that are known, 9 occur in the eastern Pacific and 1 at the Hawaiian Islands. The following combination of characters separate these 10 cat sharks from all other sharks in the same area: anal fin and two dorsal fins present; origin of first dorsal fin over or slightly behind origin of pelvic fins (except in Cephalurus); several series of teeth functional in both jaws, each tooth with three or more cusps (except only one cusp on some or most of the teeth of adults of Halaelurus bivius and Halaelurus chilensis); no groove connecting nostrils to mouth; nostrils without fleshy barbels.

As a rule, species of cat sharks that inhabit deep water are uniformly dark, and species that live in moderate depths have complex color patterns of brown, black, and white.

Most cat sharks lay eggs in leathery cases, but a few species bear live young.

Key to Cat Sharks, Family Scyliorhinidae

1a. Origin of first dorsal fin slightly ahead of origin of pelvic fins . . . . . Cephalurus cephalus.

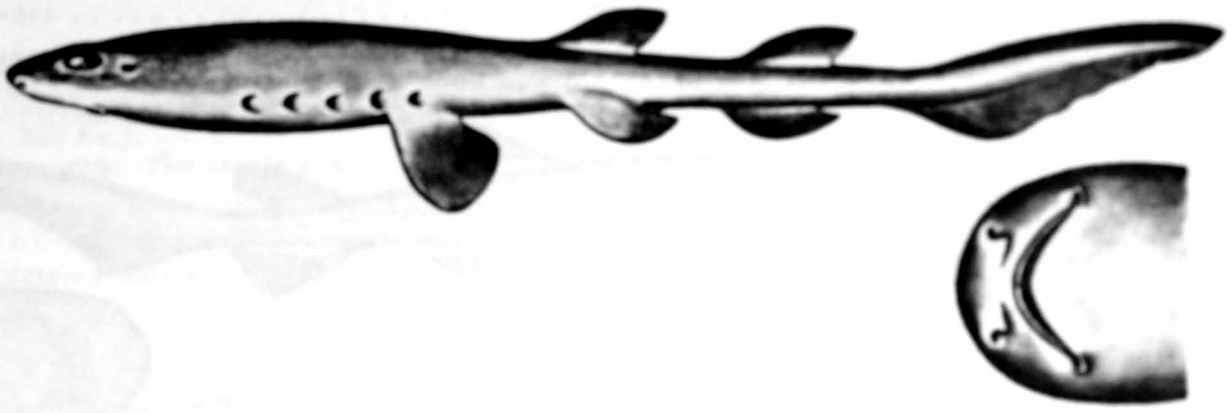


Figure 33.--Cephalurus cephalus, 19 cm. (7.5 in.) male, Gulf of California.

Descriptive notes: Head wide and flattened in front of pectoral fins.
Size: A small species, probably not exceeding 40 cm. (1.3 ft.).
Distribution: Only two specimens known, from the Gulf of California and the Revillagigedo Islands.
Remarks: A closely related species, from 365 m. (200 fm.) depth off the coast of northern Peru, is known from only one specimen and has not yet been described. It differs in body proportions, in shape of denticles, and form of nasal flaps.

1b. Origin of first dorsal fin posterior to origin of pelvic fins . . . . . 2a or 2b

2a. A crest of enlarged scales on upper margin of anterior half of tail . . . . . 3a or 3b

2b. Scales on upper margin of anterior half of tail not different from scales below margin . . . . . 4a or 4b

3a. Lining of mouth cavity dusky or black . . . . . Peppered shark, Galeus piperatus.

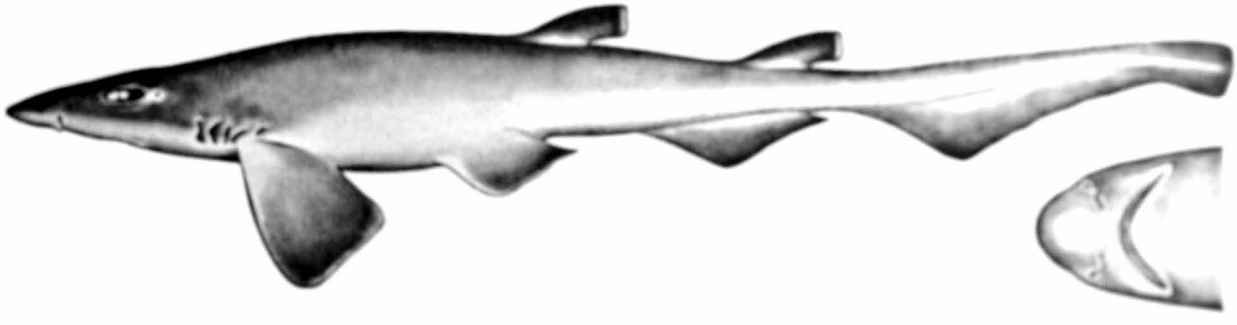


Figure 34.--Galeus piperatus, 30 cm. (1.0 ft.) female, Gulf of California.

Descriptive notes: Young with brownish mottling on dorsal surface, adults rather plain, dark above, lighter below, with tiny black pepperlike spots, especially noticeable on lower side of head and body.
Size: Full grown at about 30 cm. (1.0 ft.).
Distribution: Known only from the Gulf of California.

3b. Lining of mouth cavity white. . . . . Filetail cat shark, Parmaturus xaniurus.

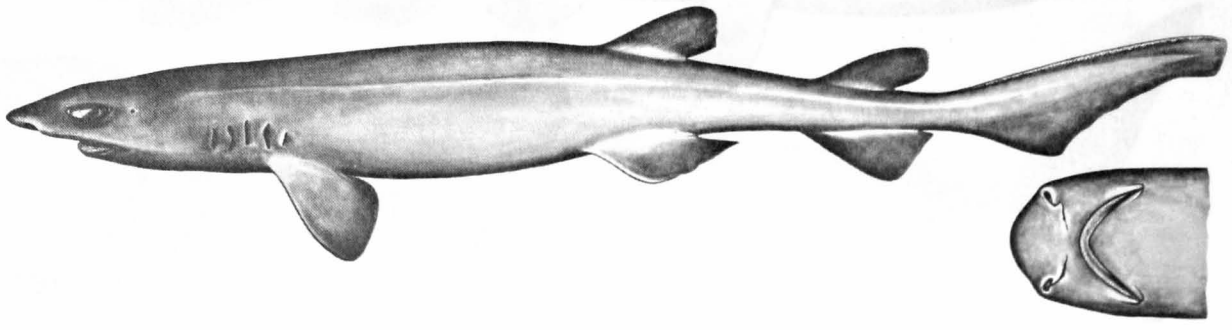


Figure 35.--Parmaturus xaniurus, 48 cm. (1.6 ft.) female, southern California.

Descriptive notes: Dorsal surface brownish black; ventral surface often similarly colored.
Size: Probably grows to about 50 cm. (1.6 ft.).
Distribution: From central California southward, at least to the Gulf of California.

4a. No labial grooves at corners of mouth (see fig. 2A, ventral view of head). . . . . Swell shark, Cephaloscyllium ventriosum.

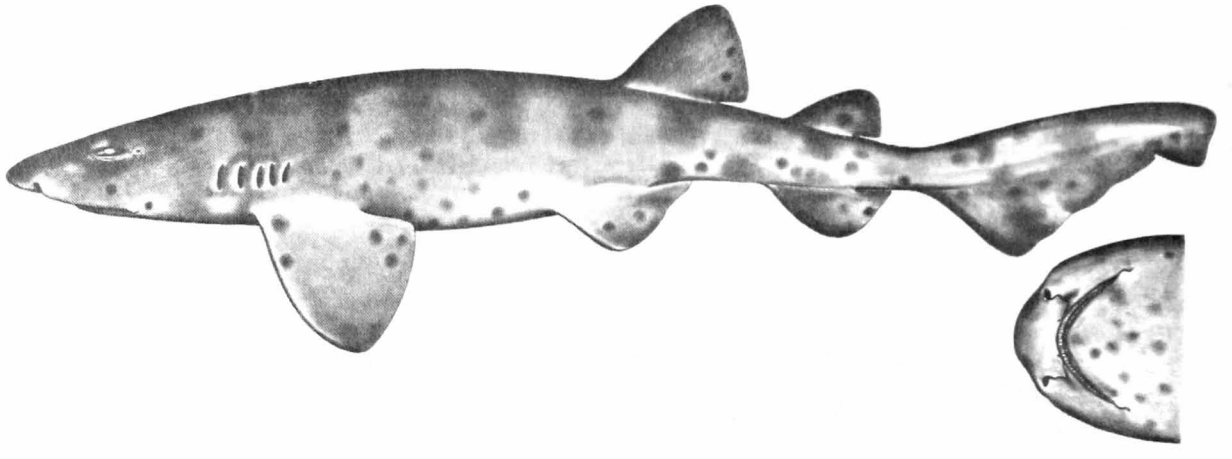


Figure 36.--Cephaloscyllium ventriosum, 40 cm. (1.3 ft.) male, California.

Descriptive notes: Variegated color pattern of indistinct brown saddles with alternating blotches and small spots of black and white; when caught, the swell shark may inflate its stomach with air, hence the name.
Size: Reaches a length of about 1.0 m. (3.3 ft.).
Distribution: Common in Monterey Bay, Calif., to southern California where it occurs near shore in shallow and deep waters; occasionally found southward to Acapulco, Mexico; also in Chile.
Remarks: We regard Cephaloscyllium uter a synonym of C. ventriosum.

4b. Labial grooves present at corners of mouth . . . . . 5a or 5b

5a. Color uniform brown or black without markings; snout long, distance from tip of snout to front of mouth about equal to mouth width; undersides of snout with a conspicuous pattern of pores (fig. 37) . . . . . 6a or 6b

5b. Color either variegated or plain; snout shorter, distance from tip of snout to front of mouth only about one-half the mouth width; undersides of snout with inconspicuous pores. . . . . 8a or 8b

6a. Scales on body surface closely packed, each scale a minute, slender spine with a single point . . . . . Apristurus spongiceps.

Descriptive notes: Shape of scales distinctive; other details lacking.
Size: One specimen known, an adult 50 cm. (1.6 ft.) long.
Distribution: Known only from vicinity of Bird Island, Hawaii, in 570 to 1,460 m. (313-800 fm.).
Remarks: The single specimen was unavailable for study.

6b. Scales on body surface overlap each other, each scale small, with three points . . . . . 7a or 7b

7a. Distance between dorsal fin bases 6.0 to 7.2 percent of total length . . . . . Brown cat shark, Apristurus brunneus.

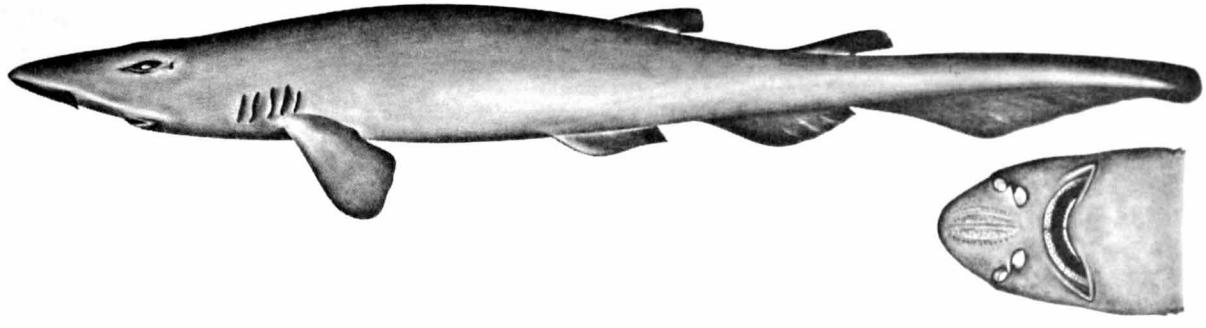


Figure 37.--Apristurus brunneus, 33 cm. (1.1 ft.) female, Washington State.

Descriptive notes: Body long and slender; head flattened; body plain brown.
Size: Eight adult specimens examined were 55 to 65 cm. (1.8 to 2.1 ft.) long.
Distribution: Continental slope southward from British Columbia, at least to northern Baja California.

7b. Distance between dorsal fin bases 9.7 percent of total length . . . . . Apristurus nasutus.

Remarks: Apristurus nasutus is a South American species, similar and possibly identical to A. brunneus. A single specimen examined from central Chile showed the difference in distance between dorsal fin bases; most other characters appear to be identical, but the pectoral fins of our specimen of A. nasutus were proportionately longer than pectoral fins of A. brunneus specimens at hand.

8a. Color plain dull grayish black on dorsal surface, a little lighter below; no well-defined spots or blotches; labial grooves of upper and lower jaws short, their lengths much less than horizontal diameter of eye . . . . . Halaelurus canescens.

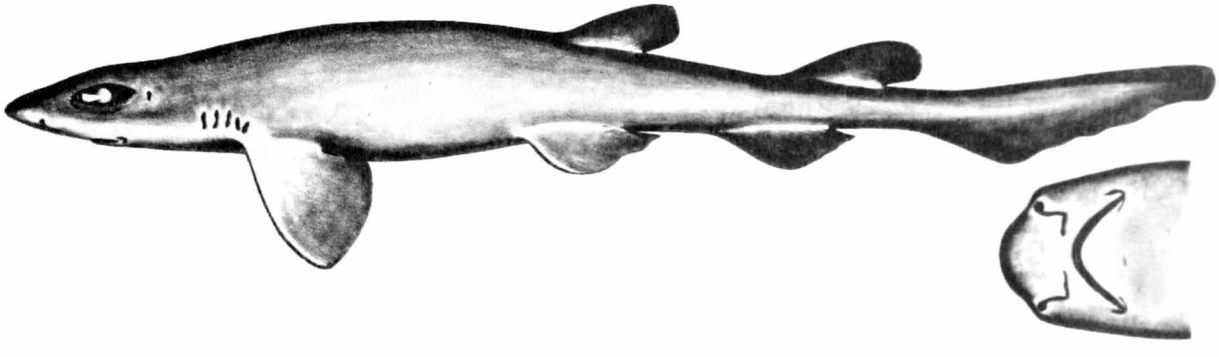


Figure 38.--Halaelurus canescens, 24 cm. (9.5 in.) female, central Chile.

Descriptive notes: Mouth wider, eye larger, caudal fin longer, and labial grooves shorter than other species of Halaelurus in eastern Pacific. The teeth are small and numerous, as compared with the teeth of H. bivius and H. chilensis, and do not exhibit the change in form with growth that characterizes the tooth development pattern in those two species.
Size: Grows to about 70 cm. (2.3 ft.).
Distribution: Known from off Peru and Chile, in depths of about 750 m. (400 fm.).

8b. Dorsal surfaces of body with numerous blotches and black spots, and sometimes with white spots also; ventral surfaces lighter but sometimes with a few spots of darker color; labial grooves of upper and lower jaws very long, their lengths about equal to horizontal diameter of eye. . . . . 9a or 9b

9a. Outer nasal flap much longer than inner nasal flap, with a prominent projecting lobe usually longer than wide; dorsal surfaces usually with a few irregularly spaced white spots among darker spots and blothces; small patch of denticles over posterior end of eye of adults moderately enlarged but denticles sharp-pointed, rough to touch. . . . . Halaelurus bivius.

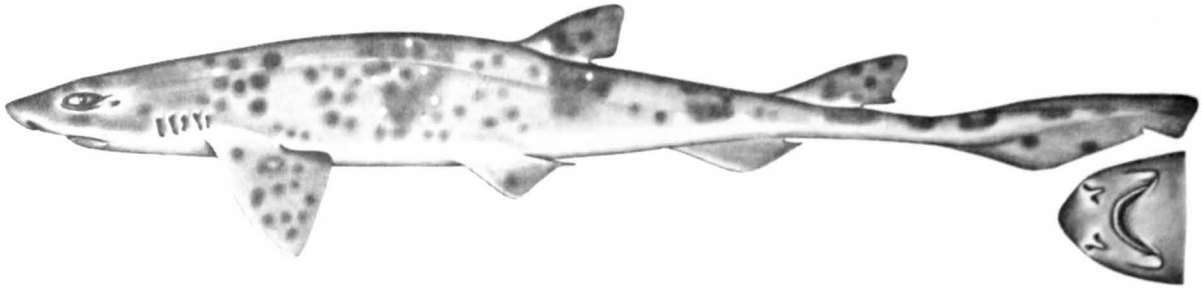


Figure 39.--Halaelurus bivius, 44 cm. (1.5 ft.) female, southern Chile.

Descriptive notes: Comparing adult males of bivius and chilensis we find that in bivius the head is narrower and longer, the snout more definitely pointed and longer, and the arch of the jaws longer and narrower than in chilensis.
Size: Adult males at hand are about 60 cm. (2.0 ft.) long.
Distribution: Known from southern Chile, in cool shore waters.
Remarks: H. bivius occurs around the southern tip of Chile to Argentina in the western South Atlantic.

9b. Outer and inner nasal flaps about the same length, outer flap without a projecting lobe; dorsal surfaces usually without white spots among darker spots and blotches; small patch of denticles over posterior end of eye of adults enlarged and lacking points, smooth to touch . . . . . Pintarroja, Halaelurus chilensis.

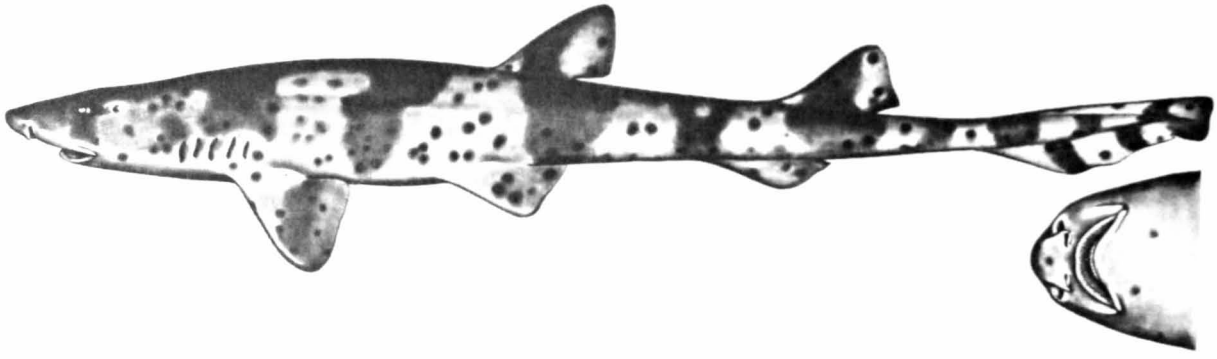


Figure 40.--Halaelurus chilensis, 39 cm. (1.2 ft.) female, Peru.

Descriptive notes: In young specimens two rows of enlarged scales (tubercles) present on back, one row of about 12 scales on each side of midline, regularly spaced from back of head to first dorsal fin; enlarged scales less prominent in larger specimens, obscure or absent in adults. Color of some adult specimens very dark, with markings on dorsal surfaces obscured. In addition to color differences, adult H. chilensis differ from the young in having mostly unicuspid teeth instead of the tricuspid form.
Size: An adult male at hand is 54 cm. (1.8 ft.) long.
Distribution: From Peru to southern Chile, in inshore waters.
Remarks: Both Halaelurus bivius and H. chilensis exhibit remarkable changes with growth. Our specimens of the two species are not numerous enough to determine these changes in detail. Apparently the teeth of young examples of both species are tricuspid, but after sexual maturity the replacement teeth of males are unicuspid and proportionally longer. The jaws of our immature examples of H. chilensis are rather broad with a low arch, but the jaws of the adults that we have seen have high arches and are similar in shape to the jaws of adult male H. bivius.

HAMMERHEAD SHARKS, FAMILY SPHYRNIDAE

Contrary to popular opinion, all hammerhead sharks are not the same; in fact there are nine distinct species, six of which are found in the eastern Pacific. All six species are found close to shore; some are more or less restricted to shallow waters, but others range far out to sea. Most hammerhead sharks are found in warm waters, but at least one species is common in the cooler waters off California and Chile; two other species wander occasionally into cool waters.

Identification of species of hammerhead sharks is facilitated by differences in the shape of the head. It should be kept in mind, however, that the head shape changes to some extent with growth, so that young hammerheads may look somewhat different from older individuals. The size of a specimen may also be of help in its identification. Three species (Sphyrna corona, S. media and S. tiburo) do not exceed 1.5 m. (5.0 ft.) in total length, but the other three (S. lewini, S. mokarran and S. zygaena) grow much larger.

The following key and descriptions are adapted from Gilbert (1967). Liberal use should be made of the figures for comparison with the specimen at hand.

Key to Hammerhead Sharks, Family Sphyrnidae

1a. Contour of front margin of head distinctly undulated (figs. 41, 42 and 43); fifth gill slit smaller than first gill slit; horizontal diameter of eye greater than distance between eye and nostril . . . . . 2a or 2b

1b. Contour of front margin of head smooth or only slightly undulated (figs. 44, 45 and 46); fifth gill slit about equal to first gill slit; horizontal diameter of eye less than distance between eye and nostril . . . . . 4a or 4b

2a. Front margin of head divided into three lobes; midline of head rounded (or nearly straight in large individuals), not indented; base of anal fin about equal to base of second dorsal fin . . . . . Smooth hammerhead, Sphyrna zygaena.

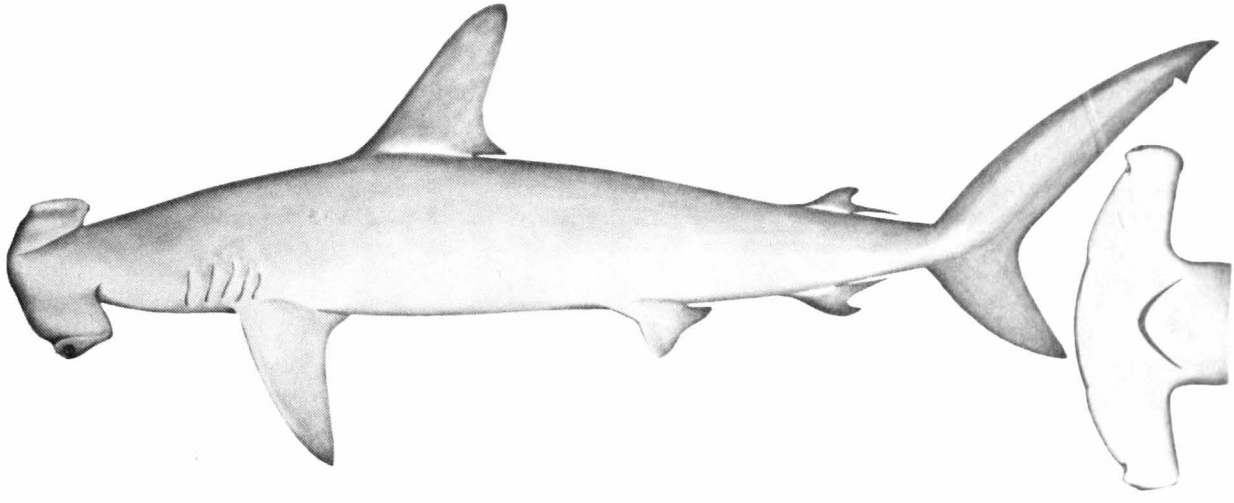


Figure 41.--Sphyrna zygaena, 257 cm. (8.4 ft.) female, southern California.

Descriptive notes: Rear tip of second dorsal fin about twice as long as height of fin; anal fin much higher than second dorsal fin; upper and lower teeth usually smooth, but sometimes weakly serrated, especially in large individuals; lower precaudal pit absent; base of anal fin slightly smaller than base of pectoral fin.

Size: A large shark may grow to about 4.0 m. (13 ft.), but largest one on record from eastern Pacific was about 3.4 m. (11 ft.).

Distribution: Pelagic, on the high seas and in coastal waters; usually in cooler waters; recorded from central California to the Gulf of California, Panama (one record), the Galapagos Islands, and from Ecuador to Chile.

2b. Front margin of head divided into four lobes; midline of head indented; base of anal fin longer than base of second dorsal fin . . . . . 3a or 3b

3a. Length of free rear tip of second dorsal fin about twice height of fin; first dorsal fin erect, not swept backward. . . . . Scalloped hammerhead, Sphyrna lewini.

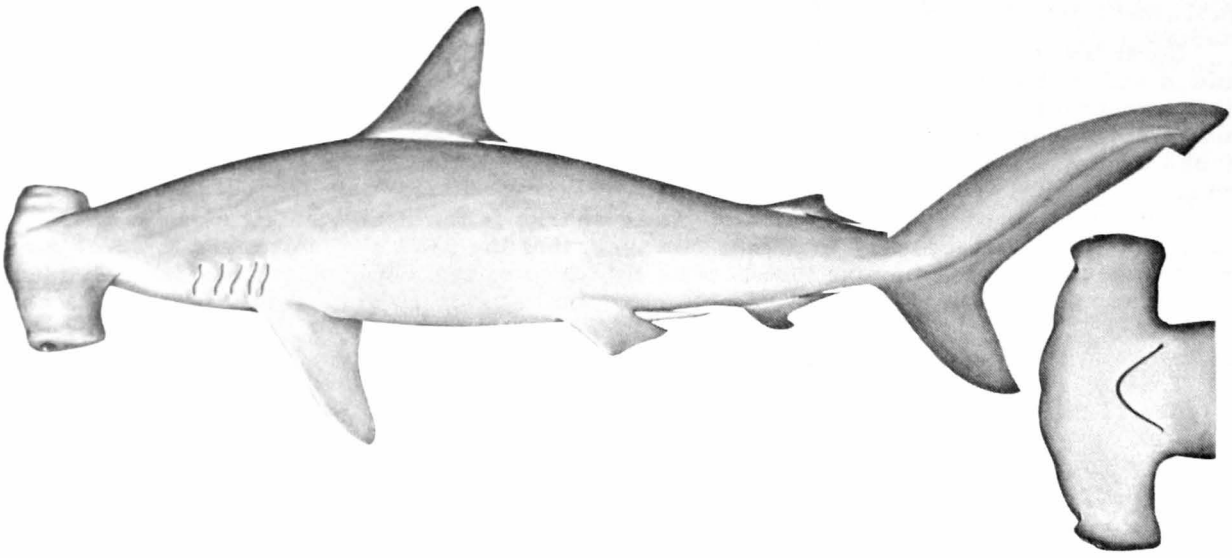


Figure 42.--Sphyrna lewini, 227 cm. (7.4 ft.) male, probably Baja California.

Descriptive notes: Bases of anal, pectoral and pelvic fins about equal; anal fin much higher than second dorsal fin; lower precaudal pit usually present; outer margin of pelvic fins straight; bases of teeth wavy, but cusps not conspicuously serrated, at most weakly and irregularly serrated.

Size: A large species, probably grows to about 3.7 m. (12 ft.).

Distribution: Pelagic, inshore, and far out at sea; usually found in warm waters but occasionally wanders into cooler waters; reported from southern Baja California to Ecuador, and the Hawaiian and Revillagigedo Islands; possibly occurs occasionally near northern Peru, a report from southern California was erroneous.

Remarks: Embryos and young of scalloped hammerheads have relatively longer and narrower heads than the specimen figured.

3b. Length of free rear tip of second dorsal fin less than 1.5 times height of fin; first dorsal fin distinctly swept backward . . . . . Great hammerhead, Sphyrna mokkaran.

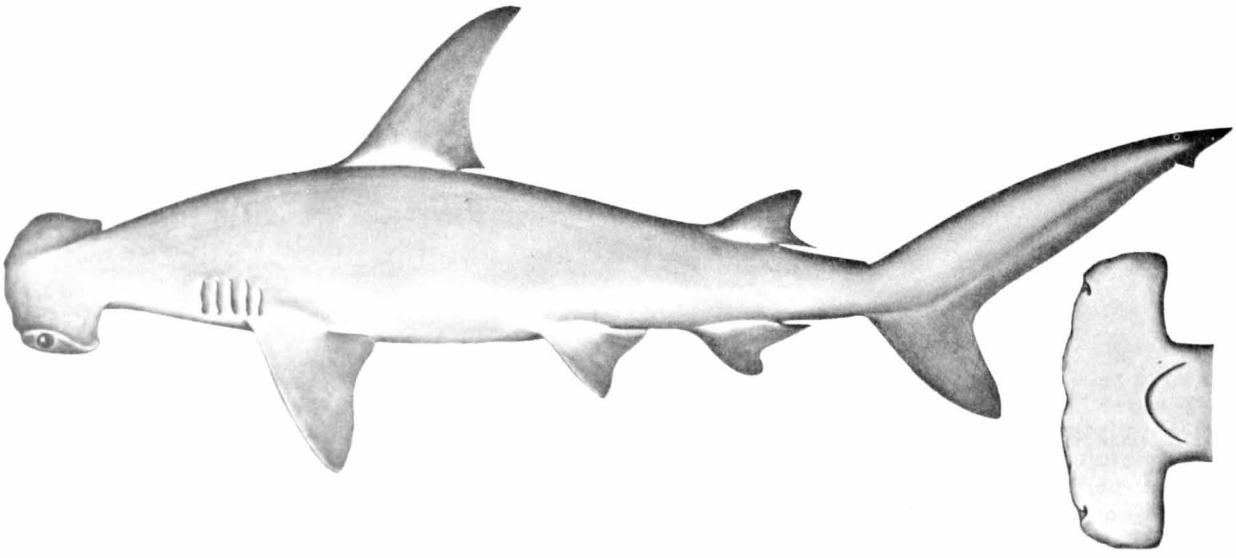


Figure 43.--Sphyrna mokarran, 123 cm. (4.0 ft.) male, Gulf of California.

Descriptive notes: Head nearly rectangular in large individuals, but front margin extended forward in young; second dorsal fin slightly higher than anal fin; lower precaudal pit present; outer margin of pelvic fins falcate; teeth distinctly serrated.

Size: Largest of all hammerheads, one caught off Acapulco, Mexico, measured 4.33 m. (14.2 ft.); probably grows to about 5.5 m. (18 ft.).

Distribution: In warm coastal waters and probably out at sea; from southern Baja California and the Gulf of California to Panama; possibly strays to northern Peru.

4a. Head spade-shaped, the anterior margin extended forward and smoothly rounded, without a notch at the midline; rear tip of first dorsal fin never extends to a point over base of pelvic fins . . . . . Pacific bonnethead, Sphyrna tiburo.

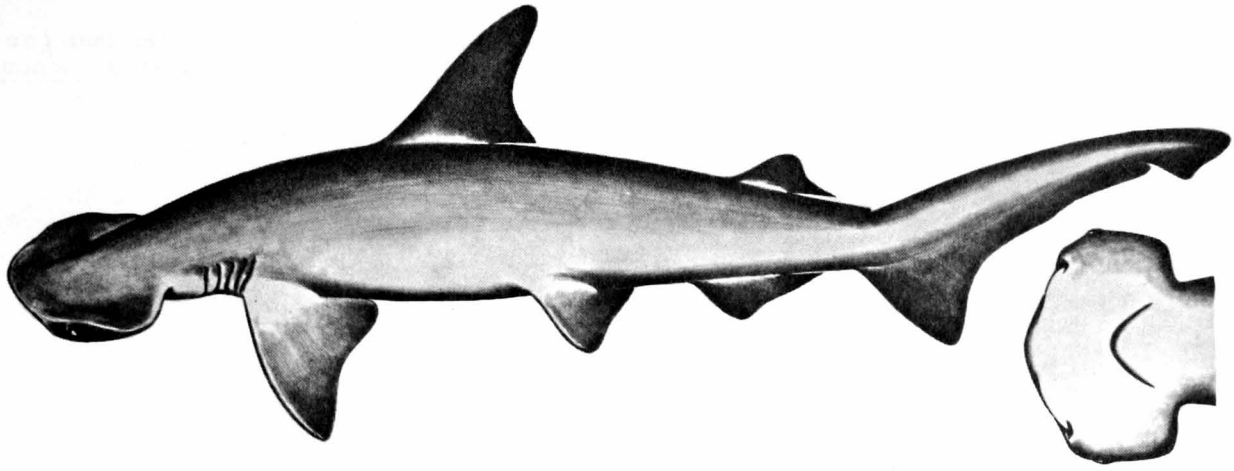


Figure 44.--Sphyrna tiburo, 69 cm. (2.2 ft.) male, Gulf of California.

Descriptive notes: Head spade-shaped; teeth not serrated, those in corners of lower jaws without sharp points; lower precaudal pit present; origin of first dorsal fin well behind rear end of pectoral base.
Size: A small shark, grows to perhaps 1.4 m. (4.5 ft.).
Distribution: Inshore, from the Gulf of California to northern Peru; occasionally found as far north as southern California.
Remarks: The Pacific bonnethead was first described as Sphyrna vespertina, but later workers considered it identical with the Atlantic bonnethead, tiburo. In his recent revision of family Sphyrnidae, Gilbert (1967) considered the two forms distinct at the subspecific level, the Pacific bonnethead taking the name tiburo vespertina and the Atlantic form tiburo tiburo.

4b. Head not spade-shaped, the anterior margin nearly straight, or with slight undulations, or sometimes with a shallow indentation at the midline; rear tip of first dorsal fin extends beyond anterior part of base of pelvic fins . . . . . 5a or 5b

5a. Distance from middle of front margin of head to front of mouth usually less than two-fifths (40 percent) of greatest width of head. . . . . Scoophead, Sphyrna media.

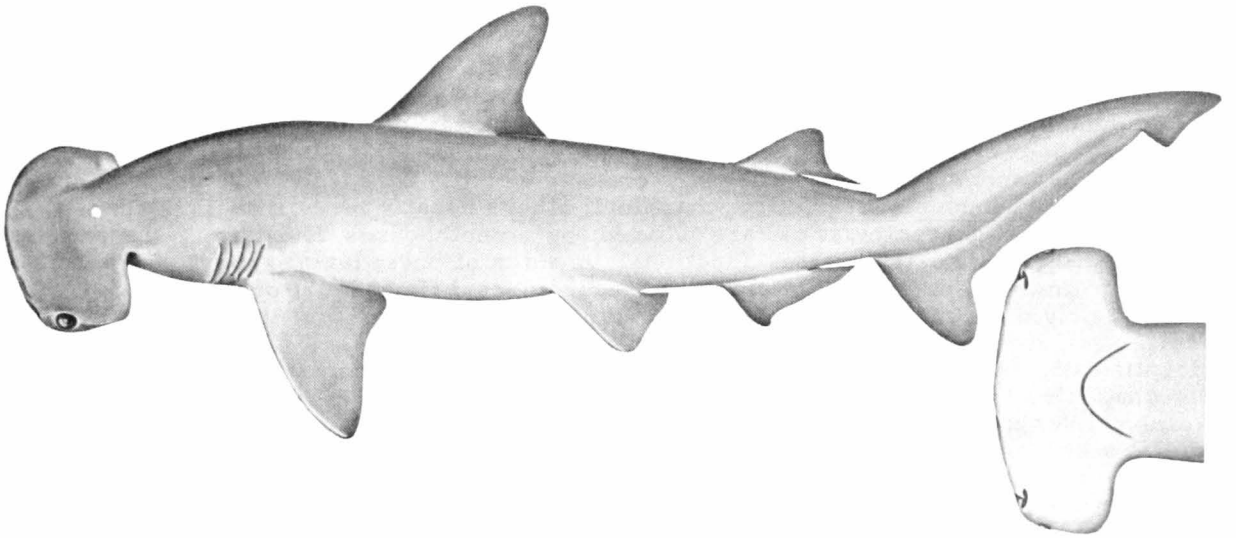


Figure 45.--Sphyrna media, 83 cm. (2.8 ft.) female, Gulf of California.

Descriptive notes: Head wide, front margin relatively straight, sometimes with slight undulations or a shallow notch at the midline; all teeth with pointed cusps; anal fin somewhat falcate, apex pointed; lower precaudal pit present.

Size: A small species of hammerhead; grows to about 1.5 m. (5.0 ft.).
Distribution: Inshore from the Gulf of California to Ecuador, and probably to northern Peru.

b. Distance from middle of front margin of head to front of mouth usually greater than two-fifths (40 percent) of greatest width of head. . . . . Sphyrna corona.

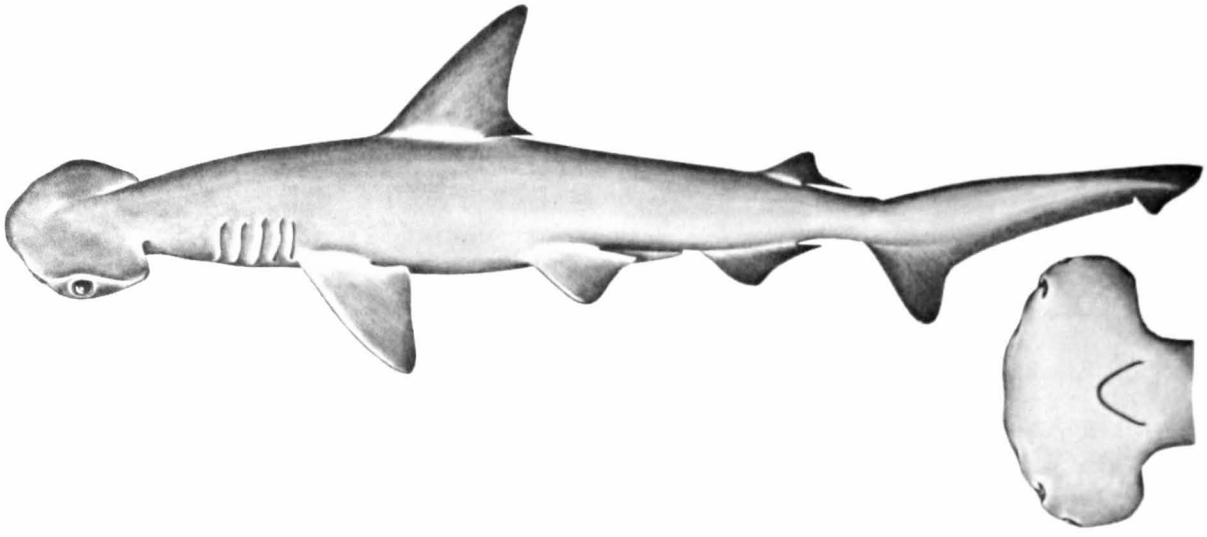


Figure 46.--Sphyrna corona, 66 cm. (2.3 ft.) male, Pacific side of Panama.

Descriptive notes: Head somewhat extended forward, front margin sometimes divided into four lobes by shallow indentations; midline of head sometimes with a shallow indentation; all teeth with pointed cusps; anal fin less falcate and its apex more rounded than in S. media; lower precaudal pit present.
Size: Probably the smallest species of hammerhead, perhaps growing to 90 cm. (3.0 ft.).
Distribution: Inshore, reported from Colombia to southern Mexico, but possibly present from the Gulf of California to northern Peru.

SMOOTHHOUNDS, FAMILY TRIAKIDAE

Smoothhounds are relatively small sharks, none exceeding 1.8 m. (6.0 ft.), and are usually found close to shore near the bottom.

Three genera and seven species have been described from the eastern Pacific: Mustelus (four species), Rhinotriacis (one species), and Triakis (two species). At least two other unidentified smoothhounds, and probably several more, exist in the eastern Pacific. No smoothhounds have been recorded from the Hawaiian Islands or the Galapagos Islands, but we have seen three specimens that were allegedly collected at the Galapagos Islands. We consider the reef whitetip, Triaenodon obesus, a carcharhinid; others usually place it in Triakidae.

The following characteristics are shared by smoothhounds found in the eastern Pacific: teeth small, more than two series functional in sides of jaws; labial grooves, nasal flaps, and spiracles prominent; precaudal pits absent; second dorsal fin at least one-half as large as first dorsal fin; origin of anal fin well behind origin of second dorsal fin; lower intestine spirallike in form.

Identification of species of smoothhounds is complicated by remarkable variations in color, and in shapes and positions of parts of the body. Individual differences, changes that occur with growth, and even differences between sexes contribute to the variations.

Relationships among the genera and species are not clear because of lack of adequate information on life histories and morphological variation within species. Tooth shape has been used as the primary distinguishing character to separate the genera, but we have found this character, by itself, unsatisfactory for eastern Pacific members of Triakidae. The mode of development may be a clue to the affinities of the species. Embryos of T. semifasciata are not attached to the uterine wall of the mother by a placenta, but embryos of Rhinotriacis henlei, Mustelus californicus, and M. lunulatus all have placental attachment. The mode of development of South American triakids is not known.

Key to Smoothhounds, Family Triakidae

1a. Body with numerous dark bars and large dark spots . . . . . Leopard shark, Triakis semifasciata.

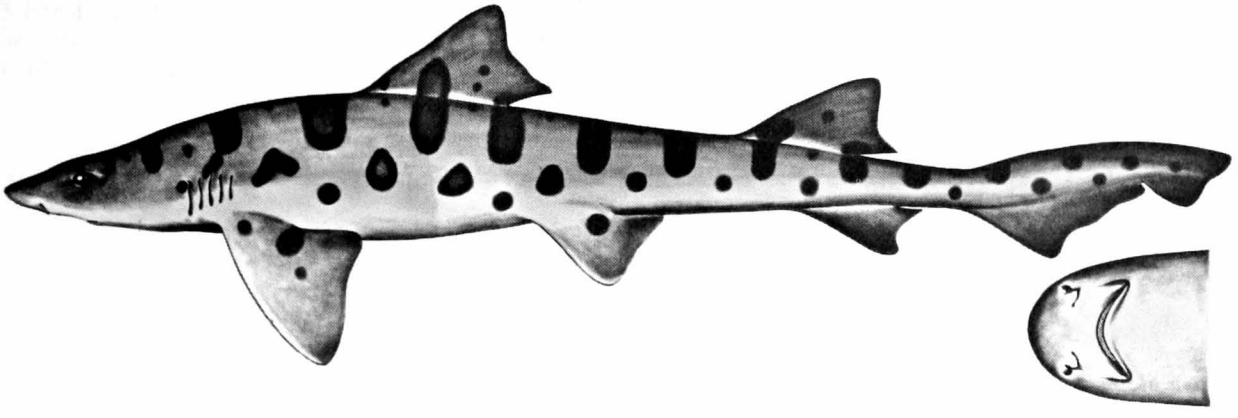


Figure 47.--Triakis semifasciata, 57 cm. (1.9 ft.) female, central California.

Descriptive notes: Color pattern unique; snout rather blunt; teeth sharply pointed, usually with smaller secondary cusps on one or both sides of the main cusp (secondary cusps may be absent in some large individuals).
Size: Males grow to about 1.5 m. (5.0 ft.), females to about 1.8 m. (5.9 ft.).
Distribution: Inshore, from central California to the Gulf of California; may occur as far north as the coast of Oregon.
Remarks: A few individuals have anomalous color patterns with irregular dark streaks rather than bars and spots.

1b. Body plain gray or brown, or with either bars or spots, but never both . . . . . 2a or 2b

2a. Snout tip somewhat rounded; lower jaw rounded (fig. 48, ventral view of head). . . . . Tollo manchado, Triakis maculata.

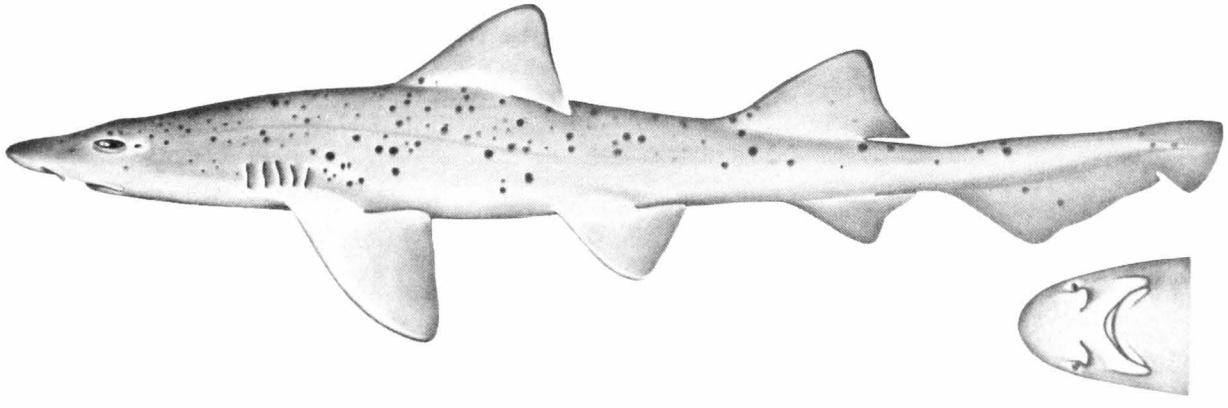


Figure 48.--Triakis maculata, spotted phase, 31 cm. (1.0 ft.) female, Peru.

Descriptive notes: Teeth of young usually with two or three low, sharp asymmetrical cusps; older individuals apparently with only a single narrowly triangular cusp rising from a broad base; most young and some older individuals light gray, mottled with small dark spots; some young and most adults plain gray; first dorsal fin broad and low, triangular, the rear margin sloped backward from the apex, the anterior and posterior margins usually edged with black.
Size: A stout shark, grows to nearly 1.8 m. (5.9 ft.).
Distribution: Inshore, northern Chile and Peru; one specimen reported, probably erroneously, from the Gulf of California.

Remarks: The specimen figured here is a small spotted individual; other specimens may be plain gray. A second species of Triakis, as yet unidentified, occurs in South American waters; we have seen two adult specimens from Ecuador. Since this species has a rounded snout tip and lower jaw, it will fit in the key as T. maculata. It can be distinguished from T. maculata by the shapes of the first dorsal fin and lower lobe of the caudal fin, which are similar to those of Mustelus lunulatus (compare the fins in fig. 50A with those of T. maculata).

2b. Snout tip pointed or only slightly rounded; lower jaw distinctly angular, the sides nearly straight, coming together to form a broad tip at the forward end (fig. 49, ventral view of head) . . . . . 3a or 3b

3a. Midpoint of base (excluding the fleshy part) of first dorsal fin distinctly closer to origin of pelvic fins than to rear end of base of pectoral fins . . . . . Gray smoothhound, Mustelus californicus.

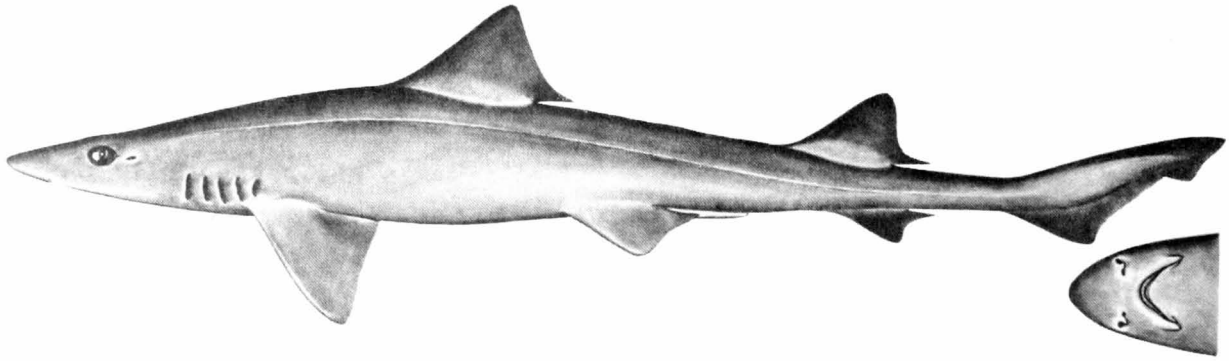


Figure 49.--Mustelus californicus, 62 cm. (2.0 ft.) male, Baja California.

Descriptive notes: Teeth rounded, in pavementlike rows; snout tip slightly rounded, may be shaprer in males and in smaller specimens; lateral line without white spots; color plain gray of all ages.
Size: Grows to nearly 1.1 m. (3.7 ft.).
Distribution: Inshore, from central California to the Gulf of California.

3b. Midpoint of base of first dorsal fin (excluding the fleshy part) about equidistant from origin of pelvic fins and rear end of base of pectoral fins, or closer to the latter . . . . . 4a or 4b

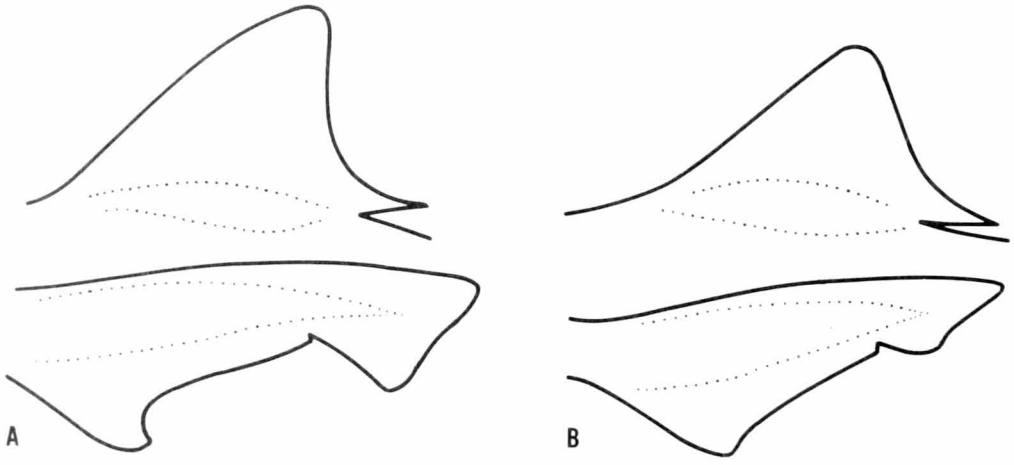


Figure 50.--Shapes of dorsal and caudal fins: A - Dorsal fin abruptly vertical from the apex, lower lobe of caudal fin distinct; B - Dorsal fin inclined backward from the apex, lower lobe of caudal fin not distinct.

4a. Rear margin of first dorsal fin abruptly vertical from the apex (fig. 50A); lower caudal lobe well marked, with a distinctly pointed tip (the lower lobe may not be well marked in specimens under 25 cm. or 10 in.) . . . . . Sicklefin smoothhound, Mustelus lunulatus.

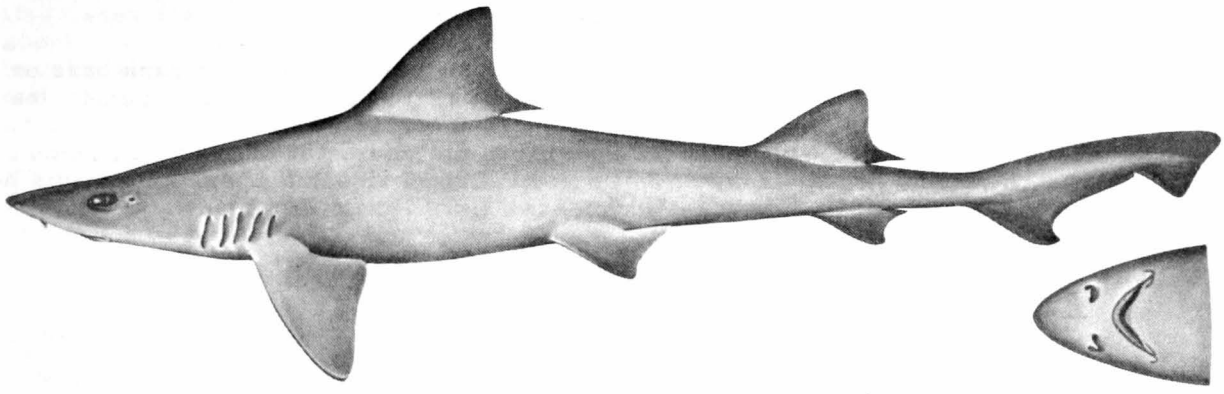


Figure 51.--Mustelus lunulatus, 66 cm. (2.2 ft.) male, Gulf of California.

Descriptive notes: Teeth small, in pavementlike rows, usually rounded but sometimes with a low, sharp cusp; color plain brown or gray at all ages; eyes large; snout rather pointed and long; fins of some specimens apparently with white tips and edges.

Size: Mature specimens in the Gulf of California, where this species is abundant, commonly are about 1.4 m. (4.6 ft.); several specimens between 1.6 and 1.7 m. (5.3 - 5.7 ft.) have been reported, but we are not certain that they were correctly identified.

Distribution: Inshore, from Baja California to Central America; probably strays as far north as southern California.

Remarks: At least two unidentified smoothhounds with fins similar to those of the sicklefin smoothhound occur in the eastern Pacific, one in the Gulf of California and the other possibly at the Galapagos Islands. We are not certain if differences in vertebral number, eye size, tooth shape, and fin sizes are significant. The unidentified forms may be new species, or may represent morphological variants of the sicklefin smoothhound.

4b. Rear margin of first dorsal fin inclined backward from the apex (fig. 50B); caudal fin usually without a well-marked lower lobe (a small lobe with a rounded tip is present in some specimens over 50 cm. or 20 in.) . . . . . 5a or 5b

5a. Teeth rounded, without sharp cusps; some individuals plain gray but most marked with dark transverse bars or white flecks . . . . . Tollo, Mustelus mento.

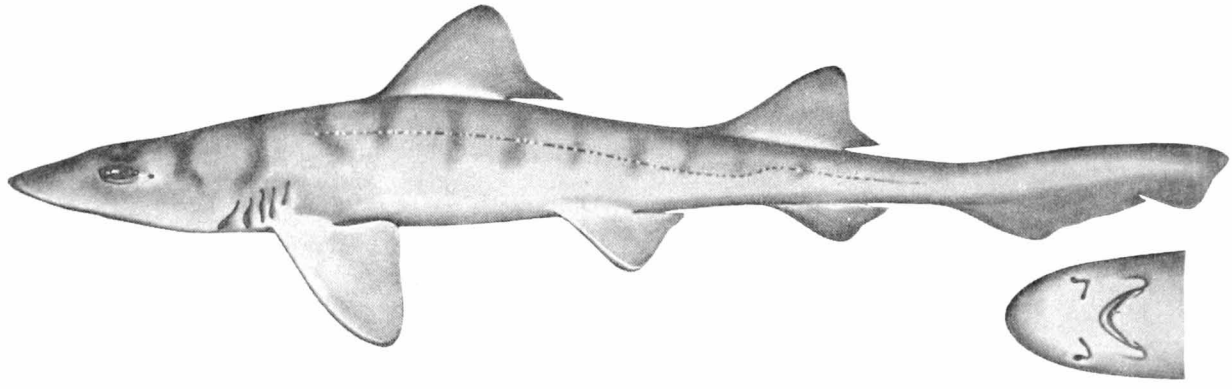


Figure 52.--Mustelus mento, 26 cm. (10.0 in.) female, Peru.

Descriptive notes: Color variable, most juveniles with dark transverse bars on the dorsal surface, or with white flecks scattered about the back and upper sides; adults often with white flecks; some juveniles and adults plain gray; lateral line usually marked with white dots and lines; lower caudal usually without a distinct lobe, but large specimens may have a short rounded lobe.

Size: Grows to at least 1.2 m. (4.0 ft.).
Distribution: Inshore, Chile and Peru; reported from the Juan Fernandez Islands off Chile; possibly present at the Galapagos Islands.
Remarks: The specimen figured here is a barred juvenile; larger specimens usually lack bars.

5b. Teeth with one to three low but pointed cusps; body plain, never with dark bars or white flecks. . . . . 6a or 6b

6a. Height of third gill slit distinctly shorter than horizontal diameter of eye. . . . . Brown smoothhound, Rhinotriacis henlei.

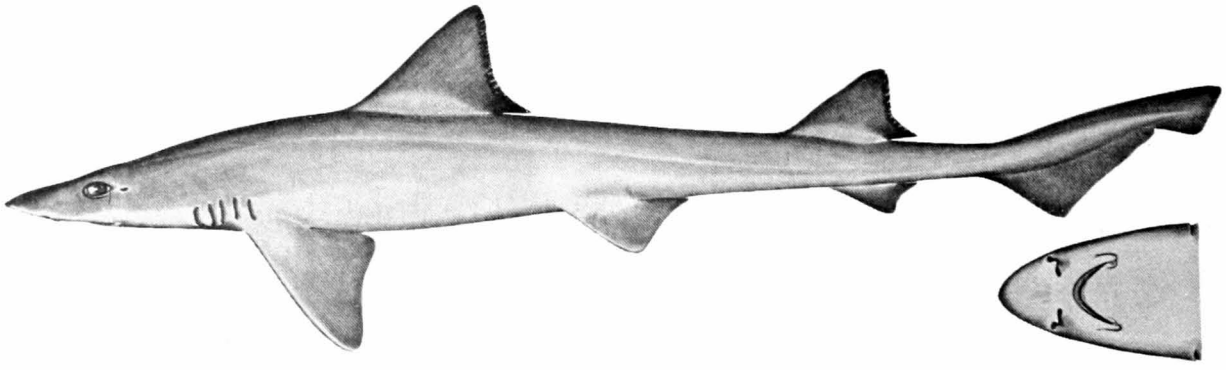


Figure 53.--Rhinotriacis henlei, 78 cm. (2.6 ft.) female, central California.

Descriptive notes: Rear margins of dorsal fins frayed and thin; teeth small, with a pointed main cusp, either unicuspid or with a smaller cusp on one or both sides of the main cusp; snout pointed; caudal fin without a distinct lower lobe, at most a small protrusion; color plain gray or brown at all sizes.
Size: A small species, grows to about 95 cm. (3.1 ft.).
Distribution: Inshore, from central California to the Gulf of California.
Remarks: The brown smoothhound has been placed by various workers in Mustelus, Rhinotriacis, and Triakis. It appears to be more closely related to species of Mustelus than to those of Triakis, but we have retained the original genus Rhinotriacis.

6b. Height of third gill slit about equal to or greater than horizontal diameter of eye. . . . . Sharptoothed smoothhound, Mustelus dorsalis.

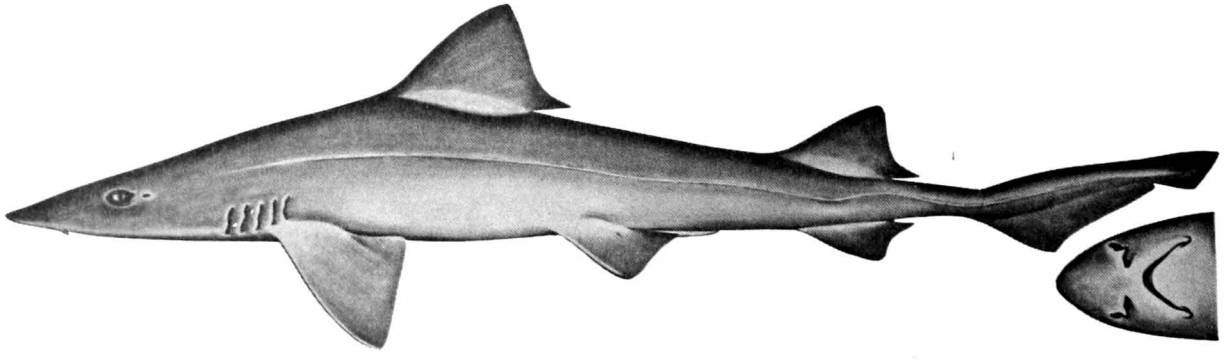


Figure 54.--Mustelus dorsalis, 39 cm. (1.3 ft.) male, Pacific side of Panama.

Descriptive notes: Snout pointed and long; eyes small; teeth erect, with a small pointed cusp arising from a broad base, infrequently with a short secondary cusp at the base; color plain brown or gray at all sizes.
Size: Not sufficiently known, probably a small species; males of 425 mm. (17 in.) were nearly mature.
Distribution: Recorded from the Gulf of California and from Costa Rica to Peru; records from the Gulf and those south of Panama were probably erroneous.

Remarks: An unidentified species which occurs off Peru will fit in the key here; it is similar to M. dorsalis in having sharply pointed teeth, relatively large gill slits and small eyes, and a pointed snout. It is apparently common off Peru and probably has been captured before but recorded as Mustelus dorsalis. The unidentified species can be distinguished from M. dorsalis by the following characteristics: horizontal diameter of eye about two-fifths (40 percent) of distance between snout tip and mouth; upper teeth oblique, usually with a secondary cusp at the base; rear margins of first and second dorsal fins and caudal fin usually frayed and thin. Corresponding characteristics of M. dorsalis are: horizontal diameter of eye about one-third (33 percent) of distance between snout tip and mouth; upper teeth erect, usually without a secondary cusp at the base; rear margins of all fins not thin, only rarely frayed. In addition, the unidentified form is a larger species; male specimens of 56 cm. (22 in.) were definitely immature, and specimens over 90 cm. (3.0 ft.) have been captured.

REQUIEM SHARKS, FAMILY CARCHARHINIDAE

The requiem sharks constitute the largest of all families of sharks. Seven genera are represented in eastern Pacific and Hawaiian waters. Three of these genera, Galeocerdo, Prionace, and Triaenodon are generally considered to be comprised of single species. Three genera, Galeorhinus, Negaprion, and Rhizoprionodon, include several species, but only one species of each genus is found in the eastern Pacific. The genus Carcharhinus, however, is represented by 14 species in eastern Pacific and Hawaiian waters. The common "gray sharks" and other "typical" sharks belong to this genus.

Because requiem sharks are diverse in form, it is difficult to characterize the family. Some traits held in common by most of the species described here are: only one or two rows of teeth upright at sides of jaws, although more rows may be upright near the center; lower caudal expanded into a distinct lobe; at least upper precaudal pit present (except Galeorhinus); lower intestine in the form of a scroll (except Galeorhinus); teeth unicuspid (except Triaenodon); spiracles absent (except in Galeocerdo, Galeorhinus, and possibly in young individuals of Negaprion).

Key to Requiem Sharks, Family Carcharhinidae

1a. Sides of trunk in front of tail extended outward to form a low, hard keel; body with dark transverse blotches or stripes, especially prominent in small individuals, but often faded in larger individuals . . . . . Tiger shark, Galeocerdo cuvieri.

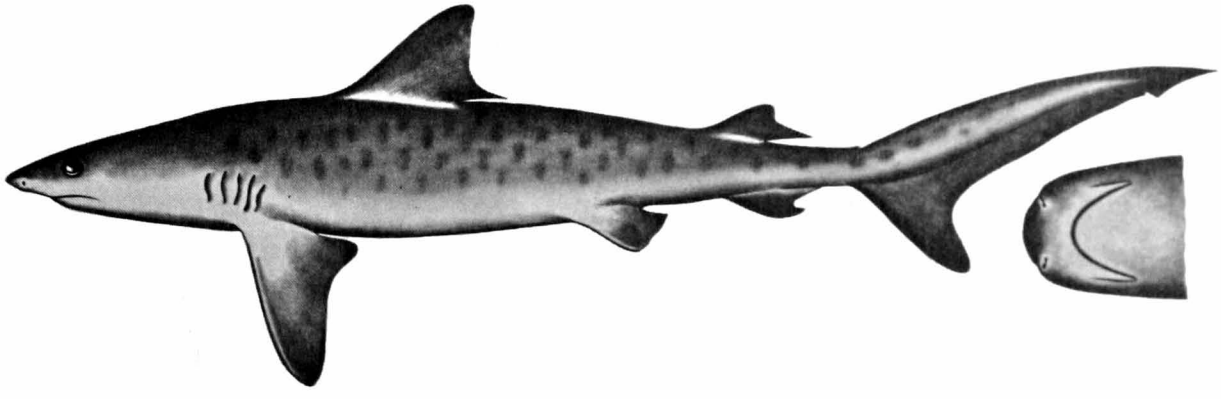


Figure 55.--Galeocerdo cuvieri, 140 cm. (4.6 ft.) female, Gulf of California.

Descriptive notes: Head blunt; mouth far forward; upper labial groove long; all teeth curved, notched on one side, and coarsely serrated.
Size: Grows to about 5.5 m. (18 ft.), but individuals more than 4.2 m. (14 ft.) long are rare.
Distribution: Usually found in warm inshore waters, but sometimes found far out at sea and in colder waters; reported from southern California to Peru, and from Cocos, Galapagos, Revillagigedos, Tres Marias, and Hawaiian Islands.

1b. Sides of trunk in front of tail without a keel (a faint keel may sometimes be present in Prionace); body without dark transverse blotches or stripes . . . . . 2a or 2b

2a. Precaudal pits absent; spiracles prominent. . . . . Soupfin shark, Galeorhinus zyopterus.

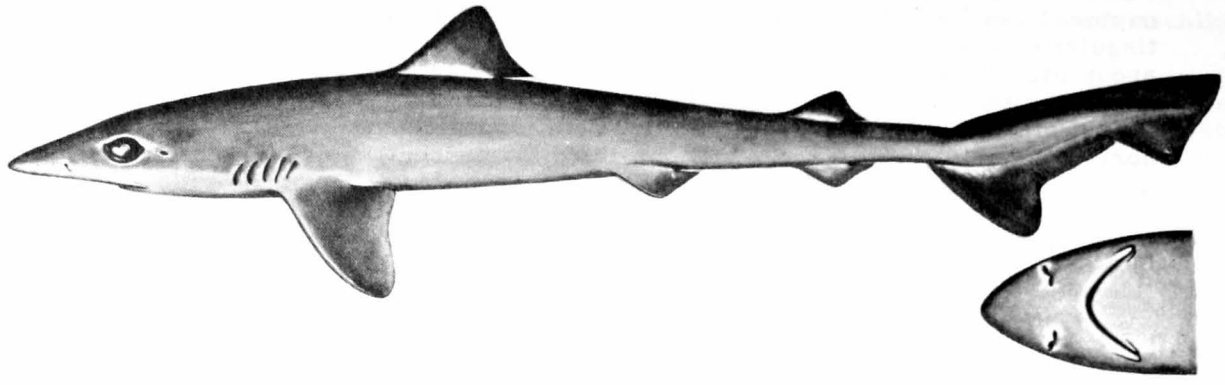


Figure 56.--Galeorhinus zyopterus, 50 cm. (1.7 ft.) female, central California.

Descriptive notes: Upper and lower teeth similar, with main cusps directed toward corners of jaws, a deep notch on one side of each tooth, with coarse denticles or points present from notch to base; main cusps nonserrated; snout long; labial folds long; eyes almond-shaped.
Size: Females grow to about 2.0 m. (6.5 ft.), males slightly less.
Distribution: Inshore in cool waters from British Columbia to central Baja California in North America, and from Peru and Chile in South America; not reported from offshore islands, with the possible exception of one individual reported about year 1900 from Laysan Island (near Hawaii).

2b. At least upper precaudal pit present; spiracles very tiny or absent . . . . . 3a or 3b

3a. Teeth multicuspid, with smaller sharp cusps on one or both sides of the main cusp . . . . . Reef whitetip, Triaenodon obesus.

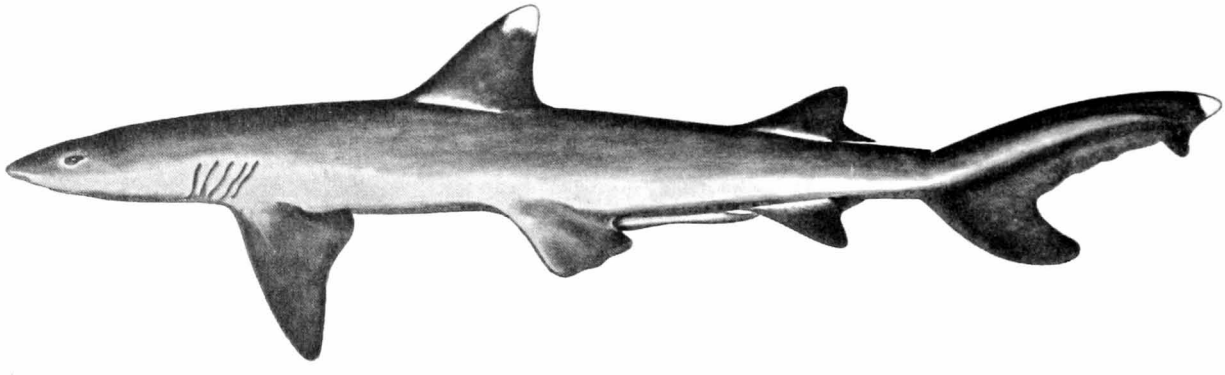


Figure 57.--Triaenodon obesus, 134 cm. (4.4 ft.) male, Johnston Island, central Pacific.

Descriptive notes: Dorsal fins and caudal fin with white tips; head depressed; snout blunt; nasal flaps prominent; spiracles absent; labial folds absent or minute; skin smooth.
Size: Reported to attain 2.2 m. (7.0 ft.), but pregnant females slightly under 1.5 m. (5.0 ft.) have been found.
Distribution: An insular species, common at the Galapagos Islands; reported from Cocos Island and the Hawaiian Islands; only one specimen has been captured near the continental shore, at Panama.
Remarks: Triaenodon nigricans Philippi, referred to as a synonym of T. obesus is a telelost. The reef whitetip has usually been included in family Triakidae, but we place it in Carcharhinidae because most of its characteristics, excluding tooth shape, are those found in carcharhinid sharks.

3b. Teeth unicuspid . . . . . 4a or 4b

4a. Second dorsal fin nearly as large as first dorsal fin . . . . . Tiburon amarillo, Negaprion fronto.

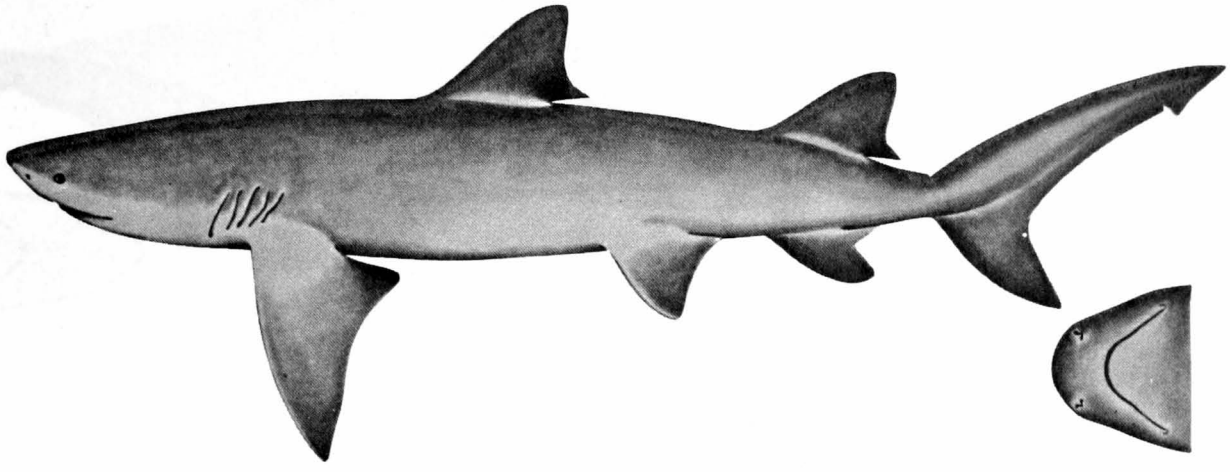


Figure 58.--Negaprion fronto, 188 cm. (6.2 ft.) female, Nayarit, Mexico.

Descriptive notes: Cusps of upper and lower teeth narrowly triangular, nonserrated, erect; snout blunt; eyes small.
Size: Grows to about 3.0 m. (10 ft.).
Distribution: In warm inshore waters, from the Gulf of California to Ecuador, and probably Peru; not reported from the offshore islands.

4b. Second dorsal fin less than one-third as large as first dorsal fin . . . . . 5a or 5b

5a. Upper and lower labial grooves prominent (fig. 59, ventral view of head) . . . . . Pacific sharpnose shark, Rhizoprionodon longurio.

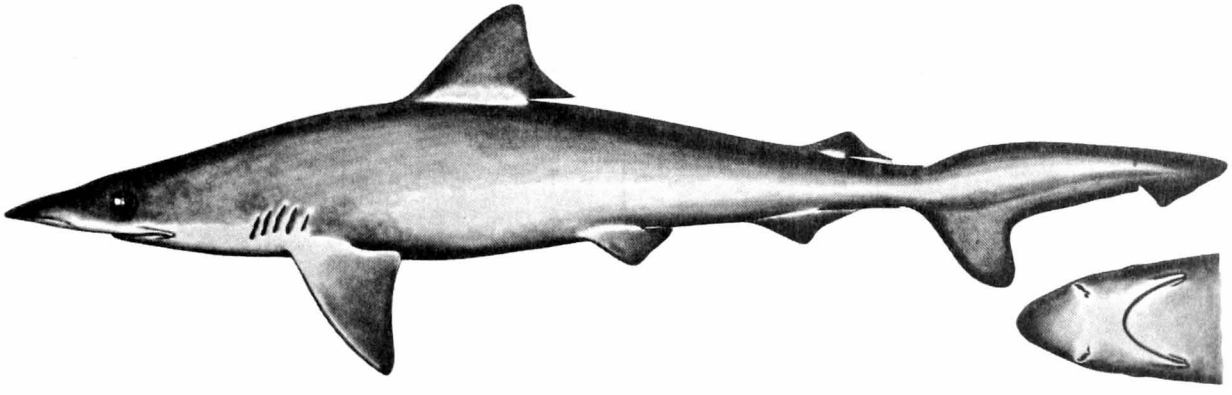


Figure 59.--Rhizoprionodon longurio, 50 cm. (1.7 ft.) male, Gulf of California.

Descriptive notes: Upper and lower teeth nonserrated, slanted toward the corners of jaws, with a deep notch on one side; snout long and sharply pointed; origin of second dorsal fin well behind origin of anal fin.
Size: A small and slender shark; grows to about 1.1 m. (3.6 ft.).
Distribution: In warm to somewhat cool coastal waters, from southern California to Peru; not reported from the offshore islands.
Remarks: This species has been referred to as Scoliodon longurio.

5b. Labial grooves very short or absent . . . . . 6a or 6b

6a. First dorsal fin far back, midpoint of its base closer to origin of pelvic fins than to rear end of base of pectoral fins; body dark blue. . . . . Blue shark, Prionace glauca.

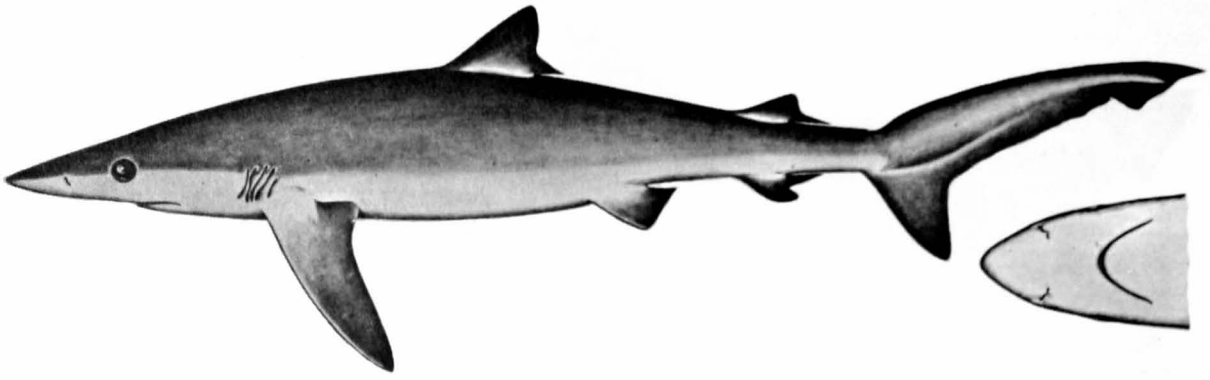


Figure 60.--Prionace glauca, 80 cm. (2.7 ft.) female, offshore eastern Pacific.

Descriptive notes: Upper teeth usually serrated (outermost series sometimes smooth in old specimens), smoothly curved; snout long and pointed; pectoral fins long.
Size: A large but slender shark, may grow to 4.5 m. (14.8 ft.); largest one on record was 3.76 m. (12.3 ft.).
Distribution: Found far out at sea and near continental shores, in warm and cool waters; reported from the Gulf of Alaska to Baja California, and from Chile, Peru, and the Hawaiian Islands.

6b. First dorsal fin further forward, midpoint of its base closer to rear end of base of pectoral fins than to origin of pelvic fins, or about equidistant from both points; body gray or brown, not blue (genus Carcharhinus). . . . . 7a or 7b

7a. A longitudinal ridge present on the middle of the back between the two dorsal fins (fig. 61A). . . . . 14a or 14b

Figure 61.--Cross section of trunk between the dorsal fins: A - Shark with a ridge on the back; B - Shark without a ridge on the back.

7b. Back smooth, no ridge between the two dorsal fins (fig. 61B); (the backs of preserved or dried specimens sometimes appear ridged). . . . . 8a or 8b

8a. Snout very blunt or broadly rounded, U-shaped . . . . . 9a or 9b

8b. Snout pointed, V-shaped. . . . . 10a or 10b

9a. Tips of most fins abruptly jet black. . . . . Blacktip reef shark, Carcharhinus melanopterus.

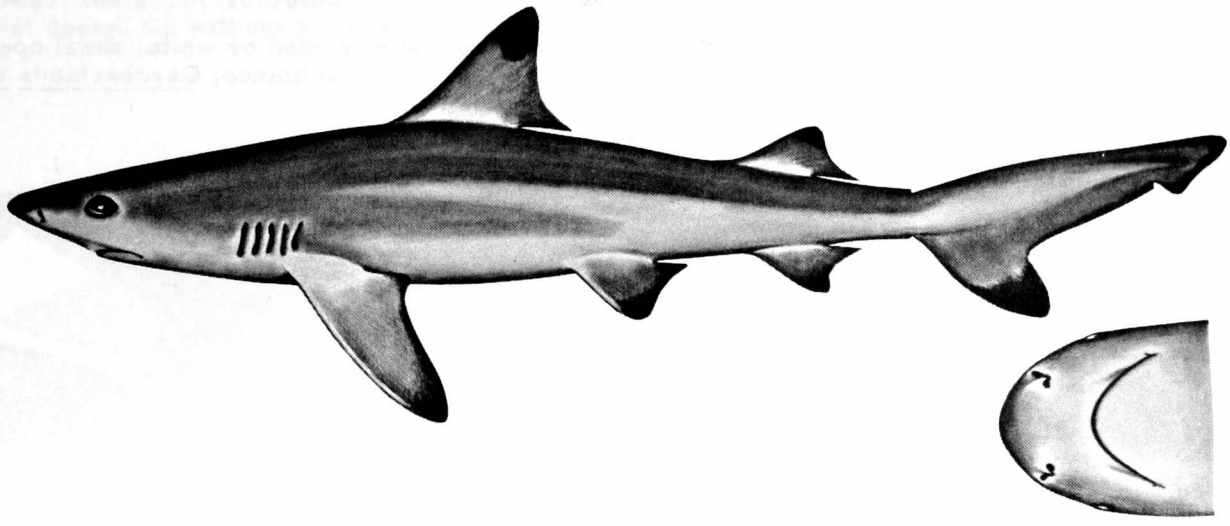


Figure 62.--Carcharhinus melanopterus, 51 cm. (1.7 ft.) male, Palau Islands, western Pacific.

Descriptive notes: Upper teeth broadly triangular, serrated; a dark band between white streaks on sides of body.
Size: Common up to 1.5 m. (5.0 ft.); grows to about 1.8 m. (6.0 ft.).
Distribution: Apparently common at the Hawaiian Islands many years ago, but now rare; not reported from the eastern Pacific.

9b. Tips of fins not black . . . . . Bull shark, Carcharhinus leucas.

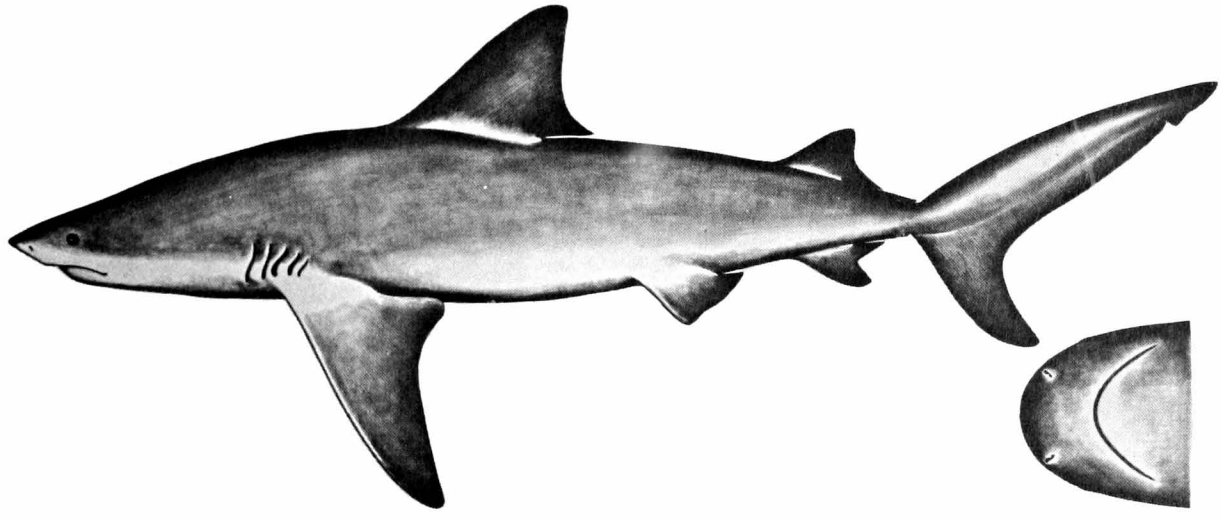


Figure 63.--Carcharhinus leucas, 175 cm. (5.8 ft.) female, Nayarit, Mexico.

Descriptive notes: Upper teeth broadly triangular, serrated; eyes small; first dorsal fin broad.
Size: A heavy-bodied shark, common up to 2.7 m. (9.0 ft.); probably grows to about 3.4 m. (11.0 ft.).
Distribution: In coastal waters from southern Baja California and the Gulf of California southward to Ecuador and probably to northern Peru; often in bays, estuaries, and near river mouths; not reported from the offshore islands; occasionally wanders as far north as southern California.
Remarks: In the eastern Pacific the bull shark has been referred to as the roundnose or pigeye shark, Carcharhinus azureus.

10a. Extreme upper tip of snout with a small black spot surrounded by white; nasal openings situated transversely and close to each other. . . . . Pico blanco, Carcharhinus velox.

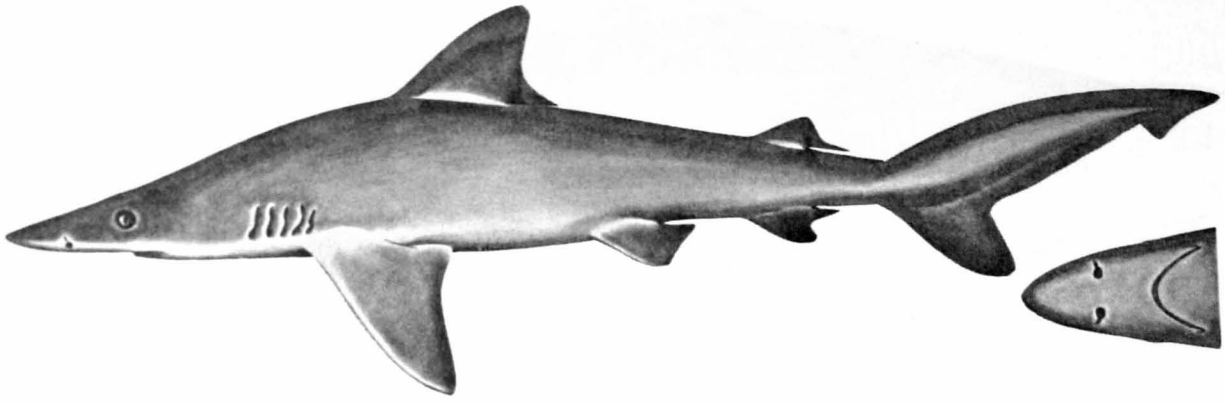


Figure 64.--Carcharhinus velox, 105 cm. (3.4 ft.) male, Gulf of California.

Descriptive notes: Teeth of upper jaw slightly curved, serrated; nostrils large; snout long and pointed.
Size: Common to 1.2 m. (4.0 ft.); grows to about 1.5 m. (5.0 ft.).
Distribution: Reported from the Gulf of California, Panama, and Ecuador; probably can be found in the intermediate shoreline, and perhaps southward to Peru; not reported from the offshore islands.

10b. Extreme upper tip of snout without distinctive markings; nasal openings oblique, far apart . . . . . 11a or 11b

11a. First dorsal fin inclined backward from the apex, rear margin usually ragged (fig. 65); origin of second dorsal fin well behind origin of anal fin . . . . . Cuero duro, Carcharhinus porosus.

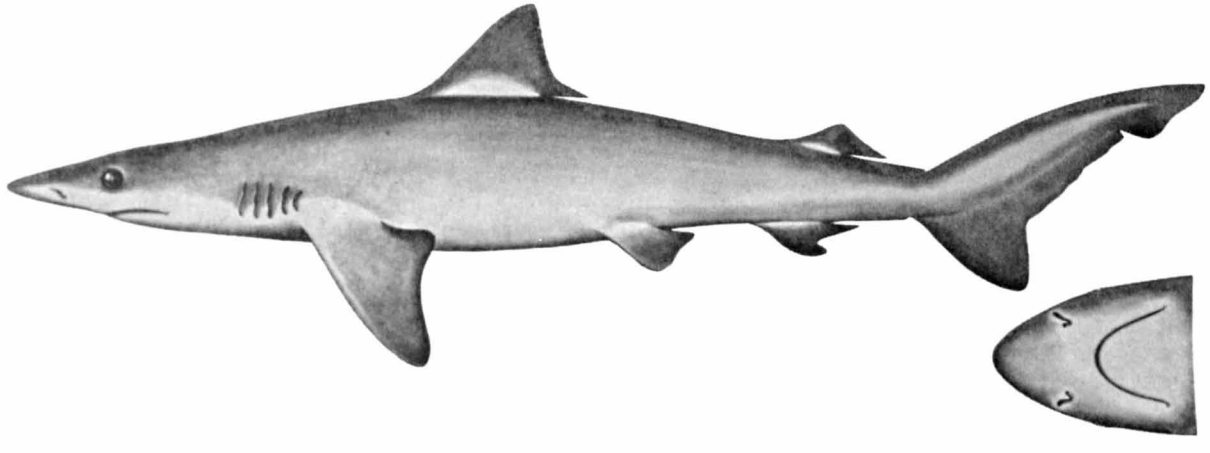


Figure 65.--Carcharhinus porosus, 54 cm. (1.8 ft.) male, Pacific side of Panama.

Descriptive notes: Upper and lower precaudal pits distinct; lower teeth finely serrated; 13 or 14 teeth on each side of the upper jaw; nostrils usually with a long narrow lobe.
Size: A small species, common to 90 cm. (3.0 ft.), probably grows to about 1.2 m. (4.0 ft.).
Distribution: In warm coastal waters from the Gulf of California to Peru; a record from the Galapagos Islands was probably erroneous.
Remarks: There is some doubt that this species is identical with C. porosus from the western Atlantic. The eastern Pacific cuero duro was first described from Panama as C. cerdale, Preserved or dried specimens often appear to have a dorsal ridge.

11b. First dorsal fin abruptly vertical from the apex, rear margin not ragged (fig. 66); origin of second dorsal fin usually about over origin of anal fin (sometimes slightly behind anal fin origin in C. remotus) . . . . . 12a or 12b

12a. Lower teeth not serrated; rear margin and lower lobe of caudal fin conspicuously dark; first dorsal fin without a black tip . . . . . Gray reef shark, Carcharhinus menisorrah.

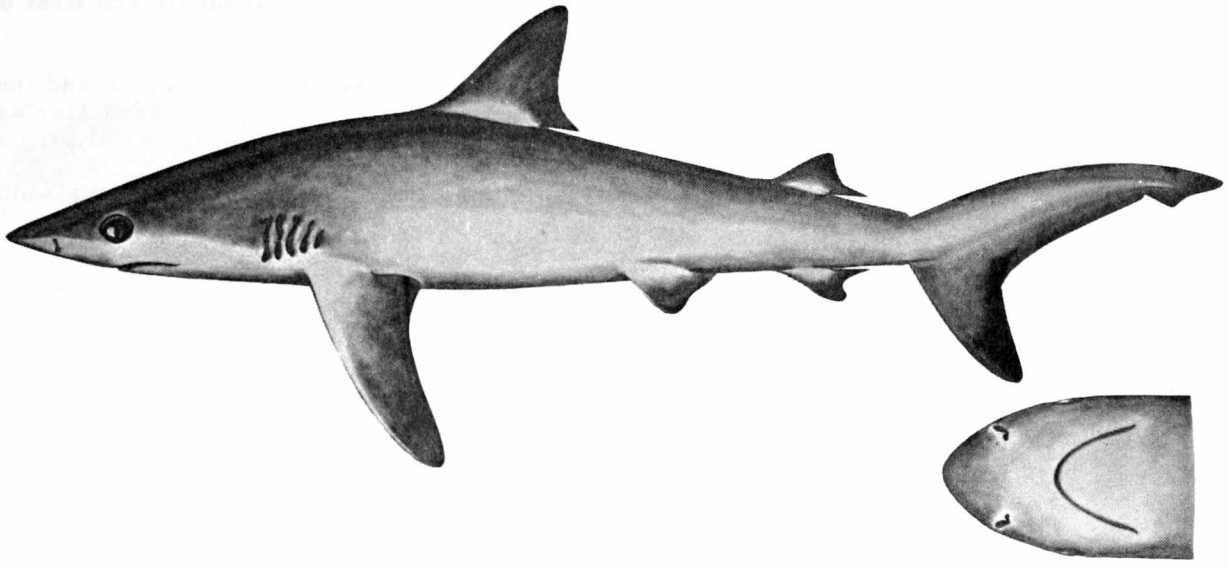


Figure 66.--Carcharhinus menisorrah, 63 cm. (2.1 ft.) female, Johnston Island, central Pacific.

Descriptive notes: Second dorsal and anal fins and undersides of pectoral fins usually dark; origin of second dorsal fin about over origin of anal fin.
Size: Common up to 2.1 m. (7.0 ft.); probably grows to about 2.4 m. (8.0 ft.)
Distribution: Coastal waters off the Hawaiian Islands; not reported from the eastern Pacific.
Remarks: Adults apparently have less pointed snouts than the juvenile specimen figured here. The scientific name will probably be changed in the future.

12b. Lower teeth serrated (a magnifying lens is sometimes needed to see the serrations); rear margin and lower lobe of caudal fin not conspicuously dark, or if dark the first dorsal fin also marked with a dark tip . . . . . 13a or 13b

13a. All fins with black tips (especially prominent in smaller individuals; in larger individuals the black is sometimes faded, except for the undersides of the pectoral fins, which remain prominently black-tipped); third gill slit about one-half as long as distance between snout tip and mouth . . . . . Volador, Carcharhinus limbatus.

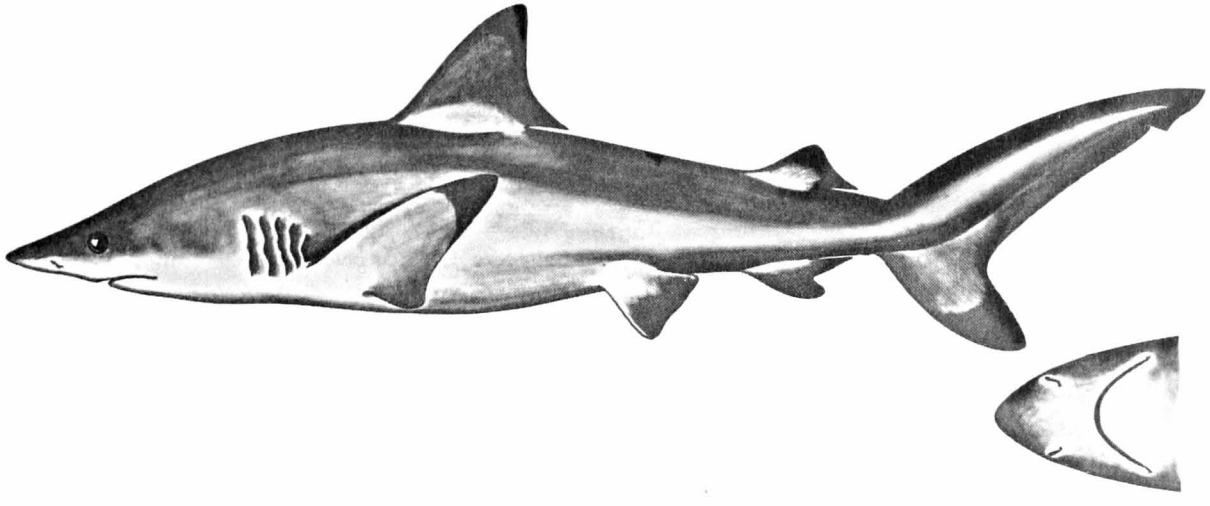


Figure 67.--Carcharhinus limbatus, 78 cm. (2.6 ft.) male, Gulf of California.

Descriptive notes: Upper and lower teeth narrow, triangular, serrated (lower teeth may be smooth in some small individuals); origin of second dorsal fin about over origin of anal fin; lower precaudal pit well marked; sides of body with a horizontal light band

between dark bands; head and back distinctly arched between snout tip and first dorsal fin; 14 or 15 teeth in each side of upper jaw.
Size: Common to 1.8 m. (6.0 ft.); grows to about 2.4 m. (8.0 ft.).
Distribution: Common in warm coastal waters, from southern Baja California and the Gulf of California to Peru; also found at the Hawaiian, Revillagigedo, Tres Marias, and Galapagos Islands; occasionally on the high seas off Guatemala, Baja California, and no doubt elsewhere in the tropical eastern Pacific.
Remarks: The volador of the eastern Pacific may be different from the small blacktip shark (C. limbatus) of the western Atlantic.

13b. Fins never with black tips; third gill slit about one-third as long as distance between snout tip and mouth . . . . . Narrowtooth shark, Carcharhinus remotus.

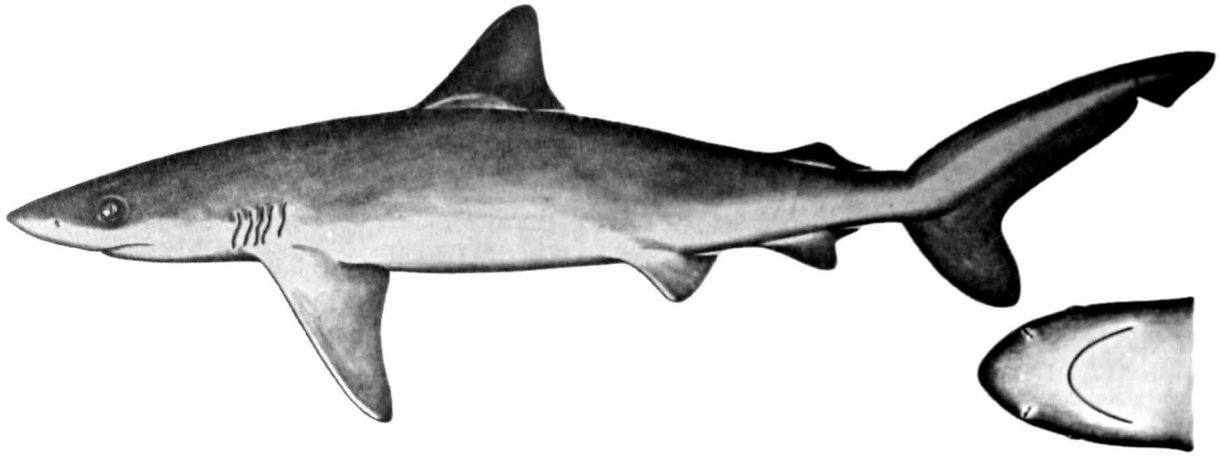


Figure 68.--Carcharhinus remotus, 72 cm. (2.3 ft.) female, southern California.

Descriptive notes: Cusps of upper teeth nearly symmetrical and erect in small specimens, but curved in larger ones; lower teeth with few and tiny serrations that are difficult to see without magnification; 15 or 16 teeth on each side of upper jaw; nostrils with a short lobe; origin of second dorsal fin sometimes slightly behind origin of anal fin; lower precaudal pit not well marked in young, but prominent in large specimens.
Size: A slender shark when young, but stocky when adult; grows to about 2.7 m. (8.9 ft.).
Distribution: In coastal waters off southern California, Baja California, and Peru; possibly occurs between these areas but probably rare in tropical waters; not reported from the offshore islands.
Remarks: The scientific name will probably be changed in the future.

14a. First dorsal fin, and usually pectoral fins also, with white tips . . . . . 15a or 15b

14b. Fins without white tips. . . . . 16a or 16b

15a. Apex of first dorsal fin broadly rounded, its tip white but mottled with tiny dark spots; second dorsal fin usually with dark markings. . . . . Oceanic whitetip shark, Carcharhinus longimanus.

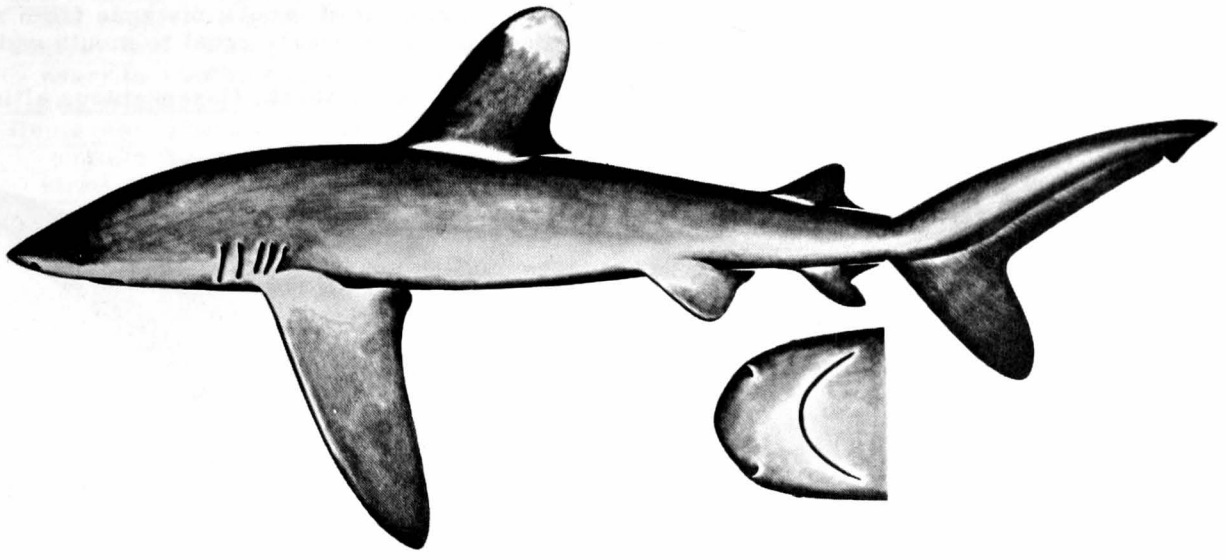


Figure 69.--Carcharhinus longimanus, 178 cm. (5.8 ft.) female, offshore eastern Pacific.

Descriptive notes: Upper teeth broadly triangular; pectoral fins long, tips rounded and usually white, mottled with small dark spots; snout tip rounded.
Size: Probably grows to about 3.5 m. (11 ft.), but reported to grow larger in other areas.
Distribution: Pelagic in warm seas, rarely comes to the continental shore; reported only from southern and central Baja California, and the Revillagigedo and Hawaiian Islands, but probably can be found in all warm waters far out to sea, and seasonally near southern California.
Remarks: The middorsal ridge is absent in some individuals.

15b. Apex of first dorsal fin pointed; tips of dorsal, caudal, and pectoral fins white, not mottled with black; second dorsal fin without dark markings. . . . . Silvertip shark, Carcharhinus albimarginatus.

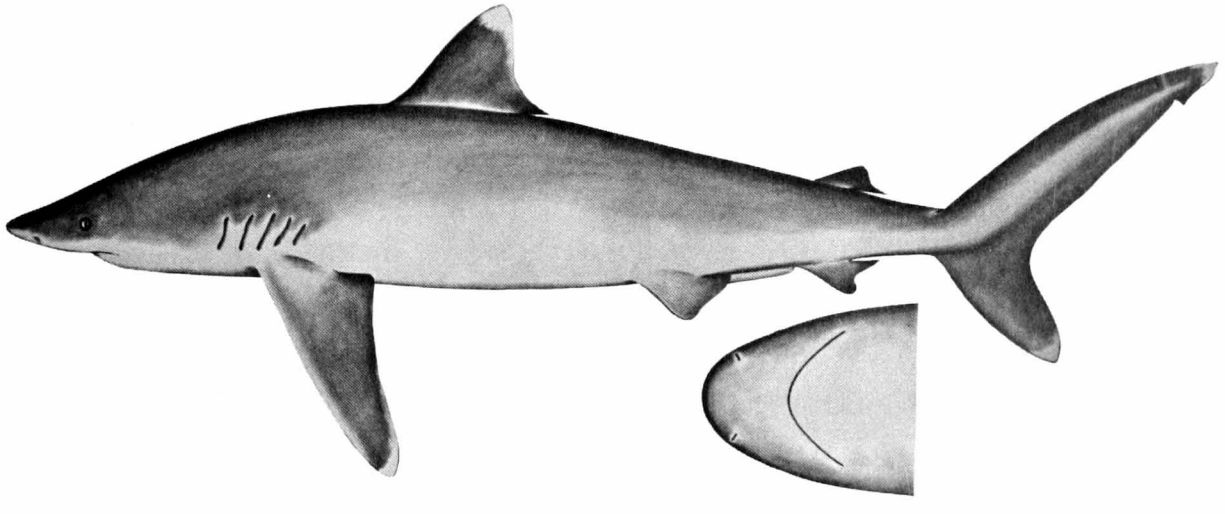


Figure 70.--Carcharhinus albimarginatus, 190 cm. (6.2 ft.) male, Revillagigedo Islands, Mexico.

Descriptive notes: Most upper teeth broad, with a deep notch on one side; snout tip rounded.
Size: Grows to about 3.0 m (9.8 ft.).
Distribution: Usually close to offshore islands, but larger individuals are sometimes found far out at sea, and occasionally near the continental shore; reported from Cocos, Galapagos, and Revillagigedo Islands, banks off southern Baja California, and at sea off Guatemala and Colombia.
Remarks: The silvertip shark has often been referred to as Carcharhinus platyrhynchus.

16a. Nostrils with a distinct fingerlike lobe (fig. 71, ventral view of snout); distance from snout tip to mouth notably greater than width of mouth (may be nearly equal to mouth width in very large individuals); snout moderately pointed . . . . . Bignose shark, Carcharhinus altimus.

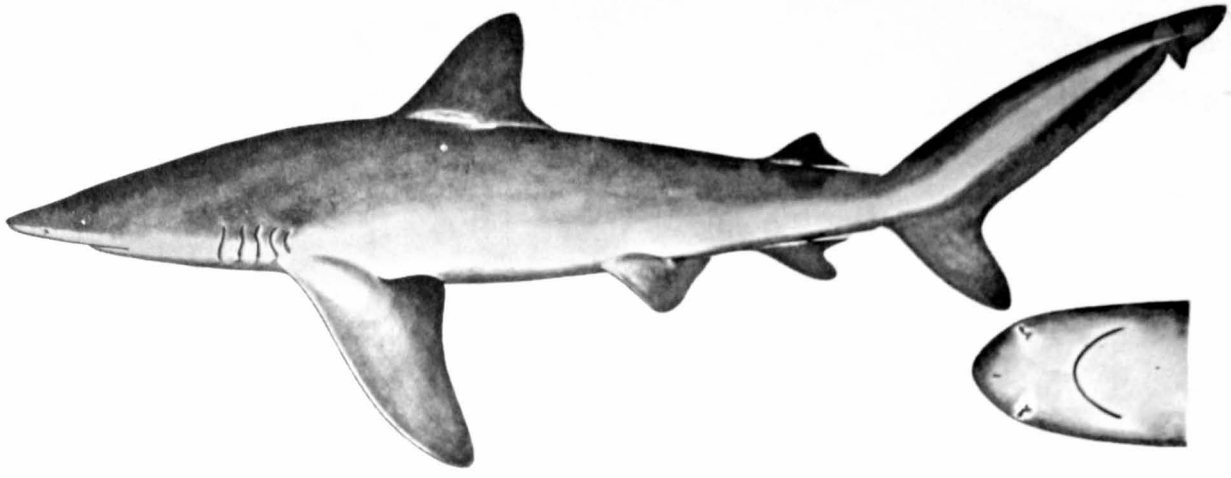


Figure 71.--Carcharhinus altimus, 157 cm. (5.2 ft.) male, Colombia.

Descriptive notes: Upper teeth broadly triangular; body sometimes a distinct coppery-red in life, but dull gray after death; middorsal ridge very prominent; snout very long in young, but relatively shorter in adults.
Size: Grows to about 2.7 m. (8.9 ft.).
Distribution: Known from Colombia, Ecuador, near the mouth of the Gulf of California, and the Revillagigedo Islands; probably occurs elsewhere between these widely separated localities.
Remarks: The bignose shark is usually caught on the bottom in waters over 145 m. (80 fm.) deep, but is sometimes found in shallower waters at night.

16b. Nostrils without a fingerlike lobe; distance from snout tip to mouth about equal to or (usually) less than width of mouth; snout moderately pointed (in C. falciformis only) or broadly rounded; (C. obscurus, fig. 74, rarely has a short fingerlike lobe on the nostril, but its snout is short and rounded) . . . . . 17a or 17b

17a. Length of free rear tip of second dorsal fin more than twice height of fin; snout moderately pointed (similar to C. remotus, fig. 68). . . . . Silky shark, Carcharhinus falciformis.

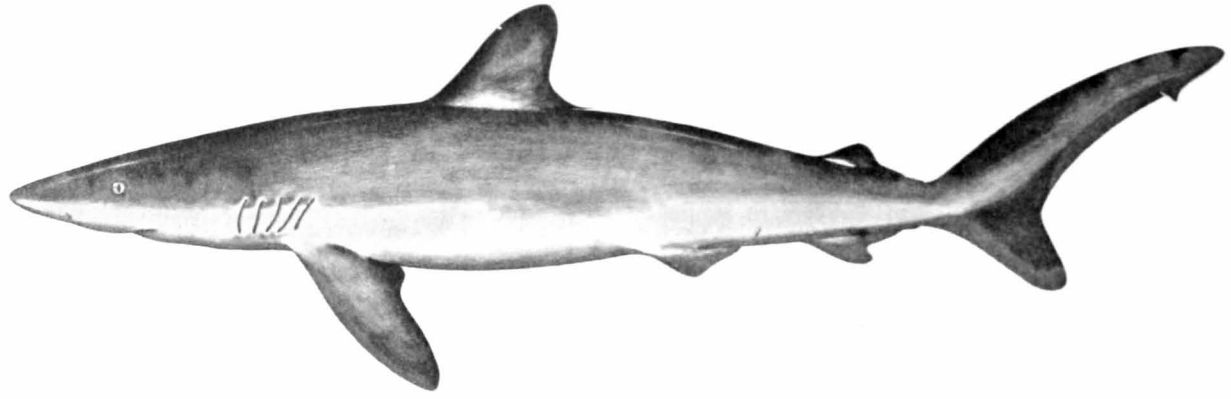


Figure 72.--Carcharhinus falciformis, 91 cm. (3.0 ft.) female, offshore eastern Pacific.

Descriptive notes: Snout moderately pointed; most upper teeth asymmetrical, with a pronounced notch on one side; dermal denticles (scales) small and low, giving the skin a smooth texture; shape of forst dorsal fin distinctive (see fig. 72; rear margin of first dorsal fin of large specimens may be abruptly vertical from the apex).

Size: Largest specimens in the eastern Pacific are about 2.6 m. (8.5 ft.), but silky sharks are reputed to grow much larger in other areas.
Distribution: Pelagic in warm waters; also found close to offshore islands, and on banks near the continental shore; reported from the Hawaiian, Cocos, and Revillagigedo Islands, and offshore from southern Baja California to Peru.
Remarks: The lower lobe of the caudal fin of larger individuals is more pointed than in the juvenile figured here. This species has been referred to as the neteater shark, Carcharhinus malpeloensis, in the eastern Pacific, and C. floridanus in the central Pacific.

17b. Length of free rear tip of second dorsal fin not greater than twice the height; snout broadly rounded (fig. 74) . . . . . 18a or 18b

18a. Origin of first dorsal fin over rear end of base (not the inner posterior corner) of pectoral fins . . . . . Sandbar shark, Carcharhinus milberti.

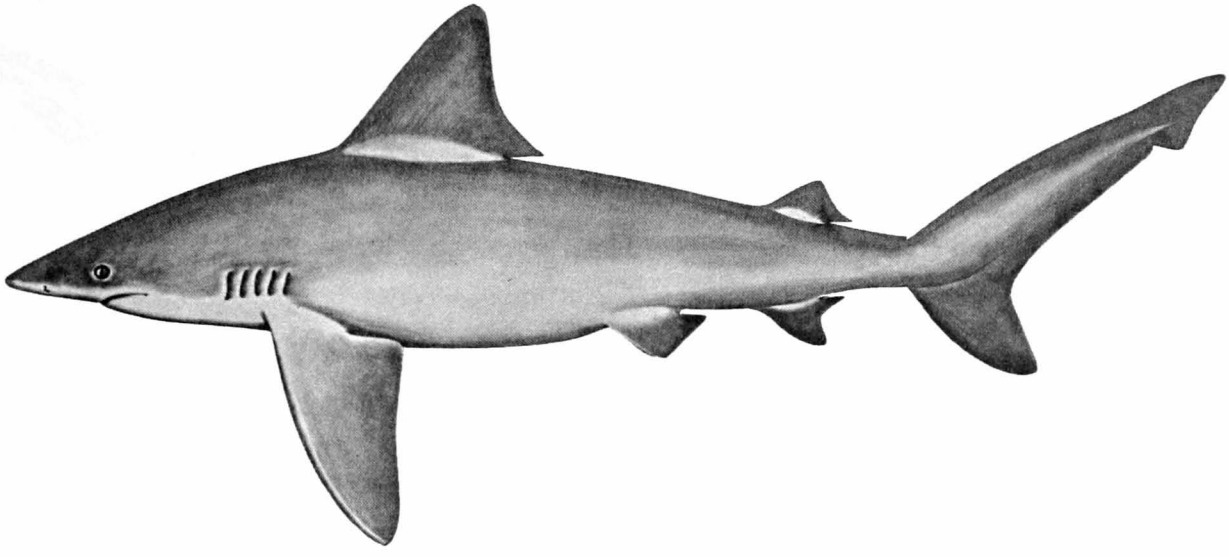


Figure 73.--Carcharhinus milberti, 150 cm. (4.9 ft.) female, Atlantic, adapted from Bigelow and Schroeder (1948).

Descriptive notes: Upper teeth serrated, broadly triangular; first dorsal fin notably high and erect, middorsal ridge prominent.
Size: Probably grows to about 2.1 m. (7.0 ft.).
Distribution: Coastal waters off Hawaiian Islands; not reported from the eastern Pacific, but possibly present at the Galapagos Islands.

18b. Origin of first dorsal fin about over inner posterior corner of pectoral fins. . . .19a or 19b

19a. Second dorsal fin low, rear margin nearly straight (fig. 74); first dorsal fin low and broad, front margin shaped like an arc of a circle . . . . . Dusky shark, Carcharhinus obscurus.

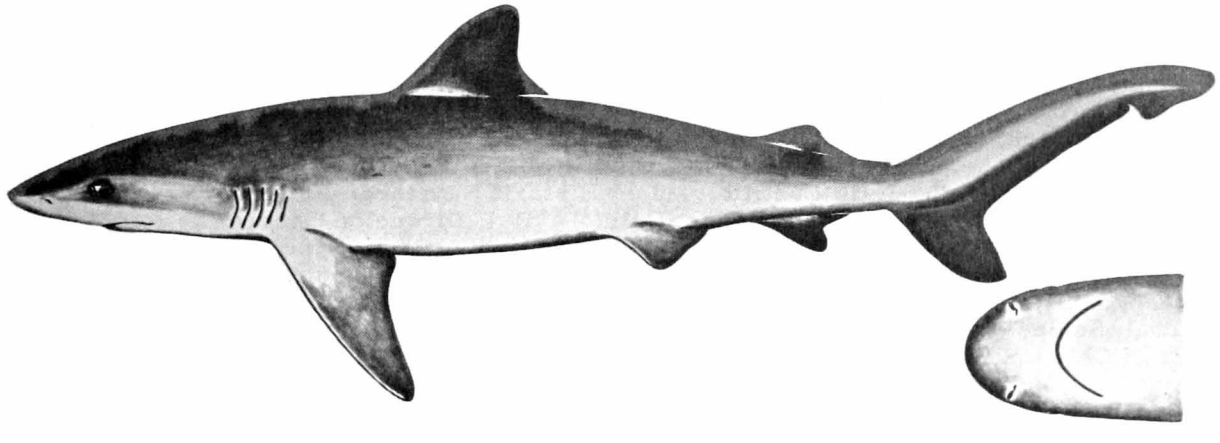


Figure 74.--Carcharhinus obscurus, 89 cm. (2.9 ft.) female, southern California.

Descriptive notes: Upper teeth serrated, broadly triangular, height of second dorsal fin usually less than 2.3 percent of total length of shark; usually less than 100 precaudal vertebrae.

Size: Grows to about 3.7 m. (12 ft.).
Distribution: Inshore waters from southern California to the Gulf of California; occasionally found at sea and at the Revillagigedo Islands; possibly present at the Hawaiian Islands.
Remarks: The dusky shark has been commonly referred to as Carcharhinus lamiella, the bay shark.

19b. Second dorsal fin relatively high, its rear margin highly concave (fig. 75); first dorsal fin high and erect, front margin nearly straight . . . . . Carcharhinus galapagensis.

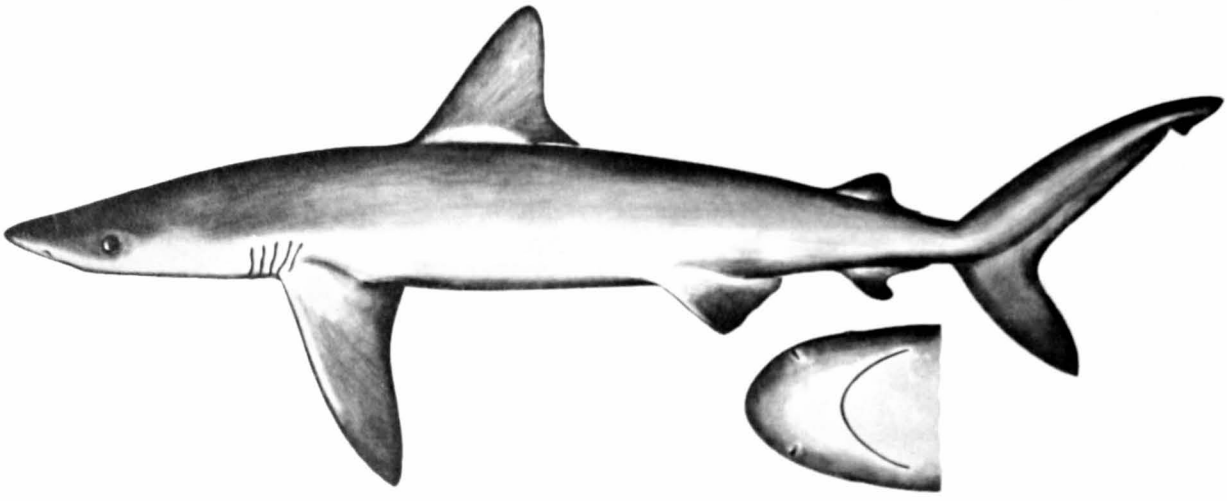


Figure 75.--Carcharhinus galapagensis, 103 cm. (3.4 ft.) female, Revillagigedo Islands, Mexico.

Descriptive notes: Upper teeth serrated, broadly triangular; height of second dorsal fin usually over 2.4 percent of total length of shark; usually more than 100 precaudal vertebrae.
Size: Grows to about 3.7 m. (12 ft.).
Distribution: Abundant at the offshore islands (Cocos, Galapagos, Malpelo, and Revillagigedo Islands); large individuals also found on the high seas (off Colombia and Guatemala, and on banks off southern Baja California), and sometimes close to the continental shore; probably occurs in Ecuador, Peru, and the Hawaiian Islands.

ACKNOWLEDGMENTS

Many individuals and agencies assisted us in various aspects of this work. J. A. F. Garrick aided with the difficult groups of requiem and squaloid sharks, as well as with other groups, and Carter R. Gilbert helped identify hammerhead sharks, Leonard J. V. Compagno called our attention to many details of species descriptions and distributions. All three have allowed us to use information in advance of the publication of their works.

Among others, the following institutions and their members assisted us to obtain specimens and information: Estacion de Biologia Marina de Montemar, Universidad de Chile (Walter Fischer); Museo de Historia Natural de Chile (Nibaldo Bahamonde); Instituto del Mar del Peru (Norma Chirichigno and Julio Castillo); Museo Historia Natural de Peru (Hans-Wilhelm Koepcke); Instituto Nacional de Pesca del Ecuador (Quinto Avila); Direccion General de Pesca e Industrias Conexas, Mexico (Antonio Vasquez del Mercado and Anatolio Hernandez); Fisheries Agency, Japanese Government; Nankai Regional Fisheries Research Laboratory, and crew of Shoyo Maru; Smithsonian Institution, U.S. National Museum, and Smithsonian Oceanographic Sorting Center; National Science Foundation and its Southeastern Pacific Biological Oceanographic Program (Edward Chin and James Pine) and the crew of R/V Anton Bruun; Scripps Institution of Oceanography; Los Angeles County Museum; University of California at Los Angeles; California Department of Fish and Game; Stanford University; California Academy of Sciences; University of Washington; Bernice P. Bishop Museum, Hawaii; and University of Hawaii.

REFERENCES

AMERICAN FISHERIES SOCIETY.
1960. A list of common and scientific names of fishes from the United States and Canada. 2d ed., Amer. Fish. Soc., Spec. Publ. 2, 102 pp.

BEEBE, WILLIAM, and JOHN TEE-VAN.
1941. Eastern Pacific Expeditions of the New York Zoological Society. XXV. Fishes from the tropical eastern Pacific. (From Cedros Island, Lower California, south to the Galapagos Islands and northern Peru.) Part 2, Sharks. Zoologica 26(2): 93-122.

BIGELOW, HENRY B., and WILLIAM C. SCHROEDER.
1948. Sharks. In John Tee-Van (Editor-in-Chief), Fishes of the western North Atlantic. Mem. Sears Found. Mar. Res. 1, Part 1: 59-576.

CLEMENS, W. A., and G. V. WILBY.
1961. Fishes of the Pacific coast of Canada. 2d ed. Fish. Res. Bd. Can. Bull. 68, 443 pp.

DE BUEN, FERNANDO.
1959. Notas preliminarias sobre la fauna marina preabismal de Chile, con descripcion de una familia de rayas, dos generos y siete especies nuevos. Bol. Mus. Nac. Hist. Nat. 27(3): 171-201.
1960. Tiburones, rayas y quimeras en la Estacion de Biologia Marina de Montemar, Chile. Rev. Biol. Mar. 10 (1, 2, and 3): 1-50.

GARMAN, SAMUEL.
1913. The Plagiostomia (Sharks, skates, and rays). Mem. Mus. Comp. Zool. 36, 515 pp. [Plates 1 to 75 in separate volume.]
1959. Studies on New Zealand Elasmobranchii. Part 8. Two Northern Hemisphere species of Centroscymnus in New Zealand waters. Trans. Roy. Soc. New Zealand 87, Parts 1 and 2: 75-89.
1960. The species of Squalus from New Zealand and Australia; and a general account and key to the New Zealand Squaloidea. Trans. Roy. Soc. New Zealand 88, Part 3: 519-557.

GARRICK, J. A. F.
1967. Revision of sharks of genus Isurus with description of a new species (Galeoidea, Lamnidae). Proc. U.S. Nat. Mus. 118(3537): 663-690.

GARRICK, J. A. F., and LEONARD P. SCHULTZ.
1963. A guide to the kinds of potentially dangerous sharks. In Perry W. Gilbert (editor), Sharks and survival, pp. 3-60. D.C. Heath and Company, Boston.

GILBERT, CARTER R.
(1967). A revision of the hammerhead sharks (family Sphyrnidae). Proc. U.S. Nat. Mus. 119(3539): 1-88.

GOSLINE, WILLIAM A., and VERNON E. BROCK.
1960. Handbook of Hawaiian fishes. Univ. of Hawaii Press, Honolulu, ix 372 pp.

GUDGER, E. W., and B. G. SMITH.
1933. Natural history of the frilled shark, Chlamydoselachus anguineus. In E. W. Gudger (editor), Bashford Dean Memorial Volume Archaic Fishes, Art. 5 pp., 245-319. American Museum of Natural History, New York.

HILDEBRAND, SAMUEL F.
1946. A descriptive catalog of the shore fishes of Peru. U.S. Nat. Mus. Bull. 189, 530 pp.

JORDAN, DAVID STARR, and BARTON WARREN EVERMANN.
1896-1900. The fishes of North and Middle America. U.S. Nat. Mus. Bull. 47, Parts 1-4, 3313 pp.

MANN F., GUILLERMO.
1954. Vida de los peces en aguas chilenas. Ministerio de Agricultura, Santiago, Chile. 342 pp.

ROEDEL, PHIL M., and WILLIAM E. RIPLEY.
1950. California sharks and rays. Calif. Dep. Fish Game, Fish Bull. 75: 88 pp.

ROSENBLATT, RICHARD H., and WAYNE J. BALDWIN.
1958. A review of the eastern Pacific sharks of the genus Carcharhinus, with a redescription of C. malpeloensis (Fowler) and California records of C. remotus (Dumeril). Calif. Fish Game 44(2): 137-159.

MS. #1610