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VOLUME IX. NUMBER 1

THE MARINE FISHES OF NEW YORK AND SOUTHERN NEW ENGLAND

By J. T. Nichols

American Museum Natural History

C. M. Breder, Jr.

New York Aquarium

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Zoologica Vol. IX, No. 1.

THE MARINE FISHES
OF NEW YORK AND SOUTHERN NEW ENGLAND

By J. T. Nichols
American Museum of Natural History

and

C. M. Breder, Jr.
New York Aquarium

(Figs. 1–263 incl.)

PREFACE

The area considered herewith comprises shore waters from Chatham and Nantucket west to the New Jersey shore within 50 miles of New York City, and includes only those species that occur further in shore than the 25 fathom line.

Conditions on this stretch of coast are comparatively uniform. On the other hand they become abruptly more northern north of Cape Cod, and progressively more southern as one proceeds further south along New Jersey, where the shore trends north and south instead of east and west.

These are home waters for the writers. Here the marine fishes have been as thoroughly studied as anywhere in America, and it seems appropriate to make these studies available for ready reference by such a compilation as has been attempted.

The material is based primarily on earlier scattered publications by one or the other of the writers and on the following standard works; 1896–1900. Jordan and Evermann, Fishes of North and Middle America, Bull. 47 U. S. Nat. Mus.; 1913, Sumner, Osburn, and Cole, Catalogue of the Marine Fauna, in Biol. Surv. of Woods Hole and Vicinity, Bull. Bur. Fisheries, XXXI, part II; 1918, Nichols, Fishes of the Vicinity of New York City, Am. Mus. Nat. Hist., Handbook, Ser. No. 7; 1925, Bigelow and Welsh, Fishes of the Gulf of Maine, Bull. Bur. Fisheries for 1924, XL, pt. 1. All other readily available sources have also been used, such as various articles in "Copeia" (notes by Latham and others); articles in "Zoologica" and "Bull. N. Y. Zoological Soc.;" and much material has been drawn from various publications of the U. S. Bureau of Fisheries by diverse authors, particularly that relating to life histories. A considerable amount of unpublished material which we had to hand, has also been utilized.

Practically all the records from Sandy Hook Bay since 1920 have been made as a result of the activities of the collecting boat of the New York Aquarium, the 'Seahorse.' Through its use the pound nets in that bay have been accessible in addition to the boat's own gear. Consequently, as the trips have been frequent, we feel that our knowledge of present day conditions in Sandy Hook Bay are particularly comprehensive.

Annotations under Woods Hole refer to that general vicinity, being taken from "Catalogue of the Marine Fauna" above referred to; annotations under New York refer to a fifty mile radius.

Aside from these sources a considerable amount of material has been furnished by Mr. Roy Latham of Orient, who has gone over all matter relating to that locality and added thereto from his unpublished observations. He has also furnished numerous varied items and should be credited as author of all Orient material.

For many years it has been expedient to follow the nomenclature of Jordan and Evermann (1896–1900. Fishes of North and Middle America) in faunal works of this sort. The large amount of work done in Systematic Ichthyology since 1900 renders this nomenclature less and less satisfactory, and such changes from it in generic names have here been introduced as are clearly indicated in Jordan's recently published "Genera of Fishes," the last volume of which was issued by Stanford University in 1920. Recent changes in specific names have been accepted or rejected in accordance with the writers' judgment. It should be stated furthermore that they do not follow the modern tendency to split genera into smaller and smaller units, believing this tendency to be unnecessary and transitory; and that they prefer to use a name which may not stand according to canons of nomenclature rather than one the identity of which might be questioned, for such purposes as the present at least.

A word as to arrangement: a descriptive paragraph is first given for each group of fishes—the group corresponding in almost every case to the family as recognized by Jordan and Evermann. Where more than one genus occurs within our region in a given group, a key to the several such genera, which we believe will prove of service in differentiating them, follows. When several members of a genus occur a few words of description to aid in their differentiation follow the name of each species. It is without the scope of this work to present an adequate descriptive treatment of the fishes considered. but it is believed that such descriptive matter as is given will aid the amateur ichthyologist in placing species as they come to hand. Care has been taken in the selection of the single popular name of each fish used. Popular nomenclature develops along the lines of the English language, unhampered by codes which determine technical names; but although popular names are theoretically more subject to change than technical names, it is useful that they should be standardized so far as the nature of the case will permit.

The text figures, are intended to supplement the scanty keys and descriptions as an aid to identification. They should be considered more as character sketches than as detailed drawings. All available sources have been drawn on as bases for these figures, and several had to be made from actual specimens. It is rather strange that this is the first attempt to figure every species from this area; adjacent to the greatest center of human activity.

The opening paragraph under each species, entitled Distribution, gives the status and migration dates so far as is known within our region, and

this is followed by a similar statement of the fish's status at the three localities, Woods Hole, Orient and New York. To repeat: Annotations under Woods Hole refer to that general vicinity and have been taken from the "Catalogue of the Marine Fauna," 1923, Sumner, Osburn and Cole, above referred to. Annotations under New York refer to a fifty mile radius and are those found in "Fishes of New York," 1918, Nichols, revised and brought up to date. The data from Orient, as we have said, is furnished by Latham, either directly or indirectly.

Next follows a paragraph giving the general range of the species, which in turn is followed by one or more paragraphs of a general nature, relating to habits, economic use, or philosophic discussion.

The material under Life History, comes next, and a final statement gives the maximum size of each fish so far as data is at hand. This latter is given in inches, but the measurements of fish eggs and young fish are so much better expressed in millimeters, that for them we retain the technical, less familiar metric system. The accompanying scale (on fly leaf) compares the two systems.

It has seemed to the writers essential that both the New York Aquarium and the Department of Ichthyology of the American Museum of Natural History have a book of this sort on the marine fishes of New York available for ready reference, to answer the numerous queries constantly received from fishermen and others. It is the writers' purpose also to place it in the hands of the public in such form that by its aid they can answer these queries for themselves. It is furthermore believed that it will be of value in directing attention to what is still unknown about fishes near home and stimulate a study of them.

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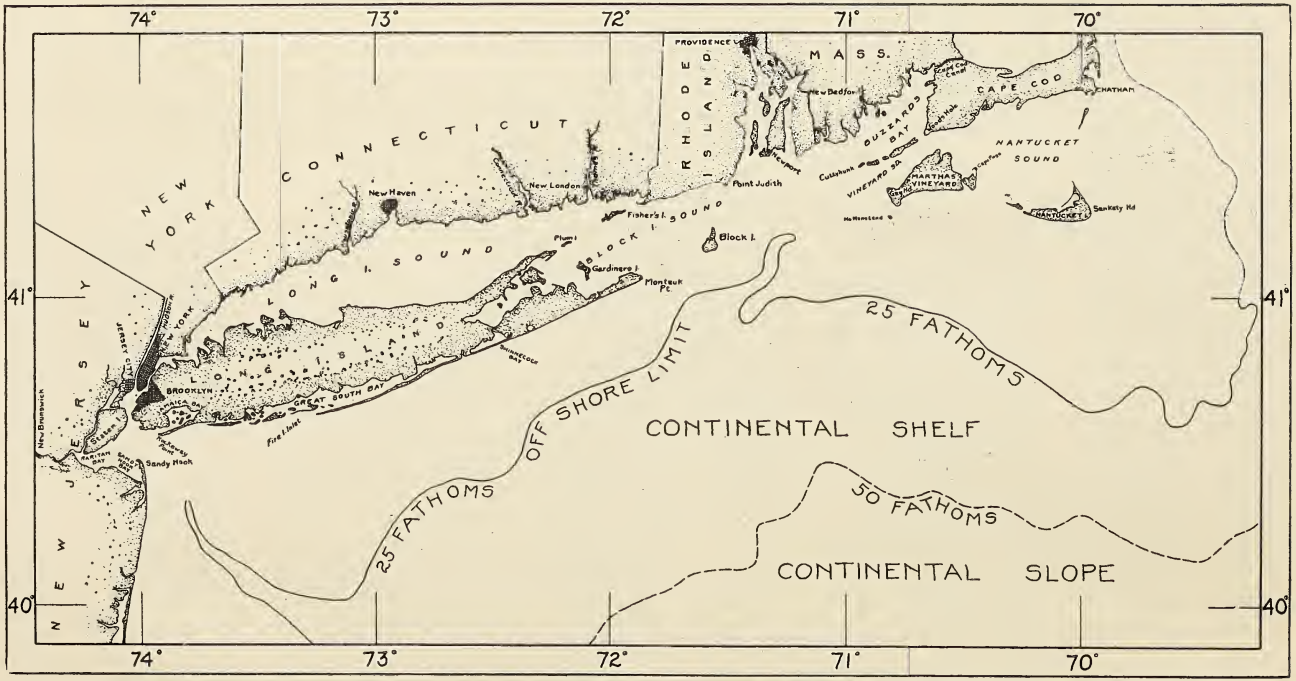


Fig. 262. Sketch chart of New York and Southern New England. The region treated extends from Chatham, Massachusetts (to the east) to fifty miles south of New York City on the New Jersey shore (to the west). The twenty-five fathom line (solid) marks its off-shore limit; a broken line at fifty fathoms showing the edge of the continental shelf beyond.

INTRODUCTION[1]

Aspects of the Study of Fishes

Ichthyology, or the scientific study of fishes, like that of any other group of animals, may be roughly divided into three aspects, Systematic, Economic and Philosophic.

Systematic Ichthyology deals with defining, naming and classifying fishes. It is a very necessary preliminary to every other branch of the subject, without which our knowledge would fall into the utmost confusion. The most satisfactory system which has been devised for assigning technical names to fishes (as indeed to all animals and plants), and the one universally followed, is to combine two names, the first or generic name shared by the kinds most closely related, the second or specific name diagnostic of the one which bears it. The generic name is always spelled with a capital, the specific name with a small letter.

Economic Ichthyology is the study of fishes in relation to human welfare, and its most important branch naturally is concerned with their use as food—fisheries, fish-culture, etc. Few people realize on what a large scale fish-culture, fish-farming it might be called, is carried on. In the year ending June 30, 1917, the United States Bureau of Fisheries distributed roughly three hundred nineteen millions of fish eggs and four thousand seven hundred thirty millions of young fishes to be planted in various waters.

Philosophic Ichthyology concerns itself with the fish and its place in nature, the broadest and purest aspect of the science. It follows the evolution of fishes by the evidence of fossil records from early periods in the earth's history to the many specialized forms of the present day. It examines the wonderful correlations existing between the habits and structures of fishes. In fact its possibilities and ramifications are without limit.

The series of vertebrate (back-boned) animals from fishes to man is characterized by an increasingly complictaed structure, and increasingly complicated environment for the individual to react to, and an increasingly complicated mentality. Fishes doubtless possess the simplest, lowest type of vertebrate mind. A great deal of their behavior can be explained as reflex action, a definite stimulus followed by a definite response. The bass sees a glittering minnow and strikes at it. An artificial minnow affects him similarly and he reacts towards it in the same way. One of the most complicated mental phenomena we have observed in fishes was illustrated by two porgies in a tank at the New York Aquarium. One of these had a bullying attitude, the other one a cringing attitude. From time to time the former would dart in the direction of the latter, which would slink away in evident alarm. Though the difference in size between the two was insignificant, clearly the former was ruling the tank, and they both knew it, that is, each one was adjusted mentally to reply to stimuli in a way appro-

[1] Taken largely from "Fishes of New York," 1918.

priate to the rôle he was playing. A parallel human situation would be associated with definite emotional states of mind, whence we may argue that the fish is capable of such. As a matter of fact, as is well known to aquarists, the first of two fish to be introduced in a tank is likely to lord it over subsequent arrivals, and very probably in this case the more aggressive individual was so by reason of such seniority.

How to Describe and Identify Fishes

The first problem which faces the student of fishes is to differentiate between the many species. The sea is large, and thousands of distinct species of fishes find a place in it. Fresh waters, especially those of the cold and temperate north, harbor a comparatively small number. The species vary in every conceivable particular from the minute structure of their bone and the form of the internal organs to the proportions of the body or the number of rays in the fins. A few simple characters and proportions are customarily used in comparative descriptions of fishes, and it is necessary to master these before a specimen can be properly identified, that is, assigned to the name by which it is known in literature. All measurements are taken in a straight line, as with a pair of dividers. A fish's standard length is by custom the distance from the tip of the snout to the base of the tail fin; the total length extends this distance to the tip of that fin. Its depth is the greatest vertical distance from the upper to the lower contour of the body, exclusive of fins. The length of the head is measured from the tip of the snout to the most posterior point on the border of the gill-cover exclusive of spines which may project still further backward. The eye measurement is the greatest diameter of same. The maxillary measure is taken from the tip of the snout to the posterior end of the maxillary, or movable bone at the side of the upper jaw. The interorbital is the least distance between the eyes across the top of the head. The snout is measured from its tip to the front of the eye. These absolute measurements are of little value, as a fish's size is not fixed (unlike the size of a fully feathered bird, for instance, which is constant within a few millimeters for a given species), and a given species of fish may vary considerably in size, even when full-grown, dependent on the waters it inhabits, the amount of food it has had available, and other factors. It is the proportions between the different measurements that are fairly constant within a given species, and which we rely upon for making diagnoses. The larger measurements, as the length of the head and depth of the body, are stated according to the number of times they are contained in the standard length of the fish, and similarly the smaller measurements, as that of the eye or maxillary, according to the number of times they are contained in the head. The fish's anterior paired fins are known as the pectoral fins. They may be placed on the lower surface, on the side behind the head, or at the throat. The posterior paired fins are the ventral fins. A median fin behind these is the anal fin. One, two or more fins in the midline of the back are known respectively, beginning with the anterior one, as the first, second and third dorsal fins. The fin at the end of the tail

(which may be pointed, rounded, square or forked in outline, and is occasionally unsymmetrical) is the caudal fin. The number of supporting rays in a particular fin are important in the diagnosis of a fish, as their number is constant within narrow limits of variation, in any one species, somewhat as a normal man has five fingers and toes, no more, no less. These rays may be divided into two classes. First, spines, solid, rigid and sharp-pointed. Second, soft rays, more or less split or branched terminally, jointed and flexible. It is customary to distinguish between the two by using Roman numerals for the spines. Dorsal X, 14 means a dorsal fin with ten spines followed by fourteen soft rays. Dorsal X-14 would mean two entirely separate dorsal fins, the first of spines, the second of soft rays. The lateral line of a fish is a series of pores, usually one on a scale, beginning at the shoulder and ending at the base of the caudal fin. It may be straight or variously curved, complete, (if it covers the entire distance) or incomplete, and is sometimes duplicated, or broken in the middle, or lacking altogether. The number of scales is of course, in inverse ratio to their size, and is written thus: 5–32–8, which signifies five horizontal rows between the lateral line and base of first dorsal fin, thirty-two more or less obliquely vertical rows crossing the lateral line, and eight horizontal rows between the lateral line and anal fin; or the scales may be counted from lateral line to ventral (or pelvic) fin, and so stated.

There is a regrettable lack of good popular books which will be of service to the amateur in identifying fishes. Almost the only comprehensive work, the "Fishes of North and Middle America" by Jordan and Evermann, in four volumes, is too technical and too bulky. A comparatively small number of species of fishes occur in one locality. It is hoped that the grouping, keys and few words of description of related forms given will aid the average saltwater fisherman to name correctly such as may come into his hands.

Learning the name our predecessors have given a fish is necessary to an intelligent understanding of what is known about the species. As has previously been pointed out, however, this is only a first step, which should not be an end in itself to the student, but only a means. After the fishes have been identified the whole field of research in either economic or philosophic ichthyology lies before him. The data here presented make apparent the great gaps in our knowledge of even our more common species. It is not necessary that a profound technical training be present for a background to advance the science. Many useful things are continually being uncovered by persons little equipped with scientific methods. For instance the sizes of young fish when taken serially for a period of a few months, each collection being averaged, gives a fair index of the growth rate. The proportion of males to females at any given date is useful, the stomach contents, record of individuals of abnormal size or coloration, and so on, add information. This information, turned over to some responsible institution, will be recorded for the common good.

The lack of data under any species indicates that we do not know of any from personal work or published records, and therefore the same is desirable.

Classification of Fishes

The dominant type of modern marine fish resembles a perch or bass. It has a large mouth, short body, and spines in the fins, particularly in the back (or dorsal) fin (which either has the anterior part made up of spines or else is divided into two separate fins, the first of which is spiny).

Probably the majority of species which exist to-day, in salt water, are of this type. In attempting to sort out or classify the remaining species, we can make out first, a more or less complete series of forms from the most primitive fish, the sharks, leading up to the perch type, and secondly, several divergent lines of development leading away from this series into still more highly specialized or more or less degenerate series. The lampreys have little relationship with any of our other fishes. Many students claim that they are not, in the true sense of the word, fish at all. The sharks and rays stand somewhat less apart from the remaining species, all of which differ from them in having the cartilaginous structures more or less replaced by bone, and all of which may be placed in the comprehensive group known as *Teleostomi*. The ganoid fishes (for example the Sturgeon) stand apart as being more cartilaginous than other *Teleostomi*, all of which belong in the major group known as *Teleostei*. There is a rather evident connection between the ganoid fishes and the herring and trout group, and the true eels seem to be degenerated derivatives from the herring-trout group. Just where the catfish group should come in is open to question. We follow the conventional treatment in placing them before the herrings and trouts, though very probably it will be proved that they are really more recent than these. Between these primitive fishes and the forms which begin to approach the perch, the line of ascent is obscure and broken, though the killifishes and a variety of specialized forms such as needlefish, stickleback, pipefish, doubtless belong to this section of it.

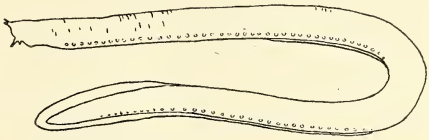
The so-called *Acanthopteri* are spiny rayed fishes including the dominant perch, bass group, and all those forms with clearly traceable relationships to it; as the mullets, etc., related to its probable immediate ancestors; or the derivative mackerel-like fishes (an adaptation to wide ranging habit over open seas). Another clearly marked line is through the angelfish (beginning with the wrasses, which, superficially at least, are more perch-like than the mackerels, ending with the very un-perch-like plectognath fishes, which might be considered the apex of specialization in fish life). The sculpin-like or mail-cheeked fishes, although a well-marked group, have certain members of sufficiently perch-like character to show their derivation. The gobies, blennies, etc., are probably one or several lines unrelated to this one, although it is conceivable that they arose through more or less sculpin-like forms. At the other end of this series there is an approach to the cod-fishes. Recent investigation and recently discovered fossils have shown that the very remarkable flatfishes were derived rather directly from perch-like fishes. The final section, the frog fishes, would seem to have been evolved from perch-like ancestors, either directly or through sculpin, blenny or goby-like forms.

HAGFISHES.

Excessively slimy, eye-less, eel-like fishes, with a round sucking mouth about which are several barbels; teeth on roof of mouth and tongue.

1. **Slime Eel**

Myxine glutinosa Linnaeus



Distribution: *Woods Hole.* Crab ledge, occasionally drawn up on codfish bait. Although this locality is actually beyond our region, it is so close to the line that the species is included.

Occurs on both coasts of the North Atlantic in rather deep water; from Arctic seas south to the latitude of North Carolina at a considerable depth.

"The hag [slime eel] is not a true parasite, as has sometimes been suggested, there being no reason to believe it ever attacks living, uninjured fish, but it is a scavanger. Judging from its habits during the brief time it survives in aquaria, it spends its time lying embedded in the clay or mud with the tip of the snout projecting, but it is an active swimmer. Probably it finds its food by its greatly specialized olfactory apparatus. So far as is known it feeds chiefly on fish, dead or disabled, though no doubt any other carrion would serve it equally well, were such available. It is best known for its troublesome habit of boring into the body cavities of hooked or gilled fishes, eating out first intestines and then the meat, finally to leave nothing but a bag of skin and bones, inside of which, or clinging to the sides of a fish it has just attacked, the hag itself is often hauled aboard. In fact, it is only in this way, or entangled on lines, that hags ordinarily are taken or seen. Being worthless itself, it is an unmitigated nuisance and a particularly loathsome one, owing to its habit of pouring out slime from its mucus sacs in quantity out of all proportion to its small size. One hag, it is said, can easily fill a 2-gallon bucket, nor do we think this is any exaggeration."

"The hag is at home only in comparatively low temperatures—cooler, probably, than 50°—and this confines it to depths of 15 to 20 fathoms or more in the Gulf of Maine in summer."—Bigelow and Welsh.

Life History: It has been claimed that this species is normally hermaphroditic. It is reputed to be male up to a size of about 33 cm. and on exceeding that size to produce ova. This hypothesis of hermaphroditism has been questioned, but is quite generally accepted.

The eggs are large (up to $\frac{4}{5}$ of an inch long), oval, tough shelled, few

(about 2 dozen), with a cluster of barbed filaments at each end. They have been found in from 50 to 150 fathoms, are demersal, and stick fast in clusters to some fixed object. There is no larval stage unlike the adult.

Size: Reaches a length of 18 inches.

LAMPREYS.

Eel-like fishes with a round, sucking jawless mouth (armed with concentric rows of teeth) slanting somewhat backward across the entire front of the head. Eyed moderately developed. Seven small holes or gill-openings on the side of the neck below and behind the eye.

2. Sea Lamprey
Petromyzon marinus Linnaeus

Distribution: Adults (or young recorded in salt water) March to December 12. *Woods Hole*, adults April to June. *Orient*, April 15 to December 12; always rare; adults May and June; post-larval young (121 mm.) Nov. 19 to 27. *New York*, not uncommon, March to December 10, one of $6\frac{5}{8}$ inches May 11 (Sandy Hook Bay).

Occurs on both coasts of the Atlantic, south on the American Side to Chesapeake Bay, rarely to Florida. Enters streams from the sea to spawn.

Lampreys are strong vigorous swimmers. They suck on to the sides of larger fishes with their peculiar mouthes, rasp through skin and scales with their teeth, and suck the blood. Cod, haddock, and mackerel are known to be attacked in this manner.

Life History: Adults enter streams to spawn in spring or early summer, as late as June 17 at the eastern end of our area. A circular nest is constructed in the stream bottom by seizing the larger stones in the mouth and removing them. Over this nest pairing takes place and in it the minute eggs are laid; 236,000 ova have been found in an individual sea lamprey. They spawn but once and then die. The larvae lack eyes and teeth. The time and condition in which they enter salt water is uncertain.

Large numbers of ripe lampreys are to be seen each spring in the Swimming River a few miles inland from Sandy Hook Bay through which they must pass in their migration from the sea. In 1923 the first run was noted on March 28 (March 25, 1925) and the last laggard was seen on May 20. The peak of the season this year was about May 8. Generally, however, it occurs in the latter part of April.

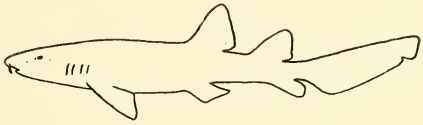
Size: Adults are 2 to 3 feet long; largest at Orient 27 inches.

Examination of 98 examples from the Swimming River showed the maximum to be 33 inches long and 2 pounds 4 ounces in weight, the minimum to be 24 inches long and 14 ounces in weight, whilst the average had a length of 29 inches and a weight of 1 pound 11 ounces.

NURSE SHARKS

Large sharks with very hard rough skin, blunt head. Mouth small, with a fleshy barbel at each corner of a quadrangular flap in front of the mouth. Two back fins of about equal size, and placed far back, the first above or behind the ventrals.

3. Nurse Shark
Ginglymostoma cirratum (Gmelin)



Distribution: A specimen of this shark is reported by H. S. Champlin from a fish pound at Pt. Judith, Rhode Island, summer of 1920. As he is familiar with the Nurse Shark in Florida and nothing else resembling it occurs on the coast, the record is credible.

Occurs in warm seas of the western hemisphere from the capes of the Carolinas (rarely) to the South Atlantic coast of Brazil, also on the west coast of Mexico.

This is a sluggish, harmless shark with no apparent protection against its rapacious kin but the toughness of its hide. Harpooners say that although it is comparatively easy to put an iron into a Nurse Shark at the first blow, if that is not successful they seem to "set" their hide, which then becomes well-nigh impenetrable.

Food: Feeds on squid, shrimp, etc.

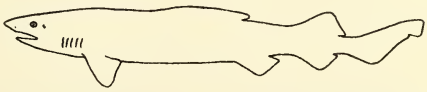
Life History: A female on July 22 (North Carolina) contained 28 eggs, about as large as a goose's egg with a delicate horny shell. It is believed that these eggs are retained for the entire incubation period, and free young released as in the Requiem Sharks. Such being the case, the nurse shark presents an interesting transition stage from those elasmobranchs (shark-like fishes) which deposit large eggs with a horny shell, as do our skates, to those which bring forth living young.

Size: Reaches a total length of from 6 to 10 feet.

FALSE CAT-SHARKS

A single species known, a large shark with the gill-openings all in advance of the breast fin, the first back fin long and low, highest posteriorly. Jaws with many rows of small, three-pointed teeth.

4. Small-toothed Shark
Pseudotriakis microdon Capello



Distribution: Two specimens only of this species known, the first from Portugal; the second, 10 feet in length, came ashore at Amagansett, Long Island.

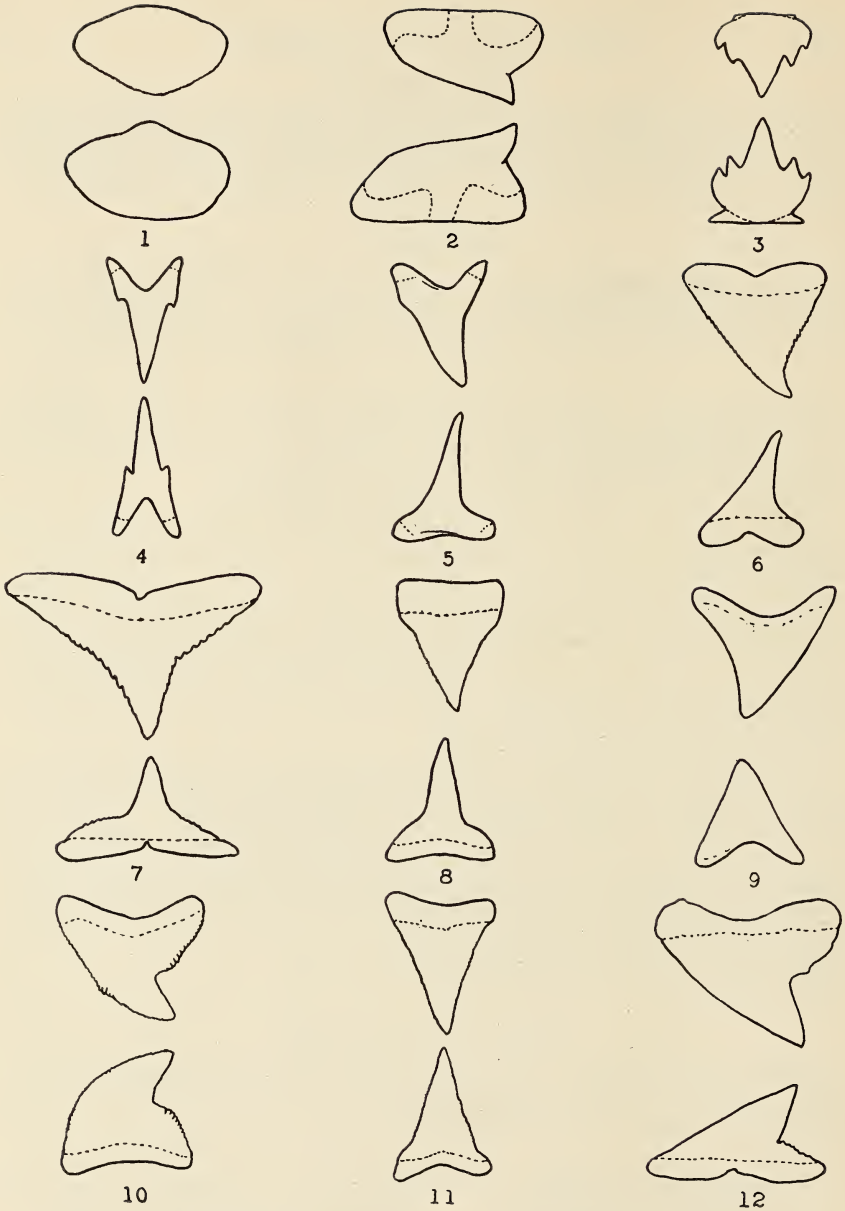


Fig. 263. Shark Teeth; an upper and lower tooth to the left of the symphasis. Those of the basking shark, (*Cetorhinus maximus*) and the small-toothed shark (*Pseudotriakis microdon*) are omitted because of their extreme small size and the ready distinction of the two species. 1, smooth dogfish, *Mustelus canis;* 2, spined dogfish, *Squalus acanthias;* 3, nurse shark, *Ginglymostoma cirratum;* 4, sand shark, *Carcharias littoralis;* 5, mackeral shark, *Isurus tigris;* 6, blue shark, *Priomace glauca;* 7, spot-fin ground shark, *Carcharhinus limbatus;* 8, New York ground shark, *Carcharhinus milberti;* 9, thresher shark, *Alopias vulpes;* 10, tiger shark, *Galeocerdo tigrinus;* 11, man-eater shark, *Carcharodon carcharias;* 12, hammerhead shark, *Sphyrna zygaena.* Eight may equally well stand for the dusky (*Carcharhinus obscurus*) or the Southern ground shark (*C. commersonii*).

REQUIEM SHARKS

Sharks with moderately developed, unsymmetrical caudal fin, the upper lobe always much the longer. Caudal peduncle not notably keeled. Two back fins without spines; the anterior over or before the center of the body; the posterior usually much the smaller. Teeth various, never long and pointed with basal cusps.

a. Teeth small, paved, not sharp. Lower surface flat. Two back fins of about equal size. *Mustelus*

Teeth larger, flat and sharp (see b).

b. Teeth large, semicircular, coarsely saw-edged, with points turned obliquely outward, those of the upper jaw identical with those of the lower. A large shark with heavy blunt head and tapering body, usually striped or spotted. *Galeocerdo.*

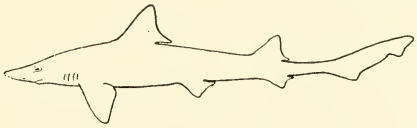
Teeth more or less finely saw-edged, the lower teeth more or less narrower than the upper. Fins sometimes tipped and edged with black but body unmarked. Second back fin much smaller than the first. (see c).

c. First back fin inserted posteriorly nearer ventral than pectoral fins. A long, slender off-shore shark, bright blue above, white below. *Prionace*

First back fin inserted anteriorly, nearer pectoral than ventral fins. *Carcharhinus*

5. Smooth Dogfish

Mustelus canis (Mitchill)



Distribution: A summer resident in our region. Recorded from May 2 to December 13. As it appears to the eastward (Woods Hole and Orient) in May, is said to be most abundant at Woods Hole in June, and to the westward is recorded somewhat later and in some years not abundant until fall in Sandy Hook Bay, it may approach from the sea in the spring and leave to a greater extent along the shore to the southwestward in the fall. *Woods Hole*, May to November, but most abundant in June. *Orient*, May 2 (1908) to November 28, average for first one taken in 15 years May 10. Immature individuals may be frequent until early in December. *New York*, common, June to December 13. Some years common throughout the season in Sandy Hook Bay; others not abundant until fall. An exception among our summer fishes in being also European.

Occurs abundantly on the warmer Atlantic coasts of Europe and America from Cape Cod to Cuba, a very rare straggler north to the Bay of Fundy.

The smooth dogfish is abundant in all salt waters near New York City in summer, and is found in shallow waters on all sorts of bottoms, bays of

of the Sound as well as the sea. Swims near the bottom, singly, though sometimes in considerable numbers at favorable points.

Food: Varied, but crustacea preferred,—lobsters, crabs, shrimps, etc. Also fishes of almost any sort, squid, annelids, amphipods, small gastropods. It hunts largely by scent, feeding mainly on crabs, and its teeth, which are small, numerous, and blunt, to deal with this kind of food, are unlike those of any other shark. It is not particular in its diet, however, and may be caught with almost any live or dead bait, being frequently taken by anglers in pursuit of other fishes. Though little used, its flesh is nutritious and palatable, as it may well be, for among the smooth dogfish's favorite food are young lobsters and the blue crab.

Life History: Females containing eggs and embryos taken throughout the summer. At Woods Hole, Bumpus believes there are probably two broods in June and August respectively, and the capture of females containing embryos is reported as late as about September 25. Number of young reported as high as 27, usually 4 to 12. In a 54 inch female, young reported as 14 inches in length.

Size: Reaches a total length of 4½ or 5 feet; over 3 feet exceptional. The majority of examples of this species taken in Sandy Hook Bay are immature. Females generally outnumber males about 3 to 2 in the pound nets. The average, maximum and minimum of the lengths and weights of 24 examples taken from that Bay during the first half of July, 1923, are given below and may be taken as representative of the locality.

Length		*Weight*			
Maximum	28¾ inches	2	pounds	12	ounces
Average	22¾ "	1	"	6	"
Minimum	14¾ "	0	"	6	"

The largest example from Sandy Hook Bay measured about 47 inches in total length and weighed 14½ pounds. It died in the N. Y. Aquarium, September 21, 1925, after being in captivity about one year during which it gave birth to 5 young.

6. **Tiger Shark**
Galeocerdo tigrinus Müller and Henle

Distribution: Probably present in our region every season in varying small numbers, August to October, the ocean, Vineyard Sound and Buzzards Bay. *Woods Hole*, occurring from August to October, rarely before August. *New York*, casual in late summer and fall (September 11).

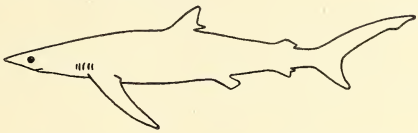
Occurs generally distributed in tropical seas. Abundant in the West Indies; a few north to Cape Cod.

Food: This large, rather sluggish shark has been found at Woods Hole to feed on menhaden, bonito, squid, etc. More detailed studies of its food

in southern waters show it to be practically omnivorous, feeding on big sea turtles, smaller sharks, carrion, and almost anything else.

SIZE: Reaches a length commonly of 11 or 12 feet, weighing five of six hundred pounds, and rarely a length of about 30 feet.

7. Blue Shark
Prionace glauca (Linnaeus)

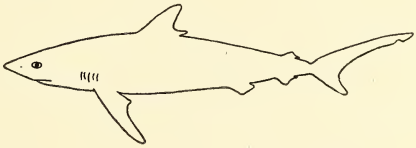


DISTRIBUTION: Very rare. July to late October. *Woods Hole,* several reported July and August. *New York,* a large one taken near City Island in late October, 1911.

A large shark of warm seas, pelagic, only occasionally taken on the coast of America, where there are records from as far north as Nova Scotia.

SIZE: Average adult about 12 feet long.

8. Dusky Ground Shark
Carcharhinus obscurus (Le Sueur)

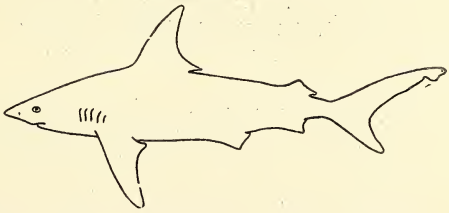


Upper teeth triangular, much broader than the lower. Snout moderately blunt. No ridge on the back. Second dorsal fin smaller than anal and placed over it; length of front of dorsal fin contained more than three times in its distance from snout.

DISTRIBUTION: There is some confusion as to the identity of sharks of this genus. At Woods Hole *obscurus* and *milberti* have been generally confused under the name *obscurus* and are reported from there June 1 into November. *Orient,* young of 22 to 32 inches, September 17 to November 1.

FOOD: Lobsters, crabs and fishes (menhaden and weakfish).

9. New York Ground Shark
Carcharhinus milberti (Müller and Henle)



Upper teeth triangular, much broader than the lower. Snout not blunt. A ridge on the back. Second dorsal fin not noticeably smaller than anal and placed about over it; length of front of dorsal (origin to tip) contained less than twice in its distance from the snout in adult.

Distribution: Common in bays of the ocean side of Long Island, mid-June to mid-September; almost all adult females, which apparently enter these inshore waters for the purpose of having their young. *Woods Hole*, of uncertain abundance, breeds. An old record (1873) refers to some other species. *New York*, almost all adult females mid-June to mid-September. Young (up to about 3 feet) July 15 to October 19 (Sandy Hook Bay).

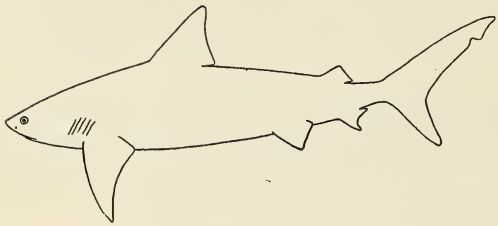
Due to the difficulty in checking up descriptions of sharks of this genus, the extra-limital range of *milberti* is uncertain. We have never seen it in the southern states.

Mr. Edwin Thorne of Babylon has secured extensive data on this shark. Females are common in the bays, present between the middle of June and the middle of September; males, very rare—seen only in August.

Food: Consists of various bottom fishes, the winter flounder, *Pseudopleuronectes*, largely predominating, and an occasional weakfish, dogfish, eel or crab.

Life History: Females carrying young taken in Great South Bay from June 22 to August 5. Young number 8 to 11, neither sex greatly predominating. When released they are about 22 inches long and weigh $2\frac{1}{2}$ pounds. One of about 3 feet seen in Sandy Hook Bay as early as June 9 may have been of the preceding year. In September, 1924, five ranged from $24\frac{7}{8}$ inches to 26 inches in total length.

Size: Adults range from a little under 5½ to 7 feet 8 inches total length, weighing between 75 and 200 pounds.



10. Southern Ground Shark
Carcharhinus commersonii Blainville

Upper teeth triangular, much broader than the lower. Snout very blunt. No ridge on the back. Second dorsal fin inserted distinctly in advance of anal; length of front of dorsal twice or a little more in its distance from snout.

Distribution: Males uncommon in the bays of the south shore of Long Island in late summer (August, earliest August 4). *Woods Hole*, status uncertain due to confusion with related species. Photographs examined of half-grown males a little over 5 feet total length,—taken August 20. *New York*, males uncommon in late summer.

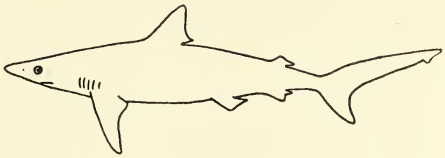
Occurs in warm waters of the Atlantic on both coasts.

Food: Inhabits coastal waters feeding on fish, large crustacea, smaller sharks and rays. Common about wharves, where it picks up refuse; seldom shows itself at the surface but is readily taken on a baited hook.

Life History: The young number about 6. On the coast of Florida they are released in spring.

Size: Adults are 8 to 8½ feet total length and weight between 250 and 375 pounds, reaching a length of 10 feet and a weight of 400 pounds (a male, North Carolina).

11. Spot-fin Ground Shark
Carcharhinus limbatus (Müller and Henle)



Upper teeth narrow, little broader than lower. Fins usually sharply black-tipped.

Distribution: Occasional in mid-summer. *Woods Hole,* 1875. At least twenty specimens during the summer of 1878. Babylon, Long Island, July 14, 1910. Easthampton, L. I., a large male, August 7, 1916 (W. Helmuth). Sandy Hook Bay, July 24, 1924, a male 35¼ inches in total length.

Occurs in tropical and sub-tropical seas, cosmopolitan. Abundant in the West Indies and Florida. Common north to the capes of the Carolinas.

Life History: Females are with young which measure about 22 inches in total length, almost ready to be released in April in the Bay of Florida The young number 3 to 6, may be of either sex or equally divided, females apparently somewhat predominate. No adult males are present in the same waters with the pregnant females at this season.

Size: Breeding females in Florida are between 5 and 5½ feet total length. Easthampton, male, 6 feet 4 inches.

HAMMERHEAD SHARKS

A specialization of the Requiem Shark type wherein the head is depressed and expanded laterally. The eyes situated at the apices of the lateral expansion.

12. Hammer-head Shark
Sphyrna zygaena (Linnaeus)

Distribution: Small individuals up to about 6 feet, rather common, July 14 to November 22. Mostly July and August. *Woods Hole,* July and October. *Orient,* one 22 inches in length, November 22. *New York,* not uncommon, mostly small examples of about 2 feet, July 14 to October 14.

Occurs in all warm seas, from Cape Cod southward on our coast. Oc-

casionally seen swimming at the surface with caudal and dorsal fins projecting. The hammerhead is a slender, active and swift-swimming shark. The most reasonable function that has been attributed to its peculiar head is that of a bow-rudder, to increase its dexterity of motion.

Food: Fish and squid.

Life History: The young of this species are in large number; 37 embryos have been taken from a female of 11 feet. Probably those adult individuals which reach our waters in summer give birth to their young at that season, due to the small size of young frequently taken here. Sandy Hook Bay, July, 1924, 3 ranged from $23\frac{1}{4}$ to $25\frac{3}{8}$ inches in total length.

Size: Reaches a total length of 17 feet, and estimated weight of 1500 pounds.

THRESHER SHARKS

Sharks with the upper lobe of the caudal fin narrow and greatly elongate, as long as the body of the fish.

13. **Thresher Shark**
Alopias vulpes (Gmelin)

Distribution: Common to the eastward, Buzzards Bay, etc. Uncommon to the west. April till late in the fall. *Orient*, two recent records, June 20, 1910, and August 12, 1912, formerly less rare. *New York*, occasional, April; July 24, 1918, Islip.

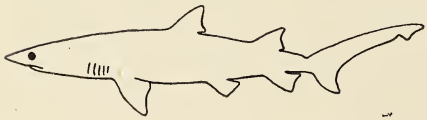
Occurs in all warm temperate seas, especially the Mediterraean, north on our coast abundantly to Block Island and rarely to the Gulf of St. Lawrence.

A surface swimmer. The thresher shark's elongate tail is not sufficiently rigid or muscular to strike an efficient blow. These sharks are said to swim round and round a school of small fish herding them into a narrow compass where they can be readily attacked, and in this sort of hunting the tail should be an asset, even aside from striking and disabling the fish, as has been reported.

Food: Fish, especially schooling surface species such as mackerel, menhaden and herring.

Size: Reaches about 20 feet total length, 15 feet not uncommon, one of 13 feet weighed about 400 pounds.

SAND SHARKS



14. **Sand Shark**
Carcharias littoralis (Mitchill)

Distribution: May 27 to November, common. *Woods Hole*, June to November. *Orient*, May 27 (1908) to October 21. *New York*, common, June 13 to October 4.

Occurs commonly between Cape Cod and Cape Hatteras, stragglers north to Maine. Very like if distinct from the European *C. taurus*.

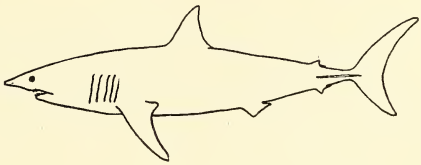
Size: Local specimens usually 5 feet or less in total length, but there is a record from Clinton, Conn., of 8 feet 10 inches, with estimated weight of 250 pounds.

MACKEREL SHARKS.

Swift and powerful sharks of more or less off-shore habitat, with the tail lunate, upper lobe only slightly longer than lower. Peduncle keeled. Teeth large, pointed, varying in shape, sometimes with basal cusps.

Teeth long, narrow and pointed without saw edges *Isurus*
Teeth large, triangular, saw-edged, the same above and below. *Carcharodon*

15. Mackerel Shark
Isurus tigris (Atwood)



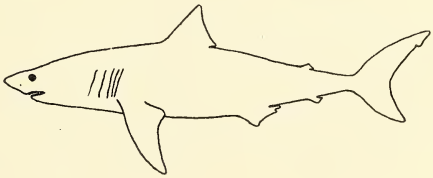
Distribution: Fairly common to the eastward, Buzzards Bay, Vineyard Sound; two reports to the west. September 11 to December. *Woods Hole*, most numerous in the fall. Taken in December. *Orient*, October 2, 1910, Sound. *New York*, casual, September 11 (1918, R. C. Murphy) to October.

Occurs from Maine (rarely), to the West Indies.

An off-shore fish which very probably seldom or never enters shallow bays or even Long Island Sound. Probably regular enough in the ocean, but seldom reported. The lunate tail and narrow, keeled peduncle of these swift, wide ranging off-shore sharks, parallels that of the mackerel-like fishes of similar habit, and for that matter of the whales and porpoises:—in a horizontal plane (cetacea), as opposed to vertical plane (fishes). It is doubtless the most advantageous form for swift continuous swimming.

Size: Reaches 10 feet or more. A 7 feet 4 inch (total length) specimen from Orient.

16. Man-eater Shark
Carcharodon carcharias (Linnaeus)



Distribution: Casual. *Woods Hole*, reported by Baird in 1871, and two, June 17 and 25, 1903. In northern New Jersey and near New York City, it was present from June to July 14, 1916, but whether more than one individual is uncertain.

Occurs cosmopolitan in tropical and sub-tropical seas, apparently everywhere rare, on our coast accidental north to Eastport, Maine.

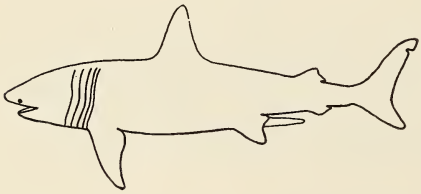
The man-eater or white shark is the largest member of the particularly swift swimming voracious group of mackerel sharks. The largest specimens are lead-white in color,—the smaller ones are dark above and white below. It is one of the largest, most powerful of existing fishes. Dr. Jordan tells of finding a fair-sized young sea-lion, whole, in the stomach of one of about 30 feet. Certain individuals, at least, are dangerous to bathers, and it is fortunate that, even in the tropics, the species is almost everywhere rare.

Food: This shark doubtless feeds mostly on large fish and sea turtles.

Size: Reaches a length of 36 feet, or more.

BASKING SHARKS

Very large sharks with the lunate caudal fin and keeled peduncle of the mackerel sharks, but teeth very small, non-functional. Gill openings very long, occupying almost the entire side of the head.



17. Basking Shark
Cetorhinus maximus (Gunner)

Distribution: Casual, a male, 14 feet total length at Westhampton Beach Long Island, June 29, 1915. *Woods Hole*, August 16, 1906, and another in 1908. Some question as to identification. One June 24, 1920, Menemsha (mounted in Boston Society of Natural History Museum). *New York*, accidental.

Occurs in cold northern seas, circumpolar. Casual south of Virginia. In the early days it was common off Massachusetts, where it was presumably extirpated by the fishery for oil. The basking shark swims sluggishly in the open ocean, generally near the surface, at times in schools.

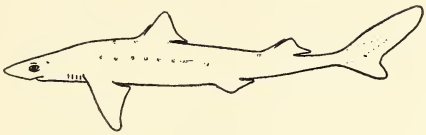
Food: It has feeding habits like those of the whalebone whales, its diet consisting of small animals which it sifts from sea water with the meshwork of its long, finely-toothed gill-rakers. "The alimentary canal of the Westhampton specimen contained a large quantity of bright red material which under the microscope resolved itself into a vast multitude of minute crustaceae." (Hussakof, *Copeia*, no. 21.)

Size: Reaches a length of at least 45 feet.

SPINED SHARKS

Small sharks with a spine in the front of each of the two back fins. No anal fin.

18. **Spined Dogfish**
Squalus acanthias Linnaeus



Distribution: Usually abundant during the winter months, October to April. Moves in great schools and may vary greatly in numbers at given localities from year to year. One or two reports of its presence in summer. *Woods Hole,* May, again in October, and in general absent in the intervening months. *Orient,* October 5 to December 12; abundant in the fall, and taken in the spring as late as mid-May, occasionally to June 27. Young sometimes abundant in July. Occasionally adults in July and August, and at that season these are probably common on the deep water ledges in the Sound. *New York,* not uncommon, October to April, rarely occurs in summer (July 12, 1916); common spring and fall.

Occurs abundantly on both sides of the Atlantic, rarely south to Cuba.

Usually swims deep, at about the same depth as the cod, in schools or packs which are sometimes of immenze size. With beam-trawl fishermen near the tilefish grounds at the edge of the continental shelf in late fall we have seen the trawl time after time fill up to overflowing with these dogfish. They were so abundant that it was impossible to catch anything else. Other fishes when brought up from this depth and pressure floated helplessly at the surface in a crippled and dying condition. Not so the tough, less specialized dogfish. These snapped viciously and struck at the hand with their spines, and when released swam away as good as ever, immediately beginning to spiral downward into the ocean depths from whence they came.

Though little marketed, the spined dogfish is an excellent food fish, if properly cooked. The flesh should be soaked or boiled in vinegar or some other acid, and cooked thoroughly with plenty of butter or oil. At one time it was rather extensively canned as "gray fish."

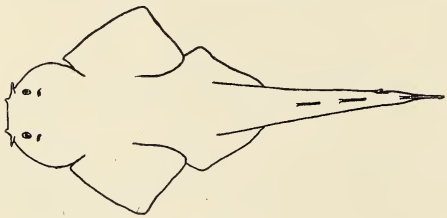
Food: Feeds on fishes (hake, herring), squid, worms; and apparently jelly-fish form an important item of its nutriment. At Woods Hole, *ctenophores,* a very abundant low group of jelly-fish, recorded as its most important food. A strong ammonia taint in its flesh which makes special cooking necessary may be correlated with this peculiar diet. At least a similar taint has been noticed in the flesh of the enormous whale shark, which occurs casually in Florida, tropical representative of the basking shark of the north. The whale shark may reasonably be supposed to sift quantities of jellyfish as food, among other things, from the warm seas where it has its home.

Life History: As in the requiem sharks, the eggs of the spined dogfish hatch within the body cavity of the mother, and the young are not released until well developed, nine inches to a foot in length. The species is peculiar, however, in that its young develop successively in twos and threes, several younger pairs being present before the oldest is released. At least this interpretation of the data is advanced by Couch, 1867, "British Fishes," who further states that for nine or ten months of the year the female produces young almost every day. Even if this be an exaggeration, the great abundance at times of this dogfish is easy to understand. On the other hand Bigelow and Welsh, 1925, "Fishes of the Gulf of Maine," consider that the spined dogfish gives birth to one or more regular litters annually of 1 to 11 young. Data furnished by F. A. Schneider on specimens brought to Fulton market by tile-fishermen in the winter of 1924 to '25 favors an hypothesis of a regular brood in early spring. Females between December and April contained from 3 to 7 well developed young, those in one fish in about the same stage of development; and generally about 4 or 5 large mature eggs. The yolk sacs were large in December, practically gone in February, young ready for extrusion in March. Between December and February fish brought in were about equally divided males and females. During March the males outnumbered the females 10 to 1.

Size: Reaches a total length of $3\frac{1}{2}$ feet, and weight (exceptionally) of 15 pounds.

MONKFISHES

Shark-like fishes, more or less flattened dorso-ventrally, but with the gills on the side of the neck, not below. Head circular; neck constricted. Pectoral fins expanded, somewhat wing-like.



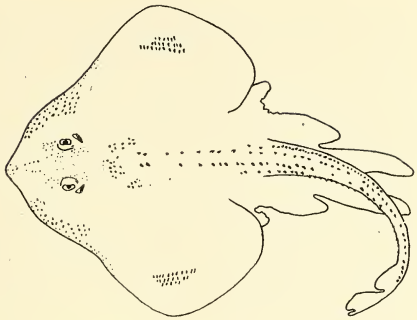
19. **Monkfish**
Squatina squatina (Linnaeus)

Distribution: Rare in summer. *Woods Hole*, one of 35 or 40 pounds, 3 or 4 feet long, September 1, 1873; one 43 inches long, Menemsha Bight, September 23, 1921 (Francis West). *New York*, rare in summer.

Occurs in warm seas, uncommon on our coast from Cape Cod southward, common in the Mediterranean.

SKATES.

Shark-like fishes, flattened to lie on the bottom, face down. Pectoral fins fused with the body to form a rhomboidal disc, from which a slender spiny tail projects. Two dorsal fins placed close together far back on the tail.



20. **Common Skate**
Raja erinacea Mitchill

Snout end of disk broadly rounded, small teeth in about 50 rows.

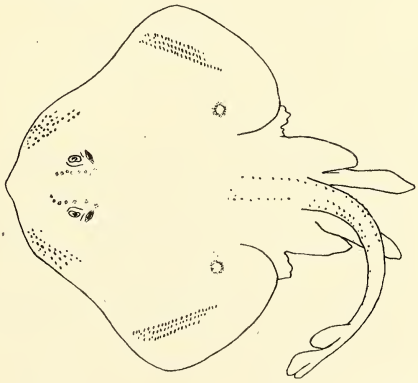
Distribution: Common resident, frequenting especially sandy bottoms, ocean bays, and open sounds, apparently more numerous to the eastward in summer, to the westward in winter. *Woods Hole*, present from April to October. *Orient*, permanent resident. *New York*, common permanent resident. In Sandy Hook Bay noted October 10 to June 1, apparently absent during the summer.

Occurs from the Gulf of St. Lawrence to Virginia. Numerous in shallow as well as deep waters. At Orient it is taken more commonly during hot summer weather in shallow rather than deep water, and is washed ashore in winter gales. Found in Gardiner's Bay throughout the winter.

Food: Usually crustacea (crabs, shrimps, amphipods), also bivalve mollusks, squid, fish (*Ammodytes*, which hides in the sand, one species of fish mentioned).

Life History: Eggs are laid in summer, from May or earlier in the spring until October. The egg-cases of skates are familiar objects washed up along the sea shore. Leathery, rectangular, with lengthwise prongs at the four corners: usually blackish. The eggs of this skate are released during the summer months.

Size: Reaches a maximum length of 2 feet.



21. **Big Skate**
Raja diaphanes Mitchill

Resembles the common skate in shape, but is larger, teeth in about 90 rows. Usually an ocellated spot on each "wing."

Distribution: Winter resident, September to June, common in water of 5 or 6 fathoms and deeper, migration probably inshore in winter, offshore in summer and an occasional individual present throughout summer months. *Woods Hole,* present from February till June and from October till the end of trap fishing; absent or very rare in summer. *Orient,* resident, rare in winter and warmer parts of summer. *New York,* rather common September to December 30, probably resident.

Occurs on the coasts of New York, Massachusetts, and northward to the Gulf of St. Lawrence, where it is common.

Skates are a first-rate food-fish, though not generally eaten by our native population, who do not like their looks. The thick bases of the pectoral fins at the side of the disk, or wings, is the part eaten.

Food: Mostly crabs, also squid and annelids, fish (herring, menhaden, billfish, etc.—Orient).

Life History: A female about a meter in length, taken May 11, contained ova ranging up to a walnut in size. Taken with egg case ready to release December 20 (Cholera Bank).

Size: Reaches a total length of 34 inches (a male, Long Beach) or more.

22. **Starry Skate**
Raja radiata Donovan

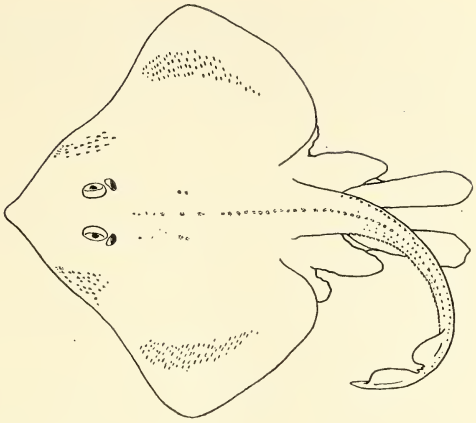
Snout ending in a short blunt angle. Body and tail armed with large bucklers, each with a stellate base. Teeth in 50 rows or less.

Distribution: *Woods Hole,* Menemsha Bight fish traps, not common, none having been taken for years (Edwards).

Occurs on both coasts of the North Atlantic, rare on the American side; the American form (called *R. scabrata* by Garman) probably a distinguishable race.

Size: Reaches a length of 2½ feet.

23. **Clear-nosed Skate**
Raja eglanteria Lacépède



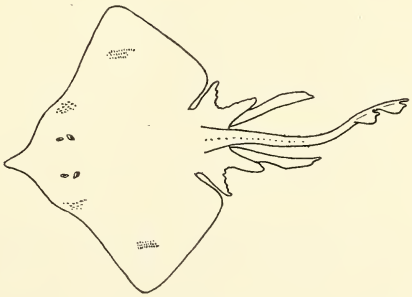
Snout ending in a pronounced, acute angle, with a translucent area on either side of it. Teeth in about 45 rows.

Distribution: Rather common summer resident. April to November 1. Uncommon at the eastern end of the region. Common at Orient, mid-June through September. *Woods Hole*, formerly a few every year, one September 14, 1911. *Orient*, April 30 to November 1. *New York*, not uncommon, June 1 to October 21. Tends to absent itself from Sandy Hook Bay in the warmest weather, none recorded in September. A southern species which we have with us in summer, its migration being apparently along the coast.

Occurs from Cape Cod (casually Cape Ann) to Florida, not very common.

Size: Latham records one from Orient, 26 inches in length, weighing 11 pounds. A larger male 25¼ inches long exclusive of the tail (snout to distal end intromittent organs) lying on ocean beach at Mastic, Long Island, May 18.

24. **Barn-door Skate**
Raja stabuliforis Garman



Head and snout long, produced, ending in a blunt-tipped angle. Teeth in about 33 rows.

Distribution: Rather common spring and fall, uncommon but regular to the eastward in summer, and occurs to the westward in winter. *Woods Hole*, common spring and fall, rare in summer. *Orient*, May 8 to December 14, regular but uncommon throughout the summer. *New York*, common, October to June.

Occurs from the Gulf of St. Lawrence to Florida. Usually taken in rather deep water.

Food: Bivalve mollusks, lobsters, crabs, and small crustacea, also squid and various fishes (cunners, and herring, menhaden, mackerel etc., recorded as food at Orient).

Life History: The egg-cases of this skate, which should be easily recognizable are not found cast up on our beaches, as they are further south (North Carolina).

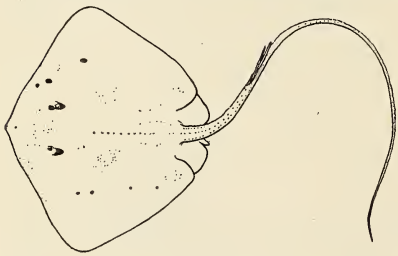
Size: Latham has measured one at Orient 52 inches long, 38 inches across, and states that specimens 100 pounds in weight have been taken near there. Reaches a maximum length of 6 feet or more.

STING RAYS

Skate-like fishes, less strictly bottom-livers than the skates. The tail long, slender, finless, whip-like, with usually a single large dangerous saw-edged spine at its base. The flattened disk is roundish with a right angle at the snout and its greatest breadth forward. The spine and shape of the disk are subject to variation as some genera approach the Eagle Rays. The top of the head is always flush with the back; not squarish and elevated.

Tail long, whip-like, with a strong saw-edged spine at its base. *Dasyatis*

Tail whip-like but short, shorter than the disk, which is broader than long, its broadly pointed "wings" used like those of a bird. Caudal spine small or absent *Pteroplatea*



25. **Sting Ray**
Dasyatis centrura (Mitchill)

Distribution: Not uncommon June 3 to October 3. *Woods Hole*, common in Buzzards Bay; rare at Menemsha, appearing in June or early July. *Orient*, formerly common, now very rare and irregular, June 3 to October 3. *New York*, uncommon, June 20 to September 23.

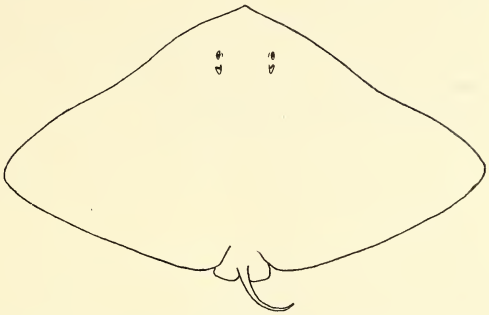
Occurs from Maine to Cape Hatteras. Abundant southward.

Food: Mollusks, crabs, annelids, etc., squid, and in one case, a small fish.

Life History: The sting rays bring forth their young alive.

Size: Reaches a length of 10 to 12 feet.

26. **Butterfly Ray**
Pteroplatea maclura (Le Sueur)



No spines at base of tail. No tentacle behind spiracle. Size moderate or small.

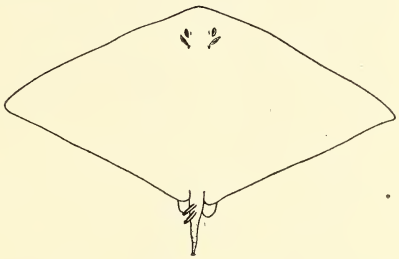
Distribution: Uncommon in summer. *Woods Hole*, reported. *New York*, rare; one in Sandy Hook Bay, July 30, 1924, a female 30½ inches across, with ova small, about 5 mm. in diameter.

Occurs from Long Island to Brazil, not uncommon on the Carolina coast.

Food: Crabs.

Size: Reaches a width of perhaps 2½ feet.

27. **Giant Butterfly Ray**
Pteroplatea altavela (Linnaeus)



One or more spines at base of tail. A tentacle behind spiracle. Size large.

Distribution: Accidental, one record. Woods Hole, July 3, 1922.

Occurs from the Mediterranean to Brazil and rarely off the capes of the Carolinas.

The butterfly ray has its name from its manner of swimming. It flits through the water with its great wings appearing much as butterflies do, flying through the air.

Size: The local record was a specimen 4 feet 2 inches across. Reaches 5 feet 10 inches width (North Carolina).

EAGLE RAYS

Flattened rays which have secondarily reassumed the free-swimming habit, the sides of the disk, or wings, being pointed, and flapping in an almost bird-like manner. Head elevated and squarish; tail long and lash-like with one or more small serrate spines at its base.

Front of the head straight across. *Myliobatis*

Front of the head emarginate. *Rhinoptera*

28. **Eagle Ray**
Myliobatis freminvillei Le Sueur

Distribution: Uncommon in summer and fall at the eastern end of the region. *Woods Hole*, not very common from July to October. *Sandy Hook Bay*, July 2, 1926, young 14½ inches wide.

Occurs from Cape Cod to Brazil.

Food: Feeds on lobsters, crabs, and large mollusks.

Size: Reaches a width of perhaps 4 feet.

29. **Cow-nosed Ray**
Rhinoptera bonasus (Mitchill)

Distribution: Not uncommon in summer, especially to the eastward.

June 13 to October 15. *Woods Hole*, rather common, July 12 to October 15. *Orient*, formerly common June to September, unknown since 1906. *New York*, uncommon. June 13 to September 11; a few taken every year in Sandy Hook Bay.

Occurs rather commonly from Cape Cod to Florida.

Food: Feeds on clams, gastropods, small lobsters, crabs and other crustacea. The Cow-nosed Ray has hard paved teeth for eating mollusks and is said to be particularly destructive to the soft clam.

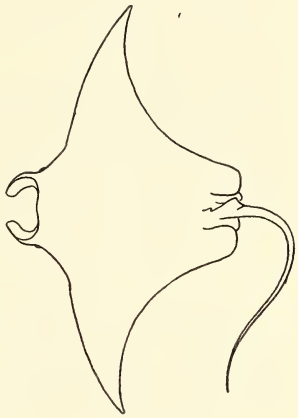
Life History: Ripe females, Woods Hole, July 12, 1889.

Size: Reaches a width of perhaps 6 feet.

MANTAS

Rays similar to the eagle rays, but with a 'cephalic fin' on either side of the broad head which can be rolled into a forwardly directed 'horn,' whence the name 'devil-fish.' Teeth fine, insignificant. Whip-like tail shorter, comparatively, than in eagle rays.

30. **Great Manta**
Manta birostris (Walbaum)



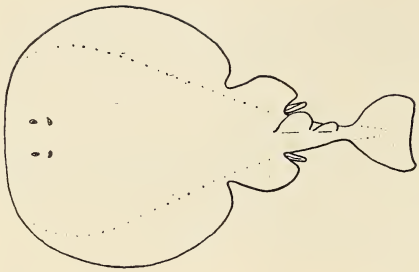
Distribution: Accidental. A large individual about 14 feet across captured 10 miles off Block Island, about September 1, 1921.

Occurs in tropical waters on both coasts of America, straggling north to the Carolinas.

Size: Reaches a width of 22 feet and weight of over 3,000 pounds.

ELECTRIC RAYS.

Bottom rays, suggesting the skates and certain of the sting rays in appearance. Disk rounded, tail stout, skin everywhere smooth, no spines. Possess electric organs, and can give a powerful electric shock.



31. **Torpedo**
Tetronarce occidentalis (Storer)

Distribution: Summer resident, May to November, regular to the eastward, very rare to the westward. *Woods Hole,* May till November, most common late in the fall at which time several may be taken together in one haul of the trap. *New York,* accidental, summer.

Occurs from Cape Cod, casually from Eastport, Me. to Cuba, uncommon; also in Europe.

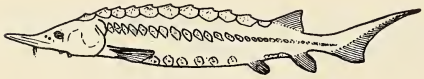
Bearing no armature of spines or prickles, the torpedo protects itself by its ability to give a severe electric shock. Before the days of kerosene the liver oil of this fish was valued for illuminating purposes.

Food: Fish.

Size: Average weight, 30 pounds. A specimen weighing 144 pounds from Nantucket, October 23, 1908. Another also from the Woods Hole region mounted by Francis West 1923, in the American Museum of Natural History, measures 4 feet 2 inches total length, 3 feet 2 inches across. Individuals as heavy as 200 pounds have been recorded.

STURGEONS

Large fishes with more or less pointed snout; mouth on the under side of the head; and unsymmetrical, shark-like caudal fin, upper lobe the longer. Body armed with tubercles and rows of large, hard, bony plates. Enter fresh-water streams to spawn.



32. **Common Sturgeon**
Acipenser sturio Linnaeus

Snout nearly ½ length of head.

Distribution: Rather uncommon. Reported at all seasons excepting January. Ascending rivers. *Woods Hole,* most numerous in June and July. *Orient,* has become rare. One of 8 feet, Greenport, May 26. Small specimens still taken in fall, September to December 8. *New York,* not uncommon, February to fall. In Sandy Hook Bay, small ones fairly common in mid-September, 1920.

Occurs on both sides of the North Atlantic, from the St. Lawrence to

Carolina and more rarely the Gulf of Mexico on our coast. Formerly abundant, but has been much reduced in numbers.

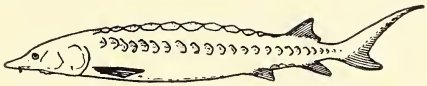
Adults enter the mouths of rivers in spring and slowly work their way up stream, usually at least beyond tide water before they deposit their eggs. A single female may produce between two and three million eggs. They eat little or nothing when running up river to spawn. The young are 4 to 5½ inches long at an age of 2 months. The old fish return to the sea after spawning, and the young may remain in the river for one or several years.

Food: The sturgeon is a bottom feeder, most abundant on sandy ground. It roots in the sand or mud with its snout, the barbels being used as organs of touch, and thus obtains worms and mollusks, doubtless also the sand launce, one of its favorite foods. It also sucks into its mouth various other fishes and crustacea.

Life History: The heavy adhesive eggs of the stur gon are deposited in spring or summer. They average about 2.8 mm. in diameter. They hatch in about six days at a temperature of 65° F. The average number produced by a female is about 1,680,000.

Size: A length of 18 feet has been recorded for this fish from Europe and from New England. A recent local individual measured 8 feet total length (Orient).

33. **Short-nosed Sturgeon**
Acipenser brevirostrum Le Sueur



Snout about ¼ length of head.

Distribution: Rather common at the western end of the region. *Orient*, irregular, usually rare, occasionally several in May, October and November. May 11 to December 2. *New York*, uncommon (May).

Occurs from Cape Cod to Florida; rare northward.

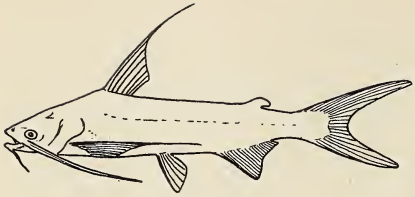
Size: Reaches 2½ feet total length (Orient).

CATFISHES.

Small or medium sized scaleless fishes with a rayed dorsal fin before the middle of the back, and small adipose dorsal near the tail. Mouth transverse, surrounded by several barbels. Dorsal and pectoral fins each with a single stout spine.

Maxillary barbel long and bandlike, dorsal and pectoral spines with bandlike filaments, lower jaw with two barbels. *Felichthys*

Barbels normal, spines without filaments, lower jaw with 4 barbels. *Galeichthys*



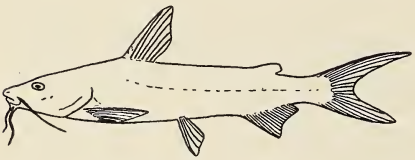
34. Gaff-topsail Catfish
Felichthys marinus (Mitchill)

Distribution: A straggler from the south. August and September. Occasionally common to the westward. *Orient*, twice recorded from Sound, June 4, 1906 and August 11, 1912. *Woods Hole*, 4 records (September 11). *New York*, occasionally common, August. *Sandy Hook Bay*, July 28, 1926.

Occurs from Cape Cod to Texas. Common southward.

Life History: The large eggs are carried in the mouth of the male until hatched and here the young find shelter until about 3 inches long and able to care for themselves. South of our territory this species breeds in June and July according to Gudger, from whose work the following data has been taken. The eggs are extremely large, averaging about 22 mm. in diameter. The male protects the eggs during incubation by carrying them in his mouth. A male of 22 inches may carry as many as 55 eggs in this manner. The fish hatch and nearly entirely absorb the yolk sac before they are liberated from their father's mouth. This period probably extends between 60 and 70 days.

Size: Reaches a length of about one foot.



35. Sea Catfish
Galeichthys milberti (Cuvier and Valenciennes)

Distribution: A rare straggler from the south. *Woods Hole*, very rare, none being recorded since 1887. Formerly recorded as at times common. *New York*, rare.

Occurs from Cape Cod to Texas; common southward.

The sea catfish is an abundant omnipresent fish in waters of the southern states, entering harbors otherwise almost barren of fish life. It is very active and hungry at night.

Size: Reaches a length of about one foot.

TARPONS.

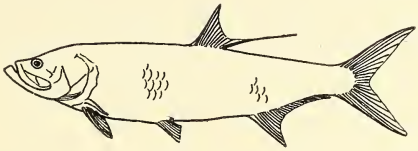
Silvery, herring-like fishes with a single soft-rayed fin in the center of the back. Scales of moderate or large size. Lateral line present. Mouth large. Dentition various. Lower jaw the longer.

Body compressed, last ray of dorsal fin produced in a filament.
A large fish with large, heavy, silvery scales. *Tarpon*

Body elongate more or less cylindrical. No dorsal filament.
Scales small. *Elops*

36. **Tarpon**

Tarpon atlanticus (Cuvier and Valenciennes)



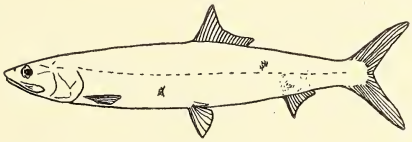
Distribution: Rare summer visitor. August to October, most frequent to the eastward. *Woods Hole*, probably present every year, chiefly latter part of September, one August 31. Local specimens 80 to 100 pounds. *Orient*, casual, August 1, 1922, 4½ feet. Mid-October, 1924, Southold Bay, N. side Paradise Pt., 17½ pounds, Capt. E. C. Rouse of Greenport. *New York*, casual, summer and fall (October). Rare in Sandy Hook Bay. Occurs from Cape Cod (casually Nova Scotia) to Brazil, common coastwise from Florida south. The gigantic herring-like tarpon commonly enters the mouths of semi-tropical rivers and it is much sought by anglers for sport.

Life History: The eggs of Florida tarpon ripen in summer. They are exceedingly small and exceedingly numerous, estimated at 12 millions in a 142 pound female. Where they are deposited and whether there is a peculiar larval form is not known. Young tarpon, less than one foot in total length, are everywhere very rare.

Size: The record seems to be 8 feet 2 inches total length; estimated weight 350 pounds.

37. **Big-eyed Herring**

Elops saurus Linnaeus



Distribution: Uncommon fall visitor, October 6 to November 4, most frequent to the eastward. *Woods Hole*, uncommon in fall, none recorded before October. *Orient*, uncommon, October 6 to November 4. *New York*, rare, October. (October 12.)

Occurs in warm seas. Cosmopolitan. Ordinarily rare, this species was comparatively common near Sandy Hook in the fall of 1923.

The following data was taken from a sample of 13 taken on October 19 from a single pound net:

Standard Length	*Weight*
Maximum 43 cm.	1⅝ pounds
Average 35 "	1¾ "
Minimum 33 "	¾ "

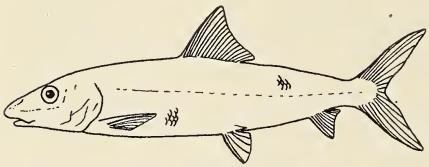
The stomachs of all were empty save one which contained a piece of *Ulva*, no doubt taken accidentally.

Examination of the scales, although they were difficult to read, suggested that these fish were just entering on the second winter of their existence, through which they bore scales large enough to read the season's marks on, that is, they were probably hatched during the spring or summer of 1921. Proportional measurements indicated that they averaged about 22 mm. last winter.

Size: Local specimens range from 8 to 15 inches.

BONE-FISHES.

Silvery, herring-like fishes with a single soft-rayed fin in the middle of the back. Mouth small, under the pig-like snout. Scales rather small. Body sub-cylindrical.



38. **Bonefish**
Albula vulpes (Linnaeus)

Distribution: Casual (October). *Woods Hole*, recorded. *New York*, accidental, October.

Occurs in warm seas, cosmopolitan, north casually to our region.

The bonefish, on account of its game qualities, ranks very high with sportsmen. It is also an interesting species from a scientific or philosophical point of view. Though nowhere occurring in the abundance or in the close schools that are characteristic of various species of herrings, it has an enormous range and is not uncommon in the warmer seas of the entire world. It is more or less related to the herring family, having doubtless been evolved from ancestors of the herrings ages ago and proved so successful in life's competition that we have it with us to-day, practically unchanged, though all its close relatives have passed into history.

Bonefish probably feed to a considerable extent on small shelly animals which they suck out of the mud, for they have hard, stony pavement-like teeth in the back of the mouth. Such teeth have often been found as fossils and we know that there were bonefish in earlier seas as far back as the Eocene. Whether, as to-day, the early bonefish belonged to a single species, or whether the tribe was then more numerous and varied, is a matter for conjecture.

Most fishes which subsist on so lowly a diet are sluggish, and protected against their enemies by hard shells, strong spines or a concealing resemblance to the mud, or weeds where they hide. Not so the bonefish. Big-eyed, alert, its long cylindrical body is endowed with phenomenal speed and strength. Many of the true herrings swim in vast compact schools,

growing fat from the rich harvest of small food they are able to sift from the water with their large mouths and network of fine gill-rakers. They are destroyed in enormous quantities by various predacious creatures and hold their own by their very ability to multiply in proportion; but the bonefish is comparatively solitary and self-sufficient.

Life History: Passes through a flattened, transparent larval form as does the common eel. Such larval forms probably do not parallel the development of the race, but are a special adaption to early life, like the caterpillar of the butterfly.

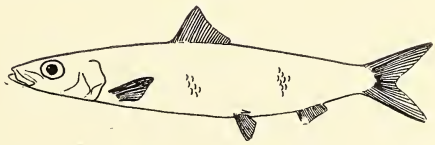
Size: Reaches a total length of 31 inches and weight of 13 pounds.

HERRINGS.

More or less compressed, silvery fishes of moderate or small size. Scales variable in size, frequently large, no lateral line. Caudal fin well forked. Mouth large, the jaws about equal or the lower somewhat the longer. Teeth very small or absent. Gill-rakers very long and fine. A single soft-rayed fin in the middle of the back. Frequently knife-like, keeled scutes along the ventral outline.

a.	Belly rounded, covered with ordinary scales.	*Etrumeus*
	Belly compressed, armed with serrae which are more or less bony and sharp (see b).	
b.	Last ray of dorsal produced in a filament	*Opisthonema*
	Scales with their posterior margins vertical and pectinate.	*Brevoortia*
	Not as above (see c).	
c.	Ventral scutes weak, scales about 57	*Clupea*
	Ventral scutes weak, scales about 45.	*Sardinella*
	Ventral scutes strong and sharp (see d).	
d.	Cheeks longer than deep, scales 50 to 52.	*Pomolobus*
	Cheeks deeper than long, scales about 60.	*Alosa*

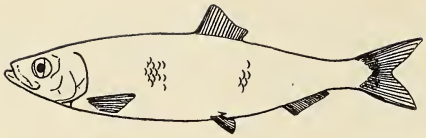
39. **Round Herring**
Etrumeus teres (De Kay)



Distribution: Uncommon in summer and fall, at times occurring in large numbers, May 24 to December 8. *Woods Hole*, ordinarily rare, occasionally abundant, July 3 to October 21. *Orient*, more or less common every summer, May to October, sometimes abundant, May 24 to December 8. *New York*, uncommon, July to October.

Occurs from Cape Cod (casually Maine) to the Gulf of Mexico, mostly on sandy shores, not rare southward.

Size: Average 5 or 6 inches, largest 7 inches total length. (Orient.) A very large one, 15 inches (Sandy Hook Bay).



40. Sea Herring
Clupea harengus Linnaeus

Distribution: Present at all seasons in irregular numbers, few or none from mid-July to fall. Adults abundant to the eastward in fall and fry taken there throughout winter. *Woods Hole*, adults with spawn appear about October 15, remaining until cold weather, fry taken by townet from October to June. *Orient*, May 15. A few adults (12 inches) July 16. *New York*, irregular, all seasons, Uncommon in Sandy Hook Bay, medium sized individuals to July 7, and again on October 17.

Occurs northerly in the North Atlantic on both coasts, occasionally south to Cape Hatteras in winter.

Food: The herring is probably the most numerous fish in the colder waters of the North Atlantic. It swims in great schools, feeding on plankton. Having reached the length of about ½ inch, it depends almost exclusively on copepod crustacea for food. As it grows older it feeds more and more on larger shrimps, etc. Bigelow and Welsh say:

"When feeding on copepods herring swim open-mouthed, often with their snouts at the surface, crossing and recrossing in their tracks and evidently straining out the minute crustaceans by means of their branchial sieves, a straining apparatus of coarser mesh than that of the menhaden and consequently capturing larger plankton and letting the microscopic plants pass through.

"When feeding on euphausiids, as we ourselves have often seen them engaged and with which the large fish are often gorged, they pursue the individual shrimps, which often leap clear of the water in their efforts to escape."

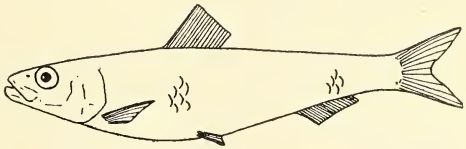
Herring are an important food of other larger fishes. The silver hake in particular at times drives schools ashore, sometimes stranding on the beaches with its intended victims. The finback whale devours them in quantity, and squids destroy the young.

Life History: In our territory the spawning season of the herring is at its height in November. The eggs are demersal and adhesive, adhering to any nearby submerged object; usually stones or sea weed. The average number deposited by a female is about 30,000. The average diameter of the ova is about 1¼ mm. They hatch in about 22 days at a temperature of 45° Fahr. The larval fish have a length of about 6 mm. on hatching and remain close to the bottom until the yolk sac is exhausted. The growth of the herring appears to be highly variable from one locality to another, dependent on a large number of factors. They appear, however, to reach maturity in about the third year. At times a length of 18 inches is reached,

although such a size is unusual and the average spawning fish is most frequently about 12 inches in length.

Size: 14 inches total length, weight 12 ounces; 13 inches total length, weight 14 ounces; very large individuals (Orient). The maximum is about 18 inches.

41. Spanish Sardine
Sardinella anchovia Cuvier and Valenciennes



A conspicuously striate area on either side of the nape; the two adjacent behind and diverging forward.

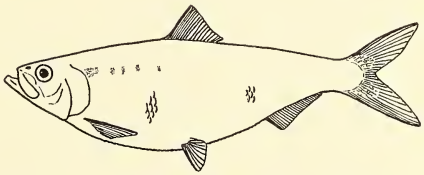
Distribution: *Woods Hole,* generally rare, sometimes numerous, appears during September, October and November. We have to hand a specimen 3¼ inches total length, Montauk, September 17, 1923, Murphy and Harper, but know of no definite record further west.

Occurs from Cape Cod to Rio de Janeiro, and is represented in Europe by the allied *S. aurita,* questionably distinct.

Food: Feeds on copepods (Woods Hole, August).

Size: Commonly reaches about 6 inches.

42. Hickory Shad
Pomolobus mediocris (Mitchill)



Peritoneum pale. Head long, about 4 times in length to base of caudal.

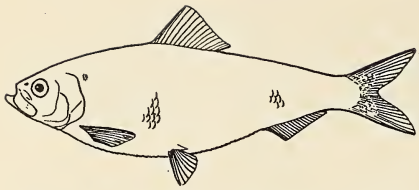
Distribution: Rather common April 1 to December 20, most numerous in the fall, has not been recorded to the westward before July. *Woods Hole,* present from spring till end of trap-fishing season, most numerous in the fall. April 1 to December 20. Common spring and fall, adults rare and irregular in summer, young sometimes abundant in July and August. New York, July 8 through November.

Occurs from Cape Cod (casually Maine) to Florida, not ascending stream to spawn.

During August examples were taken in Sandy Hook Bay which averaged about 250 mm. in standard length.

Food: Feeds on fish (launce, anchovies, herring, silversides, porgy, cunner, etc.) squid, small crabs, and other crustacea.

Size: Reaches 2 feet in length and a weight of 2½ pounds.



43. **Alewife**
Pomolobus pseudoharengus (Wilson)

Peritoneum pale. Head short and heavy, about 4⅔ times in length to base of caudal.

Distribution: Abundant, present at all seasons, rare in January. Adults arrive from February to April, ascending fresh-water streams to spawn, and return to the sea in May, where they are sometimes abundant in fall. *Woods Hole*, arrives in March and April, passing then into fresh-water and returning in May. Abundant also in October and November. *Orient*, throughout the year; irregular and uncommon in winter after December 20; abundant March to May, and in fall. *New York*, common, February to December 18.

Occurs from Nova Scotia and the Gulf of St. Lawrence to the Carolinas, entering fresh water streams to spawn in their tributary ponds or quiet stretches.

Food: The alewife is chiefly a plankton feeder, subsisting on minute crustacea. It also eats larger shrimps and various small fishes, and on the other hand often contains food as small as diatoms, even when adult.

This fish is excellent eating, and a favorite bait for cod, etc.

River herrings of the genus Pomolobus, the shad, and the sea herring, which also moves in shore to spawn, move off shore to avoid unfavorably low winter sea temperatures. There is no evidence that they undertake any extensive north-south migrations along the coast.

Life History: Spawns in streams and ponds in April and May, returning to the sea when spent. By fall the young have all found their way down to salt water, where they live until sexually mature, usually in schools as does the herring.

The examination of a series of fishes of this species from their spawning grounds in the Swimming River, a confluent of Sandy Hook Bay, revealed that the ripe males averaged 240 mm. in standard length while the females averaged 15 mm. more. The sexes were present in about equal numbers in both 1922 and 1923. During the latter year the first specimen was seen on March 26 and the last one on May 13. On May 2, 6 per cent. of the fish were spent. As in other places the runs of this species precede that of the shad, a few only now being taken in this stream.

The eggs average over 100,000 for each female. They are adhesive and demersal, adhering to anything with which they come in contact, somewhat after the manner of those of *Clupea*, whose eggs they about equal in diameter. At a temperature of 60° F. they hatch in about six days into active larvæ. According to Smith, in North Carolina they reach a length

of 3 or 4 inches by fall. This is in fair agreement with the results of the examination of scales from a small series of fish from this River, although our data indicates a slightly faster growth, as follows:

Standard Lengths.

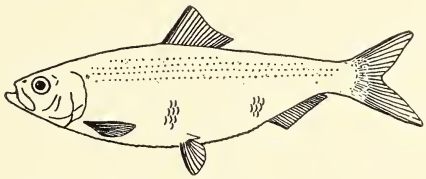
1st winter	*2nd winter*	*3rd winter*	*4th winter*	*5th winter*
116 mm.	196 mm.	233 mm.	249 mm.	254 mm.

Fish approaching their second and third winter are most common in Sandy Hook Bay in summer. Small examples of about 60 mm. standard length, approaching their first winter, are sometimes fairly common in July.

The bulk of the spawners were four years old according to our calculations. No previous spawning rings could be discerned and it seems likely that this was the first spawning for these fishes. At this size they average a little less than one-half pound. In July fishes of this species taken in Sandy Hook Bay averaged about 70 mm. in standard length, which in comparison with the above table would make them of the last spawning. One from a little further east, Mastic, L. I., July 29, 1923, was 67 mm. standard and 83 mm. total length. As one proceeds eastward the warming of the sea water in spring is delayed, and one would expect the season to be a little later.

Size: Reaches 14¾ inches total length (Orient).

44. **Glut Herring**
Pomolobus aestivalis (Mitchill)



Peritoneum black, otherwise much like *pseudoharengus*.

Distribution: Rather common June 1 to December 9. The evidence indicates that its abundance shifts from west to east during the warmer months. *Woods Hole*, common, comes later than the alewife, taken in September and October. *Orient*, usually rare, June 20 to December 4, sometimes abundant from July 20 to mid-August. *New York*, not uncommon, June 1 to August, young to December 9.

Occurs on the Atlantic Coast from Nova Scotia to Florida, more abundant than the alewife in the Southern States and less abundant northward.

This species closely parallels the alewife in habits as in appearance. No commercial distinction is made between the two.

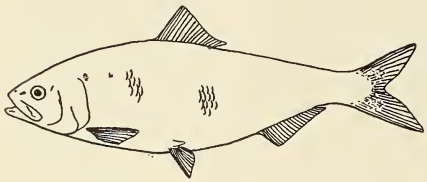
Life History: Spawns in brackish ponds (Woods Hole); does not run far above tide-water.

Development: This anadromous clupeoid spawns in fresh or nearly fresh water. The spawning season is a long one but appears to be at its height in July. The eggs are demersal, slightly adhesive, yellowish in color and have an average diameter of 1.0 mm. The eggs hatch in about 50 hours at a

temperature of 72° F. When newly hatched the larvae measure about 3.5 mm. At a length of about 40 mm. most of the diagnostic characters of the adult are present.

A young one picked up cast on the ocean beach (at Long Beach, L. I.) December 9, 1920, was 45 mm. in standard length, of course in its first year; and one on November 5, 102 mm., presumably in its second. Others averaging 83 mm. in standard length taken in Sandy Hook Bay on June 2, 1925, and specimens averaging 96 mm. from Jamaica Bay, October 21, 1925, would seem to have been in the same year class, spawned the preceding summer (1924).

Size: Reaches one foot or somewhat over in length.



45. Shad
Alosa sapidissima (Wilson)

Distribution: Not uncommon, though far less numerous than formerly. Present from March 16 to December 20. Runs towards fresh-water streams to spawn about May 1, and is rarely met with coastwise after October. *Woods Hole*, comes about May 1, remaining only about a week, contains well advanced spawn on arrival. *Orient*, irregularly common April 16 to June 1; adults rare in summer and fall; young more frequent in fall, to December 20. Average spring arrival (16 years) April 20. *New York*, not uncommon (March 16) May to October (December).

Occurs from the Gulf of St. Lawrence to Florida; and has been successfully introduced on the Pacific coast.

Shad are taken commercially, commonly in nets, but there are numerous instances of their taking the hook.

Food: They are primarily a plankton feeder, subsisting on small or minute crustacea; copepods being a large item in their food.

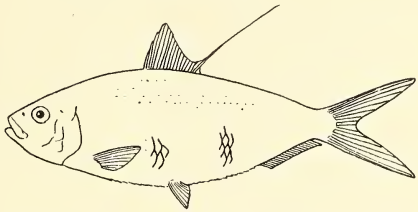
Life History: Shad enter rivers in spring to spawn, when the river water has warmed to 50° or 55°. Consequently the run begins at correspondingly later dates along the coast, January in Georgia, April in the Potomac, May and June at the northern end of their range. Sandy or pebbly shallows are selected as a spawning ground. The adults return to the sea is summer, the young in the fall at a length of 8 inches or less.

The few shad yet to be found in our polluted rivers appear after the run of alewife has passed its peak. The males arrive first, followed in a short time by the heavier females. These average about 28,000 eggs apiece, but there are records as high as 156,000. The ova have a specific gravity slightly greater than one, are non-adhesive and average about 3 mm. in diameter. The time of incubation is about one week at a temperature of

60° Fahr. They hatch into larvae not quite 10 mm. in length. By the time winter sets in a length of from 3 to 9 inches is attained, depending upon conditions in which they are living. They reach maturity in about the third or fourth year, and when ripe the males average about 3 pounds and the females about 4¾ pounds. The record for the Atlantic coast is 13½ pounds.

Size: Adult fish average about 4 pounds in weight. Males sometimes reach a weight of 6 pounds and females 8 pounds. The maximum size for the species is 2½ feet in length, and 12 to 14 pounds in weight.

46. **Thread Herring**
Opisthonema oglinum (Le Sueur)

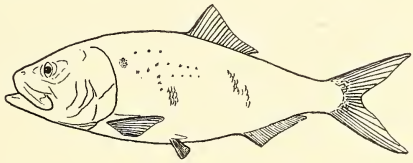


Distribution: Uncommon and irregular, July 7 to October 21, very exceptionally present in numbers then mostly to the west. *Woods Hole*, very rare, July till fall. *Orient*, rare, July. *New York*, usually uncommon, July 7 to October 21, sometimes present in numbers. Always present in summer in Sandy Hook Bay.

Occurs abundantly in the West Indian fauna, regularly north to Carolina and sometimes strays to Cape Cod.

Size: Reaches 8½ inches in total length (Orient).

47. **Menhaden**
Brevoortia tyrannus (Latrobe)



Distribution: Very abundant everywhere—(March) April 12 to November 28 (adult) and December 15 (young). *Woods Hole*, (March) May 20 to December 1. Most abundant in June. *Orient*, April 12 (average April 26) to November 28 (adult) and December 15 (young). Young sometimes occur in great waves in fall, peaks of these waves occurring in October and November. In 1917 a similar wave of lesser magnitude occurred between July 20 and August 15; that year the first young having appeared on July 1. The same year the size of the young was about constant from July 20 to October 20, indicating migration to the west from some area of later spawning. *New York*, abundant, May to November (December 5). In 1921 Menhaden diminished in numbers in Sandy Hook Bay as the weakfish increased after September 15.

Occurs from Nova Scotia to Brazil. Menhaden occur off our shores in immense compact schools throughout the summer. They swim at the surface, often with their back fins out of the water, are much preyed upon by other fishes, as well as being caught in bulk for oil. The menhaden often runs into brackish water. A serious epidemic occurred among menhaden to the eastward in 1904, and enormous numbers of dead drifted to shore in Narragansett Bay and considerable numbers in New Bedford Harbor.

Food: As they swim, their wide mouths are kept almost constantly open, gulping salt water, which is strained out through the exceedingly fine, long gill-rakers, the fish thus securing a rich food-supply of microscopic plants, particularly diatoms, and the smallest crustacea, getting very fat.

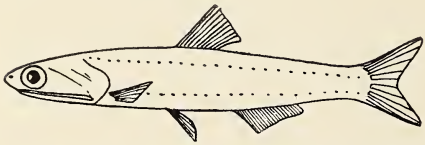
Life History: Schools of young 19 to 25 mm. in length are common during July at Woods Hole. At Orient a total length of 51 to 76 mm. is recorded July 1; 102 mm. July 20 to August 15; 76 to 127 mm. October 26; averaging 127 mm. and a few of the largest 208 mm., November 21.

The spawning of the menhaden covers practically the entire year. That is, at some point along the Atlantic coast these fish may be found spawning during nearly any month. In our latitude, however, the act seems to be confined to the warmer months, and is probably going forward in June, a little earlier to the west, later to the east. The eggs are highly transparent, spherical, and range from 1.4 to 1.6 mm. in diameter. The perivitelline space is usually large and a single oil globule is present. Incubation occupies about 48 hours at a temperature of 72° F., and on hatching the slender larvae average 4.5 mm. At 23 mm. all the fins are differentiated and the intestine is highly convoluted. At 40 mm. they resemble the adults in all important essentials. Maturity seems to be reached in about the third year.

Size: One taken in 1876 measured 18 inches, probably the largest on record. A weight of 1 pound 13 ounces is recorded from Orient. In Sandy Hook Bay most of the fish taken in the pound nets are less than a foot in standard length. There is generally a mode at about 9½ inches, and another at 5 inches in the late fall.

ANCHOVIES

Small, herring-like fishes, swimming in large schools at or near the surface. Mouth, very large, opening beneath a more or less produced pig-like snout. A single soft-rayed fin in the middle of the back. A silvery band along the center of the side.



48. Flat Anchovy
Anchovia perfasciata (Poey)

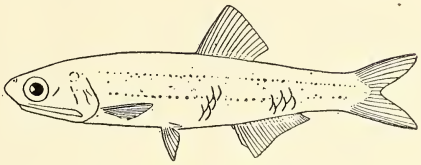
Anal rays 14 to 16. Slender, depth about 6 times in the length to base of caudal.

DISTRIBUTION: Recorded from the vicinity of New York City in September.

Occurs rather commonly from the Florida Keys to Cuba.

SIZE: Reaches a length of perhaps 5 inches.

49. Striped Anchovy
Anchovia brownii (Gmelin)



Anal rays about 20. Body compressed, moderately slender, depth about 4¾ in the length to base of caudal. Eye larger, 3½ in the head. The silvery band sharp and bold.

DISTRIBUTION: Rather uncommon in summer and fall, more numerous to the eastward, May 1 to November 14. *Woods Hole*, usually abundant, present from first of May till late in fall. *Orient*, rather uncommon, June 25 to November 14. *New York*, uncommon, summer (June 27, 1921, and July, 1923, Sandy Hook Bay).

Occurs from Cape Cod to Brazil, abundant on the Florida coast and in the West Indies.

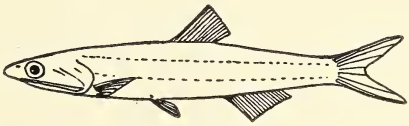
Schools of this anchovy, with those of the hardhead, *Atherina stipes* (Muller and Troschel) are usually to be found about wharves in Florida, as are schools of Menidia in the north.

FOOD: Usually copepods, also univalve mollusks.

LIFE HISTORY: With ripe spawn till August (Woods Hole).

SIZE: Up to 6¼ inches total length (Orient). Specimens slightly over 4 inches in standard length were taken in Sandy Hook Bay, July, 1923, where they usually measure about 2⅜ inches.

50. Silvery Anchovy
Anchovia argyrophana (Cuvier and Valenciennes)



Anal rays about 19. Body little compressed, slender, depth about 6. Eye small, 4 in head.

DISTRIBUTION: Not uncommon at times to the eastward, rare to the westward. June to November 23. *Woods Hole*, irregular, sometimes absent, sometimes numerous, most numerous in fall, to November 20. *Orient*, one taken November 23, 1917. *New York*, casual, June to August 20, also November 18.

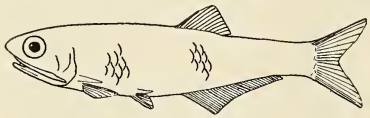
Occurs in the Gulf Stream, occasional northward.

The eastern end of our region, though actually somewhat further north

and with generally colder water, lies closer to the Gulf Stream drift than does the western end, New York being situated in a broad bight in the coastline. Hence various fishes which, either as adults or young, occur in the Gulf Stream, tend to be more frequent there. This anchovy is an example.

Life History: This anchovy spawns, like the following, chiefly in July and August. The eggs are similar to those of *A. mitchilli* but are larger, the long diameter ranging from 1.15 to 1.25 mm. whilst the short one ranges from 0.55 to 0.80 mm. The newly hatched larvae are about 3 mm. long. The yolk is absorbed in about a day. By the time 5.2 mm. is reached the vertical fins begin to show differentiation and the intestine becomes greatly convoluted as in most young clupeoids.

Size: Up to 6¼ inches total length (Orient).



51. Common Anchovy
Anchovia mitchilli (Cuvier and Valenciennes)

Anal rays 25 or 26. Snout blunt and body deep, depth about 4. Silvery band diffuse.

Distribution: Abundant to the east and less numerous to the westward, most numerous in fall, May 1 to December 14. *Woods Hole*, abundant, May 1 till fall. *Orient*, common, June 11 to December 14. *New York*, common, May to October 30.

Occurs from Cape Cod (rarely Maine) to Texas on sandy shores, entering rivers, abundant.

Life History: The spawning of this delicate species takes place in midsummer, and it is believed that the spawning act is performed usually at dusk. The eggs are pelagic, transparent and contain no oil globule. The yolk has the appearance of being fragmented into numerous pieces. The egg is elliptical. The greatest diameter ranges from 0.65 to 0.75 mm., while the lesser ranges from 0.45 to 0.55 mm. At about fourteen hours after fertilization the eggs sink in sea-water and the development is typical. The incubation period is about 24 hours at the end of which time larvae 1.9 mm. in length emerge. They are transparent and show no pigmentation In twelve hours they attain a length of about 2.7 mm. At about sixteen hours after hatching, the yolk is completely absorbed. The critical period for this species is at the close of the second day after hatching. At a length of 7 or 8 mm. the fins begin to become rayed and from then on the development slowly changes the post larva into the adult. The age at spawning is unknown. In Sandy Hook Bay one group appeared to grow from 65 mm. average standard length in the latter part of May, to 70 mm. in the middle of July. Near the end of July a smaller group of about 45 mm. appeared, very likely fish one year old.

Size: Reaches 4 inches in total length.

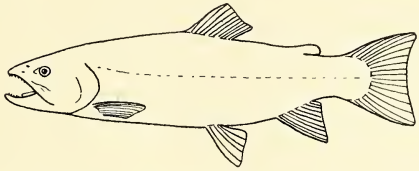
TROUT

Trimly built, active fishes with large mouths and strong teeth. Usually silvery (when in the sea). Single soft-rayed fin in the center of the back, a small adipose fin nearer the tail. Scales fine, scarcely evident.

Spots on sides black. *Salmo*

Spots on sides red or blue, not black. *Salvelinus*

52. **Rainbow Trout**
Salmo irideus Gibbons



Rainbow trout. Black spots not x shaped; scales 135–140; teeth in the center of the roof of the mouth persistent.

Distribution: The rainbow occasionally runs to sea from local coastwise streams where it has been planted. A recent definite instance is the capture of a female specimen, 12¾ inches standard length, Sandy Hook Bay, June 9, 1925, and July 1, 1926.

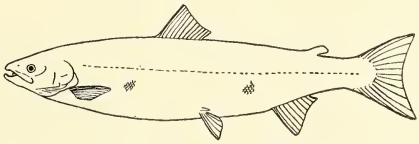
Occurs in California, and widely planted elsewhere in the United States.

Life History: The rainbow trout spawns from November to March in the eastern part of the United States. The eggs are heavy and non adhesive as with others of this family. They average about 0.5 mm. in diameter. They hatch in from 42 to 45 days at a temperature of 50° and the yolk sac is absorbed in about 30 days.

The males attain maturity in 2 years but few females before the third.

Size: Reaches a weight of upwards of 10 pounds.

53. **Atlantic Salmon**
Salmo salar Linnaeus



Black spots usually x or xx shaped; scales about 120 in a lengthwise series; teeth in the center of the roof of the mouth few and deciduous.

Distribution: Formerly numerous, entering rivers. Now very rare to the west, a few occur to the east. *Woods Hole*, a few (chiefly small specimens) taken every year, generally in May, also one of 25 pounds, June 28, 1899. *Orient*, one definite record, May 13, 1909. *New York*, now casual.

Occurs in the North Atlantic, ascending favorable rivers on the European and American side, north of Cape Cod, to Hudson Bay, formerly probably abundant in the Hudson and occasional in the Delaware.

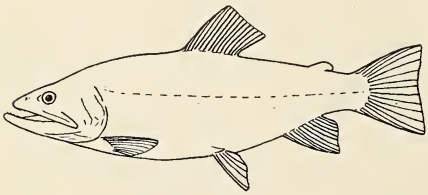
Salmon are believed to move off shore in the winter and in shore in the

summer, whether or not ready to enter fresh water and spawn. They feed very little when in fresh water at least when about to spawn, and as most of their growth occurs in summer normally, it is interfered with by spawning. Each fish spawns from one to several times, some more often than others, and those which do so every year after adolescence do not reach so large a size.

Food: The salmon in the sea is an active predaceous fish, preying on other smaller fishes and to some extent crustacea. Sand launce, herring and capelin are among its favorite fish foods.

Life History: The Atlantic Salmon spawns near the head waters of rivers in October and November. The cold waters of such localities makes the incubating process a long one, hatching not occurring before April or May. The eggs are heavy, non-adhesive, and average about 7 mm. in diameter. They are deposited amid coarse gravel, lodging in the interstices, which fact doubtless aids in keeping them from being washed down to sea. The average number a female deposits is over 9,000. The maximum is nearly 21,000. The larval salmon is slightly less than an inch in length on hatching, and possesses a large yolk sac which is absorbed in about 40 days. After passing from the larval stage it acquires a series of vertical bars on the sides. This coloration is retained for about two years. at the end of which time it may be from 6 to 8 inches long. At this size and age it passes down stream to the sea and takes on the appearance of the adult. When next heard from it has attained a weight of from 2 to 6 pounds and in the northern extent of its range passes up-stream with adults. In our territory, however, this migration is usually omitted, but by the time it is about 4 years old it returns to the spawning beds for the consummation of that act and, unlike the Pacific salmons, may return to the sea to repeat its spawning migration the following year.

Size: 88 pounds (Great Britain) appears to be the largest on record.



54. Brook Trout
Salvelinus fontinalis (Mitchill)

Distribution: Not uncommon in fresh-water streams, entering the sea to the eastward. *Woods Hole*, some enter salt water and pass the winter there.

Occurs (native) in clear cold streams from Maine to the Saskatchewan and northward to Labrador, south in the mountains to the southern states, enters the sea freely from New England northward.

Trout lie in pools or eddies or behind snags whence they dart away with lightning-like rapidity when alarmed, or spring upon their prey when it

drifts within range. The eastern brook trout is one of the wariest and gamest of fish and to land it taxes the sportsman's best skill. It seldom exceeds 2 or 3 pounds in weight and a 5 pound fish is a very large one, though there are records of still larger.

Food: They feed largely on insects which drop by chance upon the surface of the water.

Life History: Brook trout spawn in September and October in clear rapid streams over a gravelly bottom. The eggs are heavy, non-adhesive, and average about 1.6 mm. in diameter. The maximum number produced by a large female is over 9,000,000. At a temperature of 50° Fahr. hatching is reached in about 50 days and the yolk sac is gone in 25 days more. At 37°, hatching is prolonged to 125 days and the absorption of the yolk sac takes about 40 days. Maturity is usually reached in the second year. The growth of this species under good conditions is generally about as follows:

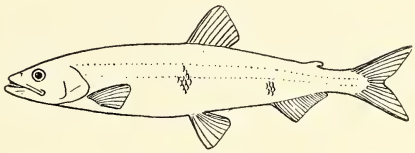
Age	*Weight*
1 year	1 ounce
2 years	9 ounces
3 years	1 pound

Size: An individual 14½ pounds (from Ontario) appears to be the largest on record.

SMELTS.

Small, silvery, trout-like fishes. Silver color more or less concentrated in a lateral band. Scales (in our species) larger than in the trout, about 68 in a lengthwise series. A single soft-rayed fin in the middle of the back and small adipose fin behind it.

55. **Smelt**
Osmerus mordax (Mitchill)



Distribution: Rather common, present throughout the year. Most numerous in the colder months. *Woods Hole*, resident, most abundant in March. *Orient*, resident, October 2 to June 9, common November to April, also summer records for July 14 and August 28. *New York*, common, resident. *Sandy Hook Bay*, May 11, 1926.

Occurs from Virginia, rarely, New Jersey regularly, to the Gulf of St. Lawrence, entering streams from the sea.

In our region only the young or an occasional larger individual can be found in the bays during the warmer months.

They are very abundant, being taken in large numbers by nets and by hook and line and are one of the choicest of our food-fishes.

Food: The smelt is active and predaceous, feeding greedily on swimming crustaceans and smaller fishes.

Life History: Spawns in February and March (Woods Hole). The smelt enters fresh or brackish waters, usually rivers or brooks for the purpose of spawning in early winter. As soon as the spawning is completed, they return to the sea, and when summer approaches they move off shore (not far) to find cool waters. The eggs are demersal and adhesive and average about .05 inches in diameter. A 2 ounce fish may deposit up to about 50,000 eggs.

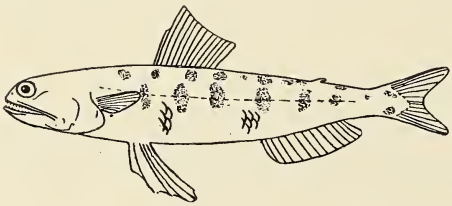
Size: Adults are 7 to 9 inches in length, maximum 13 or 14 inches.

LIZARD FISHES

Cylindrical, elongate fishes with a single soft-rayed back fin and a small adipose fin near the tail. Mouth very large with strong pointed teeth. Color mottled. Ventral fins placed anterior to the back fin instead of about under it as in trout and smelt.

Head short, blunt, compressed. *Trachinocephalus*

Head depressed, with flat triangular snout. *Synodus*

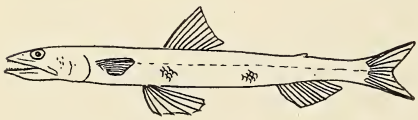


56. **Snake-fish**
Trachinocephalus myops (Forster)

Distribution: A straggler from the south in summer and fall, July to October. *Woods Hole*, rare, recorded for July, September and October.

Occurs in the West Indian fauna from South Carolina to Brazil, occasionally north to our region.

Size: Reaches a length of about 9 inches.



57. **Lizard Fish**
Synodus foetens (Linnaeus)

Distribution: A straggler from the south, usually rare, occasionally rather common to the westward. September to October 30. *Woods Hole*, a few nearly every year during September. *Orient*, once, October 9. *New York*, October, to October 30. *Sandy Hook Bay*, September 22, 1926 three examples $5\frac{1}{4}$ inches standard length.

Occurs on sandy shores from Cape Cod to Brazil, very common from South Carolina southward.

The lizard fish is mottled in color to match the sandy bottom on which it lies in shallow water, darting swiftly on small fishes which chance to pass its way.

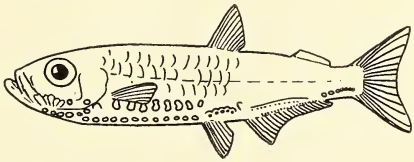
Life History: At a length of 40 mm. (standard) the young are translucent with six pairs of oval pigment spots placed one on each side of the ventral mid-line.

Size: Reaches 12 inches total length (Orient).

LANTERN FISHES

Small fishes of the open sea, usually silvery in color, with rows of luminous spots along their lower surfaces, which shine like glass beads, and can emit phosphorescent light at night. A soft-rayed fin on the back, and frequently an adipose fin behind it. Eyes and mouths usually large. A varied group that has been separated into several families.

58. **Pearlsides**
Maurolicus pennanti (Walbaum)



A single dorsal fin of 11 or 12 rays nearer tail than snout, its last ray over origin of much longer anal. A low, inconspicuous, adipose fin. Mouth large, the maxillary produced backward. A series of luminous spots along the lower side of head, body and tail. Scales rather large, deciduous, usually lacking in dead specimens. Depth 4 in standard length.

Distribution: *Woods Hole*, picked up dead on the beaches, one in January 1884, and 21 specimens collected by Edwards, November 27, 1906.

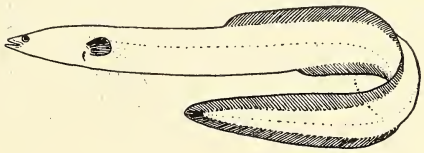
Occurs widely distributed on the open seas. This is the only species of the diverse lantern fishes of which we have record for the region. It is included on the supposition that it is pelagic rather than abysmal, coming to or near the surface at night. Several other species should occur but are so far unrecorded.

Size: Reaches a length of 2 or 3 inches.

EELS.

The true eels have a rather large mouth with short, strong teeth; the lower jaw the longer; well developed pectoral fins, and the body covered with small, imbedded linear scales arranged in groups, at right angles to one another. These can only be clearly made out with a magnifying glass.

59. **Common Eel**
Anguilla rostrata Le Sueur



Distribution: Abundant resident everywhere, particularly in shallow, weedy, or muddy water. Hibernates in mud with the first frost (Orient).

Occurs from the Gulf of St. Lawrence to Mexico and the West Indies, and even Brazil, entering Atlantic and Gulf drainage.

The common eel is found in both salt and fresh water, penetrating to almost every muddy little pond or stream in the interior of the country. It breeds, nevertheless, only in the deep sea. "Silver Eels" individuals with silvery sides have never been taken from the mud in Orient, although common in the fall run.

Food: Feeds on shrimps, crabs, mollusks, worms, small fishes, etc., also sometimes a scavenger.

Life History: The development of the common eel, long a mystery to both naturalist and layman, is now fairly well understood, by the former at least, although no doubt the countryman will continue to explain that loose horse hairs come to life if dropped in water, and showing *Gordius* as evidence, will boldly state that these will eventually become eels fit for consumption.

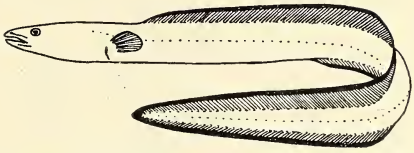
Such is not the case, however, and we know the eel to be a catadromous species, that is, one which descends to the sea for the purpose of spawning. All during the warmer months this downstream migration takes place and it is doubtful if a return is ever made as we have no record of large eels migrating upstream. They eventually find their way to an area of oceanic waters southwest of the Bermudas. The minute ova are thus extruded in mid-ocean and hatch into very uneel-like larvae—the *Leptocephalus*. This creature is cigar shaped in outline, but extremely flat, and so transparent as to make it very difficult to see. From the time of hatching, which is in the fall, the young eels gradually work back to the continent, being assisted by favorable currents. By the time they reach our coasts they are out of the *Leptocephalus* stage and have the general form of the mature eel, although they are still highly transparent. During April these are common in the bays and inlets of our territory and average about 53 mm. in length. On account of their extreme low visibility they are not so well known then as they are a little later when pigment darkens them and they begin to pass upstream. At this time it is almost impossible for them to escape notice, so great is their number, every country boy knowing them under the name of elver. Even in such foul cesspools as New York Harbor, they are still to be found in numbers every spring. Urchins of lower New York amuse themselves each year by fishing them out with tin cans along the Battery wall.

Some of these migrating eels eventually find their way far inland. These, so far as known, are always the larger females, as the smaller males remain near the coast in brackish water. The length of their stay in freshwater varies and may be extended to cover many years, landlocked individuals even spending a good portion of man's alloted span in such environments.

Size: Reaches a maximum length of 4 or 5 feet; largest Orient specimen taken 6¼ pounds.

CONGER EELS

Very like the true eels in superficial characters, but lacking scales.



60. **Conger Eel**
Leptocephalus conger Linnaeus

Distribution: Generally common (April 16) May 17 to December 30. Has periods of abundance to the eastward. *Woods Hole*, appears in July and remains till fall (October). Some years common; others rather rare. *Orient*, summer resident, most common in October and November, earliest date April 16. *New York*, uncommon, summer to December 30. *Sandy Hook Bay*, October 11, 1926.

Occurs almost cosmopolitan in warm and temperate seas of the northern hemisphere, but not found in the eastern Pacific.

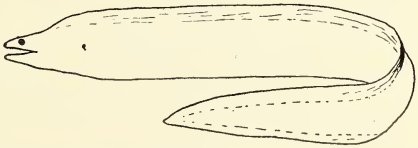
Food: Feeds on fish, (herring, butterfish, eel) and worms. The conger eel is found only in salt water, usually not very close to shore.

Life History: Like the common eel the conger passes through a ribbon-like, transparent, small-headed, larval *leptocephalus* stage. It spawns but once and then dies, moves off shore to spawn, and ripening of the sexual products is accompanied by changes in the shape of the head, loss of the teeth, etc., while the eyes of the male become enormous. The number of eggs produced has been estimated at from 3 to 6 millions.

Size: Largest recorded specimen caught at Falmouth, weighed 12 pounds. Reaches a length of 8 ft.

MORAYS

Shore eels without pectoral fins, and without tongues. Body compressed. Gill opening small and rounded, dorsal and anal fins continuous as a fringe around the tip of the tail. Mouth large with pointed teeth.



61. **Reticulated Moray**
Mureana retifera Goode and Bean

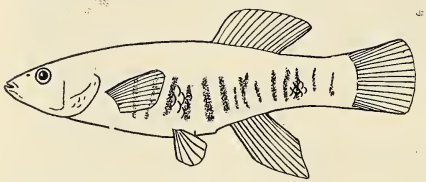
Distribution: One specimen, 6 feet 2 inches long, weighing 39 pounds, taken in a lobster pot at Tuckernuck Island, July 25, 1899.—H. M. Smith.

Occurs off the coast of South Carolina in rather deep water.

KILLIFISHES

Small, coastal, shallow-water, salt or brackish water fishes, with a small transverse mouth with small teeth; single soft rayed dorsal fin behind middle of back, and squarish or rounded caudal fin.

Teeth all pointed in bands. *Fundulus*
Teeth all pointed in a single series. *Lucania*
Teeth incisor-like, tricuspid, in one row. *Cyprinodon*



62. **Striped Killifish**
Fundulus majalis (Walbaum)

The head of the striped killy as seen from above, is rather pointed. Its sides are whitish—a color never approximated by the common killy—and marked with bold, black streaks, vertical in the male (as in the figure), horizontal in the female.

Distribution: Abundant resident in shallow water throughout the region *Woods Hole*, abundant resident. *Orient*, abundant resident, taken from mud in coldest parts of winter. *New York*, abundant resident.

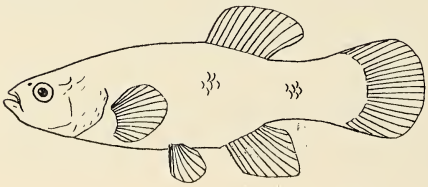
Occurs from Cape Cod to Florida, less numerous southward, and replaced on the Gulf Coast by related species.

Swims in loosely organized schools of varying size, along sandy or pebbly shores of ocean, sound or bay, and a few scattered individuals are usually to be found, and it is sometimes abundant, associated with common killifish in weedy or muddy waters of bay and marsh.

Life History: Spawning schools swim in still, shallow water close to the shore line in summer. The males now assume very handsome colors, clear yellow shades on the fins and a dark mark on the side of the head. Begins spawning in June; ripe males and females taken in Sandy Hook Bay, June 1 to 23. Fertile spawn obtainable throughout July and early August at Woods Hole.

The eggs, sometimes laid in sand 3 or 4 inches deep are spherical, deep amber in color and slightly adhesive. They average about 2.16 mm. in diameter. Development is gradual, the fish not leaving the egg until it is a post larva, which at a temperature of 65° F. takes about 58 days. It hatches as a well developed fish, with its full complement of fins substantially as in the adult. About nine days after fertilization peristaltic movements of the cardiac dilation are regular and readily observable.

Size: Reaches a total length of 7 inches (Orient), occasionally even 8 inches.



63. **Common Killifish**
Fundulus heteroclitus macrolepidotus
(Walbaum)

The head of the common killy is broad and blunt, viewed from above, and generally the sides have no noticeable streaks, though sometimes comparatively light or dark vertical ones are present. The scales in a lengthwise series number 35 to 38.

Distribution: Abundant permanent resident, in shallow water throughout the region. *Woods Hole*, abundant resident. *Orient*, abundant resident. *New York*, abundant resident.

Occurs from the Gulf of St. Lawrence to the Gulf of Mexico, everywhere abundant. Three geographical races can be differentiated, our northern one is *F. h. macrolepidotus*, *F. h. heteroclitus* occurs in the Carolinas, *F. h. grandis* (commonly reaching a length of 6 inches) from Florida to Texas.

Particularly abundant in weedy or muddy shallows of bay and marsh, running freely into brackish to almost pure fresh water, and thriving on pollution.

The common killifish, also called mummichog, is probably the most abundant small fish in this vicinity. This name, sometimes shortened to "mummy," is of Indian derivation, and signifies "going in crowds." It swarms in shallow, salt and brackish water and very frequently a specimen will be found in quite fresh water. It benefits mankind by destroying quantities of mosquito larvae. It can undergo great changes in temperature and salinity and will live in water too foul for other species, and for a considerable time out of the water altogether. In fact, of all our fishes, it is one of the most tenacious of life.

This species is probably particularly prone to occur in fresh water in early spring, when this may be expected to be warmer and with more abundant feed than the adjacent salt or brackish areas. On March 23 (1924, J. T. N.) where the source of a brackish creek ran out of a swamp at Mastic, L. I., 'as a narrow muddy gutter beneath the bushes, many Fundulus were churning the edges of same, and of 13 taken with a random scoop of an old basket, one was a *heteroclitus* about 3½ inches total length, 10 were *heteroclitus* 1½ to 2¼ inches, 2 were *diaphanus* 1⅜ to 2½ inches; though there is no chance of any taint of sea water here.' *Heteroclitus* is rare, if it occurs at all, in this part of the creek in summer, though of course abundant in the broader slightly brackish portions of same nearer the bay.

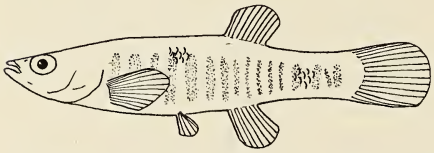
Food: As nearly omniverous as its small size will permit, eating enormous numbers of diatoms and Foraminifera, feeding on small crustacea, mollusks, insect larvae, and even fishes, also a variety of vegetable matter, eel-grass, etc.

Life History: Males assume bright colors when spawning as follows: blue black, more or less marked, especially posteriorly, with narrow whitish cross-bars and pinkish white spots. Lower half of opercle, belly, ventrals, edges of anal, caudal and dorsal bright yellow. Dorsal with a black spot posteriorly. At the same time females have the ordinary dull colors,—olive brown, practically unmarked, belly pearl; usually with narrow blackish cross-bars more or less distinct, especially posteriorly. Males with nuptial colors occur as early as April 27 (Mastic, Long Island). Spawning takes place in grassy or weedy shallows in salt, brackish, or almost fresh water.

Ripe spawn has been taken as early as the middle of May and as late as early August. Young of all sizes intermingle during the summer. Cross-fertilization has been effected between this species and *F. majalis*. Spawning (in salt or brackish water) may be in excited crowds splashing in the shallows, or singly, as per the following observation. June 18, in shallow brackish water over a hard bottom with thin coating of mud, weed growing here and there. Occasionally two *F. heteroclitus* would dart in across a weedy strip. The larger of the two was a dark bluish male, the other pale olive in color, doubtless a female. When she poised in the water he would range alongside of her, and when she darted away follow swiftly after. Once she went to the bottom for a moment or two, where her consort pressed down and against her, leaning over her and trembling with spread fins.

The eggs are spherical, amber in color and slightly adhesive. They average about 1.97 mm. in diameter. Development is gradual, the fish not leaving the egg until it is a post larva, which at a temperature of about 65° F takes about 40 days. About six days after fertilization peristaltic movements of the cardiac dilation are regular and readily observable.

Size: 4 or 5 inches long.



64. **Fresh-water Killifish**
Fundulus diaphanus (Le Sueur)

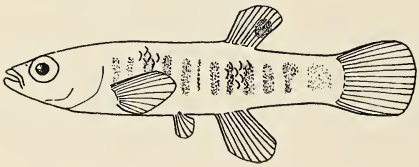
Resembles the common killifish somewhat, but the head is less blunt, scales smaller, about 45 instead of 35 to 38.

Distribution: Common in small streams close to salt water. To the westward we have never found it in other than fresh-water. *Woods Hole*, a brackish and fresh-water species, seldom or never found in undiluted sea water.

Occurs in streams and lakes from the coast of Maine to Cape Hatteras, abundant near salt water.

Where it occurs in the narrow running fresh water heads of brackish creeks this species is rather sparsely distributed, seldom more than 3 or 4 individuals swimming together. They hang poised in the water and dart away swiftly when alarmed, giving the impression of a distinctly faster fish than *heteroclitus*.

Size: 4 or 5 inches long.

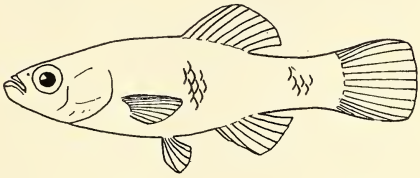


65. **Lucy's Killifish**
Fundulus luciae (Baird)

Insertion of the dorsal fin behind, not before or above that of the anal, as in the preceding three species; dorsal with 8, anal with 10 rays; scales about 35.

Distribution: Occasional in July on the New Jersey coast. Occurs from Long Island to Virginia, rare.

66. **Rain-water Fish**
Lucania parva (Baird and Girard)



The rain-water fish, very seldom reaching a length of 2 inches, may be recognized by the dark edges of the scales, which make them stand out prominently. Aside from the sheepshead minnow, it is deeper than others of its relatives occurring locally, the depth contained only slightly more than 3 times in the length. A small dark mark at the base of the back fin in front is characteristic, though not always present.

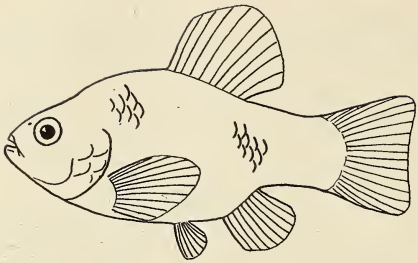
Distribution: Fairly common resident in shallow weedy coastal fresh and brackish water, easily overlooked. We have no knowledge of its occurrence on the south shores of Long Island Sound. *Woods Hole*, fairly common, resident, brackish water. *New York*, very locally common, brackish water.

Occurs on the Atlantic Coast from Connecticut to Key West, with a preference for brackish water. In Florida it is abundant in pure sea water. At times becomes very abundant among water weed in fresh or slightly brackish waters tributary to Moriches Bay, Long Island.

May be kept successfully and will breed in balanced aquaria. When several are placed in a tank they at first swim about in a more or less compact school, but when they become accustomed to their surroundings scatter about the tank. They are moderately active and take their food indifferently at the surface, at the bottom or in mid water. They show good spirit, frequently chasing one another, but are not bad fighters.

Life History: Has spawned in an aquarium with abundant and fine vegetation, water temperature about 64°, in late February; incubation period about 2 weeks. From 3 weeks or so after hatching, about ¼ inch total length, the young resemble adults but are more slender with proportionately larger caudal fins.

Size: Reaches a length of 2 inches.



67. Broad Killifish
Cyprinodon variegatus Lacépède

The Sheepshead Minnow may be recognized by its great breadth, contained from two to two and two-third times in the length from tip of snout to base of tail fin. Breeding males are bright steel blue and orange. Females and young dull colored with irregular vertical marks.

Distribution: Resident, abundant, particularly to the westward. *Woods Hole*, resident, locally abundant, generally not uncommon. *Orient*, common resident. *New York*, abundant, resident.

Occurs from Cape Cod to the Gulf Coast, very abundant southward, a distinguishable race, *C. v. riverendi* in the Florida Keys and Cuba.

Life History: Males with bright blue and orange breeding colors seen from June 1 to 23, and fish apparently spent taken on July 14 and 22 (Sandy Hook Bay). Spawns in June and ripe eggs recorded July 13 (Woods Hole).

In the breeding season males are commonly found several together, swimming actively about, fighting and chasing one another in circles, their steel-blue backs flashing. In one such case where no females were present a male was observed to go repeatedly to the bottom and wriggle vigorously with its belly against the mud so that little clouds of the same rose on either side (Mastic, June 18).

In the waters around New York City the males of the broad killifish acquire their brilliant nuptial coloration concomitantly with the development of the female roe, in the late spring and early summer, although ripe fish are sometimes seen as early as May or as late as September. Spawning frequently takes place in the shallow and usually brackish arms of the smaller bays. The larger tide pools which become landlocked at low tide either entrap considerable numbers of them in their search for a suitable spawning place or they choose them by preference. At least they are generally to be found in the largest numbers in such places amid sea wrack and general debris in company with the more abundant common and striped killifish.

The spawn is not all deposited at one time, a few eggs being laid daily for some period of time or a number may be laid at a time with longer intervals intervening. The eggs are spherical and of a translucent yellowish color. They vary from 1.2 to 1.4 mm. in diameter, sink in sea water and owing to the possession of numerous adhesive threads adhere to each other or any

submerged object on the slightest touch. They hatch in from 5 to 6 days at a temperature of about 60° F. into quite well developed larvae although the primitive fin fold is still present. The newly hatched fry measure about 4 mm. in length. Five days later the yolk is practically gone. By the time a length of 10 mm. is reached most of the diagnostic characters of the adult have been acquired. Probably maturity is reached at the age of one year. The average size for females is about 45 mm. and for males about 48 mm. The sexes appear usually in about equal numbers.

SIZE: Reaches about 2½ inches standard, 3 inches total length.

NEEDLEFISHES

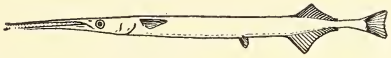
Slender, elongate fishes with silvery sides, swimming swiftly at the surface. Jaws of approximately equal length prolonged in a beak, set with pointed teeth.

Body more or less cylindrical. *Tylosurus*

Body much compressed, flattened from side to side. *Ablennes*

68. **Bill-fish**

Tylosurus marinus (Walbaum)



Dorsal and anal fins short, each with about 13 developed rays. Caudal almost equally lunate; peduncular keel inconspicuous. A dark vertical bar on the side of the head.

DISTRIBUTION: Common summer resident, May 7 to December. *Woods Hole*, May to October. *Orient*, May 7 to November 20. *New York*, common, June to December.

Occurs abundantly from Cape Cod to Texas, casual in Maine.

The bill-fish, abundant with us in summer, inhabits salt water, and also enters the mouths of fresh rivers and creeks, swimming in small schools at the surface and preying on other smaller fishes, especially the common silverside. It reaches a length of 4 feet, but is usually much smaller. It is transparent green in color with silvery sides.

This species has the interesting habit of launching itself out of water and skipping over the surface as might a lance or spear. It is a habit shared by others of its elongate relatives which are represented by numerous species in tropical waters. A common species with a flattened body (*Ablennes hians*) is especially noteworthy as a leaper and can cover considerable distances by turning on its side and letting the air or water strike against its flattened surface. One of the most noteworthy specializations of structure which occur in fishes and serve definite habits is found in the flying fish, which is allied to the billfish and halfbeak. The elongated and strengthened breast fins of the flying fish, which when folded extend backward almost or quite to the tail, are spread when the fish leaps from the water, supporting it for protracted journeys through the air. But there seems little doubt that the leaping habit was common to the group before the flying fish developed its wings and in this case at least the habit preceded the correlated structure.

Food: Eats fish and shrimp (*Woods Hole*).

Life History: Often ascends rivers far above tide water and probably breeds in fresh as well as brackish and salt water.

While usually not seen in Sandy Hook Bay before September, in 1923 they appeared early and were of correspondingly small size. Below is given the average lengths of the individuals taken in serial collections from one place in the Bay. It is taken that they represent catches from a group of fishes spawned at approximately the same time and therefore the table is considered a good index of the rate of growth in these waters.

Date Collected		*Average Standard Length*
July	25, 1923	105 mm.
August	2, "	165 "
"	9, "	190 "
"	16, "	210 "
"	23, "	215 "
"	30, "	245 "

Size: Recorded up to 28 inches total length (Orient) and Jordan & Evermann give 4 feet.

69. Houndfish
Tylosurus acus (Lacépède)

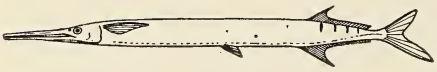
Dorsal and anal fins long, each with over 20 developed rays. Lower lobe of caudal decidedly the longer; a conspicuous black keel on the peduncle.

Distribution: Of casual occurrence to the eastward. *Woods Hole*, rare or casual, a specimen 4 feet long dated July 27, 1886.

Occurs in the Mediterranean and the West Indies, occasionally straying northward.

Life History: The young of this species apparently follow drifting offshore weed, instead of swimming actively in close under the mangroves as do those of some. One about 6 inches long so identified was scooped with drifting gulf-weed in Biscayne Bay, Florida, April 20, 1917. It was cylindrical and slender, caudal unequally forked. Bright silvery, translucent, with broad very indistinct dark bars on side, back darker. Dorsal high posteriorly, black, A black peduncular keel slightly developed. Beak from eye 2 times rest of head. Dorsal rays 24.

Size: Reaches a length of 6 feet or more.



70. Flat Needlefish
Ablennes hians (Cuvier and Valenciennes)

Distribution: Accidental, twice. *Woods Hole*, summer of 1895, and August 14, 1902.

Occurs in the West Indian fauna from Florida to Brazil, generally common.

Size: Reaches a length of 5 feet.

THE HALFBEAKS

Silvery, elongate fishes, resembling the needlefishes, but the upper jaw short. The lower jaw only prolonged in a long, spear-like point without teeth.

a. Body slender, band shaped; pectoral fins very long *Euleptorhamphus*
Body moderately slender and compressed, pectorals moderate. (See b.)

b. Ventrals far in advance of dorsal. *Hyporhamphus*
Ventrals not far in advance of dorsal. *Hemiramphus*

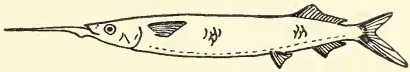
71. Common Halfbeak
Hyporhamphus roberti (Cuvier and Valenciennes)

Distribution: Common summer resident to the eastward, varying in numbers, uncommon to the westward. June 10 to Nov. 7. *Woods Hole*, common to abundant, July, August and September. *Orient*, not uncommon June 10 to November 7. *New York*, uncommon, August to October 16.

Occurs on both Atlantic and Pacific Coasts of America, from Woods Hole (casually Maine) to Florida and New Orleans, Mazatlan to the Galapagos. Represented by the closely related *H. unifasciatus* in the strictly West Indian fauna, including the Florida Keys.

Size: Reaches 12½ inches in total length (Orient).

72. Ballyhoo
Hemiramphus brasiliensis (Linnaeus)



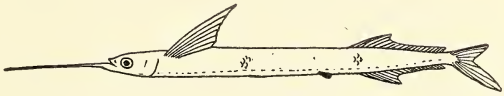
Distribution: Accidental, one record. *Woods Hole*, August 9, 1898.

Occurs in the West Indian fauna, Key West to Bahia.

Food: The ballyhoo feeds chiefly on algae.

Size: Length 15 inches.

73. Flying Halfbeak
Euleptorhamphus velox Poey



Distribution: Accidental, two records. *Woods Hole*, Newport (Goode), off Nantucket (Putnam).

Occurs in the West Indies, rare, occasionally northward in the Gulf Stream to Massachusetts.

Size: Reaches a length of about feet 2.

SKIPPERS.

Slender, flat, silvery fishes, with jaws produced in a slender beak. Soft dorsal and anal fins opposite, far back, several mackerel-like finlets between each and the forked caudal.

74. Skipper
Scomberesox saurus (Walbaum)

Distribution: August to December, rare and irregular, occasionally not uncommon, known from as far west as Fire Island. *Woods Hole*, usually very rare, in occasional years more numerous, records for August September and December. *Orient*, rare and irregular, September 21, 1910 (25 taken), September 27 and November 2, 3 and 18. New York, 1, Fire Island Beach, about 2 miles east of light, August 9, 1923, Fred. M. Schott.

Occurs off shore in temperate parts of the Atlantic, rather common north of Cape Cod and France.

This is an off-shore fish swimming in great schools at or near the surface. It is preyed upon by larger predaceous fishes such as pollack and bluefish, also by porpoises. It frequently strands on the beaches, probably in an effort to escape such enemies, to which may also be ascribed its habit of leaping out of water, often in schools.

Life History.—The skipper spawns in the open sea. Its fry are abundant at the surface in the Atlantic between 11° or 12° and 40° North. Their jaws do not commence to elongate until the fish have attained a length of about 40 mm. The lower jaw grows faster than the upper at first so that young 100 to 150 mm. in length look like half beaks.

Size: Reaches 30 inches (Miami, Mowbray); 14 inches total length recorded from Orient; Bigelow and Welsh give up to 18 inches.

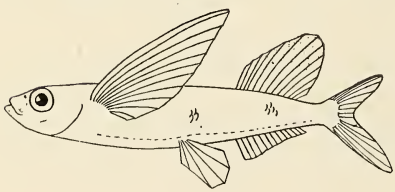
FLYING-FISHES

Small mouthed; large eyed; large scaled, silvery, herring-like fishes with deeply forked tail fins, the lower prong of the fork the longer. Body usually not greatly compressed and pectoral fins narrow, strong, and very long, used to support the fish in gliding leaps of considerable distances in the air.

a. Ventral fins small, nearer tip of snout than base of caudal. *Halocypselus*
Ventral fins longer, at or behind middle of body (see b).

b. Pectoral fin moderate, not reaching beyond middle of dorsal, body elliptical in cross-section. *Parexocoetus*
Pectoral fin long, body angular in cross-section (see c).

c. Anal fin shorter, its base considerably less than that of dorsal, its rays 9 or 10. *Cypselurus*
Anal fin longer, its base little less than that of dorsal, its rays 11 or 12. *Exonautes*



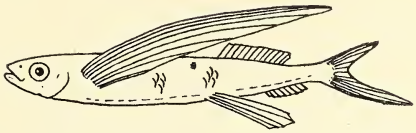
75. Short-winged Flyingfish
Parexocoetus mesogaster (Bloch)

Distribution: Accidental, one record, Newport.

Occurs cosmopolitan in tropical seas, northward in the Gulf Stream, the commonest Flying-fish off the Carolinas.

Size: Reaches 7 inches in length.

76. **Atlantic Flyingfish**
Cypselurus heterurus (Rafinesque)



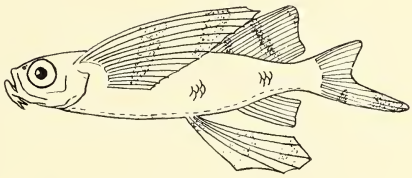
Resembles *C. furcatus*. Pectorals less boldly marked; dorsal and anal without black.

Distribution: Uncommon in summer, rare to the westward. *Woods Hole*, probably the commonest flying-fish, several definite records, July 10 to August 21. *New York*, recorded. One 12 inch specimen (total length) taken in Great South Bay August 18, 1926.

Occurs in the Atlantic Ocean, generally common southward on both coasts, straying north to the banks of Newfoundland and to England.

Size: Reaches 15 inches in length.

77. **Spot-fin Flyingfish**
Cypselurus furcatus (Mitchill)



Second ray of pectoral divided (first simple). Third and fourth rays longest. Pectorals blackish with a broad diagonal white band; dorsal and anal marked with black.

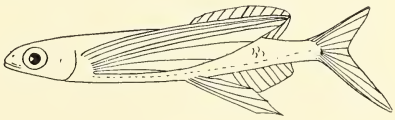
Distribution: Accidental, recorded from Newport and near New York City.

Occurs in warm seas, north to the Mediterranean, straying to Cape Cod.

Life History: The young of this flying fish (the species was based on such a young individual by Mitchill) have a large eye, comparatively short pectoral, large ventral, and a double barbel at the chin. They possess a variegated black white and yellowish color and occur with drifting gulf weed up to a total length of at least 85 mm. (over 3¼ inches).

Size: Reaches 6 inches in length.

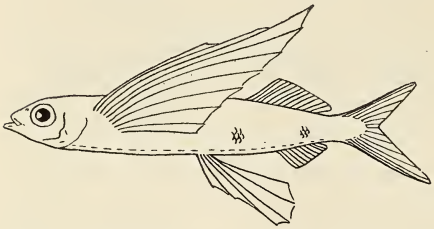
78. **Blunt-nosed Flyingfish**
Cypselurus gibbifrons (Cuvier and Valenciennes)



Second ray of pectoral simple, like the first, third ray divided, snout very blunt, obtusely descending.

Distribution: Accidental, recorded from Newport.

Occurs in the Atlantic, only two specimens known.



79. **Four-winged Flyingfish**
Exonautes affinis (Günther)

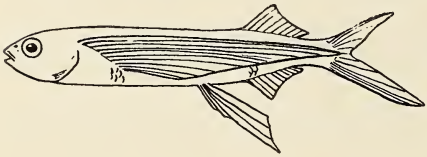
Pectoral fins blackish with a broad diagonal white stripe.

Distribution: Rare, mostly to the eastward. *Woods Hole*, of variable frequency but usually scarce. *New York*, accidental. Due to varying interpretation given Linnaeus' "*Exocoetus volitans*" at different times, it is not certain that the above data really applies to this species, which in any event is to be expected as a rare straggler in our region.

Occurs in the Atlantic, or cosmopolitan in tropical and subtropical seas if the same as *E. speculiger*, which is likely North in the Gulf Stream.

This is one of the flying-fishes, characteristic of the open sea, occurring often in large schools and trusting to their power of flight to escape predacious oceanic bonitos and dolphins of which they form the principal food.

Size: Reaches 12 inches in total length, usually smaller.



80. **Black-winged Flyingfish**
Exonautes rondeletii (Cuvier and Valenciennes)

Pectoral fins uniform dusky.

Distribution: Accidental. *Woods Hole*, one or two records? August 7, 1886, and October 13, 1900. Although a question has been raised as to the validity of our records, the species is to be expected as a casual or accidental, and would not easily be mistaken.

Occurs cosmopolitan in tropical seas, north to Florida.

This is one of the commonest large, off shore, cosmopolitan species of flying-fishes. Its longest flights above the surface of the ocean have been estimated at one-eighth of a mile.

The lower lobe of the flying-fish's forked caudal fin is the longer and very strong, doubtless of service in launching the fish at the beginning of its flight. When it leaves the water pectoral fins (wings) and ventrals also,

when these are enlarged and posterior in position, are spread stiffly as planes, and not infrequently a rapid vibrating movement of the pectorals through a narrow arc can be observed as the flight commences.

The longest flights start more or less into the wind and curve off before it, the maximum elevation of some 10 or 20 feet being attained with the wind abeam. At their close the fish may either plunge into the water or drop down so that the lower caudal lobe cuts the surface, and sculling vigorously again throws the fish into the air, and the original flight may thus be repeated once or twice with diminishing distances before the fish goes under.

Flying-fishes are the commonest, an almost omnipresent form of fish-life over the broad trade wind belts of the ocean. They fly primarily to escape pursuing predaceous fishes, and alarmed by a ship rise and scatter before her bows 'like grasshoppers in a meadow.' They also are most in evidence and make the longest flights when there is a fresh breeze blowing, at such times taking the air, the smaller species in flocks, apparently for sport. At night individuals frequently cross a ship, strike against the rigging and fall to the deck, to appear next morning as a table delicacy fried in corn meal or bread crumbs. This very rarely happens in the day time, and it is evident that they can see where they are going above water and control their direction to some extent by banking (leaning to the side).

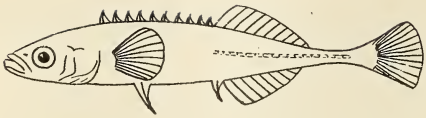
There has been considerable discussion as to the part played by wing-motion in maintaining and propelling the flying fish in the air. It is now rather generally conceded that such part is slight, and motion observed referable to muscular tension in setting the wings, 'warbling' of same in the wind, or some such cause. The structure and proportions of the flying-fish have been analyzed from an aeronautical point of view showing it to be a very efficient glider, and observations would indicate that in addition to the initial impulse attained in the water it also utilizes the internal energy of the air (wind). While in agreement with this point of view we hesitate to discard wing-motion entirely as a factor if an insignificant one, particularly for small individuals an inch or so in length, the wings of which have been observed to be in constant rapid motion like those of an insect during their very short flights.

Size: Reaches 11 inches or more in length.

STICKLEBACKS

Very small fishes of fresh, brackish, and salt water. Mouth small, eye large. Several stout disconnected spines on the back, in front of the soft rayed dorsal fin. Ventral fins with similar spines. Caudal fin rounded or squarish.

Dorsal spines 8 to 11.	*Pygosteus*
Dorsal spines 3.	*Gasterosteus*
Dorsal spines 4, divergent.	*Apeltes*



81. **Ten-spined Stickleback**
Pygosteus pungitius (Linnaeus)

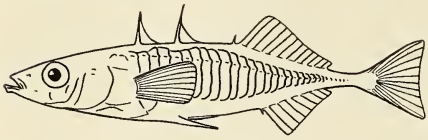
Distribution: Common resident. *Woods Hole*, common resident. *Orient*, resident. *New York*, common resident.

Occurs circum-polar in fresh and brackish water, south to Long Island. Frequents weedy brackish water at the heads of harbors.

Life History: Spawns in April and May (Woods Hole).

The male often but not always, builds a nest attached to grass or weeds, in which the female spawns. He guards nest or eggs until they hatch in about 12 days into fry about 6 mm. long.

Size: Reaches 3 inches.

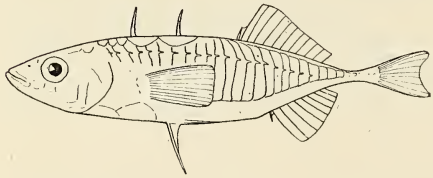


82. **European Stickleback**
Gasterosteus aculeatus Linnaeus

Distribution: The common resident *Gasterosteus* at *Woods Hole* is recorded as this rather than the following form. *Woods Hole*, common resident, most abundant in March and April.

Occurs in the coasts and streams of northern Europe, also said to be the common resident form in New England, extending south to New Jersey.

Life History: Breeds in May and early June (Woods Hole).



83. **Two-spined Stickleback**
Gasterosteus bispinosus Walbaum

Distribution: Common resident. *Woods Hole*, fairly common in summer. *Orient*, common resident. *New York*, common resident.

Occurs on our Atlantic coast, south to New Jersey. To what extent it is replaced, especially on the coast of New England and the provinces, by *aculeatus* is uncertain. Found in salt and slightly brackish water. Its food consists of small animals (fish, fish-eggs, crustacea and other invertebrates) and plants (diatoms). It is usually to be found in shallow water among eel grass or seaweed.

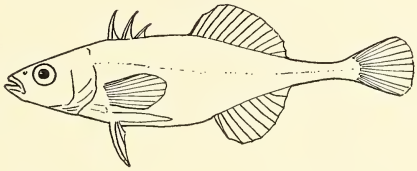
Life History: A spent female of 40 mm. in standard length and a number of young which followed her were scooped up in the Horseshoe, Sandy Hook Bay, over a depth of about eight feet, fully an eighth of a mile from the

nearest clump of Zostera, on June 7. The young fishes (39 of which were taken by the single dip of the net which entrapped the elder one) ranged from 14 to 17.5 mm. in standard length and displayed a modal length of 16. The possibility of parental care on the part of the female was thus forcibly suggested. In this same locality ripe adults in the latter part of May and early June average, females 56 mm., and males 52 mm. standard length.

In general the spawning habits in this genus (*Gasterosteus*) are as follows. In spring or early summer males assume bright breeding colors and fight fiercely among themselves. In a sheltered spot the male builds a nest, a barrel-shaped mass of bits of grass, etc. weighted down with pebbles and cemented together with mucous threads secreted by his kidneys, which nest is an inch or so in diameter. To it he escorts one or a succession of females, each of them depositing 100 or 150 eggs in the central cavity, which stick in clumps to one another and to the nest. The male enters the nest to fertilize the eggs, and guards it jealously against all intruders for the week or ten days it takes the eggs to hatch, then tears it down, but continues to guard the young until they can shift for themselves, at hatching they are between 4 and 5 mm. long, when 6 weeks old about 15 mm., resembling the adult in form.

Size: Reaches 4 inches in length.

84. **Four-spined Stickleback**
Apeltes quadracus (Mitchill)



Distribution: Abundant resident. The most generally distributed of our sticklebacks, and the commonest in salt water. *Woods Hole*, very common, resident. *Orient*, common resident, collects in large schools in the Sound in November and December. *New York*, abundant resident.

Occurs from New Brunswick and Nova Scotia to Virginia, abundant northward.

Primarily a salt water species, but enters brackish or even fresh-water.

Food: Feeds on copepods (Woods Hole).

Life History: The four-spined stickleback spawns during May, June and July in the vicinity of New York, and usually in brackish water. Ripe fish are quite common along the bay side of Sandy Hook during these months.

The eggs are spherical, adhestive and demersal, more yellowish in color than those of *G. aculeatus* and have an average diameter of 1.6 mm. They hatch in six days at a temperature of 22° C. The newly hatched larvae are from 4.2 to 4.5 mm. in length, and are very similar to those of *G. aculeatus* of the same stage, but are more heavily pigmented.

As is usual with this family the eggs are cared for by the paternal parent

with what seemingly almost amounts to intelligence. In this particular species a nest is built by the male which is bound together by means of threads formed from exudations of a pore near the vent. The nest when completed measures about half an inch in height and about three-eighths of an inch in diameter, and has an opening at the top through which the eggs are introduced. The eggs and young are attended for some time by the male. As in all animals which protect their offspring, the number is comparatively reduced, the females of this fish not ordinarily laying more than twenty-five eggs.

Size: 1½ to 2½ inches in length. In Sandy Hook Bay the largest taken measured 1¾ inches standard length, although the adults do not average over $1^3/_{16}$ inches.

TRUMPET-FISHES.

Silvery and elongate, free swimming fishes with inconspicuous minute scales. The snout is prolonged so as to suggest the beak of a needlefish, but tubular with a small mouth at its end. Caudal fin forked, with a whip-like lash arising from the center of the fork.

85. **Trumpet-fish**
Fistularia tabacaria Linnaeus

Distribution: Rare summer visitant, September to early November. *Woods Hole*, a few every year, present in September, October and early November. *New York*, uncommon, September and October, to October 16.

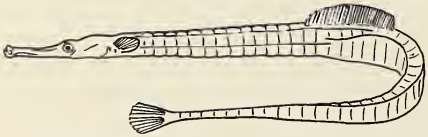
Occurs in the West Indian Fauna, a few straggle northward to Massachusetts.

Size: Reaches a length of 6 feet, the usual size locally 7 or 8 inches, and largest 20 inches exclusive of caudal (Woods Hole).

PIPE-FISHES

Small fishes, found hiding among eel-grass and sea-weed, with a more or less elongate tubular snout and small mouth at its end. Body hard, leathery, tubercular, marked off in segments. A delicate, squarish soft-rayed fin on the back. The pipe-fishes proper are very slender and elongate with a delicate, fan-shaped caudal fin. The sea horses are irregular in outline, the tail finless and prehensile.

Slender, head in line with body, caudal fin present. *Syngnathus*
Stout, head not in line with body, tail prehensile. *Hippocampus*



86. **Northern Pipefish**
Syngnathus fuscus Storer

Distribution: Very common, resident to the east and probably also to the west, though there recorded only in summer. *Woods Hole*, very com-

mon, resident. *Orient*, resident, most common in spring, an early date March 1. *New York*, abundant, June to December 13.

Occurs from Halifax to North Carolina, with center of abundance in our region.

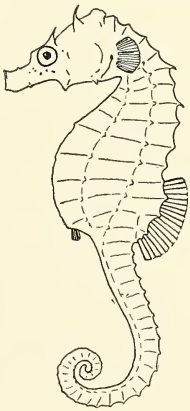
The pipe-fish is not an active swimmer but lurks abundantly among eel-grass and other marine weed and may even be caught in the hand. It usually glides slowly forward, propelled by the dorsal fin, when alarmed attempts swimming in an eel-like manner. Plentiful among eel-grass along shore, also found in the open sounds among floating weed, and dredged at a depth of 17 fathoms (*Woods Hole*).

Food: Small crustacea, and to a less extent fish eggs and fry. As well as being concealed by the weed in which it lurks, the pipefish has a rank odor, which may protect it from possible enemies.

Life History: The pipe fish may be in breeding condition as early as May 13, and commonly spawns about June 1; males carrying eggs in the brood-pouch found throughout July (Woods Hole).

The entire family of which this species is a member are marsupial in habit, that is, they carry their embryos and larvae in a ventrally placed sac especially constituted for that purpose. However, instead of the female assuming the responsibility as in marsupial mammals, it is the males which harbor the offspring. The eggs are apparently fertilized at the moment of transfer from the oviduct of the female to the pouch of the male. Males with eggs or young in their pouches are not rare in this territory during summer. A young example 13 mm. in standard length was taken at the surface in townet just outside of Sandy Hook Bay on June 21, 1921. From individuals kept in aquaria it is known that pipefish reach 70 mm. within about 2 months after hatching. Beyond this the rate of growth and age at maturity is unknown.

Size: Reaches about 9, occasionally 12 inches total length. A female of 9 inches standard length was taken on August 10, 1923, in Sandy Hook Bay. Size of other adults taken during the same season averaged 5⅜ inches.



87. **Northern Seahorse**
Hippocampus hudsonius De Kay

Distribution: Uncommon summer visitant throughout the area. To the westward it becomes comparatively plentiful over periods of several years duration, and perhaps resident, and then becomes rare, following severe winters. *Woods Hole*, a few every year during August and September, earliest July. *Orient*, once only, August (Greenport). *New York*, sometimes common, April to November, casual in winter (February).

Occurs on the Atlantic Coast from Cape Cod (casually Nova Scotia) to Charleston.

Life History: The breeding habits of the seahorse are in many ways similar to that of the previously described pipefish, the male assuming the rôle of guardian of the young. Seventy-five or more little seahorses may be liberated from the pouch of a large male.

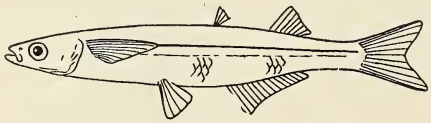
The males for some days after expelling their offspring, which act is done by pressing the pounch against some solid object, swell out their pouches repeatedly. The function of this action seems to be that of flushing out the brood chamber for the sake of sanitation. The rate of growth is not known. The young on expulsion average about 7 mm. in length as measured if straightened out.

Size: Commonly reaches a length of about 4 inches. One of about 6 inches, Point O'Woods, L. I., picked up Nov. 30, 1924, Katherine Wager Smith; 7½ inches is the largest on record.

THE SILVERSIDES

Small, slender, free-swimming fishes with a silvery lateral band and forked caudal fin. A small anterior dorsal fin of a few delicate spines is situated well in advance of a longer soft dorsal. Our species have the jaw of such a structure that the front of the head slants obliquely backward and downward. Lower jaw the longer; mouth small, with teeth.

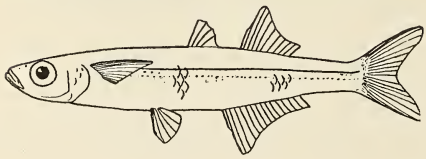
Scales with comb-like edges. *Membras*
Scales cycloid. *Menidia*



88. Rough Silverside
Membras lacineatus (Swain)

Distribution: Casual to the westward. *New York*, casual. Occurs from Virginia to South Carolina, and is replaced further south and west by a closely related species, *Membras vagrans*.

Size: Reaches a total length of about 4 or 5 inches.



89. Tide-water Silverside
Menidia beryllina (Cope)

The fresh-water silverside has only about 17 or 18 soft rays in the anal fin instead of 23 as in *M. m. notata.*

Distribution: Locally abundant, permanent resident to the west in fresh, though entering brackish water. Apparently a summer resident to the east and found also in salt water. *Woods Hole,* shores everywhere, abundant, appearing early in spring; seen as late as December.

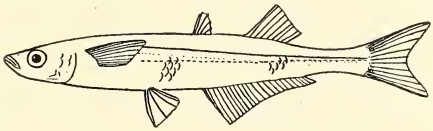
Occurs in coastwise Atlantic waters of the United States north to Woods Hole, and apparently the same species found up the Mississippi. Abundance and distribution in the Southern States uncertain.

Unlike its salt-water relative, the fresh-water silverside swims in schools which are generally made up of fishes all of about the same size and age. It is also a fatter and less bony fish and fried well is the delicious crisp "whitebait" which we sometimes see on our bills-of-fare. This is a case where differences between two closely related fishes are so slight and technical that the two can be distinguished with certainty only by a naturalist, yet associated with these differences are differences in habits and quality which make of one a prized food fish, the other, though certainly good to eat, a bait fish only.

Life History: Spawns in June and July, apparently later than *Menidia m. notata.*

Size: Reaches a length of up to 3 inches.

90. Common Silverside
Menidia menidia notata (Mitchill)



Anal fin with about 23 rays.

Distribution: Abundant resident, perhaps absent in mid-winter to the east. *Woods Hole,* April to December, most abundant late in the fall. *Orient,* resident, abundant only in fall. *New York,* abundant resident, most numerous in late summer and fall.

Occurs on the Atlantic coast of the United States, north to Halifax, Nova Scotia, passing into an allied form *M. m. menidia* to the southward (Virginia southward).

At the apex of fish life in shore waters in late summer and fall, this becomes perhaps the most abundant free swimming species, and is extensively preyed on by fishes and birds (young of blue-fish and mackerel, red-throated loon, etc.).

The common silverside, sometimes called "spiering," is a very abundant species in salt water near New York, and also enters brackish bays and estuaries, occasionally ascends to pure fresh water, and forms an important item of food with predacious fishes everywhere. Large schools made up of silversides of various sizes may be seen in summer time from almost any coastwise dock.

Food: Includes vegetable material and diatoms, but mostly carnivorous, eating small crustacea, worms, annelids, mollusks, etc.

Life History: Spawns in June and July, fry 15 mm. in length at surface in July (Woods Hole).

The height of the spawning season of *Menidia* is in June. The place of spawning is in shallow bays, great schools usually congregating for this purpose. Ripe fish are abundant in lower New York bay at this time. The eggs are spherical and vary from 1.1 to 1.2 mm. in diameter. They are yellowish in color, demersal and held together in clumps by the tangled skeins of their adhesive filaments. At a temperature of 72° F. they hatch in eight or nine days. The newly hatched larvae are approximately 5 mm. long. The yolk sac is absorbed before hatching. By the time a length of 15 mm. has been attained the fins are well formed and the young fish are well on their way toward the assumption of adult characters.

Fishes of the running year are taken in Sandy Hook Bay near the end of June with an average length of 20 mm. Fish of the previous year measure about 45 mm. at this same time while mature examples still spawning with a length of 90 mm. are taken as late as the end of July. The season of spawning for this species seems somewhat protracted and a considerable variation in size exists but individuals nearly alike in this respect show some tendency to seek each other's company.

At Chesapeake Beach, Maryland, on the afternoon of April 19, 1908, numerous Menidia were spawning in the edge of the water at points where weed and such riff-raff was partially buried in the beach. The tide was rising, probably pretty well up, and the spawning fish were wriggling actively as though stranded in the wash of the ripples which followed one another in, and at times one was almost or quite clear of the water. Close approach to a spot where they were, caused them to disappear from it, and it was difficult to capture any without a net.

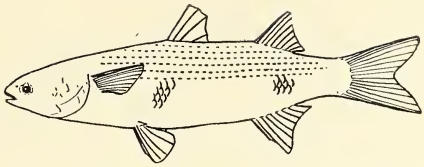
Allowing for the difference in latitude it was surprising to find the species spawning here at a date so much earlier than in our more northern region. It has occurred to the writers that the northward flight of transient shore-birds in May may pick up a great many such fish-eggs deposited along the strand tending to advance the season of the southern *Menidia* to April and retard that of the northern to June.

Size: 6 inches total length,

MULLETS

Small or moderate sized fishes of the bays, with a small transverse, toothless mouth, somewhat on the under side of the head. Body cylindrical and little compressed with moderate sized scales. More or less silvery in color, with well forked caudal fin. Small first dorsal of a few slender spines, separated from the longer and soft rayed second dorsal as in the silversides.

91. **Striped Mullet**
Mugil cephalus Linnaeus



Soft dorsal and anal fins almost scaleless. Sides with dark longitudinal stripes indicated along the rows of scales.

Distribution: Numerous in late summer and fall. *Woods Hole*, present from June to December, most common in fall. *Orient*, taken in fall and rarely (from mud) in winter. *New York*, common in late summer and fall, said to be a permanent resident, some individuals, at least, hibernating.

Occurs cosmopolitan in temperate and warm seas, from Cape Cod (casually Maine) to Brazil on the east coast of America.

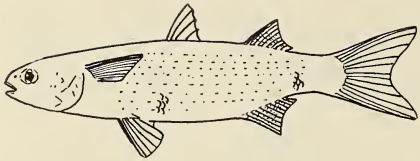
Life History: Mullet less than an inch in length are more or less larval or different from the adult. They are compressed, bright silvery with dark backs, have comparatively larger teeth, and only 2 anal spines, what will later become the third spine a simple but articulate soft ray. In this stage they are surface swimmers, and the differences between various species have not been worked out.

The striped mullet apparently spawns in the fall and winter as the appearance of ripe fish is made in New York by about the middle of September. These fish which generally average about 20 cm. are exceedingly fat. They are still present in October. In the spring young are seen about 1 inch long which by the end of summer have reached an average length of about 2⅜ inches (standard length). The actual spawning grounds are unknown as is the development of this species. As the mullet ages the intestine becomes progressively more convoluted and longer proportionately, which fact is probably to be correlated to a change in feeding habits of from one of plankton to one containing a high percentage of the higher marine plants. Maturity seems to be reached at an age of two years. The largest mullet recorded is a female of 19½ inches although they probably often attain a slightly greater size.

The growth of *Mugil* in Sandy Hook Bay may be indicated by the following table listing the average sizes of young fish at various collecting dates:

Date	*Average Standard Length*
July 12, 1923	26 mm.
" 25, "	34 "
August 2, "	34 "
" 9, "	42 "
" 16, "	52 "
" 23, "	54 "
" 30, "	54 "
October 9, "	80 "

Size: Reaches a length of 1 to 2 feet, 13 inches the largest individual recorded locally (Woods Hole).



92. **White Mullet**
Mugil curema Cuvier and Valenciennes

Soft dorsal and anal fins scaled. Sides uniform silvery.

Distribution: Common summer visitant, June 4 to December 13, mostly schools of young from August through October. *Woods Hole*, common June 28 (1¼ inches in length) to October. *Orient*, June 4 to December 13, large schools of young sometimes present in late September and through October. *New York*, common, August to November 9. In 1925 more common in Sandy Hook Bay than *M. cephalus* which was generally somewhat larger.

Occurs from Cape Cod to Brazil, common.

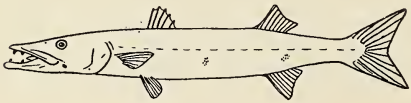
Life History: Schools of young of uniform size are frequent in the shallow borders of salt and brackish bays off the south shore of Long Island in late summer. A number of individuals 10 to 13 cm. total length picked up stranded at Long Beach September 30, apparently from a school trapped by the vagaries of the surf, perhaps on southward migration.

It is not known how far north the breeding range of this species extends as mature fish north of Florida are decidedly rare although the young are common enough all along our coast. The spawning season is at its height in May and June.

Size: Adults are about 1 foot in length.

BARRACUDAS.

Pike-shaped, surface fishes with long jaws set with irregular, formidable pointed teeth. Caudal fin forked, and a small first dorsal fin of a few slender spines well in advance of the longer second dorsal, as in the silversides and mullets.



93. **Great Barracuda**
Sphyraena barracuda (Shaw)

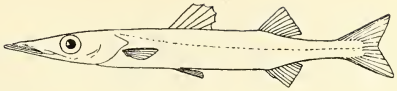
Scales large, 75 to 85. Teeth very large. Some irregular inky black spots on the flanks.

Distribution: Casual to the eastward. *Woods Hole*, a rare straggler, the last recorded being in September 1897.

Occurs in the West Indian fauna, regularly north to South Carolina.

Size: There is an official record of a Barracuda 5 feet 3 inches total length, weight 54 pounds taken with rod and reel in Florida, and unauthenticated reports of its reaching a length of over 10 feet.

94. Northern Barracuda
Sphyraena borealis DeKay[2]



Scales small, 115 to 130. Pectorals not reaching front of spinous dorsal. Maxillary not reaching front of orbit.

Distribution: Summer visitant, in regular numbers, young rather common, adults less so. June 20 to December. *Woods Hole,* July to December, most common after October 1, young common, adults rare. *Orient,* variously common or uncommon. June 20 to November 12. *New York,* uncommon, June 20 to November 16.

Occurs on the Atlantic coast of the United States from Cape Cod to Cape Fear.

Food: Small fish, also young gastropods.

Life History: A young one, 2⅜ inches in total length, Sandy Hook, July 8, shows several interesting 'larval' characters. Lower jaw much projecting, its tip ending in a black fleshy flap; scales of posterior part of lateral line large, keeled, forming a caranx-like keel on peduncular region. Color when fresh somewhat translucent or silvery with dark blotches or bars. In alcohol dark saddles on the back, dark blotches along mid-line of side continuous in a dark band posteriorly, two or three large dark blotches on mid-line below, the first covering the front of the base of the anal.

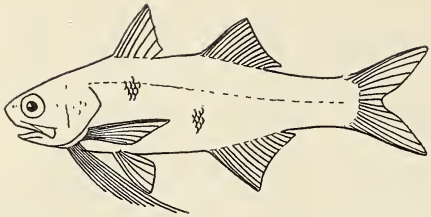
Keeled peduncular scales, present as a larval character in this species are particularly interesting on account of their being a striking permanent character of the whole group of unrelated Carangin fishes. The characters of larval fishes present an interesting field for investigation and discussion, with a bearing on our understanding of the evolution of this diversified group of animals. As a fish grows it frequently passes (just by reason of its changing size) from one ecological niche to another, and must be adapted to each, independently, with little or no support from the preceding generation; young fishes are frequently more specialized than their elders and there is a tendency for such specialized larvae to become permanent. The general rule that ontogeny tends to recapitulate philogeny is sometimes badly upset.

Size: Reaches 12 inches, rarely more.

THREADFINS

Rather small fishes with two well separated dorsal fins of approximately the same size; the first of spines, the second of soft rays. Eye large, near the end of the projecting, pig-like snout. Mouth large. Several threadlike filaments arising from just in front of the base of the pectoral fins. Caudal fin forked. Scales rather small.

[2] *Sphyraena guachancho* of the West Indies, north to Florida, has been recorded from Woods Hole 1876, Buzzards Bay, 1883, the records open to question due to chance of confusion with *borealis*. It has scales 120 to 130, pectoral reaching front of spinous dorsal, maxillary reaching front of orbit.



95. **Eight-fingered Threadfin**
Polynemus octonemus Girard

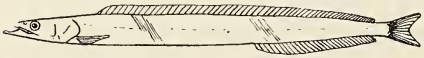
Distribution: Casual, July 23 to October 28. *Woods Hole*, two records, September 1882, October 28, 1908. *Orient*, one record. July 23, 1917. *New York*, August 15 (1924, Sandy Hook Bay, 6¾ inches standard length) to September.

Occurs on sandy shores of the south Atlantic and Gulf states, scarce.

Size: Reaches 10 inches total length (Orient).

SAND EELS

Elongate, compressed, silvery fishes with pointed head, projecting lower jaw, and forked caudal fin. A single low fin of slender spines or unbranched rays extends almost the entire length of the body.



96. **Sand Launce**
Ammodytes americanus DeKay

Distribution: Permanent resident, abundant in late fall and early spring to the east and through the winter to the west. *Woods Hole*, abundant, taken throughout the year, most numerous in late fall and early spring, rare in winter. *Orient*, resident, often abundant in fall; uncommon in winter and warmer parts of summer; dug from soft-shell clam flats in winter. *New York*, permanent resident, abundant in colder months, uncommon in summer.

Occurs abundantly on sandy shores from Labrador and Newfoundland to Cape Hatteras.

An important food for the mackerel and other fishes; eaten by the bluefish in summer; porpoises and even finback whales at times feed on them.

The sand launce is abundant in the wash of sandy ocean shores, especially during the colder months of the year, diving in and out of the loose sand bottom with great agility. At times quantities of sand eels (perhaps driven by enemies such as the silver hake) are washed ashore and lie strewn along the water's edge, a rich harvest for the gulls. It is occasionally trapped by its habit of burrowing in the sand. I have found the head of one which was still alive projecting from a sand flat exposed by the falling tide.

Probably perfect adaptation to burrowing in the sand, removed this form from the influences of general competition with other fishes and consequent evolutionary change, at some point in past time, so completely

that it is now impossible to say to what manner of fishes it is most closely related.

Food: It is omniverous feeding on all sorts of small marine animals, but predominantly on crustaceans.

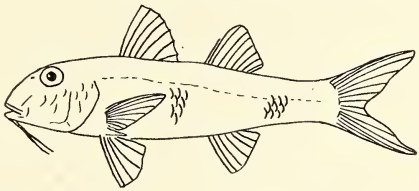
Life History: The spawning habits of this species are doubtless similar to those of the closely related European launce which deposits its eggs on sandy bottoms at a depth of about 10 fathoms in winter. The eggs are oval, less than a mm. in long diameter. Fry have been taken at Woods Hole in March.

Size: Reaches a length of about 6 inches. Averages 4 inches standard length near New York in May. An overgrown specimen from Frenchmans Bay, Mt. Desert, Me., 7 inches in total length.

GOAT FISHES[3]

Rather small fishes with forked caudal fins, and a weak-spined first dorsal fin about as large as the second dorsal. Scales of moderate size. Mouth inferior (lower jaw the shorter). A long double barbel at the chin.

97. **Northern Goatfish**
Mullus auratus Jordan and Gilbert



Distribution: Uncommon and irregular in late summer and fall, July 25 to November 7. *Woods Hole*, usually rare, a few in September, irregularly more numerous, July 25 to September 20. *Orient*, uncommon September 9 to November 7. *New York*, occasionally common September and October.

Occurs from Cape Cod to Florida.

Size: Reaches a length of 8 inches, local specimens usually 4 inches or less, the largest 6½ inches total.

CARDINAL FISHES

Small, symmetrical, chunky fishes, with large mouth, large eye, and rather large scales. A first dorsal of weak spines separate from and not differing greatly in size from a second dorsal of soft rays. Anal spines 2 (rarely 3).

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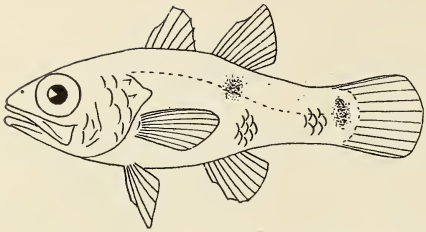
[3] The young of some species of squirrel fish, of which there are several in the West Indian fauna, are reported as accidental at Woods Hole. They are large eyed, spiny finned, coarse scaled fishes, more or less red in color, with more than 5 soft rays in each ventral fin, and the middle of 3 anal spines very stout.



98. **Spotted Cardinal Fish**
Apogon maculatus (Poey)[4]

Base of caudal without blackish blotch; a black blotch below soft dorsal, on peduncle, and on opercle.

Distribution: Casual in the Woods Hole region. Eleven specimens September 1 to 16, 1899.

Occurs in the West Indian fauna, from West Florida to Brazil.

Size: Reaches a length of about 4 or 5 inches.

SEA BASSES

Symmetrical, rather large-mouthed fishes with a spiny anterior and soft-rayed posterior portion to the dorsal fin, the two usually, not always, connected at the base. Eye moderate in position and size. Pseudobranchiae well developed. Ventral fins without a scaly flap at their base. Upper corner of operculum with one or two more or less obscure flattened spines. The fins not densely scaled, lateral line not extended across the caudal. Ventral fins usually inserted slightly behind the pectorals, their rays regularly 15. Scales moderate or small, more or less rough. Teeth pointed, in bands, some of them generally hinged. Caudal rounded, squarish, or weakly forked.

a. Anal spines wanting. *Rypticus*
Anal spines 3, well developed, (see b).

b. Two dorsal fins (see c).
One dorsal fin, spinous portion sometimes separated from soft-rayed by a deep notch (see d).

c. Dorsal fins entirely separate; anal soft rays 12. *Roccus*
Dorsal fins barely joined at base; anal soft rays 9. *Morone*

d. Head armed with rough spiniferous crests. Spines of anal and ventrals somewhat serrate on the anterior edge. *Polyprion*
Not as above; ventrals anterior to pectorals; scales 55 to 60. *Centropristes*
As above, but ventrals below or behind pectorals; scales 90 to 140 (see e).

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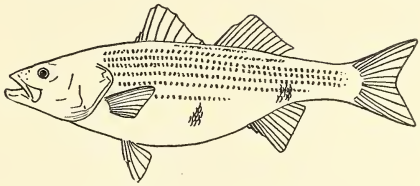
[4] There is a record of the Mediterranean Cardinal Fish, *Apogon imberbus* from Newport, which is questionable, due to chance of confusion with this or some other American form.

e. Anal with 11 or 12 soft rays. *Mycteroperca*
Anal with 7 to 9 soft rays, head very broad above. *Garrupa*[5]
Anal with 7 to 9 soft rays, head rather narrow above. *Epinephelus*



99. **Striped Bass**
Roccus lineatus (Bloch)

Distribution: Fairly common, permanent resident at least to the westward, most numerous in fall. *Woods Hole*, less common than formerly, May 1 to November 1, most frequent in June. *Orient*, resident, rare in summer and usually so in winter; irregularly common fall, October 1 to December. *New York*, fairly common, permanent resident, most common in fall.

Occurs on the Atlantic coast from the Gulf of St. Lawrence to Florida, most common from Cape Cod to Cape May. Introduced successfully on the Pacific coast. Found in both fresh and salt water.

The striped bass is caught from our ocean shores and also ascends the Hudson River abundantly. It is the finest food fish taken locally. Before the weakfish arrive, rod and line anglers from New York City often take their boats up the Hudson River in pursuit of striped bass. After the weakfish have gone, striped bass are again in season. They are now often fished for off the beach by casting through the surf. This is the type of fishing hereabouts in which the catch of fish is of least importance. Just an occasional bass to lend a touch of sanity to the performance will keep a whole row of anglers on the beach vying with one another in the skill and distance with which they can cast through the surf. Most of the bass now taken near New York are small, from two to six or seven pounds in weight. It takes special skill to hook and land the bigger ones, unless by luck.

Food: Eats fish and large crustacea, as crabs and lobsters.

Life History: To the south of our territory this species spawns in May. The eggs are non-adhesive, and average about 3½ mm. in diameter. They are very slightly heavier than water, so probably are constantly drifting about during incubation. At a temperature of 58° Fahr. they hatch in about three days. The maximum number recorded is 2,200,000, although a large female probably will exceed this number greatly. This species ascends rivers for the purpose of spawning or may spawn in bays. New York Bay was formerly an important spawning ground.

Size: Often reaches 30 to 90 pounds, 125 pounds, the maximum.

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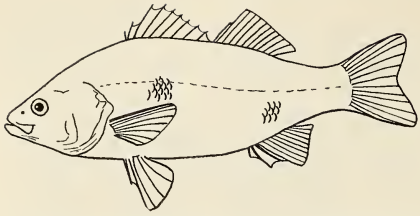
[5] Young of the black jew fish, *Garrupa nigrita* are reported casual at Woods Hole, but this is a very large fish, over 100 pounds, its young comparatively little known, and the identification of these specimens is open to question.



100. **White Perch**
Morone americana (Gmelin)

Deeper-bodied than the striped bass, depth 2⅔ times in length to base of tail fin; mouth smaller, tail fin only slightly forked. Color uniform silvery or whitish on the sides, more or less olivaceous on the back. Somewhat similar to *Bairdiella* but with 3 anal spines.

Distribution: Common permanent resident. Occurs along shore in undiluted sea water from fall till early spring. *Woods Hole*, abundant permanent resident. *Orient*, locally common resident, more generally common in fall and winter. *New York*, common permanent resident.

Occurs on the Atlantic coast from Nova Scotia to South Carolina. A fresh and salt water species.

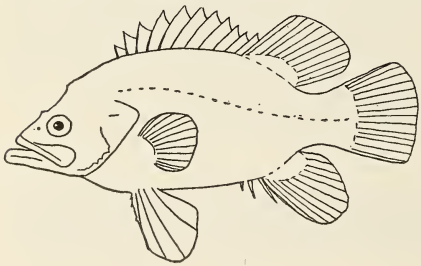
Found in shallow water, bays creeks or ponds, where it wanders in small schools, and congregates in the deeper parts to spend the colder months in a more or less sluggish condition.

The well known white perch is a close relative of the striped bass and agrees with it in essentials of structure. It is characteristic of coastwise ponds but also found in brackish or even salt water. This is a fish about the size of a yellow perch or a trifle larger, and as a table fish superior to that species. It may readily be told from the yellow perch by the absence of black bars on the sides and the form. The white perch is one of the most universally popular panfish throughout the Atlantic seaboard.

Food: Fish, shrimps and other crustacea.

Life History: Spawns in fresh and brackish ponds in May and June. (Woods Hole). This species spawns in April and May in fresh or brackish water (New York). The eggs, about ¾ mm. in diameter sink and stick together in masses or to any object on which they rest; and average about 40,000 to the female. At a temperature of 58° Fahr. they hatch in about three days. In many ways the spawning of this form is similar to that of *Roccus*.

Size: The maximum size is about 15 inches long, 2 or 3 pounds in weight.



101. **Wreckfish**
Polyprion americanus (Bloch and Schneider)

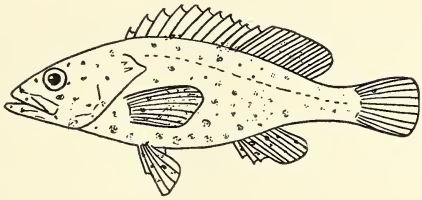
Distribution: Accidental in August, one record, New York, a young fish.

Occurs off the coast of Europe.

The adults are not uncommon in deep water of 300 fathoms or more, said to live mostly about wrecks. The young swim near the surface, especially southward.

Size: Reaches 5 or 6 feet in length.

102. **Rock Hind**
Epinephelus adscensionis (Osbeck)



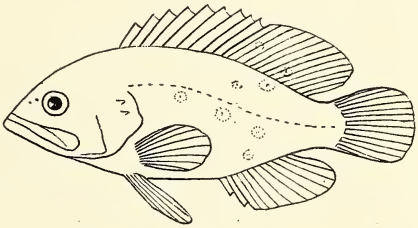
Second dorsal spine short, lower than third or fourth. Maxillary without scales; body and bases of fins covered with small red or orange spots, darker than the ground color, which turn dusky in preservative. Caudal somewhat rounded.

Distribution: Accidental. One young specimen, Katama Bay, September 19, 1899.

Occurs in the South Atlantic Ocean, and the West Indian fauna of the North Atlantic from Florida Keys to Brazil.

Size: Reaches a length of about 16 inches.

103. **Snowy Grouper**
Epinephelus niveatus (Cuvier and Valenciennes)

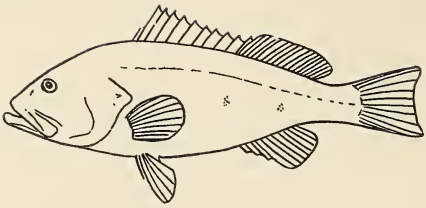


Second dorsal spine short, lower than third or fourth. Maxillary more or less scaled. Body marked with large spots, steel blue in life, paler than the ground color.

Distribution: Not rare in the Woods Hole region, August to November, unknown elsewhere in our region.

Occurs in the West Indies and to Brazil, occasionally northward in the Gulf Stream, not common.

Size: Reaches a length of about 2 feet.



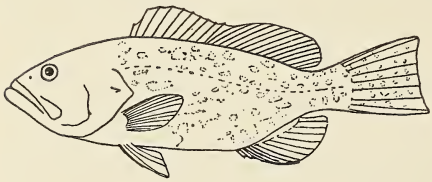
104. Red Grouper
Epinephelus morio (Cuvier and Valenciennes)

Second dorsal spine elevated, not lower than third or fourth. Color brownish or reddish, more or less variegated. The bases of the jaws always reddish.

Distribution: Young casual to the eastward, September 1 to 26. *Woods Hole*, casual, September 1 to 26.

Occurs on the Atlantic coast of America from Virginia to Rio Janeiro.

Size: Reaches length of 1 to 3 feet.



105. Black Rockfish[6]
Mycteroperca bonaci (Poey)

Angle of preopercle not salient; ten gill-rakers, besides rudiments on the lower limb of the arch; scales about 110.

Distribution: Casual to the eastward. *Woods Hole*, several records, August, September and October.

Occurs in the West Indian fauna from Florida to Brazil, abundant about the Florida Keys and Cuba.

The typical marine sea-basses, one of the dominant groups of modern fishes, fall naturally into two rather ill defined series, the temperature and the tropical. The former has many Mediterranean species, and is well developed in California waters, but our common sea bass, *Centropristes*, is almost its only representative here, where due to the influence of the Gulf Stream, groupers and rockfish, representative of the tropical series are a possibility as stragglers summer and fall, and in winter the ocean is boreal in character.

Size: Reaches 2 or 3 feet in length.

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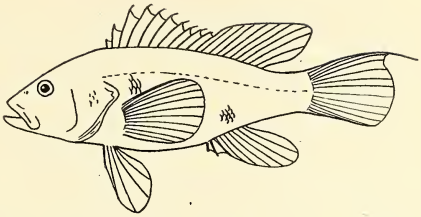
[6] The Cuban rockfish, *Mycteroperca interstitialis*, is recorded at Woods Hole, but in view of its close resemblance to this and other more probable species, the identification is doubtful.



106. **Sea Bass**
Centropristes striatus (Linnaeus)

Distribution: Common, spring, summer and fall, April to December 7. *Woods Hole*, common, May 10 to October. Most abundant from July to September. *Orient*, April 30 (1913) to October 18 (adult) and December 7 (young). *New York*, common, April to December. An apparently somewhat shorter season to the east may indicate east-west migration along the coast.

Occurs from Cape Ann (rarely Maine) to northern Florida, common between Cape Cod and Cape Hatteras. Adults occur in rather deep water, minimum a couple of fathoms, close to rocky bottom.

The sea bass which is one of our best and commonest local food-fishes, is most plentiful on fishing banks a little off-shore, and the young which have a dark, lengthwise stripe abound in coastwise bays in autumn.

The hardness of its flesh makes it desirable for packing in ice, and prevents rapid deterioration in hot weather. It is an excellent chowder-fish and delicious boiled or broiled. It is the species most sought in summer by the steamers which regularly take fishermen from New York to the outside banks of the Long Island and New Jersey shores.

Food: Fish, squid, and crabs.

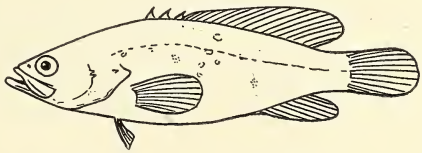
Life History: Spawns from middle of May to first of July (Woods Hole.)

Sea bass spawn during the month of June. The eggs are buoyant, non-adhesive, and average about 1 mm. in diameter. At a temperature of 50° Fahr. they hatch in about five days.

Small examples of 20 mm. in standard length may be taken from the oyster beds about one-half mile off Staten Island during August.

In June in Sandy Hook Bay, sea bass very likely a year old averaged 175 mm. in standard length; on July 31 a ripe female of 8⅝ inches (219 mm.) was taken. From September 6 to 19, 1922, examples taken in a dredge showed an average growth of from 25 to 40 mm. standard lengths.

Size: A 5-pound sea bass is an unusually large one, but there are records for almost twice that weight. Commonly reaches 18 inches length and 3 pounds weight. Largest at Orient 7 pounds. The record is 8 pounds 2 ounces, a fish caught off New York.



107. **Soapfish**
Rypticus bistrispinus (Mitchill)

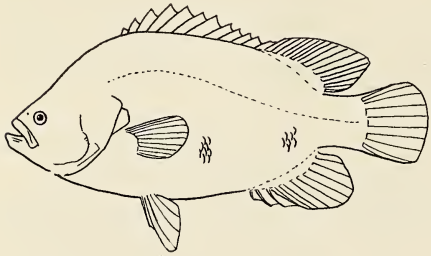
Distribution: Accidental, one record, Newport.

Occurs in rather deep water from Charleston to Key West.

Size: About one foot in length.

TRIPLE-TAILS

Large, bass-like fishes, with rather small, rough scales; deep compressed body: eye near front of the head; lower jaw projecting; preopercle serrate. The soft rayed dorsal and anal fins project backward in blunt points. The anterior spinous dorsal fin consists of stout spines and is connected with the base of the soft rayed fin behind it. Caudal fin rounded. Body outline concave over the eye.



108. **Triple-tail**
Lobotes surinamensis (Bloch)

Distribution: Rare in summer and fall, July 13 to December. *Woods Hole*, very rare, August 15 to December. *New York*, rare, July 13 to October.

Occurs generally distributed in warm seas, north to Cape Cod.

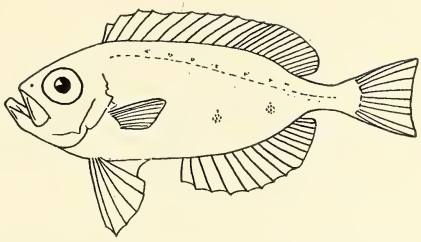
We know of few recorded instances of this species being met with in numbers on our Atlantic Coast. In late September, 1923 Dr. C. L. Summers found them numerous, weighing from 14 to 21 pounds, about an old wrecked steamer off Beaufort, N. C. They could be seen disporting vigorously in the surf washing over the wreck, and when hooked proved active and gamey.

Size: Reaches 3 feet in length.

BIG-EYES

Large-eyed fishes differing from the sea basses in that the head as well as the body is everywhere covered with fine rough scales, and the anal fin is similar to and scarcely shorter than the dorsal.

Scales small, 80 to 100, depth of body less than half length. *Priacanthus*
Scales moderate, 35 to 50, depth of body more than half of length. *Pseudopriacanthus*

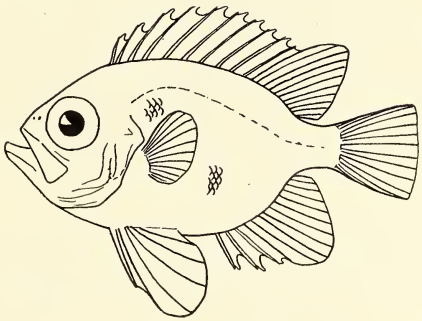


109. **Big-eye**
Priacanthus arenatus Cuvier and Valenciennes

Distribution: Young rare in fall to the eastward, October 10 to November 7. *Woods Hole,* rare in fall, to November 2. *Orient,* rare in fall, October 10 to November 7.

Occurs in the tropical Atlantic, south to Brazil, young northward in the Gulf Stream to the coast of Massachusetts.

Size: Reaches a length of about one foot.



110. **Deep Big-eye**
Pseudopriacanthus altus (Gill)

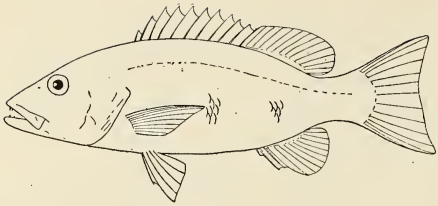
Distribution: Rare in late summer and fall, August 20 to November 3. *Woods Hole,* usually rare, many taken in September 1899. *New York,* very rare, August 20 to November 3 (1922, Point O'Woods, Mrs. H. W. Smith).

Occurs in the West Indian fauna, north to Charleston, The young stray north in the Gulf Stream to Massachusetts, occasionally being washed ashore or trapped in puddles on the beach; they are very easily identified, flat, almost circular in outline, and bright red.

Size: Largest 11 inches long.

SNAPPERS

Small or medium sized, compressed, symmetrical fishes, with a single back fin composed of an anterior spiny and posterior soft rayed portion of about equal length, a scaly flap at the base of the ventral fins. Upper corner of operculum without spines. The maxillary moderately, not excessively, protractile. Teeth pointed, unequal, some of them large. Fins not scaly.



111. Gray Snapper
Lutianus griseus (Linnaeus)

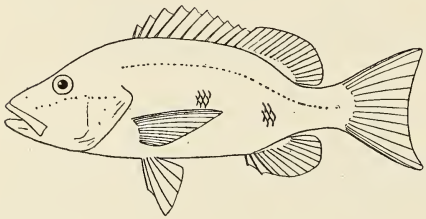
Anal fin more or less rounded. No black lateral spot. Comparatively elongate,—depth 2¾ to 3 in standard length. Mouth large, maxillary 2½ in head.

Distribution: Casual, *Woods Hole*, August, September and October.

Occurs in the West Indian fauna, New Jersey to Brazil.

This is the common shallow water snapper about the Florida Keys. Small schools of young ones prowl along the edges of the mangroves, and larger individuals frequent the deeper channels among the reefs. Wary, alert, strong, swift and adaptable, the gray snapper abounds where competition in fish life is keenest, an excellent example of the highest development in modern spiny-rayed fishes.

Size: Reaches a length of about 18 inches.



112. Dog Snapper
Lutianus jocu (Bloch and Schneider)

Anal fin more or less rounded. No black lateral spot. Depth about 2½ in standard length. Maxillary about 3 in head. Fins orange or yellow in life. Scales (counted above lateral line) about 55. A whitish area below eye.

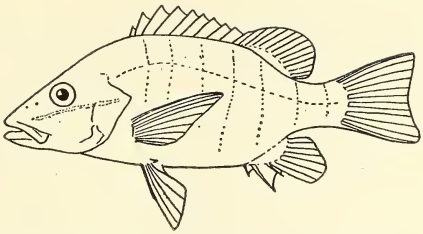
Distribution: Accidental, one record, a young fish. *Woods Hole*, September 21, 1897.

Occurs in West Indian fauna from the Florida Keys to Brazil.

The dog snapper is reputed to be unwholesome. All other species of this genus are excellent food fish.

Size: Reaches a length of about 2 feet.

113. Schoolmaster Snapper
Lutianus apodus (Walbaum)



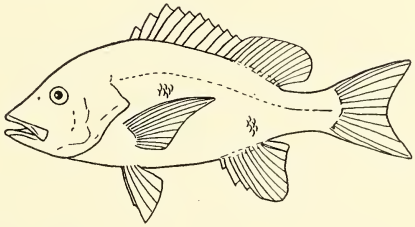
Resembles *L. jocu*, but scales larger (counted above lateral line) about 45; no whitish area below eye; etc.

Distribution: Young casual at Woods Hole, August 29 to September 20.

Occurs in the West Indian fauna from the Florida Keys to Brazil.

Size: Reaches a length of about 18 inches.

114. Red Snapper
Lutianus aya (Bloch)



Anal fin angulated, its middle rays more or less produced. Maxillary reaching opposite front of pupil. Color rather uniform bright red in adult, young with a black spot on the side.

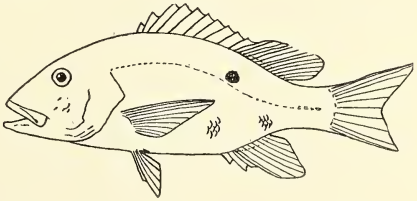
Distribution: Young casual at Woods Hole, September to October 10. *New York*, accidental, October.

Occurs in the West Indian fauna from Florida to Brazil, straying north to Long Island. Favors rocky banks in rather deep water.

Perhaps the best food fish of all the snappers, and shipped extensively to northern markets. A fine large red snapper, baked, is unsurpassed as a table dish.

Size: Reaches a length of 2 to 2½ feet.

115. Mutton Snapper
Lutianus analis (Cuvier and Valenciennes)



Anal fin angulated, its middle rays more or less produced. Maxillary

reaching only to opposite front of eye. Colors olivaceous, rosy below, fins red. A small but distinct black spot on the side at all ages.

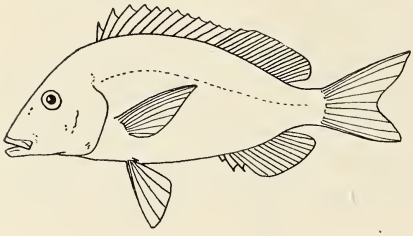
Distribution: Rare at Woods Hole, August, September and October.

Occurs in the West Indian fauna from Florida to Brazil. A favorite southern food fish.

Size: Reaches a length of 27 inches, weighing 21 pounds.

GRUNTS

Small, compressed, symmetrical fishes with a single back fin composed of an anterior spiny and posterior soft rayed portion of about equal length. A scaly flap at the base of the ventral fins. Upper corner of operculum without spines. The maxillary moderately, not excessively, protractile. Teeth small, pointed. Fins usually more or less scaly.



116. Pigfish
Orthopristis chrysopterus (Linnaeus)

A lengthwise pit or groove on the chin. Mouth not large, the maxillary 3⅓ in the head. Dorsal with 16, anal 12 or 13 soft rays. Color bluish, with small bronze spots.

Distribution: Rare in late summer and fall, occasionally common to the westward, June 29 to November 17. *Woods Hole,* one record, October 21, 1908, 8¼ inches long. *Orient,* rare, June 29. *New York,* occasionally common, August to November 17.

Occurs on south Atlantic and Gulf coasts of the United States from Long Island to the Rio Grande.

This species apparently enters our region following the coast from the southwest, in contrast with various others which apparently drift north as young in the Gulf Stream. Large as well as small specimens occur, and it is more frequent to the westward than to the eastward.

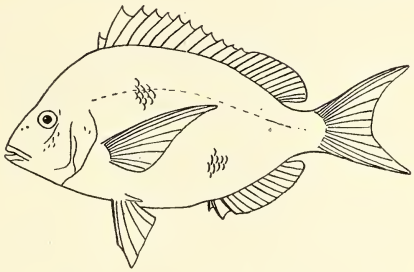
Size: Reaches 12 to 15 inches; a local specimen of 9½ inches total length.

PORGIES

Small compressed, symmetrical fishes with a single back fin composed of an anterior spiny and posterior soft rayed portion of about equal length; a scaly flap at the base of the ventral fins. Upper corner of operculum without spines. The maxillary moderately, not excessively, protractile. Teeth in the back of the mouth flat, molar-like. Anterior teeth more or less incisor-like, sometimes compressed. Fins not scaly.

a. Second interhaemal spine (above the anal fin) 'pen shaped,' hollowed. *Stenesthes*
Second interhaemal spine normal, not as above, (see b).

b. Incisor teeth in front of jaws conspicuously notched. *Lagodon*
Incisors entire or with a shallow notch. *Archosargus*



117. Porgy
Stenesthes chrysops (Linnaeus)

Distribution: Abundant in summer and fall, April 16 to December 4. *Woods Hole*, abundant, May 1 to the latter part of October, most abundant in June and July. *Orient*, abundant, April 16 (1913) and April 18 (1908) to December 4. *New York*, abundant, April to November.

Occurs from Cape Ann (casually Maine) to South Carolina, probably moving off into deeper water with the approach of winter. Occurs mostly in bays and coastwise, taken down to 17 fathoms (Woods Hole).

Foods: Small crustacea, worms, mollusks, fish, squid, etc., and also vegetable debris.

Porgies usually congregate in schools, and feed at or near the bottom, sand or mud preferred.

Life History: Spawns early in June (Woods Hole); males with running milt June 1 to 23 (Sandy Hook Bay). Young from 1 to 3 inches in total length sometimes very abundant October 10 to December 1, at which dates the adults have fallen off in number.

Porgies spawn in June and July. The eggs are buoyant, transparent and spherical, varying from 0.85 to 0.90 mm. in diameter. A single oil globule is normally present in the yolk. At a temperature of 72° F. they hatch in about 40 hours after extrusion. On hatching the larvae measure about 2.8 mm. At 25 mm. most of the diagnostic characters have been developed but still there is comparatively little resemblance to the adult, chiefly on account of the much slimmer body of the young.

Measurements and the examination of the scales of specimens from Sandy Hook Bay indicate growth as set forth in the following table which gives what are apparently the normal sizes of fish up to the age of three years.

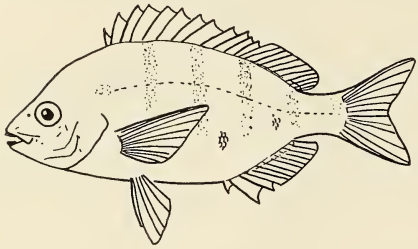
Average Standard Length

1st Winter	*2nd winter*	*3rd winter*	*4th winter*
70 mm.	112 mm.	117 mm.	180 mm.

In September most of the fish average about 180, while there is a smaller group of about 68, which show as 70 in the above table.

Spawning probably takes place for the first time in the third summer.

Size: A specimen from Orient had a total length of 16¼ inches, weight 2 pounds. Said occasionally to reach a weight of 3 or 4 pounds.



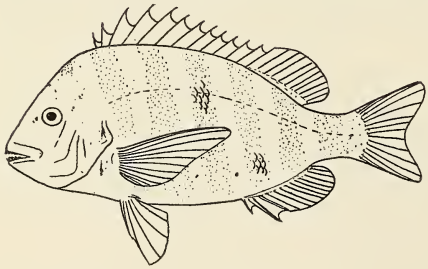
118. **Pinfish**
Lagodon rhomboides (Linnaeus)

Distribution: Usually rare, sometimes common to the eastward, summer and fall, June to October 25, (November 18). *Woods Hole*, usually rare, sometimes common June to October 25. *Orient*, rare, August 2 to November 18, occurs each fall. *New York*, occasional, summer and autumn.

Occurs on the Atlantic and Gulf coasts of the United States from Cape Cod to Cuba, abundant from some point south of New York to Pensacola. Occasionally adults are taken in Sandy Hook Bay. Young are more frequently common in the fall, although exceptionally scarce in 1923 and 1924.

Date	*Average Standard Length*
August 31	45 mm.
October 19	65 "

Size: A very large specimen taken in Buzzards Bay measured 10½ inches.



119. **Sheepshead**
Archosargus probatocephalus
(Walbaum)

Distribution: Rather common formerly in summer, now rare, June to October. *Woods Hole*, July and August. *Orient*, formerly irregularly common, now unknown, last record August 19, 1904. *New York*, June to October.

Occurs from Cape Cod to the Florida Keys and Texas, common southward. Casual in the Bay of Fundy.

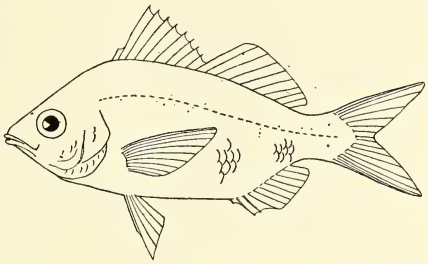
Life History: In Florida this species spawns during March, whilst it spawns later in more northern parts of its range. The eggs measure about 0.8 mm. in diameter and are non-adhesive and buoyant. They hatch in about 40 hours at a temperature of 77° F.

Size: Reaches a length of about 30 inches, and weight of 20 pounds.

GERRIDS

Small porgy-like fishes with the upper jaw excessively protractile, capable of being thrust far forward. Outline of the lower jaw concave.

120. Common Mojarra
Eucinostomus gula (Cuvier and Valenciennes)



Distribution: Rare in irregular numbers in late summer and fall, mostly to the eastward, August to October. *Woods Hole*, rare in irregular numbers, August to October. *New York*, accidental, August.

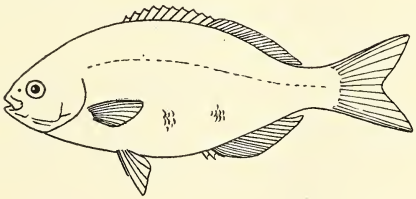
Occurs from Carolina to Brazil, the young ranging northward to Woods Hole.

Size: Reaches a length of 4 to 5 inches.

KYPHOSIDS

Deep-bodied, compressed, porgy-like fishes, with small incisor teeth, each tooth with a conspicuous horizontal process or root.

121. Bermuda Chub
Kyphosus sectatrix (Linnaeus)[7]



Dorsal with 14, anal with 12 soft rays, scales about 85.

Distribution: Rare in summer and fall, more numerous to the eastward, April, September to November 2. *Woods Hole*, not rare in summer and fall (October 15) mostly about 6 inches long, occasionally met with in April.

[7] The yellow chub, *Kyphosus incisor*, has been reported once from Nantucket. Its range is Cuba, Brazil, etc., and the identification is open to question. The scale-count of this species is about 65.

Orient, two records, June 3; and November 2, 1915. *New York*, rare, September and October.

Occurs from Cape Cod to the West Indies and Canary Islands. Sometimes found among gulf weed at surface. (Woods Hole.)

SIZE: Reaches 18 inches.

CROAKERS

Symmetrical fishes resembling the sea basses, with scaly caudal fin, the lateral line extended across it. The spiny and soft-rayed dorsal united at the base. Anal fin short; soft dorsal long.

a. Lower jaw projecting, caudal fin emarginate. *Cynoscion*
Not as above, the lower jaw more often included, central caudal rays more often longest (see b).

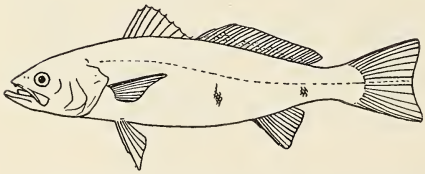
b. Lower jaw without barbels, (see c).
Lower jaw with one or more barbels (see f).

c. Teeth of lower jaw, which is slightly included, wanting or deciduous. Caudal fine emarginate. *Leiostomus*
Teeth well developed, permanent in both jaws (see d).

d. Gill-rakers short and thick, usually not longer than posterior nostril. Lower jaw included. A large fish with a squarish caudal and black spot at its base above. *Sciaenops*
Gill-rakers comparatively long and slender. Lower jaw slightly projecting (see e).

e. Mouth very oblique. Preopercle without bony serrae. *Larimus*
Mouth not very oblique. Preopercle with bony serrae. *Bairdiella*

f. Lower jaw with several slender barbels. Preopercle with bony serrae. *Micropogon*
Lower jaw with several slender barbels. Preopercle nearly entire. *Pogonias*
Lower jaw with a single thickish barbel at its tip, snout piglike projecting beyond the mouth. *Menticirrhus*



122. **Weakfish**
Cynoscion regalis (Bloch and Schneider)

Soft rays of dorsal and anal scaled; gill rakers 9 to 12 on the lower part of the first arch. Upper parts freckled with irregular, ill defined brownish spots.

DISTRIBUTION: Abundant in summer and fall, April 20 and 25 at Orient, May 4 at New York to December 8; adults rare or absent after October 15 (Woods Hole), October 30 (Orient) and early November (New York). *Woods Hole*, abundant, (April 1898) May to mid-October. *Orient*, April

20 and 25 (average arrival May 7) to December 8 (young only after October 30). *New York*, common May 4 to November (December 6, adult).

Occurs on the Atlantic and Gulf coasts of the United States from Massachusetts Bay to Mobile.

While with us the weakfish prefers sandy shores and water of no great depth, swimming either near the surface or near the bottom, often in large schools. It is the principal salt-water game fish pursued with rod and line by dwellers of New York City. Straggling weakfish usually reach our waters in May, but the middle of June has generally arrived before they appear in abundance, the time of their appearance being dependent upon whether the season is an early or a late one, and the corresponding temperature of the water. For days before the weakfish come some of the most enthusiastic fishermen have been going out diligently to find them, and the first schools are welcomed with enthusiasm by the angling fraternity who at once take to boats in their pursuit.

The baits most in favor for weakfishing are white worms and shedder crab. Sometimes the white worm bait is topped with a live shrimp impaled on the very tip of the hook, and shrimps are frequently used as "chum" to lure the fish about the boat.

When large weakfish become very abundant off the ocean beaches, as they frequently do, sailboats (now mostly replaced by power boats) cease trolling for bluefish, lie in the wind, and fish for the "weaks" with metal bluefish "squid," in a manner known as "jigging." The "squid" is lowered to near the bottom, and at intervals lifted rapidly through a foot or two of water and allowed to drop back again.

Food: Fish (menhaden, butterfish, and many other species), squid, shrimp, occasionally amphipods. Weakfish of 13 to 20 inches commonly take menhaden 4 or 5 inches long, three such fish may be found in a weakfish's stomach. Young weakfish 6 inches in length have been taken from stomach of adults weighing 3 and 4 pounds (Orient).

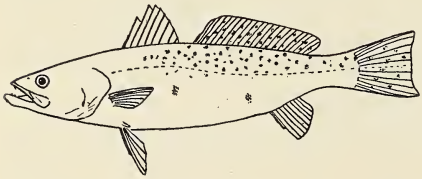
Life History: The weakfish spawns throughout our region in the larger bays and possibly in the open sea as well. The season extends from early May to September, and the greatest amount of spawn is deposited before July. The spawning occurs near the bottom, generally in from 3 to 5 fathoms of water, and probably usually at night. The fertilized eggs rise to the surface at once where they drift about in the currents. Fertile weakfish eggs have been taken in tow-nets at temperatures ranging from 60 to 70° F. They are spherical and almost colorless and are somewhat adhesive when first extruded. This latter character they soon lose. The eggs from different females vary considerably in diameter, ranging from 0.74 to 1.10 mm. The smaller sizes predominate. From one to four oil globules are present in the yolk. As development advances they coalesce into one and the specific gravity of the eggs becomes greater, causing them to sink before hatching. At a temperature of from 68° to 70° F., they hatch in from 36 to 40 hours. The newly hatched larvae are about 1.75 mm. in length and possess a large yolk sac. At about 24 hours after hatching their

length is 2.2 mm., the yolk sac is much reduced and the pectoral fins are distinct. In specimens of 12.5 mm. the fins are fully differentiated and the larval fin fold is gone. The growth of the young weakfish is rapid during the summer but practically ceases with the coming of winter. Fish hatched on June 1 average as follows for the next five months: July 1, 30 mm.; August 1, 80 mm.; September 1, 130 mm.; October 1, 170 mm.; November 1, 180 mm. On account of the extended spawning season and the consequent great overlapping of the year classes and the wide variation in size the first winter, it is extremely difficult to follow the growth satisfactorily. However, the following averages are offered, being based on scale examination. First winter—100 to 130 mm., second winter—210 mm., third winter—280 mm., fourth winter 330—mm., fifth winter—360 mm. (14 inches). The first spawning occurs at an age of three or four years for the females while the males mature a year earlier (2 or 3 years). Spawning occurs annually thereafter.

Young weakfish between 1 and 2 inches in length have a conspicuously projecting lower jaw like the adult, but a pointed, graduated caudal fin.

Size: Inshore, school weakfish do not average over a pound in weight. Offshore, they run larger, 5 or 6 pounds being common, and 10 pounds not rare. Thirty pounds have been reached by the species.

In Sandy Hook Bay the majority of adult weakfish average about 14 inches in standard length, and generally range from 8½ to 17 inches. Fish of over 20 inches are exceptional in that bay. Young fish of about one year, measuring 4 to 5⅛ inches are sometimes taken, but as a rule are not common.



123. Southern Weakfish
Cynoscion nebulosus (Cuvier and Valenciennes)

Soft rays of dorsal and anal scaleless; 6 to 8 gill rakers on the lower part of the arch. Back posteriorly with round black spots, similar somewhat smaller spots on dorsal and caudal fins. *Sandy Hook Bay*, July 9, 1926, 14 inches standard length.

Distribution: Casual, three records at Orient; June 3 to June 15; Gardiners Bay, about 1½ pounds each.

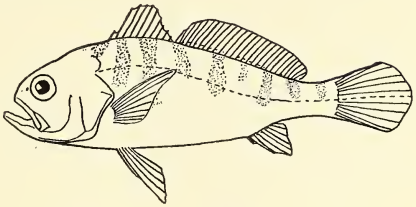
Occurs from New York to Texas, common southward.

Life History: The development of the southern weakfish, which is rare north of Delaware Bay, is not so well known as that of its congener *C. regalis*. The eggs and larvae are unknown, the smallest post larvae recorded already having a length of 28 mm. Scale examination shows the growth to be somewhat as follows: first winter, about 115 mm., second

winter, 230, third winter, 310, fourth winter, 360, fifth winter 400, and sixth winter 430.

SIZE: Reaches a weight of about 7 pounds.

124. Banded Croaker
Larimus fasciatus Holbrook



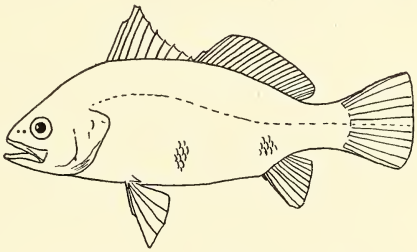
DISTRIBUTION: Accidental, at least 3 times, July to August 13. *Woods Hole*, once, August 13, 1889. *New York*, accidental, July and August.

Occurs from Chesapeake Bay to Galveston, Texas.

LIFE HISTORY: The life history of this small straggler to our shores is very poorly understood. Young fish of 40 mm. in length closely resemble the adult in coloration and form. The average size attained by this species is in the neighborhood of 110 mm., and individuals of more than 200 mm. (8 inches) are uncommon.

SIZE: Reaches a length of about 10 inches.

125. Silver Perch
Bairdiella chrysura (Lacépède)



Somewhat similar in appearance to *Morone* but has only 2 anal spines.

DISTRIBUTION: Sometimes common to the westward in summer and fall; not recorded east of Long Island; May 23 to December 18. *Orient*, casual, May 23, a fish 6 inches total length, and November 15, one of 9 inches. *New York*, sometimes common, June 28 to December 18.

Occurs on sandy shores from western Long Island to Texas.

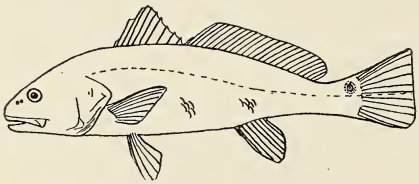
This is another southern summer species, which from its greater abundance to the west unquestionably reaches our region, when it does so, by a coastwise migration or extension. It is in contrast with various southern stragglers which occur most frequently with us about Woods Hole, and the reason is not far to seek. Its young as well as the grown fish live in inshore waters and are not subject to dispersal by ocean drifting.

LIFE HISTORY: The northward extension of the range of the silver perch stops at New York, but nevertheless it is abundant on the New Jersey

coast, where the height of its spawning season is in May. The eggs are spherical, transparent, slightly yellowish in color and buoyant. They range in diameter from 0.7 to 0.8 mm., and contain a single large colorless oil globule. The eggs of the silver perch hatch in from 40 to 45 hours at a temperature of from 66 to 70° F. The fry on hatching average about 1.7 mm. in length. It takes them about two days to absorb the yolk. At a length of 30 mm. the young resemble the adults in all essential respects. By the first winter first hatched in May are about 120 mm. in length; by the second about 160; by the third about 180. The following spring they are mature and thereafter growth is much slower. A fish of 230 mm. (9 inches) may be six years old.

Sometimes fairly common in Sandy Hook Bay in June and July, ripe, ranging from 150 to 180 mm. in standard length, females slightly more numerous than males, no small fish recorded. Spent fish are occasionally taken in the latter part of July and early August.

Size: Reaches a length of about one foot.



126. Channel-bass
Sciaenops ocellatus (Linnaeus)

Distribution: Uncommon in summer at the western limits of the region, May to October. *Woods Hole*, one record. *New York*, almost unknown on the Long Island and not rare on the New Jersey shore, May to October, rare in Sandy Hook pound nets, one of 2 feet 8½ inches, Sandy Hook Bay, September 13, 1921, and another somewhat larger on June 18, 1924.

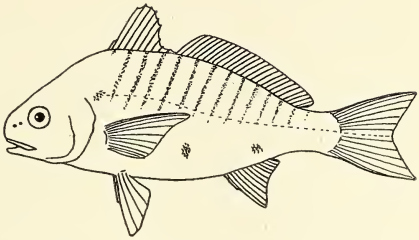
Occurs on the Atlantic coast of the United States on sandy shores from New York to Texas.

Channel bass furnish excellent sport, being frequently angled for through the surf. The large ones, over 15 pounds, are coarse and not very good eating. They are rare in this immediate vicinity but common farther south on the New Jersey coast. The species feeds on mollusks and crustaceans. The name "red drum" is current for this species in the literature, but the "red drum" of the best informed New Jersey anglers is a true sea drum.

Life History: The channel bass does not normally range further north than New Jersey and apparently most of the breeding is done south of the Chesapeake Capes. The breeding season is confined to the late fall and early winter. The eggs and larvae are unknown, the smallest example on record being 40 mm. long. The general form of the adult is present at this stage, although the color markings are quite different, the small fish being blotched rather gaudily. Three year old channel bass may vary from 390

to 590 mm. (15¼ to 23⅛ inches) in length. In the 6th year they may measure about 826 mm. (34¼ inches).

Size: Reaches a length of 2 to 5 feet and weight of 10 to 75 pounds.



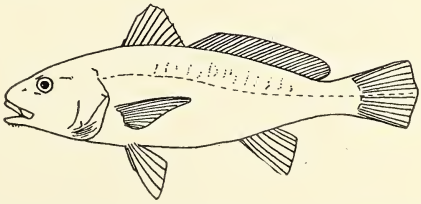
127. Spot
Leiostomus xanthurus Lacépède

Distribution: Common in summer and fall, May 19 to December 29, every few years becomes very abundant. *Woods Hole*, small specimens common in fall, throughout October. *Orient*, common in summer and especially in fall May 19 to November 27 (December 15, 1908). *New York*, common, June 1 to December 29, most numerous in September.

Occurs from Cape Cod to Texas. At intervals of several years the spot, locally called Lafayette, becomes excessively abundant about New York (as in 1925) when it became necessary to shut down the generators of the Brooklyn Edison Company to permit their crews to shovel out the fish) and may be caught in numbers from piers along the city's waterfront. A few may be found in this vicinity any summer.

Life History: The spawning season of the spot is in the late fall and early winter. The eggs and larvae are unknown and the smallest post larvae recorded has a length of 19 mm. (from Chesapeake Bay). Delaware Bay marks the northern limit at which this species spawns in any considerable numbers. From an examination of the scales it is inferred that the rate of growth is somewhat as follows: one year old fish average 100 mm.; two years 195 mm.; three years 265 mm. Young spot somewhat resemble the young of *Micropogon undulatus* but the squarely truncate tail of the former at once distinguishes it. The maximum recorded size for this species is 300 mm. (11¾ inches) but such examples are rare. About 270 mm. seems to be the average for the large sized fish.

Size: Reaches 12 inches in total length and a weight of ¾ pounds.



128. Croaker
Micropogon undulatus (Linnaeus)

Distribution: Irregularly common in summer and fall at our western

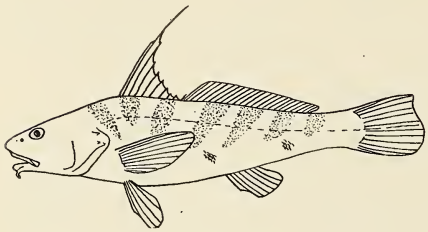
limits. June 13 to October 22 (adult) November 26 (young). *Woods Hole*, once, September 9, 1893. *New York*, common some years June 13 to October 22 (adult) November 26 (young).

Occurs generally common from New York City to Texas on sandy shores.

Young croakers, 2½ to 3½ inches total length, have been taken from the stomach of a red-throated loon in November.

Life History: The spawning season of this species is a long one, extending from August to December and possibly later to the southward. Spawning usually takes place in the larger bays and estuaries. The eggs and larvae are not known, and the smallest post larvae that have been examined measured 11 mm. There is little resemblance to the adult at this stage. The central rays of the caudal fin are produced considerably. By the time a length of 80 mm. has been reached a definite resemblance to the adult can be seen, although the caudal rays are still produced centrally. In the early fall young croakers about 25 mm. long sometimes may be taken on the oyster beds in lower New York bay and other places. In the first winter croakers average 40 mm., the second 150, the third 220, and the fourth 265 mm. (10½ inches). Maturity is reached in the third or fourth year.

Size: Reaches a length of one foot or more.



129. Kingfish
Menticirrhus saxatilis (Bloch and Schneider)

Distribution: Rather common in summer and fall, April 28 to December 8. *Woods Hole*, adults common in June, uncommon after July 15, young found till early October. *Orient*, April 28 (1913), April 29 (1910), average May 7, to December 8. *New York*, not uncommon, May 15 to November 4.

Occurs from Cape Ann to Florida, most common northward of Chesapeake Bay to Cape Cod, casually to Casco Bay, Maine.

The kingfish is common on sandy ocean shores and is frequently taken by casting through the surf, as is the larger striped bass. It lives at or near the bottom, preferably a sandy one.

Food: Crabs, squid, amphipods, isopods, shrimps, worms, young fish, bryozoa (Woods Hole).

Life History: Adults full of spawn in June (Woods Hole). The spawning season of the kingfish on the Jersey coast is centered in late June and early July. The eggs are buoyant, very faintly yellowish, transparent and spherical, measuring from 0.76 to 0.92 mm. in diameter. From one to ten

or more oil globules may be present in the yolk. If more than one they coalesce as development advances so that on hatching all possess but one. The period of incubation is about 48 hours at 69° F. The newly hatched larvae measure from 2 to 2.5 mm. and are practically helpless, floating in an inverted position while they await the absorption of the yolk sac. By the fifth day the sac is gone and the fry are more active, but the increase in length has been very slight.

Post larval kingfish come closely to resemble the adults at a much smaller size than any other Sciaenid we know of. At a size of 30 to 40 mm. the agreement in all essential features is close. Fish hatched in June may attain a length of 20 mm. by July 1, 80 mm. by August 1, and over 150 by September 1. This is when rapid growth is possible and conditions are especially favorable. Usually however, fish hatched in June or early July reach a length of 100 mm. by this latter date.

The average length during the first winter is 120 mm., the second 250, and the third 350 (13.7 inches). Maturity is reached during the third or fourth summer, that is, at the age of two or three years. The males probably mature mostly in the second and the females mostly in the third.

In support of the preceding general statements concerning the rate of growth of this species, the following actual measurements made on fishes taken in Sandy Hook Bay during 1923 are given:

Date	*Average Standard Length*
August 2, 1923	42 mm.
" 9, "	48 "
" 16, "	49 "
October 9, "	95 "
" 19, "	100 "

In 1925 the growth rate was apparently as follows:

Date	*Average Standard Length*
July 29, 1925	30 mm.
August 13, "	45 "
September 3, "	115 "
October 1, "	120 "

These figures may represent two groups, as the increase between August 13 and September 3 appears to be too great. In any event they represent the actual average lengths of fish taken on the respective dates.

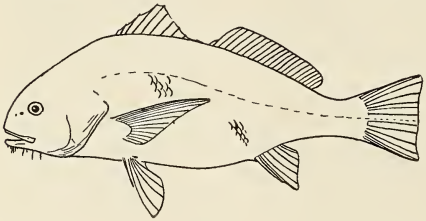
New York lies just beyond the northern limit of the range of *Menticirrhus americanus*[8] which so closely resembles *M. saxatilis*. It appears in company with the latter on the Jersey coast in late summer. Spawning is apparently somewhat later than that of *saxatilis*, nearly ripe fish having been seen at

[8] Outer teeth of upper jaw moderately enlarged, filamentous tip of first dorsal reaching past front of second. Sides sharply marked with dark. *M. saxatilis*

Outer teeth of upper jaw greatly enlarged, filamentous tip of first dorsal usually not reaching second. Dark marking on sides obscured. *M. americanus*

Atlantic City (just south of our range) as late as August. Apparently in Florida waters they spawn still later, or there may even be two spawning seasons. The eggs and larvae are unknown. At a length of 20 or 30 mm. the resemblance to the adult is already marked, both in form and coloration. Maturity is attained in about three years. The growth in northern waters seems to be somewhat slower than that of *M. saxatilis* but this is to be expected near the northern limit of the range of a species.

Size: Averages 2 to 3 pounds in weight, grown fish being from one to 6 (?) pounds. An individual 16¾ inches total length from Orient, weighed 2 pounds.



130. **Sea Drum**
Pogonias cromis (Linnaeus)

Distribution: Rare to the eastward, rather common to the westward, summer and fall, May to December 18. *Woods Hole*, very rare (May), September and October. *Orient*, June 14 to September 1, only a few recent records, 5 such in 20 years. *New York*, rather common, May to December 18.

Occurs on the Atlantic and Gulf coasts of the United States from Long Island (casually Massachusetts Bay) to the mouth of the Rio Grande. Also recorded from the South American coast south to Argentina.

The sea drum has stony, paved teeth in its throat for crushing shellfish. It makes a loud, peculiar grunting sound, "wop, wop," so that a talkative school can sometimes be heard swimming past under a boat lying quietly at anchor. It is caught by surf fishermen from the New Jersey shore, and its large size recommends it to these sportsmen, though they generally consider that in fighting qualities it is inferior to the equally large, more slender and athletic channel bass, which is taken in the same waters.

Young fish are conspicuously marked with broad vertical black bands. Large ones are as a rule uniformly dark blackish. On the New Jersey coast certain large individuals are coppery red in color. They seem to possess a slightly different contour from the others, and are known as "red drum," but no technical differences to distinguish them are known, nor is it certain what is the cause of the difference.

Life History: The life history of the sea drum is practically unknown, the smallest examples recorded being 3 inches long. At this length they are in the barred condition common to them up to a foot or more. There is a regular summer migration to the New Jersey coast which may have some connection with breeding habits. The fish which appear there are usually in excess of 20 pounds, although banded examples as small as 12

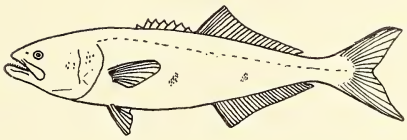
pounds have been occasionally taken. There is recorded an angler's catch of a fish weighing 146 pounds from Florida, and examples up to 60 pounds are not rare.

SIZE: Reaches 4 feet standard length. The largest recorded weighed 146 pounds.

BLUEFISH

A symmetrical, swift-swimming, active, predacious fish, with a small, low dorsal fin of slender spines, before the longer, soft-rayed second dorsal, similar to the anal beneath it. Scales fine and rough. Caudal very deeply and strongly forked and with a narrow peduncle, which has neither keel nor scutes.

131. Bluefish
Pomatomus saltatrix (Linnaeus)



DISTRIBUTION: Abundant in summer, middle of May to November 28, common from mid-June to mid-October, the young somewhat later. *Woods Hole*, abundant, arrives middle of May to first week in June, most numerous in July and October. *Orient*, adults June 1 to October 5, young to November 28. *New York*, abundant, May to October. There is a regular longshore migration of the largest young of the year in September and October, when they are taken abundantly in the traps on the New Jersey coast. At *Orient* the largest young ("snappers") school up and enter the Sound between September 25 and October 15. Beyond that date those still present are gradually smaller.

Occurs in the warmer parts of the Atlantic, and in the Indian Ocean, and has increased in numbers on our Atlantic coast within historic times. Its limit to the northeast appears to be Penobscot Bay. Apparently subject to wide fluctuations in numbers over long periods.

Bluefish schools occur in the Indian Ocean as well as in the Atlantic but are not known in the Pacific. The fish's stay with us is confined to the warm months though it may be found further south on the coast throughout the winter. It is tremendously destructive to smaller species, especially to the schools of menhaden. It grows rapidly and furnishes exceptionally fine food as well as sport. The bluefish is the salt water species which can pre-eminently be taken by trolling with a shiny metal "squid" in place of any bait. In late summer and fall the young of the bluefish known as "snappers" furnish excellent sport on light tackle in inshore waters.

Bluefish are taken commercially by lines more than by nets to which they are very destructive. There is a fishing ground near Sandy Hook where a great many are taken by chumming with hand-lines from boats. One man is kept busy grinding menhaden and throwing it overboard to form an unbroken strip of chum, cutting the back from each menhaden as he does so,

to serve as a bait. The others haul in the bluefish, which work up through the chum, hand over hand, about as quickly as they can bait and throw over their lines. It is strenuous work for the crew, who are exhausted after about two hours of it. Finally, when tired out or when the fish suddenly stop biting, one of the boats starts back to the city, and they all follow, racing to get to market before the catch shall have sent down the price of fish.

The larger bluefish occur off shore, smaller ones in the bays. Though their game qualities may be superior, they are accessible to a far smaller number of New York city anglers than the weakfish.

Food: Very voracious, preying on squid and various fish,—hake, herring, scup, cunner, noted at Woods Hole. The young eat small fish as a rule, *Menidia* being a favorite, but shrimps and amphipods also eaten. When some 7 or 8 inches in standard length, they prey on small butterfish and spot.

Life History: A few have well-developed spawn on arrival, young of the year 1½ inches long ordinarily first seen in July, though noted as early as May 29 (Woods Hole). Young of 1¼ to 1⅝ inches total length were abundant in the Sound at Orient, June 10, 1918, they having just appeared that day. By October 11 most of the fish hatched in spring are about 6 inches standard length (Sandy Hook Bay).

The bluefish spawns in the spring in our latitudes, but little is known of its development though it has probably one of the fastest rates of growth of any vertebrate animal. This belief is founded on the following considerations: Among vertebrates, at least, the highest rate of growth is doubtless to be found among those which need expend a minimum of energy to move their bodies, and possess a minimum of weight to carry. This at once limits the case in point to aquatic animals, as with them weight is practically annihilated and the adjustments of fishes such as *Pomotomus* for locomotion are perfected to a remarkable degree. They are especially formed for ease of locomotion, and the mechanical perfection of their locomotor apparatus is extreme. So, when it is considered that the bluefish is one of these, and furthermore, is one of the most rapacious feeders known, it is not a tax on the imagination to believe that much of the food consumed gives rise to a prodigious growth. In 1921 a series of young bluefish taken in Sandy Hook Bay made possible the construction of the following very smooth growth-curve, without the same having been smoothed or 'doctored' in any way, but standing just as plotted:

Date		*Average Standard Length*
June	23, 1921	46 mm.
"	29, "	56 "
July	7, "	67 "
"	27, "	83 "
August	25, "	113 "

After this date multimodal curves began to appear on plotting, and it is our belief that other schools of bluefish spawned earlier and later, began to

mingle with this group. The one other date which matches well with the above series is that of October 17 on which day one of the modes was 151 mm.

Producing this curve downwards it coincides well with a spawning occurring in the latter part of May:

Date		*Average Standard Length*
July	26, 1923	70 mm.
August	2, "	95 "
"	9, "	100 "
"	16, "	120 "
"	23, "	125 "
"	30, "	135 "
September	6, "	137 "
October	9, "	155 "
"	19, "	176 "

Here again multimodal curves began to appear in the fall, but were so far below as to force the conclusion that they represented other schools. For example, on October 9 a mode appeared at 76 mm., leaving a large gap between it and that of 155 mm. with no intermediates.

Young bluefish taken by Robert R. Fridenberg at Freeport, Long Island, during 1925, showed the following average growth in total lengths:

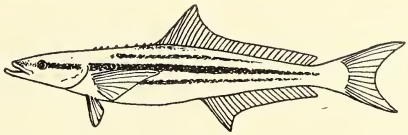
Date		*Total Length*	*Weight*
August	10, 1925	6 inches	1 ounces
"	24, "	7 "	2 "
September	10, "	8 "	3 "
October	5, "	9⅛ "	4¼ "

Size: Not infrequently weighs 10 lbs; largest Orient specimen measured 32½ inches total length; 27 pounds, with a total length of 45 inches, is the largest of which there is recent record. Early in the season off-shore bluefish average about 6 pounds in weight. Later, 10 pound fish are not unusual. A century or more ago they are said occasionally to have been taken up to 40 or 50 pounds.

SARGENT FISHES

Slender fishes with large mouth and projecting lower jaw, moderately forked caudal. Along soft dorsal over the almost equally long anal. The spinous dorsal consists of low isolated spines in advance of the soft dorsal.

132. Cobia
Rachycentron canadus (Linnaeus)



Distribution: Rare in summer, both young and adults, June to September. *Woods Hole*, rare, records for July and September. *New York*, rare, June to Sept. 13 (1925, Jones Inlet, L. I., slightly over 3 inches in total length).

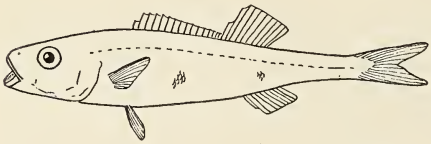
Occurs cosmopolitan in warm seas, rather common in Chesapeake Bay and southward.

Food: Feeds on any fish, among which the weakfish has been recorded; usually bottom forms such as flounders, also crabs, etc. Very voracious.

Size: A 4¾ feet specimen from Woods Hole weighed over 60 pounds.

SQUARE-TAILS

The square-tail is a peculiar fish of the open Atlantic with no near relatives It is moderately elongate and symmetrical, with a large eye, spiny and soft-rayed dorsal fins joined at the base, and a small, well forked caudal fin. Its special peculiarities include fine, hard, grooved, ciliated scales, and box-like jaws with a single series of close-set comb-like teeth.



133. **Square-tail**
Tetragonurus cuvieri Risso

Distribution: Accidental, Woods Hole, November 10, 1896 and Vineyard Sound, August 1, 1899 (taken with a dip-net among floating weed).

Occurs on the coast of southern France and at the Madeira Islands.

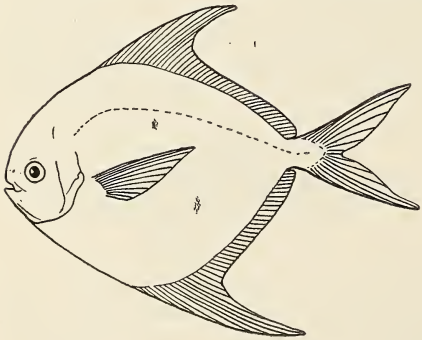
Size: One of the Woods Hole specimens was about 3 inches in length.

HARVEST FISHES

Small fishes with caudal forked, peduncle narrow. Soft dorsal and anal fins long and similar. No obvious spinous dorsal or dorsal spines. Ventral fins absent or rudimentary.

Dorsal and anal fins high, falcate. The body deep. *Peprilus*

Dorsal and anal fins moderately elevated in front, the body less deep, side of back with a series of large pores. *Poronotus*



134. **Harvest Fish**
Peprilus paru (Linnaeus)

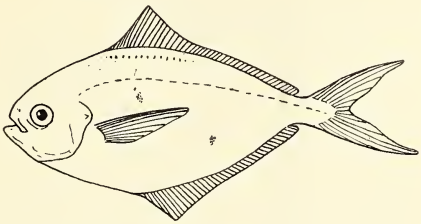
Distribution: In varying numbers, usually uncommon, summer and

fall, during June to October 20. *Woods Hole*, usually rare, occasionally common, present during June and July. *Orient*, rare, September 12 to October 20. *New York*, sometimes common, June 28 to September 17.

Occurs from Cape Cod to the West Indies and Brazil. Young sometimes found swimming beneath the Portuguese-man-of-war with *Nomeus gronovii*. Almost invariably two are taken at a time (Orient).

Size: Reaches a length of 8 inches. During 1923 this species was especially common in Sandy Hook Bay. A small series taken on August 16 averaged 141 mm. in standard length and showed a maximum of 155 and a minimum of 135.

135. **Butterfish**
Poronotus triacanthus (Peck)



Distribution: Abundant in summer and fall, (April 21) May 3 to December 1. *Woods Hole*, abundant, May 11 to late fall, an especial run in June lasting one or two weeks. *Orient*, abundant, April 21, (average May 3) to December 1. *New York*, abundant, May to October 21, most numerous in August and September.

Occurs from Nova Scotia to Cape Hatteras, thence in deep water to Florida, abundant northward.

The attractiveness of this delicately flavored fish for the table is frequently diminished by the presence of abundant cestode cysts throughout its muscles.

Food: Large ones eat small fish and squid. Smaller specimens feed on copepods, annelids, and small fish, and in September principally amphipods, in pursuit of which they venture so close to the breakers along ocean beaches as to be frequently thrown ashore.

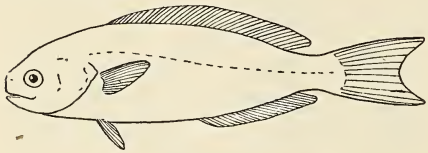
Life History: Spawns in June; the young are often observed swimming under jellyfish (Woods Hole). Young 1 to 4 inches total length common in fall, to December 1 (Orient).

With the coming of summer most of the butterfish leave shoal water. The spawning takes place chiefly in July. The eggs are spherical, buoyant, transparent and range from 0.7 to 0.8 mm. in diameter. A single oil globule is usually present. Incubation occupies less than 48 hours at 72° F. The larvae are about 2 mm. long at the time of hatching. The vent is lateral and immediately behind the yolk sac. After a length of 20 mm. has been reached the general appearance of the adult is assumed. Occcasionally in October (Sandy Hook Bay) small ones of about 22 mm. standard length are taken close to shore in loose eel grass.

Size: Butterfish from Sandy Hook Bay average about 11½ inches in standard length during July, with another group averaging about 5 inches. The former is near the ordinary maximum for the species.

RUDDER FISHES

Grouped here we have two somewhat dissimilar fishes of the open sea, with caudal fin moderately forked, peduncle moderately narrowed, soft-rayed back fin long and level, in one case with a few short isolated spines before it (*Palinurichthys*), in the other with its first few rays spinous, little differentiated from the remainder of the fin (*Centrolophus*). Scales small, smooth, inconspicuous.

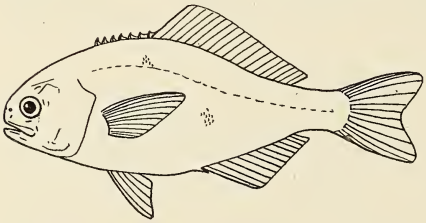


136. **Black Ruff**
Centrolophus niger (Gmelin)

Distribution: Accidental, one record, off Dennis, Mass., November 23, 1888.

Occurs off the coasts of southern Europe, not rare in rather deep water.

Size: The local record is of an individual 9 inches long.



137. **Black Rudder-fish**
Palinurichthys perciformis (Mitchill)

Distribution: Common to the eastward, uncommon to the westward, summer and fall, June to October 21. *Woods Hole*, common and generally distributed, June to October. *Orient*, rare (August 31, 1907) October 1 to October 21. *New York*, uncommon, August to October.

Occurs in the western Atlantic from Cape Hatteras to Nova Scotia, most abundant south of Cape Cod casual in Great Britain. Found in gulfweed or other floating objects and under anything adrift.

"*Palinurichthys perciformis* was more abundant in Vineyard Sound during the latter part of August [1920] than during any of the numerous occasions extending over 25 years when I have been at Woods' Hole. On certain days almost every floating box, barrel, plank and mass of eel-grass or rock-weed served as a shelter for this rudderfish, and some of the larger rafts of seaweed covered hundreds of specimens ranging from 6 to 12 inches long. Many were secured with a small dipnet thrust suddenly under bits of seaweed from a slowly moving motor boat." (H. M. Smith, *Copeia*.)

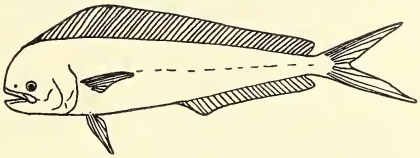
Food: Sundry small fishes, squid, small crustacea (including barnacles), univalve mollusks, etc.; algae have also been found in their stomachs.

Size: Reaches 13¾ inches total length, 1½ pounds weight.

DOLPHINS

Slender, compressed, extremely active, free-swimming fishes with a very deeply and strongly forked caudal, a firm narrow peduncle without keel or scutes. Dorsal fin high, extending the length of the back, entirely of flexible spines or jointless rays.

138. **Dolphin**
Coryphaena hippurus Linnaeus



The dolphin is elongate in form tapering gradually from the shoulder to the tail. Adult males have a very high, thin, vertical forehead. It is one of the most brilliantly colored and changeable fishes; vivid blues and yellows run across the sides of a living example like the shadows of clouds.

Distribution: Casual in late summer July to September. *Woods Hole*, adults very rare, a few young taken nearly every year in floating gulfweed, recorded for July and August. *New York*, casual, August and September.

Occurs cosmopolitan on the high seas, partial to blue water.

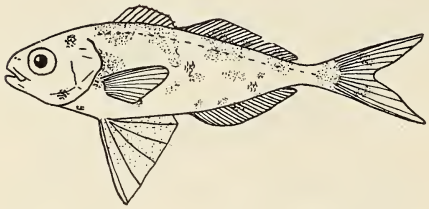
The dolphin is perhaps the swiftest fish that swims in the seas. A thousand miles of azure sea before it, a thousand miles of azure sea behind, it slips through the water swift and deadly as a brilliant colored knife; and any flying-fish in its path slow in gaining the air, promptly changes from incentive to motive power.

It associates in small schools which prey almost exclusively on the flying-fish, and is frequently caught from deep-water sailing ships on a hook set in a piece of wood over which a white rag is draped. This lure is barely allowed to touch the water and is then jerked into the air again, and doubtless similates a flying-fish to the eye of the dolphin below. Sailors say that this species is sometimes poisonous and should be cooked with a piece of bright silver. If the silver stays bright, that particular fish can be eaten. Considerable confusion seems to have existed for a long time in regard to the word dolphin, which is used almost exclusively for porpoises except among deep-sea sailors, where it is applied only to this fish. The figures of dolphins on the old Greek coin are of the porpoise, and the dolphin of heraldry was a combination of these two unlike marine creatures, often with tusks indicative of the porpoise's resemblance to a pig, but with the long spiny fin on the back characteristic of the fish. Very small dolphins hide in drifting weed or about floating wreckage and have a mottled white and yellow concealing color.

Size: Reaches a length of about 6 feet.

MAN-OF-WAR FISH

A small, symmetrical, fork-tailed fish, with bold vertical dark cross-bands, which seldom strays far from the tentacles of the drifting Portuguese-man-of-war (*Physalia*) beneath which it seeks shelter. Ventral fins broad and black.



139. **Man-of-war Fish**
Nomeus gronovii (Gmelin)

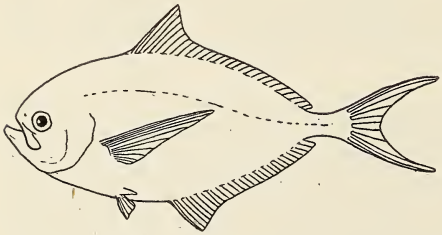
Distribution: Uncommon in the Woods Hole region, July and August, unknown elsewhere.

Occurs cosmopolitan, pelagic, in warm seas. Found only in company with the Portuguese-man-of-war, finding shelter in proximity to the dangerous stinging tentacles of the drifting communal jellyfish.

Size: Reaches a maximum total length of 6 or 8 inches.

POMFRETS

Pelagic or deep-sea fishes with a forked caudal and narrow firm peduncle like mackerels and crevallys, but with rather large scales.



140. **Pomfret**
Brama raii (Bloch)

Distribution: Accidental, one record, No Mans Land, August 9, 1904.

Occurs cosmopolitan, pelagic, usually at considerable depth.

Size: Reaches a length of about 6 inches.

CREVALLYS

Compressed, more or less silvery, actively free-swimming fishes with a strong deeply forked caudal fin, and a firm, narrow peduncle. Soft dorsal and anal long and similar. Peduncle armed either with enlarged keeled scales, that is scutes, or with a fleshy keel. Such armature lacking in certain exceedingly deep-bodied compressed silvery forms, and in the pompanos

which resemble certain harvest fishes but have ventrals present. Scales fine and smooth or rudimentary. Premaxillaries usually protractile.

a. Scales linear, embedded, so as to reinforce a silvery leathery skin, peduncle unkeeled, premaxillaries not protractile (except in the very young). *Oligoplites*
Scales not linear, premaxillaries protractile (see b).

b. Anal fin much shorter than soft dorsal, preduncle with a keel, but without enlarged keeled scales (see c).
Anal fin about as long as soft dorsal, peduncle usually with enlarged keeled scales. Pectoral fin more or less falcate (see d).
Anal fin about as long as soft dorsal, peduncle without keel or enlarged keeled scales. Pectoral not falcate. *Trachinotus*

c. No detached dorsal and anal finlets, body normally compressed, mouth moderate. *Seriola*
No detached dorsal and anal finlets, body cylindrical, cigar-shaped, mouth small. *Naucrates*
A detached dorsal and anal finlet. *Elagatis*

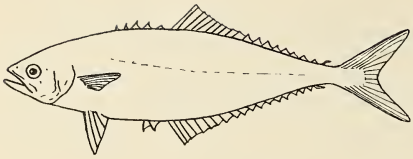
d. Dorsal outline equally or more strongly curved than ventral (see e).
Ventral outline more strongly curved than dorsal. *Chloroscombrus*

e. Lateral line with enlarged keeled scales on its entire length. *Trachurus*
Lateral line with enlarged keeled scales on its posterior part or confined to the peduncle (see f).
Lateral line without enlarged keeled scales, body elevated and strongly compressed, dorsal and anal lobes produced. *Selene*

f. Dorsal and anal followed by a detached finlet, body slender. *Decapterus*
No finlets. Shoulder girdle with a deep cross furrow, above which a fleshy projection. *Trachurops*
No finlets. Shoulder girdle normal, not as above (see g).

g. Body moderately compressed, keeled scales on peduncle well developed. *Caranx*
Body very deep and compressed, scales exceedingly small or obsolete except for a few enlarged keeled ones on peduncle (see h).

h. Dorsal and anal rays produced, filamentous, sides crossed with dark bands. *Alectis*
Dorsal and anal low, sides uniform silvery, except for a black central spot in the very young. *Vomer*

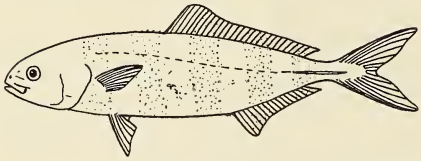


141. Leather-jacket
Oligoplites saurus (Bloch and Schneider)

Distribution: Rare, August 13 to October, apparently most frequent to the west. *Woods Hole*, four records; August 13 and September. *New York*, occasional in summer, to October.

Occurs on both Atlantic and Pacific coasts of tropical America ranging north to New York and Lower California.

Size: Reaches a length of about one foot or more.



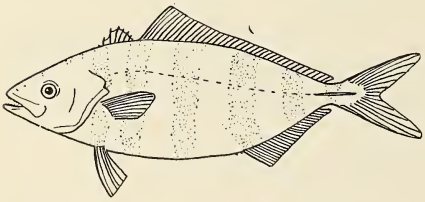
142. Pilot-fish
Naucrates ductor Linnaeus

Distribution: Casual to the eastward. *Woods Hole*, casual, has occurred at least three times, September 9 and 10.

Occurs cosmopolitan in all warm seas well off shore, casually north to Seguin Island, Me., on our coast.

The pilot-fish follows ships and off-shore sharks. It is closely related to coastwise fishes of the genus *Seriola*, which when young swim under jelly-fishes and drifting weed and, somewhat later, follow boats and coastwise sharks or frequent drifting wreckage. Such young Seriolas are banded in color, but as they attain adult proportions lose the bands, and at the same time leave the shelter of drifting objects or of larger fishes and navigate independently. The pilot-fish retains its "pilot" habits, as also its bands throughout life. It may be considered a larval or juvenal form which has become fixed.

Size: Reaches a length of 2 feet.



143. Banded Rudderfish
Seriola zonata (Mitchill)

Dorsal soft rays 36 to 38. Size small.

Distribution: Rather common, summer and fall, July 21 to November 12. *Woods Hole*, rather common July to October. *Orient*, rather com-

mon, August 1 to November 12. *New York*, rather common, July 21 to November 8, most plentiful in late August and early September.

Occurs from Cape Cod (casually Massachusetts Bay) to Cape Hatteras and beyond (Gulf of Mexico?).

"Several specimens, 5 to 7 inches long, taken under floating material in Vineyard Sound and kept in the aquarium of the Bureau of Fisheries during parts of August and September. In the absence of a suitable hover, this species will seek refuge under almost any small objects. In the aquarium, a smaller specimen used to swim under a larger one and both sought the protection of a threadfish (*Alectis ciliaris*) only 5 inches long" (H. M. Smith, in *Copeia*).

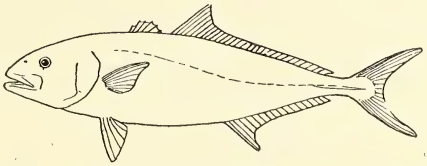
The banded rudder fish is a trimly built species, generally a few inches long, swimming in small schools with a tendency to follow boats or to linger about buoys or drifting logs. It sometimes accompanies in-shore sharks, much as the related pilot-fish accompanies those further out to sea.

Food: Fish (menidia, etc.).

Life History: A specimen ten inches total length retained full black bands, one of 11¼ inches, the smallest taken without trace of bands.

Size: A local record of 14½ inches total length, 1¾ pounds weight (Orient). Said to reach 2 or 3 feet.

144. **Great Amber-jack**
Seriola lalandi Cuvier and Valenciennes[9]



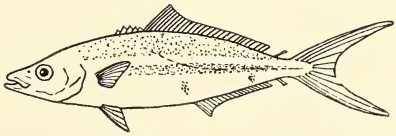
Dorsal soft rays 30 to 34. Slender, depth 3½ to 3¾ in standard length.

Distribution: Rare or casual in summer. *Woods Hole*, never common, summer. *New York*, casual, July and August.

Occurs from Florida to Brazil, straggling north to New Jersey.

Size: Reaches 5 or 6 feet.

145. **Runner**
Elagatis bipinnulatus (Quoy and Gaimard)



Distribution: Accidental in summer. *New York*, August.

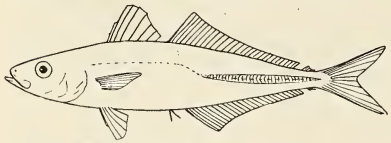
Occurs cosmopolitan in tropical seas, rare in the West Indies, recorded north to Long Island.

[9] The small amber-jack, *Seriola dumerili*, has been recorded from Woods Hole, but the 2 or 3 records for it are open to question. It occurs regularly as far north as Florida; is deeper than *S. lalandi* (depth about 3): and reaches a somewhat smaller size, 2 feet or more long.

The runner is a large off-shore fish, brightly colored, bluish above, yellow below and on the tail, with two conspicuous blue lengthwise bands on either side of the body. Large ones are usually rather solitary.

A troop of fifty or more young runners as well as several pilot-fish were observed by R. C. Murphy accompanying a 7-foot shark in equatorial mid-Atlantic.

Size: Reaches a length of somewhat over 3 feet.



146. Round Scad
Decapterus punctatus (Agassiz)

Deeper, depth 5.0 in length to notch of caudal fin. Scutes on peduncle well developed.

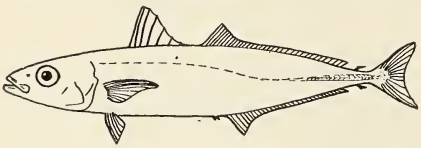
Distribution: Irregularly common in summer and fall, June 18 to November 20. *Woods Hole*, uncommon, August 11 to October 10. *Orient*, irregularly common, June 18 to November 20. *New York*, sometimes common, July.

Occurs from Cape Cod to Brazil.

Food: Young feed on copepods and annelids (Woods Hole).

Life History: Young less than 2 inches in total length, L. I. Sound, June 18 to late August; 2½ to 3½ inches, September 12 (Orient).

Size: Reaches a length of 12 inches.



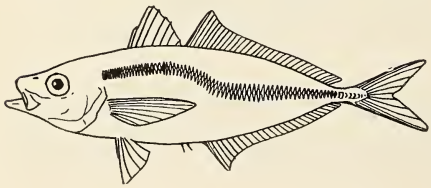
147. Mackerel Scad
Decapterus macarellus (Cuvier and Valenciennes)

Less deep, depth 5.3 to 6.0 in length to notch of caudal fin. Scutes on peduncle little developed.

Distribution: Reported sometimes abundant in fall at *Woods Hole*, as late as November 22, unknown to the West.

Occurs in warm waters of the Atlantic, straying north to Cape Cod (casually Nova Scotia) though uncommon on the American coast, races or allied species of this fish cosmopolitan in warm seas.

Size: Reaches one foot in length.



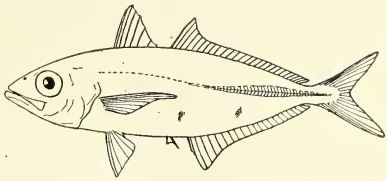
148. Rough Scad
Trachurus lathami Nichols

Distribution: Very rare in late summer and fall, August 28 to November. *Woods Hole*, one record, Newport. *Orient*, rare, August 28 to November 1. *New York*, accidental, October.

Occurs off the Atlantic coast of America, young about the Florida Keys (numerous off Key West, Feb. 23, 1910), adults probably along the western edge of the Gulf Stream. A related form is a common market-fish in Northern Europe.

Size: Reaches a length of about 9 inches.

149. **Goggle-eyed Scad**
Trachurops crumenophthalmus
(Bloch)



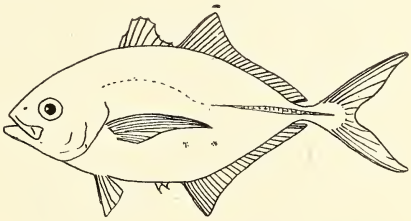
Distribution: Rather common in late summer and fall, August 1 to November 15. *Woods Hole*, common every fall, August 7 to November 15. *Orient*, not uncommon, August 1 to November 13. *New York*, not uncommon September to October 12.

Occurs cosmopolitan in warm seas, north to Cape Cod.

Food: Probably feeds mostly on small fish; annelids have been recorded as a food item at Woods Hole.

Size: Reaches a length of 10 inches.

150. **Yellow-jack**
Caranx bartholomaei Cuvier and Valenciennes



Front of soft dorsal and anal fin low, little projecting. Dorsal with 26 or 27, anal 22 or 23 soft rays. Less than 20 gill-rakers on lower limb of the arch. Breast completely scaled.

Distribution: Rare but apparently regular to the eastward in fall, August to November, not known to the westward. *Woods Hole*, numerous records, August to November.

Occurs in the West Indies, young north commonly in gulf weed to the Capes of the Carolinas.

The colors of various jack fishes are bright silvery, iridescent, often with yellow, those of the present species peculiarly rich. Its general color is bluish silver more or less suffused with olive yellow, and with rich blue, purple, and sometimes green reflections, and becomes white on the mid-

line below. The top of the head is olive, and the mid-line of the back yellow, sometimes an olive yellow and again an orange yellow. The iris is golden and the fins greyish and olive yellow. It is characterized by the olive yellow suffusion and the richness of the colors throughout.

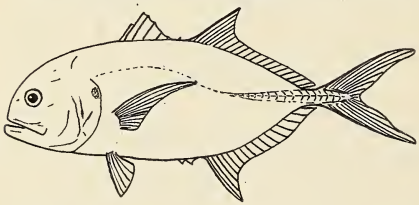
In Cuba the yellow-jack, under the name Cibi, is supposed at times to be unwholesome. It is under no such suspicion at Nassau, where it finds a ready market.

Life History: The young, some 2 inches in total length, hide about drifting gulfweed (April 20, off the east coast of Florida; in summer, at the Capes of the Carolinas). At this stage they are deep-bodied (about half as deep as long) with life colors calculated to give them low visibility among the weed. Golden olive with irregular bars of silvery white along the back and belly and spots of the same on side. Diffuse dusky bar through eye.

The young of most species of the genus *Caranx* are more or less deeper bodied than grown fish, and we have wondered if this might be in some way correlated with their drifting in ocean currents. The case of *C. bartholomaei* lends support to such an hypothesis. Associated with gulf weed, it is one of those that drifts most widely, it is also in general one of the deepest bodied species, depth being usually a good criterion to distinguish it from its close relative *C. ruber* which does not range sufficiently far north to reach our region.

Specimens under 6 inches in length (to base of caudal) have the depth contained 2½ or less times in this length, whereas specimens of *ruber* down to 4 inches have depth contained 3 times more or less, in length. In *bartholomaei* 6 inches to a foot long, however, depth falls off very rapidly, and there is no appreciable depth difference between the two species at the length of a foot. Specialized, notably deep and compressed genera allied to Caranx (Alectis, Selene, Vomer) are great drifters.

Size: Reaches a length of about 15 inches.



151. Common Jackfish
Caranx hippos (Linnaeus)

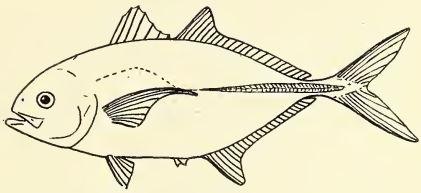
Front of soft-dorsal and anal fins elevated, projecting. Dorsal with about 20, anal about 17 soft rays. Breast with a small patch of scales in its center only.

Distribution: Rather common in summer and fall, July 1 to October 30, young or small sized individuals. *Woods Hole*, rather common July 1 to late fall, most numerous in October. *Orient*, rather common, July 30 to October 30. *New York*, rather common, July to October. Less common than the hard-tailed jack in Sandy Hook Bay. Occurs on warm coasts of the Atlantic and eastern Pacific, north to Cape Cod.

Diagnostic markings of this species are brightness of the yellow usually present on the lower parts, large black blotch on opercle, and especially a black spot on the lower pectoral rays.

SIZE: Reaches a length of about 2½ feet, and weight of about 20 pounds.

152. **Hard-tailed Jack**
Caranx crysos (Mitchill)



Front of soft-dorsal and anal fins elevated, projecting. Dorsal with about 24, anal about 19 soft rays. Breast fully scaled. Straight portion of lateral line unusually long and fully armed, 1⅔ times the arc of the curve.

DISTRIBUTION: Rather common in summer and fall, July 1 to November 4 *Woods Hole*, rather common, July 1 to late fall. *Orient*, rather common, July 18 (1911) to November 4. *New York*, rather common, July to October 21.

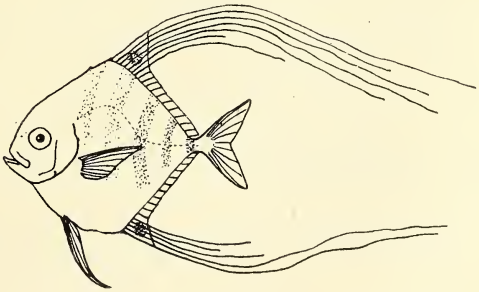
Occurs from Cape Cod (casually Massachusetts Bay and Nova Scotia) to Brazil, and on the Pacific coast of tropical America.

Under ordinary circumstances this species is characterized by the paleness and delicacy of its colors, kept in an aquarium it sometimes turns uniformly blackish, head, body and fins. Specimens from Sandy Hook Bay are usually golden yellow, sufficiently so to justify the name "Crysos," but in our experience in southern waters this might have been applied more appropriately to either of the two preceding.

FOOD: A predacious species, preying on other smaller fishes; shrimps very abundant in food of young in August (Woods Hole).

SIZE: 21½ inches total length, weight 4 pounds (Orient) the largest locally.

153. **Threadfish**
Alectis ciliaris (Bloch)

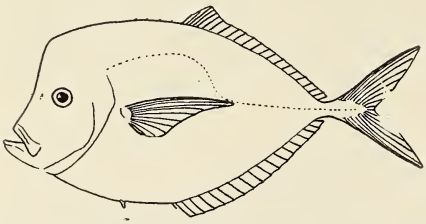


Distribution: Rare in summer and fall, June 15 to November. *Woods Hole*, rare June 15 to November. *Orient*, once, Spetmber 11. *New York*, rare, July 29 to August 12.

Occurs cosmopolitan in tropical seas, young northward in the Gulf Stream and Japan Current.

This and the two following deep, compressed genera are evidently specializations of the more normally formed, freer swimming genus Caranx. In each case as these fish approach maximum size they become less aberrant in form, more Caranx-like. Hence we may argue that the genera have arisen by fixation of juvenal characters, great depth and compression of body, perhaps correlated with wide drifting of young fish in ocean currents.

Size: Reaches a standard length of 7 inches or more, usually smaller. There is an overgrown example of 19¾ inches from the Hawaiian Islands in the American Museum of Natural History. Specimens taken during August in Sandy Hook Bay averaged about 4 inches in standard length.



154. Moonfish
Vomer setapinnis (Mitchill)

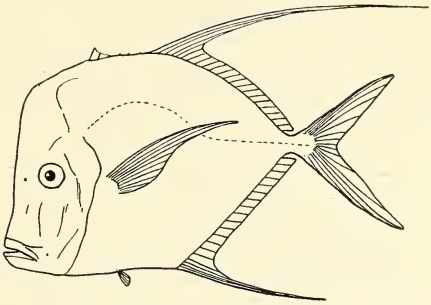
Distribution: Irregularly not uncommon in summer and fall, June to November 5. *Woods Hole*, rare to common, August and September. *Orient*, sometimes rather common, September 1 to October 30. *New York*, usually uncommon, June to November 5.

Occurs from Cape Cod (casually Maine and Nova Scotia) to Brazil, including the West Indies, and on the tropical portion of the Pacific coast of America; a distinguishable local race, as well as the typical one, found in the West Indies, and a distinguishable race on the west coast of Africa. Adults occasional in Sandy Hook Bay. Young always common in late summer and fall.

The following data indicate a slow irregular rate of growth:

Date		*Average Standard Length*
August	24, 1923	45 mm.
"	31, "	47½ "
September	6, "	45 "
October	14, "	50 "

Size: Reaches a total length of about 12 inches.



155. **Lookdown**
Selene vomer (Linnaeus)

Distribution: Uncommon in late summer and fall, August to October; young individuals. *Woods Hole,* not common, September and October. *Orient,* rare and irregular, September 17 to November 3, all very small individuals. *New York,* uncommon, August to October.

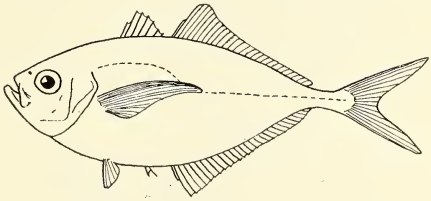
Occurs from Cape Cod (casually Casco Bay) to Brazil, and from Lower California to Peru. Not rare in Sandy Hook Bay, but not as common as *Vomer setapinnis.* Large ones about as common as small.

Date		*Average Standard Length*
July	27, 1923	44 mm.
October	19, "	65 "

On this latter date there was also taken an individual of 40 mm. which apparently belonged to another and later spawned group.

Life History: Young are somewhat deeper bodied, ventrals elongate, some of dorsal spines filamentous; filamentous dorsal spines and length of ventrals reduced in the adult, but filamentous lobes of soft dorsal and anal more extreme.

Size: Reaches a total length of about one foot.

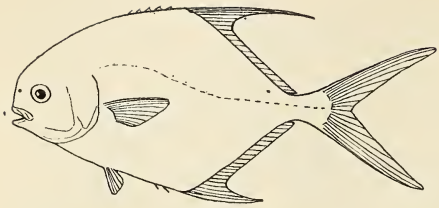


156. **Bumper**
Chloroscombrus chrysurus (Linnaeus)

Distribution: Casual in summer and fall, latest October 2. *Woods Hole,* no record. *Orient,* three records, September 12 to October 2. *New York,* accidental, summer.

Occurs from Cape Cod to Brazil.

Size: Reaches a length of about 10 inches.



157. Round Pompano
Trachinotus falcatus (Linnaeus)

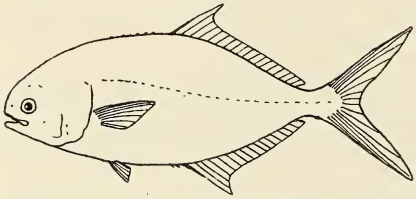
Dorsal with 19 to 20 soft rays, anal with 17 to 19; depth about $1^3/_5$.

Distribution: Young sometimes common, July to October 18. *Woods Hole*, young very common some years, no adults taken, July to October 18. *Orient*, two definite records, September. *New York*, rather common, August to October.

Occurs from Cape Cod to Brazil.

Life History: Three examples about 24 mm. in standard length were taken on October 4 among the sea weed and debris close to shore in the "Horseshoe," Sandy Hook Bay, N. J. They were a smooth velvety black and the fins were hyaline. Two of these were kept in the Aquarium for a few weeks and lost this pigmentation, becoming a silvery color similar to the young of *T. carolinus*. The iris in life was a deep ruby red. One rather similar example of the same size was taken on July 9, 1925.

Size: Reaches a length of about 8 inches.



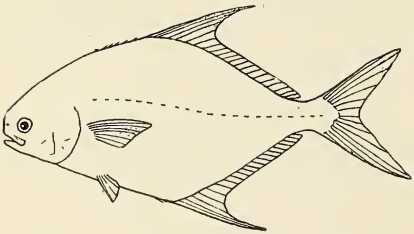
158. Great Pompano
Trachinotus goodei Jordan and Evermann

Dorsal with 19 to 20 soft rays, anal with 17 to 19; depth about 2 to $2^3/_5$.

Distribution: Several records for the young at *Woods Hole*, September.

Occurs in the West Indies north to Florida. Uncommon.

Size: Reaches a length of 3 feet.



159. Silvery Pompano
Trachinotus argenteus Cuvier and Valenciennes

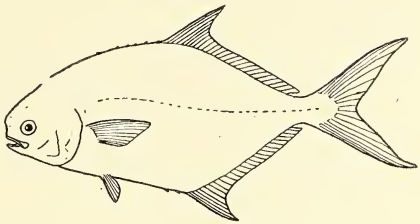
Dorsal soft rays about 25, anal 22 or 23; depth about 2; compressed and silvery.

Distribution: Accidental. *Woods Hole*, September 7, 1885, and also a more recent record.

Occurs in the West Indian fauna, rare; accidental northward.

Size: Reaches a length of about 10 inches.

160. Common Pompano
Trachinotus carolinus (Linnaeus)



Dorsal soft rays about 25, anal 22 or 23; depth 2½ in adult.

Distribution: Not uncommon in late summer and fall, mostly young, July to October 30. *Woods Hole*, young common, adults rare, July till end of September. *Orient*, twice, September 17, 1923, also October 30. *New York*, rather common, August to October 30.

Occurs on the South Atlantic and Gulf coasts of the United States from Cape Cod southward, rare in the West Indies to Brazil.

Concerning this and certain other fishes which reach our region in fair numbers, mostly young in late summer, but are unable to winter so far north, the question arises, do they regularly migrate southward in autumn, or do they become sluggish with the falling sea temperature, to be destroyed by their enemies. The pompano would be capable of such a southward migration, but there is no data to show whether or not it makes one.

The common pompano is a delicious and important food fish of the south, but grown pompanos are rare here, those which reach us annually being, almost without exception, young.

Life History: Adults were fairly common during August 1923 in Sandy Hook Bay, nearly every pound net capturing one or two daily of upwards of 10 inches. Young specimens appeared at an earlier date than usual.

The following tabular matter was compiled from serial collections so made possible:

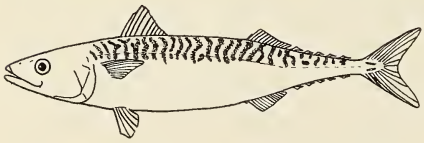
Date	*Average Standard Length*
August 2, 1923	28 mm.
" 16, "	58 "
" 23, "	53 "
" 30, "	53 "
October 9, "	85 "
" 19, "	80 "

Size: Reaches a length of 18 inches. One of the Orient specimens measured 18¼ inches total length and weighed 2 pounds.

MACKERELS

Fishes of large or moderate size, more or less cylindrical, pointed before and behind. Pre-maxillaries not protractile. Caudal very deeply and strongly forked, peduncle narrow, firm, with one or more fleshy keels. Soft dorsal and anal broken up posteriorly into several independent one-rayed finlets.

a. Caudal peduncle without median keel, spinous and soft dorsal fins well separated. *Scomber*
   Caudal peduncle with a well developed median keel (see b).
b. Body scaleless, excepting about the lateral line and corselet (see c).
   Body wholly covered with small scales (see d).
c. Spinous and soft dorsal fins well separated. *Auxis*
   Spinous and soft dorsal fins contiguous. *Gymnosarda*
d. Corselet distinct, body stout (see e).
   Corselet obscure, body long and compressed. *Scomberomorus*
e. Pectoral normal, rather short. *Thunnus*
   Pectoral very long, ribbon shaped. *Germo*



161. **Common Mackerel**
Scomber scombrus Linnaeus

This mackerel has eleven or twelve spines in the first dorsal fin. In the adult the lower parts of the sides are plain silvery. The eye is smaller than in the chub mackerel and there is no conspicuous translucent area on the snout.

Distribution: Summer resident to the eastward, migrant to the westward. May 3 to early December. *Woods Hole*, common May 10 to December 13. *Orient*, usually common to abundant summer resident, somewhat irregular. Adults rarely common. Very young fish always present June to August; latest date December 14. *New York*, sometimes common, May to July. Young occasional in summer, abundant in the fall, October 21 (1923, L. B. Hunt) to November 19.

Occurs in the North Atlantic northward to Norway and Labrador, and south to Spain and Cape Hatteras.

Grown mackerel approach the coast in spring, and move off shore and into deeper water to disappear in fall, no extensive migration along the coast has been proved for them, such as there is being referable to the configuration of the coast or following the feed. The winter grounds of the American fish are not known, but probably will be found to be at or near the bottom on the continental slope at depths of over 100 fathoms, when in shore during the warmer months the mackerel swims in vast, dense schools, either at the

surface or at times somewhat deeper. Grown fish keep pretty well out, seldom or never entering inclosed bays.

Food: Consists of small fish, small crustaeea (shrimps, copepods, pteropods), squid, fish, etc. At times, probably when larger food fails, mackerel feed by filtering smaller pelagic organisms from the sea water with their gill rakers. Related East Indian species have gill rakers well adapted for this type of feeding, but ours has not, and with it, food taken in this way can be of only secondary importance. Food of the young in Long Island Sound in the fall is mostly *Menidia;* also *Ammodytes.*

Life History: Spawns during middle or latter part of June off-shore, but young 2½ inches long have been recorded June 3 (Woods Hole) and in swarms June 23 (Orient). Massachusetts Bay and the coast of Maine are important spawning grounds.

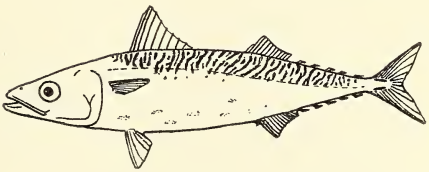
The buoyant non-adhesive eggs of the mackerel are expelled from May to July. They average about 1¼ mm. in diameter and the usual number produced by a female is not far from 41,000. A 1⅛ pound fish is recorded as producing 546,000 eggs. These eggs take five days to hatch at a temperature of about 56° F., and six more for the yolk sac to be absorbed.

In mackerel fry an inch or so in length separate dorsal and anal finlets are about becoming differentiated, these fins being entire at an earlier age at two inches the young look much like their parents.

From measurements taken in Sandy Hook Bay, fish that appear in June with an average standard length of about 200 mm., reach about 250 (9⅞ inches) in October; but their presence is erratic. Those of about 85 mm. which appear in July apparently reach nearly 200 mm. by the end of October.

Size: The fully grown mackerel averages about a foot long and weighs about a pound. Occasionally they reach a length of about 20 inches and weigh as much as 3½ pounds.

162. **Chub Mackerel**
Scomber colias Gmelin



The chub mackerel has nine or ten spines in the first dorsal fin. In the adult the lower part of the side is mottled instead of plain silvery, and vermiculations on the back are usually if not always of finer pattern. The eye is distinctly larger than in the young mackerel of the same size. There is also a translucent area on the snout much more conspicuous than in the young mackerel.

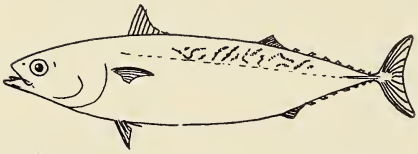
Distribution: Irregular summer and fall visitor. abundant or rare. Early June to December 12. *Woods Hole,* irregular summer visitant, July 15 to August 25. *Orient,* irregular summer visitant, usually common;

July 5 to December 12. *New York*, irregular visitant, sometimes common; early June to September 27. Normally rare in Sandy Hook Bay and frequently entirely absent. Along the Jersey coast just south of our region, Long Branch to Bradley Beach it is often common in mid-summer, far outnumbering *S. scombrus* in these pound nets. Extremely abundant in Sandy Hook Bay in October 1926.

Occurs widely distributed in the warm and temperate portions of the Atlantic and Pacific oceans, slight differences between Atlantic and Pacific fish being of subspecific rather than specific weight.

This species closely resembles the common mackerel in habits as in appearance. An air bladder is present in the chub mackerel and wanting in the common mackerel, an anatomical difference which would ordinarily be associated with at least generic distinctness (hence the first mentioned species is sometimes given generic rank as *Pneumatophorus colias*) but in our opinion should not be in this case.

Size: Reaches a length of about 14 inches.



163. **Frigate Mackerel**
Auxis thazard (Lacépède)

Distribution: Casual in summer. *Woods Hole*, three or four records (June 29, 1892, two specimens). One collected at Martha's Vineyard about July 1, 1923 (Francis West).

Occurs in all warm seas, occasionally northward to Cape Cod. Said to swim in large schools, erratic as to presence or absence in a given locality.

Size: Reaches a length of about one foot, or more.

164. **Ocean Bonito**
Gymnosarda pelamis (Linnaeus)

Dark longitudinal stripes on the lower sides. Body very robust and symmetrical.

Distribution: Irregular, numerous off-shore; September to October 10. *Woods Hole*, rarely reported; occasionally occurs as a migrant, to October 10. *New York*, September.

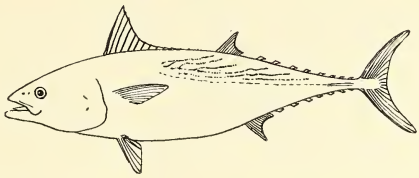
Occurs north to Cape Cod on our coast.

The ocean bonito is one of the pelagic fishes most frequently met with in the broad trade-wind belts of all oceans where it roams in small hungry

schools preying on the flying-fishes, which there are the abundant, conspicuous and characteristic form of fish life.

SIZE: Reaches a length of 2 feet or more and weight of about 20 pounds.

165. False Albacore
Gymnosarda alleterata (Rafinesque)



Black oval blotches on the side of the breast, a vermiculated saddle-like area on the back. Body robust, but caudal portion long and racy.

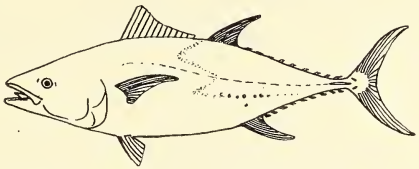
DISTRIBUTION: Not uncommon summer visitant; July to September. *Woods Hole,* irregularly present, not in large numbers, July and August. *New York,* rather common, August 23 through September.

Occurs cosmopolitan in warm seas occasionally northward to Cape Cod.

FOOD: Consist of fish (chub mackerel, squid, etc.).

SIZE: Reaches a length of 2 or 3 feet and weight of about 20 pounds.

166. Tunny
Thunnus thynnus (Linnaeus)



DISTRIBUTION: Fairly common, irregular summer visitant, late July to October 3. *Woods Hole,* formerly plentiful, but now rare. *Orient,* three records in last 20 years; last record Greenport from the sound, October 3, 1918, 250 pounds. *New York,* sometimes common (late July).

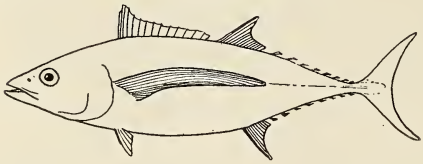
Occurs cosmopolitan in warm seas, north to Newfoundland on our coast.

Fresh from the water, a 27 pound specimen was of great beauty. Above it was dark steel blue, with grey and green. Its cheeks were silver; sides and lower parts greyish silver, highly iridescent in several colors, especially pink; and with vertical bands of longitudinally oval bright spots; these bright bands narrowing and fading out in the dark sides of the back. Dorsals dusky, except the finlets which were yellow more or less margined with black. Anal and its finlets greyish silver; caudal dusky, more or less overlaid with greyish silver at base; ventrals greyish silver outside blackish inside. A specimen 6 or 7 feet long which would have weighed perhaps 500 lbs., in shipment to the New York market from Long Island had dorsal finlets orange yellow edged with black in front and behind, anal finlets the same but black edging very narrow and posterior only; flanks with obscure oval pale linear spots and rings.

FOOD: Consists of fish (particularly the menhaden and mackerel) and squid. One of 27 pounds weight, off Block Island, August, contained some

50 individuals of a small herring about 4 inches long, one longer, slenderer Hemiramphid and one small squid.

Size: An individual 10 feet 4 inches long weighed 710 pounds; said to reach a weight of 1500 pounds.

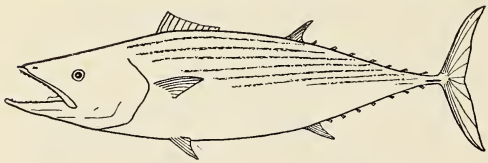


167. **Long-finned Albacore**
Germo alalunga (Gmelin)

Distribution: Casual or accidental. *Woods Hole*, one record, May 21, 1895. *New York*, reports of this fish apparently due to confusion with the false albacore.

Occurs cosmopolitan in warm seas, common in Mediterranean and on the Pacific Coast. Rare on the Atlantic coast north of Florida.

Size: Reaches 66¼ pounds (a California record).



168. **Striped Bonito**
Sarda velox Meek and Hildebrand

Conspicuous horizontal black stripes on back; body robust, mouth very large, teeth wide spaced.

Distribution: Block Island, Aug. 15 and Aug. 22, 1914, a specimen on each date, both taken from schools, not preserved. Drawn as an unknown species by Chas. K. Stillman, 1920. this figure published in Bull. Am. Game Prot. Assn. Jan. 1921. Described as *Sarda velox* from Panama City market by Meek and Hildebrand, 1923.

Size: Block Island specimens 23½ and 24 inches long weighed 4 to 7 pounds.

169. **Common Bonito**
Sarda sarda (Bloch)

Less conspicuous dark stripes on back and sides running obliquely backwards and upward.

Distribution: Common summer resident. June 15 to November 21. *Woods Hole*, usually common, June to October 1. *Orient*, usually uncommon summer resident, June 15 to November 21. *New York*, common, June to October.

Occurs on both coasts of the Atlantic, north to Casco Bay, Maine, and abundantly to Cape Cod. *Sarda chilensis* from the west coast of America is scarcely more than racially distinct.

Though usually found at the surface it sometimes swims near the bottom, for a small one (12½ inches standard length) taken off the New Jersey shore in early September had 4 partly digested sand launces in its stomach. The bonito is one of the most abundant off-shore summer fishes near New York, with habits similar to those of the bluefish. From its custom of leaping clear in the air and then falling back into the water again, it has been given the name of "skipjack" near New York.

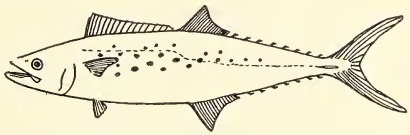
The delicate colors of mackerels change very rapidly when the fish is taken from the water. This species (on the New Jersey shore) is steel or sea green above, the longitudinal stripes dark, lower sides and belly silver. Pectoral and caudal dusky or blackish, anal whitish. First dorsal blackish, the spines paler. Soft dorsal lobe broadly blackish with paler base and pale tip. Sides with alternate broad dark and bright bands, lost almost instantly when the fish were taken from the water. At the same time the silver of the lower parts became dark greyish, and somewhat later the green of the upper parts changed to steel gray or steel blue. The green of the bonito matches the green color of these coastal waters, and it is not unlikely that if taken on blue water the same fish would be blue.

Food: Fish and squid.

Life History: Spawns throughout June. Young 5 to 6 inches long, common September 9 (Orient).

Size: Reaches about 3 feet (standard length), and 10 or 12 pounds weight.

170. **Spanish Mackerel**
Scomberomorus maculatus (Mitchill)



Front of lateral line slanting down rather evenly to lower posterior part; evenly scattered oval bronze spots on back and sides at all ages; dorsal inserted appreciably in advance of anal, depth about 4½.

Distribution: Rather common in summer, May 31 to October 5. *Woods Hole*, formerly abundant, now rare, August to October. *Orient*, rare, August 14 to October 5, abundant prior to 1870. *New York*, rather common May 31 to September.

Occurs from Cape Ann (accidental at Monhegan Island, Me.) to Brazil in the Atlantic, and also on the Pacific coast of America, large schools in the Gulf of Mexico and north to the Carolinas, rare or absent about Cuba.

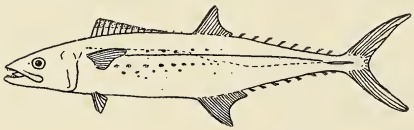
The Spanish mackerel is frequently common near New York in late summer, having at that time much the same habits as the bluefish. Its flesh is unusually rich and sweet, and it is justly famed as a table fish.

Life History. The Spanish mackerel spawns in shore in spring and

summer and apparently at night. The eggs are spherical, highly transpar ent and range from 1 to $1\frac{1}{4}$ mm. in diameter. Development is typical and rapid, the eggs hatching in from one to two days. The larvae on hatching measure 2.56 mm. in length. The yolk sac is relatively large and they drift about helplessly. At an age of three days from the time of hatching the larvae have functional mouths and vents, and measure 3.28 mm. Subsequent development is unrecorded.

About New York the spawning season is during September, becoming earlier as one goes south. The eggs are buoyant and non-adhesive. The average number produced by a female is about 20,000. They hatch in about 21 hours at a temperature of 81° F.

Size: Reaches 9 or 10 pounds weight.



171. Painted Mackerel
Scomberomorus regalis (Bloch)

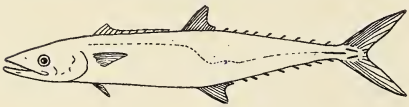
Front ofl ateral line slanting down rather evenly to lower posterior part; bronze spots on sides at all ages, which are arranged in series or tend to run into longitudinal stripes; dorsal inserted over anal, the two fins more fully scaled than in *maculatus;* depth 4½ to 5.

Distribution: Uncommon to the eastward, rare recently. *Woods Hole,* about as common as *S. cavalla,* few taken lately. *Orient,* rare, September 23 and October 2 are recent records. *New York,* unknown.

Occurs from Cape Cod to Brazil, generally scarce, common about the Florida Keys and abundant near Cuba.

Food: Consists of small fish.

Size: Reaches a length of 4 or 5 feet and weight of 20 to 35 pounds.



172. King Mackerel
Scomberomorus cavalla (Cuvier and Valenciennes)

Front of lateral line dropping abruptly to lower posterior part, the anterior portion of which is strongly undulated; immaculate, silvery, except for the young, which have spots; depth 6.

Distribution: Summer visitor. Formerly common or abundant to the eastward, now rare. July 1 to fall. *Woods Hole,* formerly abundant, now rare, July 1 to late fall. *Orient,* now rare, recent records August 17, 1910 (4 taken); September 21 to 23, 1918. *New York,* unknown.

Occurs in the warm parts of the North Atlantic, south to Africa and Brazil, abundant about the West Indies and Florida Keys.

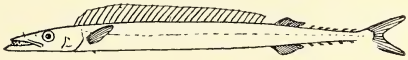
Food: Consist of fish and squid.

Size: Reaches a length of 5 feet and weight of 100 pounds.

ESCOLARS

Diverse fishes of the open sea rare on continental coasts, forming more or less of a transition from the mackerels to deep water forms, of which series the cutlass-fish, again a shore species, represents the terminal development. Our single species (*Gempylus*) has large eye, strong teeth like a barracuda, an elongate compressed body, suggestive of a needlefish, and mackerel-like finlets.

173. Snake Mackerel
Gempylus serpens Cuvier and Valenciennes



Distribution: Accidental, once, a large specimen found cast up on the sea beach near the Napeague Coast Guard Station, Long Island, by George H. Mulford, November 16, 1923. It measured 44 inches total length.

Occurs in warm seas, cosmopolitan.

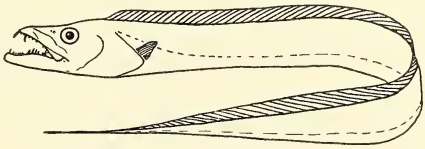
The depths at which the snake mackerel swims are uncertain, probably usually considerable in the case of the adult, though it likely sometimes approaches the surface. We have seen a young one in the collection of the American Museum of Natural History which was being carried by a white tern when taken near Ducie Island in the Central Pacific. It is likely that the species is a surface fish when only a few inches long, a member of a little known off-shore surface fauna.

Size: Reaches a total length of 44 inches, as above.

CUTLASS FISHES

Elongate, band-shaped, silvery fishes with large mouth and prominent, pointed teeth, the tail ending in a thread.

174. Cutlass-fish
Trichiurus lepturus Linnaeus



Distribution: Rare in summer, June to October. *Woods Hole*, rare but rather regular, June to October. *Orient*, casual, July 16 and August 27. *New York*, rare, July and August.

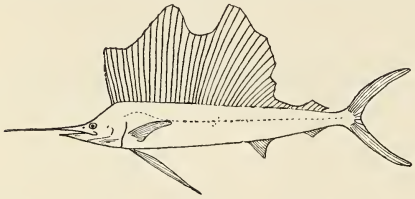
Occurs in warm seas, chiefly of the western Atlantic, but also recorded in Lower California; north to Virginia, and straggling to Massachusetts Bay. Not infrequent on sandy ocean shores.

Size: One of 19 inches, total length, from Orient, the largest taken locally. Said to reach a length of about 5 feet.

SPEARFISHES

Elongate fishes of large size, with strong, deeply forked caudal and narrow peduncle. The upper jaw ending in a long, cylindrical, bony spear.

Dorsal very high, undivided. *Istiophorus*
Dorsal low, divided in the adult. *Tetrapterus*

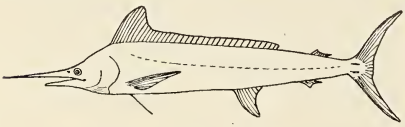


175. **Sailfish**
Istiophorus nigricans (Lacépède)

Distribution: Casual, summer and early fall, 6 or 7 records. *Woods Hole*, casual, a half dozen in early fall during 25 years. *New York*, one record, August.

Occurs in the warmer parts of the Atlantic, north to Florida and France, common in southern Florida.

Size: Six feet or more long when adult. 8 feet 4 inches in total length with a weight of 95 pounds the record.



176. **Spearfish**
Tetrapturus imperator (Bloch and Schneider)

Distribution: Generally rare in summer to the east, unknown to the west, July and August. One taken about July 1, 1890, Westhampton, the only Long Island record. *Woods Hole*, generally rare, common in July and August from 1885 to 1890.

Occurs in the warmer parts of the Atlantic, southern Europe, West Indies, occasionally northward to Cape Cod, or Maine according to fishermen.

Size: Reaches an ordinary total length of 7 feet, and is said to reach 26 feet!

SWORD-FISHES

Similar to the spear-fishes, but the prolongation of the upper jaw depressed, a flat blade like that of a sword.

177. **Swordfish**
Xiphias gladius Linnaeus

Distribution: Common to the eastward, July 1 to October, rare to the westward, June. *Woods Hole*, common in July and August, and present July 1 to October. *Orient*, rare, a record July 1. *New York*, rare, June.

Occurs cosmopolitan in warm seas, in the Atlantic rather common in southern Europe and between Cuba and Cape Breton.

Deep-water species sometimes found in their stomachs prove that they feed at a considerable depth. They have been described as rising through schools of surface fishes striking right and left with their swords, and then turning to pick up the fishes they have thus disabled, but thoroughly satisfactory detailed observations of this habit are hard to find.

On calm days swordfish are to be found scattered, lying quietly or swimming sluggishly at the surface with top of dorsal and caudal fin out of water. Prof. Ulric Dahlgren believes that they have for the most part been feeding at considerable depths and come to the surface to rid themselves of the troublesome lamprey. They are taken with the harpoon and will very rarely strike at a baited hook, probably having somewhat different feeding habits here from in California waters where not infrequently captured with rod and reel.

Swordfish are active and powerful, and when harpooned at times drive their sword into a vessel or through a small boat. There are doubtless authentic cases of their sword being driven into a vessel at sea, though possibly most such refer to the spearfish (Tetrapterus) seemingly from malice, such incidents may yet be accidental.

One taken off Block Island in December at a depth of 80 fathoms on a trawl line set for tilefish weighed 410 pounds. (C. H. Townsend in the Bull. N. Y. Zool. Soc., July, 1923.) With the approach of winter they probably move off into the depths rather than migrating southward.

Food: The food of the swordfish consists of fish (mackerel, menhaden, bluefish, silverhake, butterfish, herring, etc.) and squid. In one specimen 11 hake (1 to 2 feet long) and one menhaden were found; in another 9 menhaden.

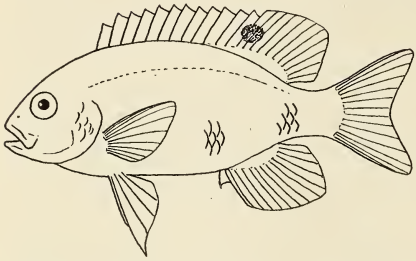
Life History: Supposed to spawn in the Mediterranean in summer, but does not do so off our coast at that season. Young fry have been found in the open Atlantic between 20° and 39° north. Swordfish have a larval stage different from the adult, with long high dorsal and anal fin, jaws equal and toothed, skin set with spinules. At half a pound weight the adult form has been assumed.

Size: The maximum weight of the swordfish is 600 to 800 pounds, though it is usually smaller, 400 pounds or less.

POMACENTRIDS

Small, spiny-finned, more or less short and deep bodied, usually highly colored, active shore fishes characteristic of tropical coral reefs. The dorsal similar to that of the wrasses, caudal moderately forked, scales moderate or rather large, lateral line wanting, mouth and teeth small, nostril single.

Preopercle sharply serrate. No black cross-bands. *Eupomacentrus*
Preopercle not serrate. Sides with black cross-bands. *Abudefduf*



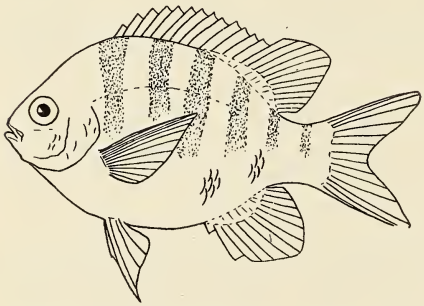
178. **Beau-gregory**
Eupomacentrus leucostictus (Müller and Troschel)

Distribution: Casual to the eastward in summer and fall, August 30 to October 4, 1899, 9 specimens, Katama Bay.

Occurs in the West Indian fauna, north to Florida.

Frequents rocks and reefs in clear, rather deep water when adult, the young abundant in shallow rocky tide pools.

Size: Reaches a length of about 6 inches.



179. **Sergeant Fish**
Abudefduf saxatilis (Linnaeus)

Distribution: Accidental, once, Newport.

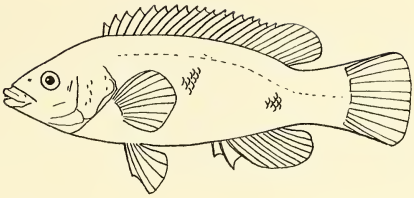
Occurs on both Atlantic and Pacific coasts of tropical America, from Florida to Uruguay in the Atlantic. Abundant in tide pools and about coral reefs everywhere. As this species is known to spawn in fall in Florida, its young would be of drifting age in the winter when they could not survive in northern latitudes, very likely the reason they do not occur in our region.

Size: Reaches a length of 6 inches.

WRASSES

Small, or moderate sized, shore fishes with large or smalll smooth scales The dorsal of spines in front, soft-rayed behind; the spinous portion decidedly longer than the soft part. Caudal usually squarish, pectorals rounded. Large strong teeth in front of the small, thick-lipped mouth.

Preopercle serrate. Scales moderate. *Tautogolabrus*
Preopercle entire. Scales small. *Tautoga*



180. Cunner
Tautogolabrus adspersus (Walbaum)

Distribution: Permanent resident, abundant to the eastward. *Woods Hole*, abundant permanent resident sometimes destroyed in great numbers during severe winters by heavy ice. *Orient*, abundant on rocky bottom in summer, very rare in winter; occasionally taken from mud; becomes common in May in the Sound and rare late in November. *New York*, common locally, where suitable ground occurs, resident.

Occurs from Labrador to Sandy Hook, New Jersey, and casually the mouth of Chesapeake Bay. Frequents rocky bits of bottom at various depths, and is abundant under wharves and around piers. Said to take refuge among eel-grass in winter. Descends to depths of 25 and 35 fathoms.

When swimming slowly, the pectoral fins of the cunner are often the propelling power, the body gliding forward smoothly and rather swiftly. This is a sort of locomotion rare among fishes and characteristic of the wrasse family, of which the cunner is the most northern representative on our coast.

It would be an excellent food fish except that it does not reach a large enough size. In consequence, where abundant, it is a nuisance to the fisherman. It is sometimes called nibbler. Northward along the New England coast it is known as cunner. Here it reaches a somewhat greater size and is largely taken in traps and extensively used for food. Near New York it is known as bergall.

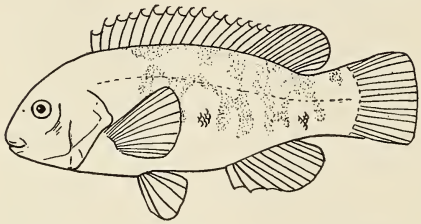
Practically omnivorous, feeding on sea-weed, hydroids, bryozoa, tunicates annelids, small crustacea (Caprella, shrimps, amphipods, crabs, isopods), univalve molluscs, small fishes (silversides, sticklebacks, pipefish, etc.), and teleost eggs.

Life History: Young taken in tow net from June to October, most abundantly in June and July. This, with the exception of the tautog, the only labrid breeding within our range, likewise spawns chiefly in June and early July and also in moderately deep water off shore. The eggs are transparent, buoyant and spherical and range from 0.75 to 0.85 mm. in diameter. They are distinguishable from the ova of the tautog only by virtue of their smaller size. They incubate in about 40 hours at a temperature of 72° F. The newly hatched fish measures about 2.1 mm. At three days after hatching the yolk is gone and the larvae have a length of about 2.9 mm. After the length of 10 mm. is reached the adult characters are assumed rapidly.

In New York Bay during September young fish were taken in dredges on oyster beds in a depth of 10 to 14 feet. It is inferred that the rate of growth

is about 2 mm. per week as the fish taken near the first of the month averaged about 18 mm. whilst those taken near the last averaged about 26 mm. Maturity seems to be reached in about the third year.

Size: The cunner is ordinarily less than a foot long and weighs under a pound. In this latitude it is generally much smaller, the large ones being more northern in distribution. In the Gulf of Maine they are occasionally taken up to 15 inches long and weighing as much as 2½ pounds.



181. Tautog
Tautoga onitis (Linnaeus)

Distribution: Common permanent resident. *Woods Hole*, common permanent resident, numbers killed by ice in severest winters. *Orient*, resident, abundant April to December 1; rarely seen in winter except in hibernation, and these rarely reaching 2 pounds in weight. A heavy migration in October and November. *New York*, common permanent resident.

Occurs from New Brunswick to Charleston, S. C., most abundant between Cape Cod and the Delaware Capes. Frequents rocks and seaweed in rather shallow water.

The tautog is a succulent morsel at all ages, and its ability to hide away among rock and weed gives it only a relative immunity from being eaten. We have seen a small one taken from the stomach of the red-throated loon. Winters in a more or less sluggish condition in slightly deeper water.

Food: Eats a great variety of crabs and shell-fish. Is said even to eat sessile barnacles of considerable size. The young eat seaweed, small crustacea and mollusks, and annelids.

Life History: Young taken in tow in June, July and August, and abundant hiding in sea lettuce (which their green color matches) in shallow bays in early fall.

The tautog is a summer spawner, the season being at its height in June and running over into July. The eggs are spherical, transparent and vary from 0.9 to 1.0 mm. in diameter. They float in sea-water although the yolk contains no oil globule. Incubation takes from 42 to 45 hours at a temperature of 72° F. which is a higher temperature than ordinarily attained on the spawning grounds. The newly hatched larvae measure about 2.2 mm. As in many pelagic larvae of diverse families, the posterior portion of the fish is free from pigment. Growth is rapid; in four days the larval tautog increases its length to about 3.3 mm. By the time a length of 30 mm. is reached the diagnostic characters of the adult have appeared, although fish of this size are somewhat more slender than the older ones.

In Sandy Hook and Jamaica Bays in fall young from 2 to 2½ inches standard length are common. Maturity probably is reached in about three years and spawning no doubt takes place in rather deep water as these fish are absent from shoal waters during the summer months.

Size: The tautog, or blackfish as it is called to the westward, grows much larger than the cunner and is one of the most valuable food fishes of the Atlantic coast, being much sought after by local anglers. The largest blackfish on record was taken near New York in 1876. It was 36½ inches long and weighed 22½ pounds. This size is, of course, very exceptional. Anything over 10 pounds is very large for the species. Largest Orient specimen 23 inches total length, 13¼ pounds.

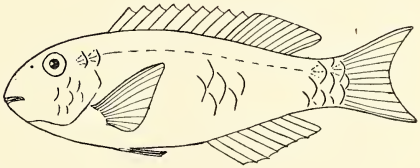
PARROT FISHES

Bright colored tropical fishes of moderate size, with large smooth scales. They resemble the wrasses, but have teeth fused into a strong nipper-like beak.

Gill-membranes broadly joined to the isthmus. Dorsal spines stiff. *Sparisoma*

Gill-membranes forming a fold across the isthmus. Teeth whitish or rosy in color. *Scarus*[10]

182. **Mud Parrotfish**
Sparisoma flavescens (Bloch and Schneider)



Distribution: Accidental, one record, November 13, 1900, picked up on shore of Buzzard's Bay.

Occurs in the West Indian fauna, common. Key West to Rio Janeiro.

Size: Rarely exceeds one foot in length.

SPADE-FISHES

Deep, compressed fishes of moderate size with small but rough scales. Spiny rayed back fin separate from the soft-rayed fin behind it, which is high and pointed and resembles the anal. Both these soft-rayed vertical fins densely scaled.

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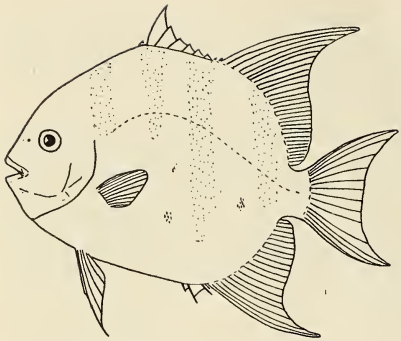
[10] The St. Croix parrot fish, *Scarus croicensis*, is recorded as accidental, Katama Bay, October 20, 1900, 2 specimens. Their identity with this, one of the less common of the numerous West Indian parrot fish, may be questioned.



183. **Spadefish**
Chaetodipterus faber (Broussonet)

Distribution: Rare in late summer and early fall, June 17 to October 6. *Woods Hole*, rare, August to October. *Orient*, rare, June 17, 1912, Gardiner's Bay, three individuals taken October 2 to 6, 1916. *New York*, occasional, summer to October 3 (1924, Sandy Hook Bay).

Occurs from Cape Cod to Rio Janeiro.

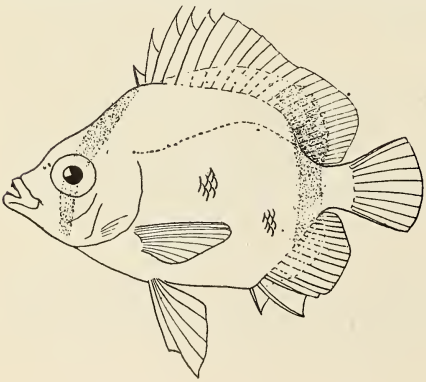
Life History: In Virginia this species spawns from June to August. The eggs are buoyant, non-adhesive, and average about 1¼ mm. in diameter. They hatch in 24 hours at a temperature of 78° F. In North Carolina the young fish reach a length of 3 inches by the latter part of August.

Size: Reaches 2 to 3 feet in length; one taken locally measured 16 inches in total length and weighed 3¾ pounds (Orient).

BUTTERFLY FISHES

Small or moderately large, deep bodied, compressed fishes with a single back fin, the anterior spinous part closely united to the posterior of soft rays. Mouth small, teeth fine and brush-like. The soft vertical fins densely scaled.

Preopercle unarmed. *Chaetodon*
Preopercle armed at its angle with a long, strong spine. *Pomacanthus*



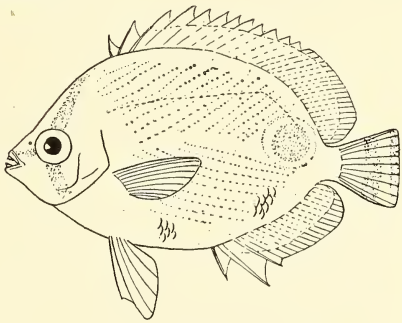
184. **Common Butterfly-fish**
Chaetodon ocellatus Bloch

Series of scales below axis of body, running obliquely upward and backward, the lowest becoming more or less horizontal. Two bold black vertical stripes, one through eye, the other connecting the bases of the soft vertical fins.

Distribution: Uncommon, August to November. *Woods Hole*, a few each year and occasionally common, August to November. *New York*, occasional, September 21 (1925, Jamaica Bay, 10 mm. standard length), October 7 (1923, Long Beach, Elizabeth T. Janvrin), November 6 (1924, Point'O Woods, L. I., Katherine Wager Smith, found lying on seaweed on the bay shore front). *Sandy Hook Bay*, September 22, 1926, ½ inch standard length.

Occurs in the West Indian fauna, the young straying northward in the Gulf Stream to New Jersey and Rhode Island. Seined among eelgrass at Woods Hole. Driven ashore through the surf at Long Beach by a southerly gale in October.

Size: Reaches a length of about 8 inches.



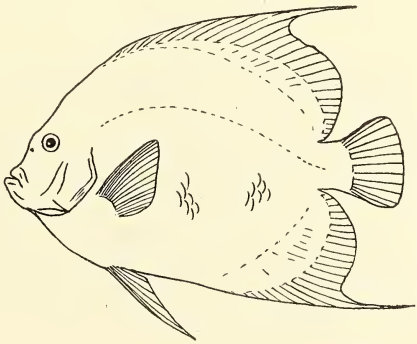
185. **Four-eyed Butterfly-fish**
Chaetodon capistratus Linnaeus

Series of scales below axis of body extending downward and backward, forming an angle with those above. A black vertical stripe through eye, and large ocellus on hind part of body.

Distribution: Usually rare, occasionally in some numbers to the eastward, in late summer and fall. *Woods Hole*, August to October.

Occurs in the West Indian fauna.

Size: Reaches a length of 6 inches.



186. **Black Angel Fish**
Pomacanthus arcuatus (Linnaeus)

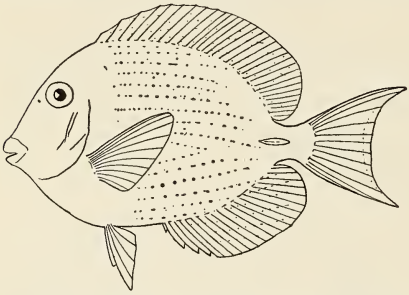
Distribution: Accidental, New York.

Occurs in the West Indian fauna south to Bahia, occasionally north to New Jersey.

Size: Reaches 1½ to 2 feet in length.

SURGEON FISHES

Small-mouthed, deep-bodied, compressed fishes. Spines and rays of the long back fin little differentiated. Scales minute. Teeth small, narrow, incisor-like. An erectile spine on the side of the peduncle.



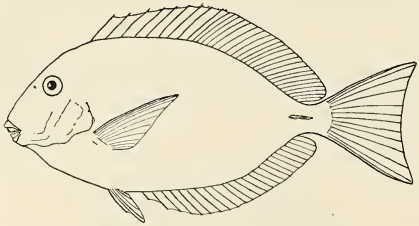
187. Blue Surgeon Fish
Teuthis caeruleus (Bloch and Schneider)

Deep-bodied, depth 1½ in length, the adult more or less deep blue in color.

Distribution: Young rare to the eastward in late summer and fall, August to October.

Occurs in the West Indian fauna, from the Florida Keys and Bermuda to Bahia, casually northward.

Size: Reaches a length of about one foot.



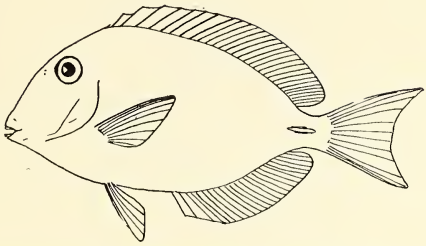
188. Common Surgeon Fish
Teuthis hepatus Linnaeus

Depth about 2 in length; caudal simply lunate, color more or less olivaceous, usually with distinct cross-bars.

Distribution: Young rare to the eastward in late summer and fall, accidental to the westward, August to October. *Woods Hole*, recorded from August to October. *New York*, accidental, October.

Occurs in the West Indian fauna from Florida to Bahia, casually northward.

Size: Reaches a length of about 10 inches.



189. **Ocean Surgeon Fish**
Teuthis bahianus (Castelnau)

Depth about 2 in length; caudal more deeply emarginate, upper lobe produced in a filament in the adult; color more or less olivaceous, usually a paler area at the base of the caudal fin.

Distribution: Young rare to the eastward in late summer and fall, August to October. *Woods Hole*, recorded from August to October.

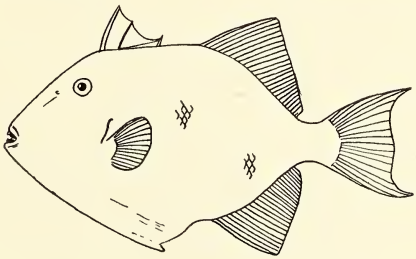
Occurs in the West Indian fauna from the Florida Keys to Bahia, casually northward.

Size: Reaches a length of one foot.

TRIGGER-FISHES

Sluggish, compressed fishes with small mouths, the teeth more or less fused and nipper-like. Skin leathery, but with evident scales. First back fin of three spines.

Gill opening with a number of large bony scales behind it. *Balistes*
Gill opening with only ordinary scales behind it. *Canthidermis*



190. **Trigger-fish**
Balistes carolinensis Gmelin[11]

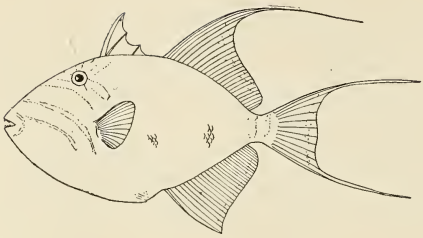
Cheek without blue bands; body with few blue spots or none.

Distribution: Rare in late summer and fall, July to November 11. *Woods Hole*, very rare, fall. *Orient*, rare, September 1 to November 11. *New York*, rare, July to October 17.

Occurs in the tropical and sub-tropical parts of the Atlantic on both coasts, occasional northward in the Gulf Stream, casually to Nova Scotia.

Size: Reaches 14 inches total length (Orient).

[11] The spotted trigger-fish, *Balistes forcipatus*, found on the west coast of Africa and about neighboring islands, has been reported as accidental at Newport, but the record needs confirmation.



191. Queen Trigger-fish
Balistes vetula Linnaeus

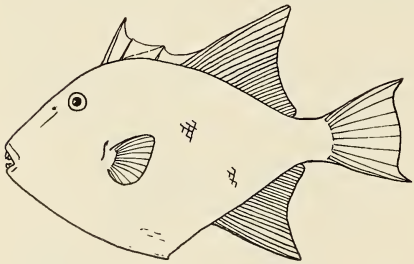
Cheek with two broad, curved blue bands, dorsal and caudal in adult with filamentous angles.

Distribution: Rare to the eastward in summer and fall, September, not recorded to the westward. *Woods Hole*, rare, summer and fall, September.

Occurs in the warmer parts of the Atlantic, common in the West Indies, occasionally north in the Gulf Stream.

Food: Amphipods, copepods and seaweed recorded as food.

Size: Reaches a length of about 15 inches without the caudal filaments.



192. Ocean Trigger-fish
Canthidermis sobaco (Poey)

Distribution: One record, Vineyard Sound, off Great Harbor; one specimen taken in floating gulfweed, July 24, 1897.

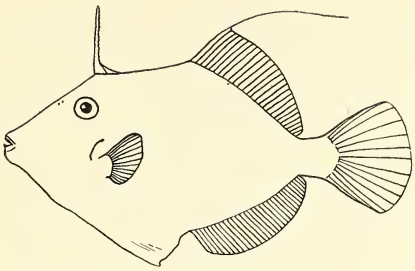
Occurs in the West Indian fauna, rarely north in the Gulf Stream.

Size: Reaches a length of 2 feet.

FILEFISHES

Sluggish, compressed fishes with small mouths, the teeth more or less fused and nipper-like. Skin leathery, scales not evident. First back fin of a single spine.

Pubic bone with a small spine at its end. *Monacanthus*
Pubic bone without spine at its end. *Alutera*



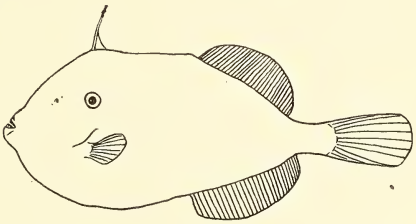
193. **Common Filefish**
Monacanthus hispidus (Linnaeus)

Distribution: Not uncommon in late summer and fall, mostly young, sometimes common to the eastward, July to November 22. *Woods Hole*, July to November, in varying numbers, sometimes very common, young only. *Orient*, September 10 to November 22. *New York*, rather common, August to November, most frequent from mid-September to mid-October.

Occurs from Cape Cod (casually Nova Scotia) to Cuba, abundant on the Florida coast. This fish appears in fall with *Alutera* in Sandy Hook Bay but is less common. 3¼ inches is about the average standard length.

Life History: Young occur in drifting gulfweed, eel-grass, etc.

Size: Reaches a length of 10 inches.



194. **Orange Filefish**
Alutera schoepfii (Walbaum)[12]

Dorsal rays about 36, anal about 38.

Distribution: Rather common summer and fall, May to November 14. *Woods Hole*, rather common, July to November 10. *Orient*, rare, only stray individuals taken, June 19 to November 14. *New York*, rather common May to November.

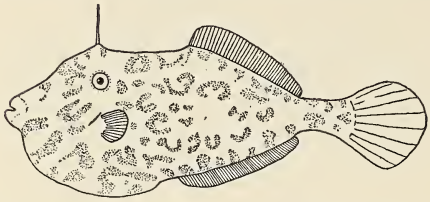
Occurs from Cape Cod (casually Portland, Me.) to Florida and Texas. Frequents sandy shores, especially near eel-grass.

Food: algae, hydroids, one specimen in August was found to have eaten a large quantity of *Pennaria*.

Common in Sandy Hook Bay in October, mostly young examples. A dozen taken on October 18 showed a mode of 7½ inches in standard lengths with a maximum of 9¾ inches and a minimum of 4¾ inches.

[12] The scrawled filefish, *Alutera scripta* with dorsal rays about 46, anal about 50, caudal fin elongate with rounded angles, sides marked with dark spots and irregular blue spots and lines, is recorded from New York on the authority of Eugene Smith. Its occurrence in our region needs confirmation.

Size: Reaches a length of 24 inches; 21 inches total length, 2½ pounds weight, the largest recorded from Orient.



195. Unicorn Filefish
Alutera monoceros (Osbeck)

Dorsal rays about 46, anal about 50. Caudal fin short, sub-truncate, with acute angles. Coloration uniform.

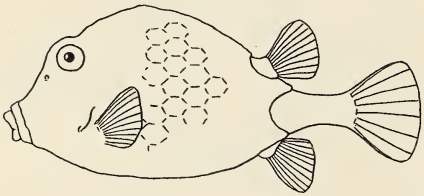
Distribution: Accidental, 2 records, *Woods Hole*, August 22, 1898, August 1, 1899.

Occurs in the West Indian fauna and appears to be cosmopolitan in warm seas.

Size: Reaches a length of 1 or 2 feet.

BOX FISHES

Sluggish, small-mouthed fishes. The teeth more or less fused and nipper-like. The body encased in a hard shell, triangular (beechnut-shaped) in our species.



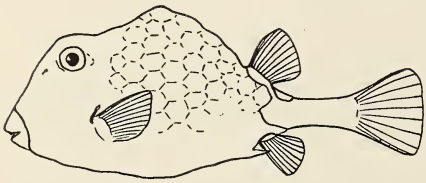
196. Trunkfish
Lactophrys triqueter (Linnaeus)

Shell with no spines anywhere.

Distribution: Several taken at Woods Hole, sometimes confused with *L. trigonus*.

Occurs in the West Indian fauna, north to Florida and Bermuda.

Size: Reaches a length of $10^3/_5$ inches.



197. Common Trunkfish
Lactophrys trigonus (Linnaeus)

Shell with distinct spines on the ventral ridges behind, none on the forehead. Shell closed behind the back fin. Body mottled with paler.

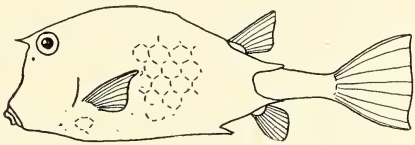
Distribution: Rare in late summer and fall, more common to the eastward, July to October. *Woods Hole*, young, (maximum one inch long) not uncommon, July to October. *New York*, occasional, August to October.

Occurs in the West Indian fauna, common as far north as the Florida Keys and Bermuda, occasionally northward in the Gulf Stream to Massachusetts.

Life History: Young occur under Gulf weed or among eel-grass at Woods Hole. When ½ inch or less in size they are squarish or orbicular in outline, (due to the slight development of the ridge in the center of the back, and the comparatively great development of the two ridges at its sides) suggesting the allied Ostracion, which does not occur in America. We have to hand one about ½ inch long picked up at Point O'Woods, September 27, wherein the ventral spines are blunt, little developed, color yellowish with dark specks.

Size: Reaches a length of about 9 inches.

198. Cowfish
Lactophrys tricornis (Linnaeus)



Shell with spines on the ventral ridges behind, also one on either side of the forehead.

Distribution: Rare at Woods Hole. September to November 6. *New York*, accidental, Fire Island Beach, about November 1, 1919.

Occurs in the tropical parts of the Atlantic, Carolina (and as a straggler Massachusetts) to Brazil, occasionally west to Galveston, east to Guinea and the Cape of Good Hope.

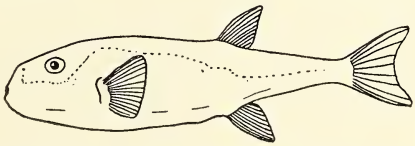
Size: Reaches a length of one foot or more.

SWELLFISHES

Small, sluggish, small-mouthed fishes, the teeth more or less fused and nipper-like. Body rotund and more or less finely prickly. Skin loose, the fish capable of swelling to a spherical form by taking in air or water.

Dorsal and anal fins more or less falcate, of 12 to 15 rays. *Lagocephalus*
Dorsal and anal fins rounded, of 6 to 8 rays. *Tetraodon*

199. Smooth Swellfish
Lagocephalus laevigatus (Linnaeus)



Distribution: Rare in fall, September 15 to November 5. *Woods Hole*, not common, mostly September and October. *Orient*, rare, November 1 to November 5. *New York*, rare, September 15 to October.

Occurs from Cape Cod to Brazil, uncommon north of Cape Hatteras.

Size: Reaches a length of 2 feet.

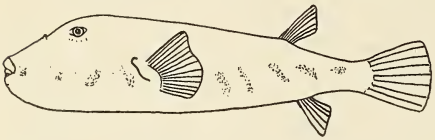
200. Southern Swellfish
Tetraodon spengleri Bloch

Narrow and slightly concave between the eyes. Sides usually with small flaps. White of lower surfaces marked off by a row of conspicuous roundish black blotches.

Distribution: Casual, *Woods Hole*, September and October.

Occurs in the West Indian fauna from Texas and Florida to Rio Janeiro, and in the Madeiras and Canaries, casually north to Woods Hole.

Size: Reaches a length of one foot.



201. Common Swellfish
Tetraodon maculatus Bloch and Schneider

Narrow and slightly concave between the eyes. No dermal flaps. Rows of blackish blotches on the side less conspicuous, irregular more or less vertical bars.

Distribution: Abundant in summer and fall, May 16 to December 15. *Woods Hole*, abundant, May 20 to cold weather. *Orient*, May 16 to December 15. *New York*, abundant, May to November.

Occurs from Casco Bay casually, Cape Ann rarely and Cape Cod abundantly to Florida.

Puffers are fishes of sandy shores and spend much of their time poking around near to the bottom, close to or often amid sea wrack, in an effort to pick up mollusks and crustaceans which together form the bulk of their food. It is not uncommon to find puffers half buried in the sand, thus resting partly protected. In working into position and covering themselves they so plow up the bottom that two ridges diverging backwardly from their snout become prominent in the sand, thus giving away their place of concealment, if such it is.

Their most striking habit is of course their method of defense, i.e., inflation, to which habit their common name refers. The mere sight of a predacious fish or enemy will often cause them to engulf enough water to become nearly spherical, although usually they attempt to flee and resort only to inflation at times of great and immediate mortal danger. Their near relative from Florida (*Tetraodon harperi*) Nichols[13] in the aquarium,

[13] *Tetraodon harperi*, described from Cape Sable, Fla., resembles *T. maculatus* closely, and specimens recorded as the latter from the Carolinas southward should be examined with reference to the former species. West Indian *T. spengleri* looks quite different from either.

at least, frequently inflates simply on sight of a dip net thrust into the tank. Sometimes in the aquarium our common puffer inflates himself for no apparent reason at all—perhaps a matter of exercise.

In feeding on small crabs the puffers go to some trouble to take the first bite from the front and use care to so direct it that it severes the nervous ganglion. This at once paralyzes the crustacean and renders it a simple matter to tear it apart. Naturally the claws of the crab are so flexed as to protect this important and vulnerable spot to the greatest extent possible This implies that the puffers must pay for their feast by receiving many little nips about the mouth. This seems to bother them but little unless the crab is of such a size that the eyes of the puffer can be reached. If it so happens that the 'reach' of the crab is equal to or greater than the distance from the mouth to the eye of the puffer the crustacean is never attacked in the manner described above, but instead many little sallies are made at other less protected points. A large blue crab may be surrounded by a half dozen or so puffers. In a short time it is so weakened and confused by their concerted attacks and constant harrying that it is relatively easy for one of them to cripple it so that the final closing in and feasting may be consummated.

Food: Consists of various crabs and other crustacea, also bivalve and univalve mollusks, annelids, seaweed, etc.

An interesting letter received from Walter B. Savary of Wareham, Mass.; dated October, 1924, doubtless refers to this species, although the colloquial name he uses for it is unusual. He writes: "Is it commonly known that the small drum fish so plentiful on our flats in summer can inflate himself out of the talons of a fish hawk? I watched a hawk fishing for drums on Little Harbor Flats in not over two feet of water. With my field glass I could see the whole performance; he was not far off at any time and I could see whenever he caught a fish, which, was by no means every time. When he did get one he would rise about four feet before the drum got his inflation started. This he seemed to do quickly and effectively for, he was out of the claws before the hawk had time to give that shake that always follows a plunge. I watched him strike, and lose four fish all in the same manner."

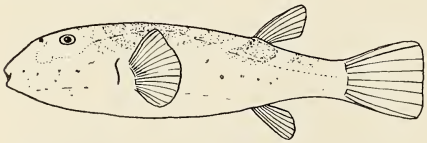
Life History: Spawns from June 1 to 10; small young abound in summer, taken in the tow from June to August, chiefly in July (Woods Hole). Young of 1 to 3 inches (total) frequently taken as late as November and first of December, (Orient). June 1 to July 15, many adults nearly or quite ripe; later, July 27 to October 31, all adults apparently spent, young from about 1 to 5 inches standard length taken (Sandy Hook Bay).

The puffers' spawning season is a rather protracted one, covering, as it does, the entire summer. Ripe females in the vicinity of New York Bay have been seen as early as June 7 whilst an occasional laggard may still be found ripe in late August or early September in the same locality. The eggs are heavy adhesive spheres of a light amber color varying from .85 to .91 mm. in diameter. At a temperature of about 67° F. they hatch in

about 4½ days into active larvae, 2.41 mm. long, of striking coloration; orange and black chromatophores forming a variegated pattern. The tip of the tail is colorless and nearly invisible. A chrome yellow spot marks the posterior ending of the chromatophores, which is abrupt. At the end of 10 days the yolk sac is nearly gone, the mouth is functioning and the length has increased to 2.65 mm. The pectorals are well developed, whilst the iris presents a startling metallic green lustre. The post larvae resemble the adults closely but are rather more chunky and have the eye much larger, and lack the color pattern of the latter. At this stage the ability to inflate exceeds even that of the adult.

We have scant knowledge of the rate of growth and the excessive overlapping of the year classes is so great that it suggests even a longer spawning season than is known to exist. In July and August examples from 20 to 70 mm. are often taken. Doubtless most of these are yearlings, the large ones from early spawnings and the small ones from late. Allowing for a proportionate decrease in the rate of growth it should take them about three years to reach maturity. Possibly the males mature a year earlier than the females as some very small ripe males have been seen.

Size: Reaches a length of 6 to 10 inches. The adults in Sandy Hook bay average about 7⅛ inches standard length in June, we have one record of a fish 8¾ inches.



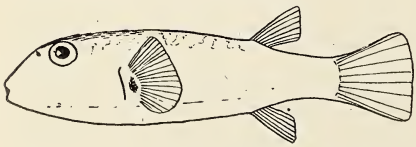
202. **West Indian Swellfish**
Tetraodon testudineus Linnaeus

Broad and flattish between the eyes. Back and sides marked with more or less irregular narrow pale curved stripes which tend to be concentric.

Distribution: Accidental, Newport, Cope.

Occurs in the West Indian fauna, common in the Florida Keys, occasionally northward in the Gulf Stream.

Size: Reaches a length of about 9 inches.



203. **Hairy Swellfish**
Tetraodon trichocephalus Cope

Spines on the head long, close set, like seal bristles. Caudal fin truncate, with prominent angles. Brownish above, faintly vermiculated with lighter.

Distribution: Known only from the type, 4 inches long, taken in the Gulf Stream off Newport.

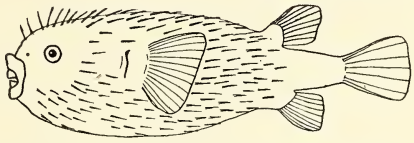
The accompanying figure has been based on descriptions as the only known specimen was unavailable.

PORCUPINE FISHES

Similar to the swellfishes but body covered with stout or long spines.

Spines long and sharp, body distensible. *Diodon*

Spines short and stout, body little distensible, except in the very young. *Chilomycterus*



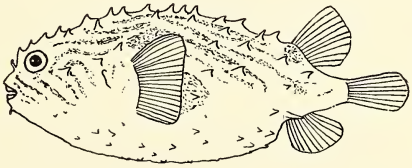
204. Porcupine Fish
Diodon hystrix Linnaeus

Distribution: Accidental, once, Buzzard's Bay near Woods Hole August 12, 1895.

Occurs cosmopolitan in tropical seas, common north to Florida, drifting further north in the Gulf Stream. Small individuals are found among eelgrass and drift great distances in floating gulfweed, larger ones are common about coral reefs.

Life History: As the size increases the spots grow smaller and more numerous. Young individuals with several large black blotches have been called *D. holacanthus*.

Size: Reaches a length of 3 feet.



205. Spiny Boxfish
Chilomycterus schoepfi (Walbaum)[14]

Upper parts with a series of undulating blackish stripes.

Distribution: Uncommon in late summer and fall, June 30 to November 5. *Woods Hole*, of irregular occurrence, generally rare, September to November. *Orient*, rare, June 30 to October 28. New York, uncommon, July 8 to November 5, fairly regular in Sandy Hook Bay in fall.

Occurs from Cape Cod (casually Massachusetts Bay) to Florida.

Food: Feeds on small crabs, shrimps and other crustacea, and mollusks.

Life History: Both large and small examples are taken in the fall in Sandy Hook Bay. The small average about 60 mm. in standard length whilst the large average nearly 90 mm. Just south of our territory (At-

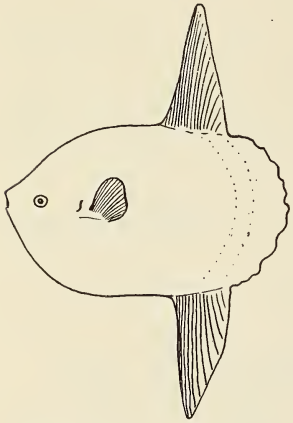
[14] The West Indian spiny boxfish, *Chilomycterus antillarum*, from Cuba and Jamaica, wherein the upper parts are covered with black hexagonal reticulations, is reported casual, at Woods Hole, *C. schoepfii* is subject to considerable individual variation, the status of related forms uncertain, and we do not feel justified in including this one here, on the basis of the data to hand.

lantic City) ripe fish have been taken in July which average about 19 cm. in standard length. The eggs are demersal, non-adhesive, highly transparent and average about 1.8 mm. in diameter.

Size: Reaches 9¼ inches total length (Orient).

SUNFISHES

Sluggish, compressed fishes with small mouths, the teeth more or less fused and nipper-like. Skin leathery, roughened like that of a pachyderm. No spines. Dorsal and anal fins high, flipper-like, the body ending immediately behind them, fringed by a narrow vertical caudal without a trace of peduncular constriction. A large off-shore fish.



206. **Ocean Sunfish**
Mola mola (Linnaeus)

Distribution: Rare in summer, June 2 to August 9. *Woods Hole*, rare, July and August. *Orient*, once, August 9, 1921, 4 feet long, 62 inches fin tip to fin tip, 250 pounds. *New York*, rare, June 2 to August 13 (1925, Sandy Hook Bay, about 4 feet long, estimated 300 pounds weight).

Occurs in most temperate and tropical seas, north to Cape Cod and more rarely to the Gulf of St. Lawrence on our coast.

To correlate the extraordinary form of this great fish with its habits would be an interesting contribution to the philosophy of the sea. We have seen it in calm weather close alongside a passing ship, making a pale mark at the surface where it lay flat on its side, fins moving a little, round pectoral projecting into the air.

Food: Includes salpae, amphipods, jellyfish.

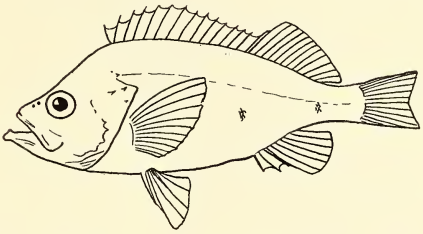
Life History: The young is spiny and very different in appearance from the adult.

Size: The record fish (from California), 10 feet 11 inches long; 10 feet 9 inches from tip to tip; estimated weight over 2,000 pounds.

SCORPION FISHES

Fishes of small size with a spiny and soft-rayed back fin of about equal length. A bony stay across the cheek, and strong spines about the large head. Ventral fins with the normal spine followed by five soft rays. Body covered by small scales.

Dorsal spines more than 12. *Sebastes*
Dorsal spines 12. *Scorpaena*



207. **Rosefish**
Sebastes marinus (Linnaeus)

Distribution: Occasional. *Woods Hole*, December 20, 1895, several specimens stranded by the tide. Also recorded from New York, in that instance perhaps from deep water.

Occurs on the northern coasts of the North Atlantic, as a shore fish as far south as Maine, in deeper water to off the coast of New Jersey.

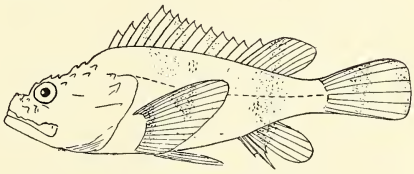
The rose-fish inhabits water of 50° or colder, and hence moves off-shore in summer from most of the New England coast where it is present in winter. It bites on any bait and its young are devoured in quantity by cod, larger rose-fish, and halibut.

Food: Consists mostly of various crustaceans, but also small fishes.

Life History: This deep water form occasionally taken withour limits, is reported to be ovoviviparous, that is, the young are brought forth in an active state after the eggs have hatched within the ovaries.

They are liberated in summer, on no special grounds, but wherever the parent may happen to be. The eggs are buoyant, and the larvae (about 6 mm. long) pelagic.

Size: Reaches a length of about 2 feet.

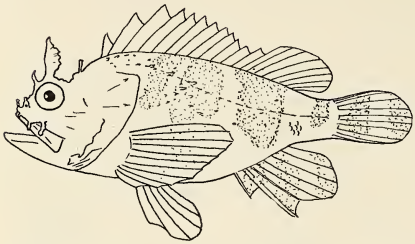


208. **West Indian Scorpion-fish**
Scorpaena plumieri Bloch

Distribution: Woods Hole, 20 specimens during August, September and October, 1899; 2 in 1900.

Occurs in the West Indian fauna from the Florida Keys to Brazil, casual northward.

Size: Reaches a length of about a foot.



209. **Lionfish**
Scorpaena grandicornis Cuvier and Valenciennes

Distribution: Accidental, one September 29, 1899, Katama Bay.

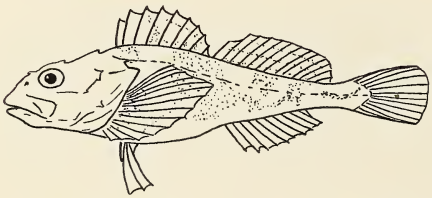
Occurs in the West Indian fauna from the Florida Keys to Brazil, accidental in Massachusetts.

Size: Reaches a length of about 8 inches.

SCULPINS

Fishes of small size with a spiny and soft-rayed back fin of about equal length, and bony stay across the cheek. Strong spines about the large head. Ventral fins with less than five soft rays. Body without true scales in our species, more or less warty and prickly.

9 or 10 dorsal spines. *Myoxocephalus*
About 16 dorsal spines, of which the first 4 are more or less separate. *Hemitripterus*



210. **Brassy Sculpin**
Myoxocephalus aeneus (Mitchill)

Anal fin with 10 or 11 rays. Brownish or coppery and white.

Distribution: Permanent resident, uncommon to the westward and common to the eastward. *Woods Hole*, very common throughout the year. *Orient*, common except in summer, November 4 to June 8 (July 30). *New York*, uncommon permanent resident. Common in Sandy Hook Bay in 1925, 120 to 132 mm. (5¼ inches) standard length, not seen there the 5 previous summers.

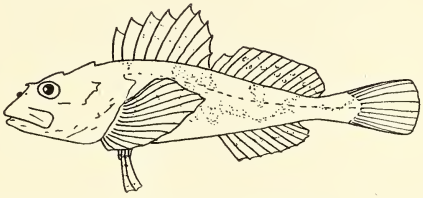
Occurs on the coast of southern New England and New York. Has recently been recognized north to the Gulf of St. Lawrence, but there is possibility of confusion existing in the determination of sculpins of northern New England. Found in waters of 2 to 15 fathoms depth.

Food: Consists of worms, small crustacea, young fish and eel-grass.

Life History: Spawns all through the winter. Eggs taken from nets and seweed in March; observed hatching April 27 (Woods Hole). Eggs in a ripe fish of about 4 inches standard length (January) were bluish green in color, like a weak solution of copper sulphate, and measured 1.6 mm. in diameter.

Size: Reaches a length of 7½ inches (Orient).

211. **Mitchill's Sculpin**
Myoxocephalus mitchilli (Cuvier and Valenciennes)



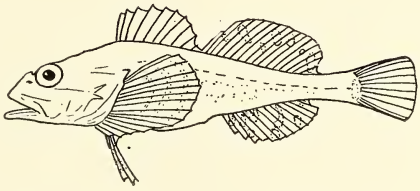
Anal fin with 10 to 11 rays. Colors sharply black and white (or livid green).

Distribution: Uncommon or rare, mostly in the colder months. *Orient*, found throughout the year, sometimes common spring and fall; November 25 to December 4, April 14 to June 28. *New York*, rare. Long Beach, March 25, 1925 (87 mm. standard length).

Occurs in Long Island waters, so far as known.

Size: Small, usually around 4 inches total length, and reaches 6½ inches (Orient).

212. **Greenland Sculpin**
Myoxocephalus groenlandicus
(Cuvier and Valenciennes)



Anal fin, of 12 to 14 rays. Upper preopercular spine moderate, about twice length of next spine.

Distribution: Common to the eastward in winter, October to January. *Woods Hole*, common, December to January. *New York*, accidental, records may be referable to *mitchilli*.

Occurs from the Arctic Ocean south along the shores of New England.

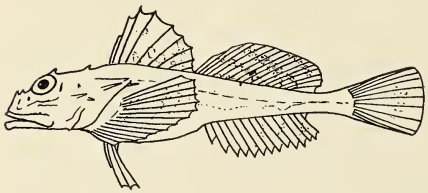
Abundant "in all the bays and inlets of Greenland, but prefers a stony coast clothed in seaweed. It approaches the shore in the spring and departs in winter. It is very active and bold, but does not come to the surface unless it be led thither in pursuit of other fish. It is easily taken with bait, and constitutes the daily food of the Greenlanders, who are very fond of it. They eat the roe raw."

Food: "It is very voracious, preying on everything that comes in its way, and pursuing incessantly the smaller fish, not sparing the young of its own species, and devouring crustacea and worms."

Life History: Spawns in November and December (Woods Hole). In Greenland "It spawns in December and January, and deposits its red-colored roe on the seaweed." (Quotations from Fabricius, copied from Jordan & Evermann.)

The eggs are 1½ to 2 mm. in diameter, incubation is slow, occupying 4 to 12 weeks according to temperature. Newly hatched larvae are 7 or 8 mm. long. By late summer they may be 1½ inches long and resemble the adult, and most of them seemingly do not mature until at least 6 inches long or 3 years old.

Size: Reaches a length of 25 inches, one of the largest sculpins.



213. Long-horned Sculpin
Myoxocephalus octodecimspinosus
(Mitchill)

Sculpin. Anal fin of 12 to 14 rays. Upper preopercular spine very long, about 4 times as long as the next below it.

Distribution: Abundant in winter, September through June, occasional in summer in somewhat deeper water. *Woods Hole*, abundant, October to January, a few in deeper water, July to September. *Orient*, common, October 1 through June. *New York*, abundant, September to May, occasional in summer. A wave of this species apparently approaches the length of our shore line simultaneously from deep water when the shore temperatures begin to fall in autumn, then withdraws westward somewhat from southern New England to winter most abundantly on Long Island; and there is an eastward movement again in spring on Long Island which does not reach New England, preceding or coincident with a return to deep water.

Occurs from Labrador to Virginia.

Sculpins are not at all valued as food, and yet what little is left of the fish when the inedible spiny head has been removed is excellent eating.

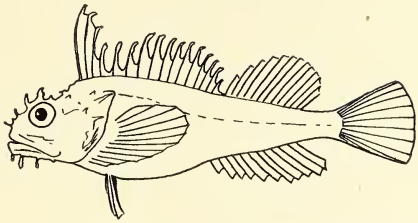
When landed on hook and line the long-horned sculpin assumes a defensive attitude as follows: it draws the upper jaw down and forward slanting the long preopercular spine up and back at an angle of 45°, and emits a low drumming sound. Other species of the genus have the same habit, perhaps most striking in this, the most heavily armed.

Food: The long-spined sculpin is a practically omnivorous carnivore. Small fish and crustaceans make up the bulk of its food, and it is also something of a scavenger.

Life History: Spawns in November and December, eggs often come ashore by the bucketful on Nobska Beach.

Size: Reaches length of about a foot, rarely 1½ feet.

214. **Sea Raven**
Hemitripterus americanus (Gmelin)



Distribution: Rather common spring and fall migrant. April and May (June 28) occasional in somewhat deeper water July and August, coastwise again September to December. *Woods Hole*, May, occasionally dredged July and August, common October and November. *Orient*, October 15, in spring to June 28. *New York*, rather common, April and May, (August) September to December. Occurs from Labrador to Chesapeake Bay, common north of Cape Cod. *Sandy Hook Bay* May 27, 1926.

Food: The sea raven feeds on invertebrates---mollusks, crustacea, worms, etc., and to a less extent on small squid and fish. It has the power of inflating its belly when lifted from the water, as also of biting the hand that frees it. In our region it moves inshore in autumn and offshore in spring.

The stomach of one of 10 inches contained several squid 5 inches in length.

Life History: With eggs October 15 (Orient), November and December. The eggs are about 4 mm. in diameter, yellow soon changing to amber color, and sink and stick together in masses. The young have grown to a length of about 45 mm. by the following summer, and live on the bottom.

Size: Reaches 17 inches total length locally, weight 3¾ lbs. (Orient). The largest on record measured 25 inches and weighed 5 pounds.

SEA POACHERS

Small, little active fishes of cold seas or deep water, with comparatively large heads and slender tails. Body covered with bony plates, angulated.

215. **Sea Poacher**
Aspidophoroides monopterygius
(Bloch)

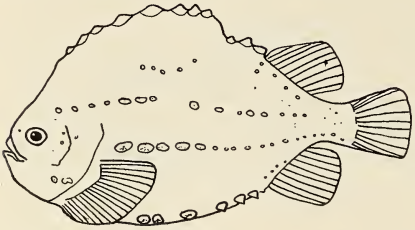
Distribution: Accidental, New York, summer. There is doubt if this species has occurred here naturally above 25 fathoms depth.

Occurs in rather deep water from Greenland to Cape Cod.

Size: Reaches a length of about 6 inches.

LUMP-FISHES

Fishes with rotund scaleless bodies, armed with rows of hard nodules, and a sucking disc on the breast.



216. Lumpfish
Cyclopterus lumpus Linnaeus

Distribution: Not uncommon in spring, April 1 to June 12. (About June 15, a half-grown fish, Fishers Island, H. L. Ferguson.) Young not uncommon to the eastward through the summer and fall, latest December 13. *Woods Hole*, adults common in spring, young found among driftweed till November. *Orient*, uncommon April 1, to June 12, young to December 13. *New York*, uncommon, April and May.

Occurs on the shores of the North Atlantic south to Long Island (casually Chesapeake Bay) and France. Common on rocky coasts, primarily a bottom fish, but also found in drifting weed. Said to be a favorite food of seals.

Food: Feeds on various invertebrates, including jellyfish, and occasionally small fishes.

Life History: Spawns in April (Woods Hole), to June 12 (Orient). Young taken in tow-net June 5 (Woods Hole), found among drifting weed throughout the summer till November (Woods Hole). Two inches total length recorded for a specimen on October 25, and 1½ inches for one on December 13 (Orient).

There is a general movement of this fish into shallower water to spawn, and deeper water after spawning. Large females (of 18 inches) produce up to 136,000 eggs. The eggs are 22 to 2.6 mm. in diameter, pink when first laid, becoming pale green or yellow and deepening in tint. They sink and stick together in large spongy masses through which the water circulates freely. Until the eggs hatch they are guarded by the male, who does not feed during this period, fans them with his fins to obtain circulation of water and freedom from silt, and drives off intruders. The young hatch at from 4 to 7.4 mm., and are at first actively pelagic. As they grow larger they hide in drifting weed, where they are abundant through the summer (to November, Woods Hole).

Off the coast of New England the surface of the green water is dotted with drifting fragments or larger masses of yellowish rockweed, frequently mixed with a little eelgrass, much as the warm blue ocean waters further east are dotted with sargassum. On the Maine coast in August it is interesting to find young lumpfish, an inch more or less in total length, hiding

in this drifting weed, and to compare their concealing color with that of the mouse-fish of the Gulf Stream. Unlike the color of the mouse-fish, that of young lump-fish, is highly variable, usually olive green, sometimes dark purplish, occasionally mottled grey. They have pale spots and bands anteriorly, usually more or less whitish or silvery and tinged with blue; such a band from the snout through the eye to the corner of the opercle, another between the eyes across the top of the head, and two short ones back of the gill cleft being pretty constant. There are apt to be pale spots on the sides, a reddish tinge posteriorly and on the fins. The eye is usually pink. If one examine details of the weed, bits will be found to match even the uniform dark purplish individuals. Possibly that this environment is with the lump-fish a temporary one, has something to do with the variety of its colors; possibly there is a greater range of color in rock than in gulf weed, and a standard low visibility pattern less possible. Bright marks, found also in mouse-fish, pelagic pipefish, and young of the yellow-jack, would seem to be an important feature of such a pattern.

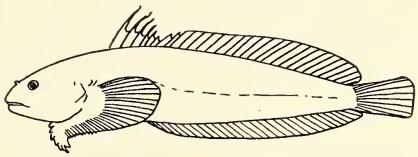
Size: A specimen of 23 inches total length, 11 inches deep, 7½ inches broad, weight 13¼ pounds recorded at Orient, and at the same locality one taken April 23, 1923, 21½ inches total length weighed 20 pounds.

SEA SNAILS

Small fishes related to the Sculpins, with long dorsal and anal, small rounded caudal, and broad pectoral fins—a sucking disc on the breast between the pectorals. Body and fins covered with loose scaleless skin.

Dorsal fin divided by a deep notch. *Neoliparis*
Dorsal fin continuous. *Liparis*

217. New England Sea-snail
Neoliparis atlanticus Jordan and Evermann

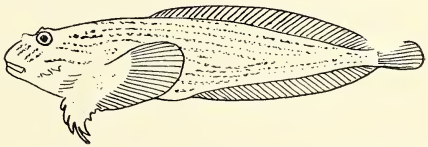


Distribution: Rare at Woods Hole, August and September.

Occurs along rocky shores from Newfoundland to Cape Cod.

Size: Reaches a length of about 6 inches.

218. North Atlantic Sea-snail
Liparis liparis (Linnaeus)



Distribution: *Woods Hole,* common in winter, occasional in summer. Also recorded from off Block Island.

Occurs on both shores of the North Atlantic, north to Spitzbergen, commonest on the European side, south to Cape Cod on our coast.

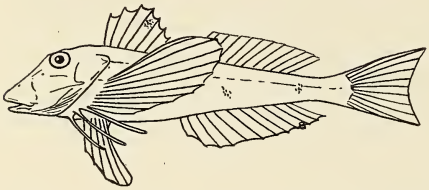
Life History: With spawn from December to March 26 (Woods Hole).

"A number of young examples of the sea snail, *Liparis liparis* (Linnaeus) were obtained from the mantle cavities of scallops at two stations, as follows:

"Forty-five miles E.S.E. from Assateague, Va., in 30 fathoms, and 45 miles E. by S. from Cape Charles, in 25 fathoms. These ranged in length from 20 to 29 mm. So far as known, this species has not been reported from so far south. A single example was also found in a scallop taken in 37 fathoms, 16 miles S. from Nantucket lightship" (W. W. Welsh, *Copeia*, No. 18, 1915).

GURNARDS

Fishes with head entirely encased in a bony armature, and set with numerous spines. Breast fin large, with three fleshy tentacles before it.



219. Carolina Sea Robin
Prionotus carolinus (Linnaeus)

A groove across the top of the head behind the eye. Pectoral fin not quite reaching middle of the soft dorsal. Brownish, with dark saddle-like marks on the back; dark under chin.

Distribution: Common summer resident, April 15 to November 21 (adult) and December 3 (young). *Woods Hole*, common, May to October or later. *Orient*, common, April 15 (average April 25) to October 31 (adult) December 3 (young). *New York*, common, May to November 21 (in 21 fathoms). Apparently withdraws into deep water for the winter months, rather than migrating coastwise, southwestward.

Occurs from the Bay of Fundy to South Carolina, chiefly south of Cape Cod. Occurs at the bottom, coastwise in shallow water, and also in water of considerable depth, moving off shore for the winter.

Sea robins make grunting noises when caught and perhaps communicate by similar sounds when under water. One observed in a creek tributary to Moriches Bay, Long Island, resting with outstretched pectorals on the mass of thick-grown finely divided potamogeton, not more than a few inches below the surface of the water, when alarmed darted down and disappeared beneath the pond-weed with a very audible croak, 'grr,' analogous to the squawk of a startled frog or the grunting of a bittern flushed from the marsh.

This species runs into brackish and muddy water and at such times has a muddy taste. It prefers a sandy bottom and sometimes buries in the sand, all but the top of the head and eyes. Though seldom eaten because of the big spiny head, sea robins are a perfectly good food fish.

Sea robins are usually found at the bottom. They frequently move slowly forward, appearing to crawl by applying the thick fleshy tentacles in

front of the breast fin to the bottom, as though these were fingers. At times they swim towards the surface, perhaps in pursuit of some smaller fish, then spread the pectorals and by their aid glide gracefully back to the bottom again. Doubtless the big bony head gives these fishes a high specific gravity, correlated with expansion of pectoral fins to this purpose.

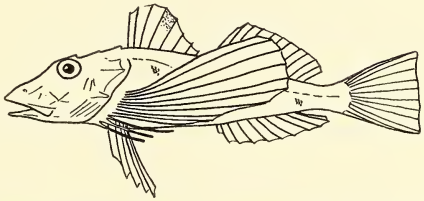
Food: A large part of its food consists of various small crustacea. It also eats small fishes, squid, worms, young bivalve mollusks, and seaweed.

Life History: Young in November from 2 to 5 inches total length (Orient). Spawning takes place in June, July and August. From the examination of ripe females it is inferred that the eggs do not all mature at once. They are buoyant, spherical, slightly yellowish, highly transparent and range from 0.94 to 1.15 mm. in diameter. Between 10 and 20 oil globules are usually present. These are frequently arranged in an annular band corresponding to the "tropic of Capricorn," taking the germinal disc as "north." Incubation at 58° F. occupies about 60 hours. On hatching the larvae are about 2.6 mm. long. The larval pectorals foreshadow the large ones of the adult. At five days the fish average about 3.2 mm. At 30 mm. they show most of the adult characteristics. Young of many varied sizes are taken throughout the year, which fact makes an estimate of the growth rate extremely difficult.

In Sandy Hook Bay fish averaging 150 mm. in standard length are taken from June to August. Young fish appear in October which average 80 mm.

Size: Reaches 16 inches total length, weight 1¾ pounds (Orient).

220. **Striped Sea Robin**
Prionotus evolans strigatus (Cuvier and Valenciennes)



No cross groove on the head. Pectoral fins longer. Sides pale with two distinct narrow lengthwise stripes; light under chin.

Distribution: Common summer resident, May 4 to November 15. *Woods Hole*, common, adults May and June, young till November. *Orient*, uncommon, May 4 to November 15. *New York*, common, May 4 to November 4.

Occurs from Massachusetts Bay to South Carolina, chiefly south of Cape Cod.

Food: Feeds mostly on crustaceans and mollusks.

Life History: Spawns in summer. Young ¾ inches long and upward throughout the summer (Woods Hole).

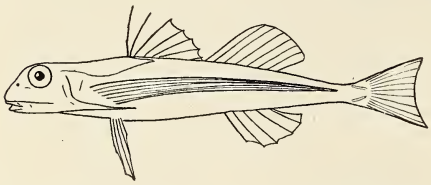
Young fish taken in Sandy Hook Bay during August average about 55 mm. in standard length; by October 1 they average about 70 mm.; ripe fish averaging about 260 mm. (10¼ inches) taken in June, examples of

about 110 mm. in October are probably a little over a year in age. South of our territory large ripe adults were taken in August (Atlantic City). The eggs were demersal, non-adjesive, highly transparent and averaged about 1.1 mm. in diameter.

SIZE: Reaches a length of about 1½ feet.

FLYING GURNARDS

An anterior spiny back fin. Entire head encased in a bony armature. No fleshy tentacles before the breast fin, which is very long and broad.



221. **Flying Gurnard**
Cephalacanthus volitans (Linnaeus)

DISTRIBUTION: Rare in fall, August 28 to October 28. *Woods Hole*, a few every year late in the fall, recorded August 28. *Orient*, rare, October 19 to October 28. *New York*, rare, August to October.

Occurs in the warm waters of both coasts of the Atlantic.

The flying gurnard makes long leaps supported by its large pectoral fins, but its aerial powers in no wise compare with those of the true flying-fishes. It jettisons above the surface of the water and then volplanes downward with pectorals spread, an act apparently homologous to that described above for the sea robin, but in that case entirely under water.

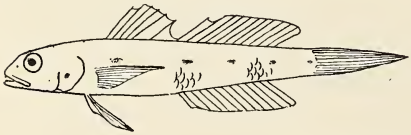
Dr. F. A. Lucas remembers (1870) taking young of this species 3 or 4 inches long associated with squid from the stomach of a bonito in mid-Atlantic a little north of the equator. Probably the young of this size are pelagic.

SIZE: Reaches 12 inches.

GOBIES

Small bottom fish, with two short separate dorsal fins, the first of slender spines. Ventral fins united.

Body scaly. *Gobius*
Body scaleless. *Gobiosoma*



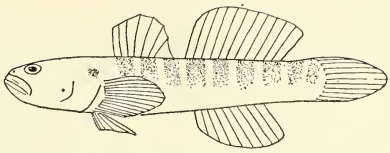
222. **Goby**
Gobius stigmaticus (Poey)

DISTRIBUTION: Accidental, one record, Woods Hole, October 4, 1906.

Occurs in the West Indian fauna from North Carolina to Brazil.

SIZE: Reaches a length of about 5 inches.

223. **Naked Goby**
Gobiosoma bosci (Lacépède)



Distribution: Rather uncommon in summer and fall, usually overlooked. *Woods Hole,* common, summer. *Orient,* once, October 30. *New York,* rather common, autumn.

Occurs from Cape Cod to Florida. Frequents shallow grassy bays, common southward.

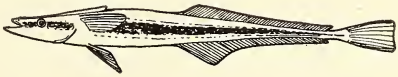
Size: Total length of an Orient specimen, 1¼ inches.

REMORAS

Small fishes, with flattened head, the top of which is occupied by a peculiar oval sucking disc with cross lamellae like the slats of a blind. By the means of this sucker they attach themselves to sharks and other large moving objects.

Body very slender, pectorals pointed with flexible rays, lower jaw produced in a flap.	*Echeneis*
Body stout, pectorals rounded, with flexible rays.	*Remora*
Body stout, pectorals rounded, their rays stiff.	*Rhombochirus*

224. **Shark Remora**
Echeneis naucrates Linnaeus

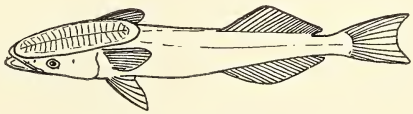


Distribution: Not uncommon in summer, July 7 to October 11. *Woods Hole,* not uncommon in summer. *Orient,* a specimen taken every year or two. *New York,* not uncommon, July 7 to October 11.

Occurs in warm seas, cosmopolitan, north to Cape Cod (casually Massachusetts Bay). Locally it is usually found attached to ground sharks (*Carcharhinus*). Occasionally attaches itself to other large coastwise fishes, as the tarpon.

Size: Reaches 38 inches total length, weight 1¾ pounds. (Orient.)

225. **Off-shore Remora**
Remora remora (Linnaeus)

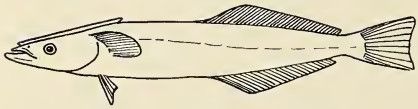


About 18 cross plates in the sucking disc, and 23 rays in the dorsal.

Distribution: Casual, usually attached to large sharks. *Woods Hole,* September 14, 1898. *New York,* casual. Three recorded in Sandy Hook Bay, July 30, and September 4, 1925, all attached to loggerhead turtles (*Caretta caretta*).

Occurs cosmopolitan in warm seas, more pelagic than *Echeneis*, casually north to Salem, Mass.

Size: Reaches a length of 15 inches.



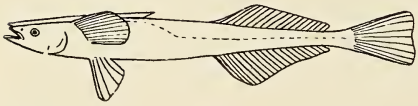
226. **Swordfish Remora**
Remora brachyptera (Lowe)

14 to 16 cross plates in the sucking disc, 29 to 32 rays in the dorsal.

Distribution: Rare at Woods Hole.

Occurs cosmopolitan in warm seas, occasionally north to Cape Cod, and probably more than casual in the Gulf of Maine also, where the swordfish is of regular occurrence, though records north of Massachusetts Bay are few. Has been taken from the gill cavity of the sea sunfish *Mola mola*, and is more frequently found clinging to the shoulders of the swordfish.

Size: Reaches a length of about one foot.



227. **Spearfish Remora**
Rhombochirus osteochir (Cuvier)

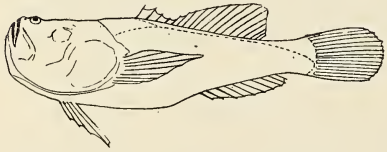
Distribution: Woods Hole, 2 records, one of these August 6, 1886.

Occurs in the West Indian fauna, north to Cape Cod. Attaches to spearfishes and sailfishes. Can frequently be picked up among the sailfishes landed on the dock at Miami, Florida. Hence it may be deduced that it sometimes attaches within the gill cavities of these fishes. Attached to the outside it would likely drop off and be lost earlier. Two large ones (gray instead of the usual tan color) taken from gill cavity of *Tetrapterus imperator* off Bimini, Bahamas (Van Campen Heilner).

Size: Reaches a total length of 8½ inches.

STAR-GAZERS

Sluggish, southern bottom fishes, with large heads, chunky bodies, rounded fins, a small spinous dorsal. Head squarish; eyes on top of head, far forward. Mouth vertical.



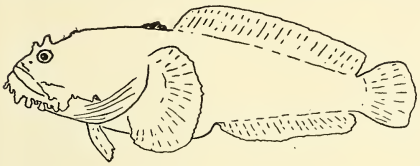
228. **Spotted Stargazer**
Astroscopus guttatus Abbott

Distribution: Accidental, fall, New York.

Occurs from Virginia casually north to Long Island.

TOADFISHES

The toad-fish is a big-headed depressed tadpole-shaped fish with a big transverse bulldog mouth. The fins are normal and rounded, the pectorals not placed on short arm-like bases. Ventrals decidedly anterior to pectorals, spinous back fin very small.



229. **Toadfish**
Opsanus tau (Linnaeus)

Distribution: Common permanent resident. *Woods Hole*, common permanent resident. *Orient*, abundant resident but not recorded from the Sound; hibernates in mud from first frost till April. *New York*, common permanent resident.

Occurs from Cape Cod (casually Maine to Cuba). Generally distributed in shallow water, frequently hiding among weeds or under stones.

One frequently finds a toad-fish isolated in some pool of water left by the falling tide, but it is dangerous to try to catch such an individual by hand, because of the chance of receiving a severe bite. One may frequently see them lying on the bottom beside some pier; when in such a position, if they be annoyed with a stick they will sometimes fasten their jaws—with firmly set short blunt teeth—upon it so tenaciously that they may be lifted out of the water.

At Orient, thousands hibernate in the mud in Long Beach Bay. They disappear in the mud at the first frost, and regardless of weather thereafter rarely appear till April. This species takes the hook freely, baited with fiddler crabs. It is stated that it makes a grunting sound, especially at night, or if handled.

Despite its pugnacity, the red-breasted merganser has been known to swallow a toad-fish of 130 mm. total length, head first and whole.

Food: Feeds on crustacea, small fish, mollusks, worms, etc.

Life History: One or both parents guard the eggs, usually placed in some crevice, empty shell, tin can or old shoe, until hatched. The young hide among weed before taking up life on the bottom.

The toadfish spawns during June and July. A medium sized female in the New York Aquarium deposited 60 eggs on July 12, 1921, when the water temperature averaged 67° F. The eggs were attached to the glass sides of the aquarium in a single-layered cluster by their prominent adhesive discs which at once distinguishes them. In a state of nature the eggs may be attached to any submerged object. The eggs are large, averaging 5 mm. in diameter and are of a deep amber color. Development proceeds as in the typical teleostean egg and incubation occupies from 10 to 26 days depending on the temperature. On hatching, the larval toadfish do not leave

their place of attachment but remain adhering by means of the yolk sac until it is absorbed. At this time they are about 16 mm. in length and resemble the adults in all essentials. Apparently by the next summer they may attain a length of about 90 mm. Their age and size at maturity is not definitely known, although the average breeding fish is about 230 mm. long. A length of 280 mm. (11 inches) is recorded but such a size is very unusual.

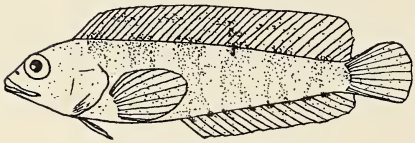
Size: Reaches a length of 15 inches.

BLENNIES

There are two types of blennies, a northern and a tropical type, both of which are represented in our fish fauna. The former have body elongate and compressed, band or eel-shaped, a well marked rounded caudal fin, long low dorsal occupying the whole back, its rays spinous.

The southern type of blennies are small bottom or weed fishes, ventral fins placed farther forward than breast fins. With or without scales, but our single species scaleless. They have spines and also a variable number of rays in the dorsal fins, sometimes separated into a spiny and soft portion, but when so the two joined at the base.

a. Scaleless. Dorsal of 11 spines and 19 soft rays body not elongate. *Chasmodes*
   Covered with minute smooth scales. Dorsal entirely of spines. Body more elongate (see b).
b. No lateral line. Depth 7 or 8. Dorsal spines between 70 and 90. *Pholis*
   Two lateral lines. Depth about 5. Dorsal spines between 40 and 50. *Ulvaria*



230. **Striped Blenny**
Chasmodes bosquianus (Lacépède)

Distribution: *New York*, occasional.

Occurs from New York to Florida.

Common in shallow water, the young very concealingly colored, hiding among weed.

Size: Reaches a length of about 5 inches.

231. **Rock-eel**
Pholis gunellus (Linnaeus)

Distribution: Abundant permanent resident to the eastward and uncommon in winter to the westward. *Woods Hole*, permanent resident, abundant along shore in early spring, at other times only in moderately

deep water (3–13 fathoms). *Orient*, young occur in winter, October 22 to June 13 (June 20), common in early December. *New York*, uncommon, autumn and winter (January). Our eastern borders lie within the permanent range of this northern fish. The migration of the adults appears to be to and from the shore. That of the young more along the coast.

Occurs on the coasts of the North Atlantic, south to Woods Hole (rarely New Jersey) and France. This fish is common along shore, usually in shallow water, hiding in the crevices of rocky or pebbly ground and in seaweed. It is agile and eel-like in its motions.

Elements of the characteristic color pattern of this species are a series of small black pale-rimmed blotches along the base of the dorsal fin, extending onto the same, and a banded anal. The general color is olivaceous or grayish. An individual spewed up in a barrel containing cod and haddock from 15 or 18 fathoms of water off Camden, Me., was per contrast clear light red in color to match the ascidians (*Boltenia ovifera*), algae, etc., of that bottom.

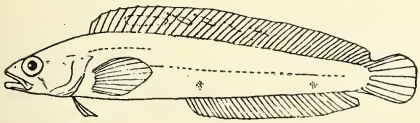
Food: Its food consists, so far as known, of worms, small crustaceans and molluscs.

Life History: Young taken in tow from April to July (Woods Hole). At Orient, total lengths of 3½ inches reported for November and December, 2½ and 5 inches for early June.

The rock eel spawns in the colder months of the year. The eggs are about 2 mm. in diameter, whitish opaque, iridescent on the surface, with a single oil globule, and are laid in holes or crannies where they stick together. Incubation occupies from 6 to 10 weeks and the young hatch at about 9 mm. They live at the surface until 30 or 40 mm. in length, and then sink to the bottom, in late summer or autumn.

We have seen a fish 4⅝ inches in total length, but recently dead, curved about its eggs within an empty oyster shell, and so brought to Nagele Bros. fish market, N. Y. from Peconic Bay in mid December; these eggs counted by Dr. E. W. Gudger as 686.

Size: Reaches a length of 12 inches.



232. **Ulva-fish**
Ulvaria subbifurcata (Storer)

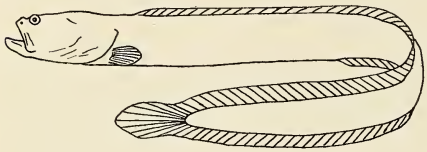
Distribution: Four living specimens recorded from the western portion of Vineyard Sound during July and August at depth of 5 to 12 fathoms. Vinal Edwards reports having found several (perhaps 10 or 12) of these fishes in the crop of a sheldrake, shot near Robinson's Hole, December or January, 1907–8.

Occurs in the North Atlantic, south to Cape Cod, very rare southward. Found among seaweed and under stones, from low tide mark down to at least 30 fathoms.

Size: Local specimens have been between 1 and 4 inches long, the species grows to 5⅜ inches, perhaps considerably longer.

GHOST-FISHES

Body elongate, rather eel-shaped, but with a well differentiated caudal fin, rounded or bluntly pointed. Head large, squarish, the eyes placed high and far forward, the mouth large, vertical.



233. **Ghostfish**
Cryptacanthodes maculatus Storer

Distribution: Occasional in winter, December and January. *Woods Hole*, occasional, December and January. *New York*, occasional. Occurs from Labrador to Long Island Sound.

Food: Its food consists of crustaceans, mollusks, and fishes.

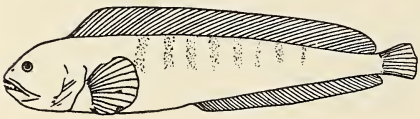
This is a bottom fish occurring from the shore down to considerable depths. It has been found inhabiting burrows in a mud flat, from above low water mark downward, "each system of burrows, inhabited by only one fish, consisted of branching tunnels about 5 cm. in diameter and from 3 to 8 cm. below the surface, originating from a more or less centrally placed mound in which was the main entrance, with other smaller openings along the tunnels and at their terminations."—(Bigelow and Welsh).

Life History: A winter spawner in the Gulf of Maine for Bigelow and Welsh have obtained its late larvae and fry ranging from 18 to 40 mm. long there in spring. Young of 21 or 22 mm. are relatively less elongate than the adult, caudal fins larger and square, mouths still nearly horizontal. They are thickly speckled above with dark brown dots which become sparser on the lower sides.

Size: Reaches a length of about 3 feet.

WOLF-FISHES

Body elongate, compressed, but scarcely eel-shaped. Back fin long and high, the rays all flexible spines. A separate rounded caudal fin. Mouth with conspicuous large canine teeth.



234. **Wolf-fish**
Anarhichas lupus Linnaeus

Distribution: Rare. *Woods Hole*, rare, *New York*, rare.

Occurs on northern shores of the North Atlantic, south to Cape Cod (rarely New Jersey) and France.

The wolf-fish is a solitary species, rather common to the northward, living on rocky or stony bottom, usually in rather deep water. It is a weak swimmer, moving in an eel-like manner. When caught it snaps viciously with its formidable teeth and with excellent aim. Though repellant in appearance it is an excellent table fish.

Food: Consists of hard-shelled molluscs, crustaceans and echinoderms.

Life History: The spawning season of the wolf-fish is in winter. Its eggs are very large, 5.5 to 6 mm. in diameter, yellowish opaque, and are laid on the bottom where they stick together in large loose clumps among weed, stones, etc. The slender, transparent larvae are about 12 mm. long at hatching, with an enormous bag-like yolk sac inclosed in a net of highly developed blood vessels, which gradually shrinks as they grow, when first hatched they lie on the bottom resting on the yolk sac. They have been taken from 21 to 44 mm. long swimming free, the yolk absorbed, in March and April, at, or more often some fathoms beneath the surface. Compared to other species young wolf-fish drift at the mercy of the currents, at most for a short period, or perhaps even sometimes not at all. Larvae of 20 to 22 mm. with large head, enormous eyes and tiny teeth, without definite separation between dorsal, caudal and anal fins, silvery on the sides at this stage, look very unlike the adult.

Size: Reaches a length of 5 feet and weight of about 30 pounds.

EEL-POUTS

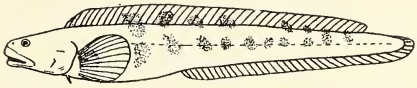
Not greatly elongate eel-like fishes. Dorsal and anal fins, of soft rays. Pectorals large and rounded; ventrals very small, at the throat. Lower jaw included.

Dorsal fin ending abruptly near tail, anal fin below continuous with caudal fringe. *Zoarces*

Dorsal and anal fins of equal height, confluent at tip of tail. *Lycodes*

235. **Shore Eelpout**

Zoarces anguillaris (Peck)



Distribution: Permanent resident, abundant in fall and winter to the westward. *Woods Hole*, less numerous than formerly. *Orient*, rare, March to June 4; October 12 to December 19. *New York*, resident, abundant in fall and winter.

Occurs from Labrador to Delaware.

In the vicinity of New York City the eel-pout is almost universally known to the fishermen as 'conger eel,' although this name rightly belongs to a true eel which is very dissimilar.

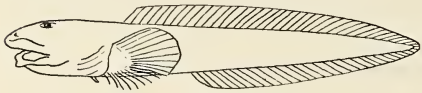
In Maine this fish comes close in to the shore and shallow water, more or less, in summer. In our region it is found in moderately deep water, with probably some inshore tendency in winter.

The break in the contour of the shore eel-pout's vertical fins just over the tail, where soft rays are replaced by a series of short spines, giving the fish a peculiar and diagnostic appearance, is apparently a defense adaptation. We have had this in mind in taking one from a hook, and noticing how it coiled back on itself, jagging the hand with these spines.

Food: Its food consists of molluscs, crustaceans and other invertebrates; to a less extent, fish.

Life History: Probably spawns in autumn. The eggs have been estimated as 1,800 in a female of 3¾ pounds, as against 200 to 400 in the otherwise closely related European fish of this genus which is ovo-viviparous, but the breeding habits of our form are not known. The growth of the eel-pout in the Bay of Fundy has been estimated as follows from a study of otoliths, —first year 1.5 to 4 inches, ninth year 16.4 to 20 inches, seventeenth year 24.6 to 27.2 inches, maturity reached when about 8 years old. If these estimates are correct it is an unusually long-lived fish.

Size: Said to reach a length of 3½ feet and weight of 12 lbs. Usual maximum between 2 and 3 feet.



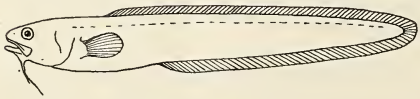
236. **Reticulated Eelpout**
Lycodes reticulatus Reinhardt

Distribution: Rarely taken in Vineyard Sound. Occurs on both shores of the North Atlantic, south to Narragansett Bay, in 17 fathoms of water and more.

Size: Reaches a maximum length of about 22 inches.

CUSK EELS

Elongate, compressed, eel-shaped fishes. Scales minute, inconspicuous. Back fin continuous with the anal fin around the tail; ventral fins each represented by a forked barbel placed at the chin or throat.



237. **Slippery Dick**
Rissola marginata (DeKay)

Distribution: *New York*, occasional, October to October 30.

Occurs from New York to Texas, not common. Frequents sandy shores, burrowing in the sand.

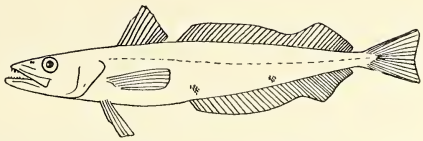
Size: Reaches a length of about 6 inches.

SILVER HAKES

Symmetrical, large-mouthed, silvery, free-swimming fishes. No spines in the fins or elsewhere. The caudal fin small, squarish, on a narrow peduncle. Two dorsal fins, the first short, the second long. Mouth large;

lower jaw projecting; with numerous strong, sharp, pointed teeth, larger than in the codfishes.

238. **Silver Hake**
Merluccius bilinearis (Mitchill)



Distribution: Permanent resident, abundant in October, November and December, uncommon or irregular at other seasons. *Woods Hole*, abundant in fall, October 3 to December, sometimes common in summer, recorded March 3. *New York*, usually abundant in fall, October 18 to December, sometimes in spring, May to June 1, uncommon in summer and present in winter.

Occurs from the Grand Banks to New York and to off the Bahamas in deep water, most abundant between Cape Sable, N. S., and Cape Cod.

The silver hake is peculiarly adaptable to depths of water being found from near the surface close in shore to depths of 300 fathoms, and it probably does not keep particularly close to the bottom. In the northern part of its range its principal seasonal movement is referable to spreading inshore with the approach of summer and retreating off shore in fall. Whether the numbers which invade our region in late fall work in from off shore as the water cools to suit their taste or are migrants from the northeast, must at present be left to conjecture.

This is a very nice table fish if eaten perfectly fresh, but soon softens.

Usually found over sandy or pebbly bottom. Frequently drives its prey so close inshore that both pursued and pursuer strand on the beaches, especially at night.

Food: A strong swift swimmer, very voracious, feeds on fish, also small crustacea, crabs (Woods Hole). A 23¼ inch specimen, Orient, November 12, had in its stomach 75 herring (*Clupea harengus*), 3 inches long.

Life History: Spawns in water of moderate depth. Young recorded 4 inches total length March 3, 6 inches total length June 9 and July 13 (Orient), 8 inches standard length, October 17 to 21 (Sandy Hook Bay). The spawning of the whiting or silver hake is at its height in July. The eggs are spherical, highly transparent and range from 0.88 to 0.95 mm. in diameter. They are buoyant. A large, deep yellowish-brown oil globule is present in the yolk. Incubation occupies about 48 hours at a temperature of 72° F., but this is water considerably warmer, than that in which they usually spawn, and the period should be longer in cooler water. The newly-hatched larvae measure about 2.8 mm. in length and are rather slender. The vent is immediately behind the yolk sac and lateral at the base of the ventral fin fold. Up to 23 mm. at least the caudal is rounded, not lunate as in the adult. By the time 30 mm. is reached most of the diagnostic characters of the adult have been attained, and probably the young take to the bottom at about this size, and during their first autumn.

Ripe fish averaging about 300 mm. (1 foot) in standard length are taken in Sandy Hook Bay in May and June. One such female of 12⅝ inches taken June 3, 1925 contained a squirrel hake 6 inches long standard, and three of its own kind measuring 4¾ to 5½ inches. These latter were no doubt yearlings, and those taken in the latter part of October which measure some 200 mm. (8 inches) must be of the same age class, having grown fast during the summer.

Size: Reaches 23¼ inches total length (Orient).

CODFISHES

Usually cold-water fishes, large or small, with fine scales; fins always spineless. The mouth is large, upper jaw usually slightly the longer, and often a small barbel at the chin. There are sometimes three separate dorsal and two separate anal fins, which is diagnostic when the case. Sometimes there are but two dorsals the first short, the second long occupying the remainder of the back, a single long anal fin. In this case the ventral fins are filamentous, placed far forward under the gill openings.

a. Three separate dorsal and two separate anal fins (see b).
One continuous anal, sometimes notched, dorsal not divided into 3 (see e).

b. Lower jaw projecting, tail fin somewhat forked. *Pollachius*
Lower jaw included, tail fin not forked (see c).

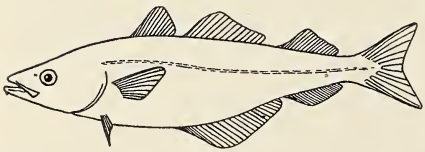
c. Mouth large, lateral line pale (see d).
Mouth small, lateral line black. *Melanogrammus*

d. Vent in front of second dorsal, size small, ventral fin narrow with a long filament at the corner. *Microgadus*
Vent below second dorsal, size large, ventral fin comparatively broad with a short filament at the corner. *Gadus*

e. Front of dorsal separated as a distinct fin (see f).
Front of dorsal continuous with remainder of fin. *Brosme*

f. Anterior dorsal of several rays, like those in second dorsal, ventral of two or three slender rays. *Phycis*
Anterior dorsal of a single ray followed by a band of fringes, ventrals with several rays (see g).

g. Barbels 3, at chin and at each nostril. *Gaidropsarus*
Barbels 4, one at tip of snout in addition to the above. *Rhinonemus*



239. **Pollack**
Pollachius virens (Linnaeus)

Distribution: Present at all seasons, adults uncommon, young common to the eastward, January through summer and fall. *Woods Hole*, adults

formerly common, now uncommon, May. Young first recorded January, most abundant April, a run in the fall. *Orient*, young common in summer, adults rare, recent records May 29 and June 14. *New York*, occasional, most often in winter, sometimes summer. Occurs in the North Atlantic south to Cape Cod, (rarely New York and casually Chesapeake Bay) and France.

The pollack is a more active fish than its congeners the cod and the haddock, and swims nearer the surface on the average, at any level between bottom and surface in fact.

Food: It congregates in large schools, and wanders widely in pursuit of feed, which consists mostly of fishes, but smaller crustaceans are also eaten extensively. Experiments on captive fish at Woods Hole have shown that it relies on keen sight more than scent in capturing food.

Young of about 5 inches total length in July and August observed feeding on the young of the squid (*Loligo pealii*) about 1 inch long (Orient).

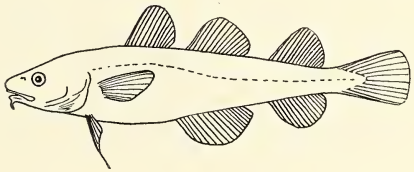
Life History: Spawns chiefly in depths of 15 to 50 fathoms. Young taken in the tow at Woods Hole from January to May, most abundant in April, about 1½ inches long. At Orient they average 5 inches total length July and August. These are probably fish less than a year old, which grow little during the winter, for young pollack average 5 or 6 inches long the second spring, 12 inches the third spring. Bay of Fundy fish when 3½ years old are 14 to 18½ inches long. The pollack may ripen when as small as 6 inches and most of them do so by the time they are 18 inches long. The annual rate of growth amounts to about 6 inches for the first two years, 4 inches for the next 2 or 3, then an annual increase of 1½ to 2 inches. Young pollack are common in the harbors of the Maine coast in summer.

This species spawns in October, November and December. The eggs are pelagic, non-adhesive and average about $1^1/_7$ mm. in diameter. The usual number per female is over 200,000 and the maximum over 400,000. At a temperature of 43° Fahr. they hatch in about 9 days and the yolk sac is absorbed in 5. The larvae are about 3.6 mm. long at hatching. At 12.5 mm. the caudal (lunate in the adult) is already slightly edentate. The average size of adult fish is 4 pounds and the maximum about 20 pounds.

Pollack tend to keep more to the surface than their associates of the same family.

Size: One of 21 pounds, length 36 inches, taken locally (Orient). The maximum recorded length in the Gulf of Maine is 3½ feet, weight about 35 pounds.

240. Tomcod
Microgadus tomcod (Walbaum)



Distribution: Abundant in winter, a few present in summer. *Woods Hole*, abundant in winter, taken throughout the year. *Orient*, common from September to May, rare in summer, often taken from mud in winter, seldom met with in the Sound. *New York*, abundant in fall, (October 17), early winter and sometimes early spring, uncommon in summer. In 1925, comparatively common all summer in Sandy Hook Bay, up to 10¾ inches in length.

Occurs from Labrador to Virginia.

In our region most of the tomcod move off shore in summer from the mouths of the streams where they have spawned, a sufficient distance to find deep water of an agreeable coolness. Further northeast they remain close to shore through the year. This species lives close to the bottom and depends, as proved by experiment, at leat to some extent, on its chemical senses to find its food. It is not a very active swimmer.

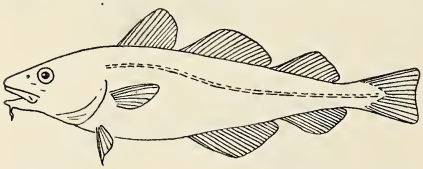
The tom-cod is a delicious pan fish and is fished for extensively in the colder months when it is running in shore to spawn. It can sometimes be taken in numbers from the wharves of the New York City waterfront. With a sleigh-bell on top of a spike stuck in the wharf, to which the line is attached, the boy fisherman may not only operate several lines at once, but keep his hands in his pockets if the air is frosty, and be advised by the cheerful tinkling of the bell whenever he has hooked a fish.

Food: Feeds on annelids, shrimps, amphipods and other small crustacea, also squid and various small fishes.

Life History: Spawns in December; young taken in the tow from January to April, most frequently March and April (Woods Hole).

The tomcod spawns near shore or in streams which are sometimes practically fresh from November to February. The ova are heavy, non-adhesive and average about 1⅔ mm. in diameter. The average number deposited is about 25,000 and the maximum is nearly 44,000. Hatching occurs 35 days after oviposition at a temperature of 40° Fahr. The larvae, at hatching are about 5 mm. long, larger than those of the cod. Four days later the yolk sac is absorbed and the little fish must forage for itself. It reaches a length of 2½ to 3 inches by the following autumn. This species seldom exceeds one foot in length.

Size: Reaches 15 inches total length, 1¼ pounds. weight, usually smaller. In June in Sandy Hook Bay adults average about 10¼ inches in standard length, a smaller group in fall ranges from 5 to 9 and averages about 7 inches.



241. **Cod**
Gadus callarias Linnaeus

Distribution: Resident to the eastward, to the westward only found in winter, except stragglers; abundant. *Woods Hole*, abundant, keeping in

deep water in winter and summer but coming to shore in fall and spring. April 1 to mid-May, October to wintry weather. *Orient*, winter resident, October 22 to June 7. *New York*, sometimes abundant, September 28 to May 29, small specimens ('rock cod') occasional in summer.

Occurs in the North Atlantic south to Virginia and France.

As regards wanderings and migrations, cod may, it seems, be differentiated into two categories. Some are more or less resident, but the schools are constantly on the move. At the northern end of its range the species enters the cold shore waters only in summer, but in general there is a spawning migration inshore in winter. This may account in part for the winter cod at the western end of our region, but that they are in part referable to a distinct east-west migration is proved by tagging experiments at Woods Hole and Nantucket shoals, a method of investigation well worth carrying farther.

The cod ranges at least as deep as 250 fathoms, and also comes close in to the shore. As a rule it swims close to the bottom, rocky, pebbly or sandy preferred, soft mud avoided. In the pursuit of small fish or squid, however, especially the capelin, even adult cod sometimes come to the top of the water.

The use of the term 'rock cod' for small individuals differing in color from the general run of large fish, apparently does not always refer to an identical variation. On ledges off the Maine coast in August, where cod varying somewhat in size were being taken, some of the smallest individuals, 15 inches in total length, were red (speckling darker and redder, whole fish more pigmented). These were either on bottom with red algae, etc., or associated with red strands of kelp which they matched closely in tone; and with them were other fish, both larger and of the same size, of standard color. It was as though fish of about this size which had been living close to the kelp or weed, assumed the adult color, probably correlated with a wider range. Again a small, slender 'rock cod,' dark colored with light spots, more contrasted in appearance in a boatload of the standard form landed at Cape Ann in February, may have owed its differences to summer life inshore, though now taken in moderately deep water, and it seems to represent a more tangible ecological variation, though presumably one resting on the history of the particular individual.

As a general food-fish the cod is superior to its relatives, the pollack and haddock, although with special cooking they are also fine and may well be more agreeable to certain palates than the cod. The flesh of the pollack being comparatively oil-less, is improved by cooking with fat pork or some such material; that of the haddock, which has a tendency to be too firm and dry, is unsurpassed as the basis of a chowder.

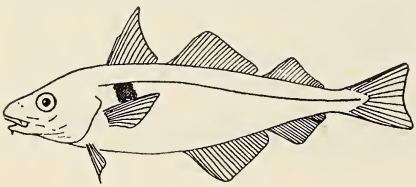
Food: Feeds on mollusks, worms, herrings, lants, crabs (the triangular *Hyas coarctatus* on ledges off the Maine coast), shrimps, brittle stars, and in fact any animal food that would recommend itself to a fish swimming over the sea bottom in hungry hordes; young observed feeding on copepods (Woods Hole).

Life History: Young ½ inch or more in length taken in surface tow in March, April and May. In the northern part of our range, at least, the spawning season of the cod-fish is an exceptionally long one, extending usually from October to April although a few stragglers are frequently recorded both before and after this range of winter months. It is probable that the spawning act is gone through by a large part of a school simultaneously, the genital products simply mixing in the general flurry of the act, as chance may dictate.

The relative percentage of the sexes varies greatly from one school to another and from season to season, although if an average were to be struck it would probably be found not vastly different, with a likely tendency towards a slight preponderance of males. Cod-fish do not deposit the entire amount of their spawn at one time, but allow the eggs to pass out as they ripen, possibly throughout the entire season.

Temperature seems to be the chief factor in the breeding of cod and the optimum is not far from 40° F. The spawning fish feed little or none and those taken by anglers are in most cases either unripe or spent, if mature. Spawning generally takes place in water over 10 fathoms deep. The eggs float up to the surface on extrusion. They are nearly transparent and usually have a slight greenish hue. They vary from 1½ to 1⅓ mm. in diameter with an average half way between. At a temperature of about 40° F. the eggs hatch in about 17 days. During the latter part of the incubating period the specific gravity usually comes to exceed that of the sea water and the eggs consequently sink before hatching. They hatch into fry about 4 mm. long, which, for a time, drift at the surface. Just when they leave the surface for the bottom is uncertain very likely at the age of 2 months or so and length of about an inch. By summer the young cod have reached a size of from 1½ to 3 inches in length; the second summer a length of from 9 to 13 inches; the third about 18 inches and the fourth about 22 inches. The females usually reach maturity in the fourth year whilst the males may reach that period a year earlier. The number of eggs produced by a single cod is enormous. A fish 3 feet 3 inches long and weighing 21 pounds may have ovaries weighing 1 pound 15¾ ounces, which have been estimated as holding 2,732,237 eggs. Seventy pound cod are recorded as producing over 9,000,000 eggs a season. When it is realized that the percentage that reach maturity about equals the parents the tremendous mortality rate for which nature allows is at once apparent.

Size: The largest on record was over 6 feet in total length and weighed 211¼ pounds. A 75 pound fish is a rarity, but those of 50 or 60 lbs. are not unusual.



242. **Haddock**
Melanogrammus aeglefinus (Linnaeus)

Distribution: Winter and spring, common off-shore and sometimes taken inshore to the eastward, uncommon to the westward, winter to May 14. *Woods Hole,* common off-shore sometimes taken inshore, March to May 14. *New York,* uncommon in winter.

Occurs in the North Atlantic on both coasts south to France and New Jersey, in deeper water to off Cape Hatteras.

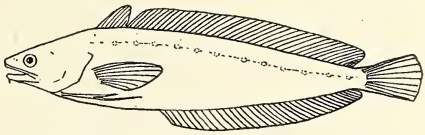
The habitat of the haddock corresponds closely to that of the cod, but it is a less adaptable fish, not extending quite so far north, quite so far south; into such shallow, or probably such deep water; or plentiful on such a variety of bottom. It is especially fond of the smooth areas between rocky patches, and also favors pebbly, gravelly, sandy, and certain types of clay bottom. It is more strictly a ground fish than the cod, and though it pursues the same schools of small fish, does not follow them to the surface. It is practically omnivorous, so far as the fauna where it occurs is concerned. The commoner mollusks, crabs, sea urchins and brittle stars are staples in its diet, and it must root out much of its food, such as burrowing mollusks and worms from the sea bottom, as pigs do. Haddock roam from place to place in search of food, and concentrate annually on their spawning grounds. Little is known of any migrations they may have beyond this, at least on the American coast.

Life History: Haddock seek more or less definite areas, often off shore banks, in between 20 and 100 fathoms of water, to spawn. They spawn from January to June producing eggs about 1½ mm. in diameter that are pelagic and very slightly agglutinous, at least when still young. A single female may extrude 100,000 to 2,000,000 eggs, according to size. Hatching takes place in 13 days at a temperature of 41° Fahr. The newly hatched larva is about 4 mm. long. The yolk sac is absorbed in about 10 days.

Young haddock live at the surface for three months or so, from 1 to 3 inches in length they have been taken associated with the red jellyfish (Cyanea). When 1 or 2 years old they are 5 or 10 inches long; when 4 or 5 years old 16 to 20 inches long; and they may spawn at a length of about 20 inches. They apparently reach a length of 2 feet when 7 to 9 years old, while spawning haddock feed very little, if at all.

Size: The usual size of the haddock is about 3 or 4 pounds more rarely up to about 17 pounds. The largest on record was 37 inches long and weighed 24½ pounds.

243. **Spotted Hake**
Phycis regius (Walbaum)



Small anterior dorsal fin triangular, not ending in a filament.

Distribution: Rather uncommon, mostly in the fall, September to December 18, also in the summer, May 19 to August. *Woods Hole,* uncommon, November, dredged in August. *Orient,* uncommon, November,

dredged in August. *Orient*, uncommon May 19 to August, sometimes common, September to early December. *New York*, uncommon, September to December 18.

Occurs from Cape Cod (casually Halifax) south to Cape Fear, N. C., ranging from shallow water to a depth of 167 fathoms.

The young of the spotted hake may be found on the bottoms of rather deep, muddy bays at any season. Its principal food is various fishes (herrings, launce, etc.) and squid.

The reputed power of this species to give electric shocks is probably unfounded, as no well developed electric organs appear to be present, and there are no well authenticated records.

Life History: Found spawning in December (off the Carolinas).

Size: Reaches a length of about 18 inches.

244. **Boston Hake**
Phycis tenuis (Mitchill)

Small anterior dorsal fin ending in a filament. Filamentous ventral fin not quite reaching anal. About 138 scales in a lengthwise series.

Distribution: Abundant spring and fall, transient or winter resident to the westward, young taken throughout summer to the eastward. *Woods Hole*, abundant, especially in October and November, young common throughout the summer. *Orient*, September 25 to May 6. *New York*, uncommon, April to May, September to December.

Occurs from the banks of Newfoundland to Cape Hatteras, abundant northward in rather deep water, and recorded to a depth of 304 fathoms. A bottom-loving fish, frequenting muddy bottoms. Worms have been found in its stomach (Woods Hole).

The principal items in the hake's food appear to be shrimps and such comparatively soft crustacea, squid, and a variety of small fish. They have keen sight for any moving object, but appear to locate much of their food by swimming close to the bottom, the tips of their threadlike ventrals dragging, acting as tactile organs. Hake bite best at night and are doubtless more or less nocturnal or crepuscular in their feeding. In Camden harbor, Maine, after fishing for some time without a bite, a small one was taken at dusk, the light beginning to fade in the west. In the same locality they were, however, taken in the daytime, still at the time, the sky covered with low hanging clouds, thick outside.

Life History: Taken with ripe eggs in July (Woods Hole). Specifically unidentifiable larval *Phycis* (17 to 22 mm. total length) were sufficiently numerous at the surface of the ocean off Long Beach, Long Island, September 30, to be thrown on the beach by an on-shore wind. They had the appearance of other small surface fishes of the same size, as young bluefish,

larval mullet, etc., narrowly dark along the back, otherwise bright silvery, the silvery iris with a decided blue tinge.

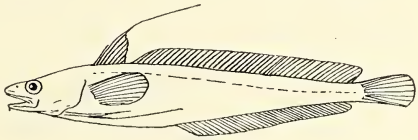
These would seem to have been the same as specimens of *P. tenuis*, 59 to 66 mm. standard (67 to 76 mm. total) length, just losing the silvery color, collected in shallow water at the shore, Shark River, New Jersey, May 26. Mr. Van Campen Heilner, the collector, reported them common at that date and gone shortly thereafter. Such specimens might easily be mistaken for *P. chuss*, as ventral filament reaches origin of anal, and scales are too little developed to be readily counted. Compared with *chuss* of the same size (49 to 65 mm. standard length) their ventral filaments are decidedly shorter, body decidedly deeper, head longer.

An individual 8¼ inches total length has been taken in the shore waters of Long Island Sound at Duck Island, Connecticut, August 11. At about this size the hake is more or less a harbor fish, common in harbors of the Maine coast, taken at Camden in August from 5½ to 11 inches standard length. One of 8 inches had the following colors; above brown, sides brassy tinged with purple; belly and ventrals contrastingly white; iris dark brown with a pale inner thread; second dorsal and anal dark grey narrowly edged with dusky; caudal a little browner; first dorsal dark, its filament pale; a dark streak bordered on each side by pinkish white extending back below eye from center of upper jaw. In the 11-inch specimen especially, the brassy color of the sides also appeared in vague spots in the brown on the back.

Young are said to be taken at Woods Hole in summer at the surface under the eelgrass and gulf weed, but it may be suspected that these are another species, perhaps *P. regius*. The young of *P. floridanus* (related to *regius*) are common hiding in gulf weed off the east coast of Florida in early February, about 1½ inches in total length and matching the weed in color.

Size: Reaches a maximum length of about 3½ feet, weight 30 pounds.

245. **Squirrel Hake**
Phycis chuss (Walbaum)



Small anterior dorsal fin tipped with a filament. Filamentous ventral fin reaching past front of anal. About 110 scales in a lengthwise series.

Distribution: Abundant, probably resident, but most numerous May to June 26, October to December 31. *Woods Hole*, abundant May and June, again October and November, dredged July and August. *Orient*, uncommon spring and fall, occasionally in summer. *New York*, common, June 26. October to at least December 31, probably present at all seasons.

Occurs from the Gulf of St. Lawrence to Virginia and out to a depth of 300 fathoms.

Food: Feeds on shrimps, amphipods and other small crustacea, also small

fish (Woods Hole). In May and June they are common in Sandy Hook Bay and almost invariably distended with stomachs crammed with *Crangon* and similar crustaceans.

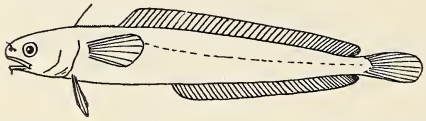
Life History: Spawns in summer. The eggs are buoyant, spherical, transparent, and about ¾ mm. in diameter. Found with nearly ripe spawn in July; young, perhaps this species taken in tow, February to October, most abundant March to July (Woods Hole). If there is a silvery surface stage as in *P. tenuis*, the young assume adult characters and descend into deep water at a much smaller size.

"During the oceanographic cruise of the U. S. Fisheries Schooner *Grampus* in the summer of 1913, large quantities of the Giant Scallop were dredged at many points on the continental shelf between Nantucket Lightship and the Virginia Capes. In a number of instances these scallops were found to contain young examples of squirrel hake, *Urophycis chuss* (Walbaum), ranging in length from 27 to 70 mm. With one exception all were taken in the region between Montauk Point and Cape May, and within the 20 fathom curve. The only occurrence at a greater depth was in 42 fathoms, 52 miles S.S.E. from Montauk Point.

"Whether these young hake habitually live within the mantle cavity of the scallop, or whether they merely use it as a refuge on the approach of an enemy, is not known. The latter hypothesis appears to be the more plausible one. In the six dredge hauls in which young hake were thus taken, 27 examples were obtained from 59 scallops. In one instance, 11 hake were obtained from 9 scallops" (Welsh, *Copeia*, No. 18, 1915).

In late November the writer found comparable young (49 to 65 mm. standard length) rather common in about 20 fathoms of water off New York hiding in the mantle cavity of the scallop, as here described.

Size: Reaches a maximum length of 27 inches, weight 6 or 8 lbs. In May and June, in Sandy Hook Bay, females predominate, ripe or nearly so, which range from 8¼ to 15 inches standard length, with an average of about 9⅞ inches.



246. **Four-bearded Rockling**
Rhinonemus cimbrius (Linnaeus)[15]

Distribution: Uncommon at Woods Hole, January to April 17, and young in tow net during June and July.

Dr. C. H. Townsend, dredging in Long Island Sound with the 'Fish Hawk,' between June 20 and July 2, 1914, records (Mss.) the rockling as very generally distributed from off Bridgeport and Smithtown Bay to off Larchmont at depths of from 5½ to 19 fathoms. At a somewhat greater

[15] The silvery rockling, *Gaidropsarus argentatus*, was recorded by Goode from Vineyard Sound. It is a far northern species and its occurrence in our region needs confirmation, especially in view of the little known silvery larval young of related fishes.

depth of 21 fathoms off Huntington Bay (a single haul) it was very abundant, at the same time he took the four-spotted flounder, shore eel-pout and silver hake in lesser numbers.

Occurs in the North Atlantic on both coasts, south to Narragansett Bay, and the latitude of Cape Fear in deep water along the continental slope.

A deep water bottom fish, known down to 724 fathoms, and uncommon inside the 25 fathom contour. Not a rock fish, found chiefly on soft bottom.

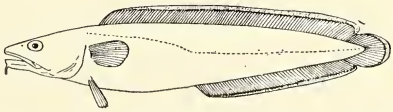
Food: Consists of shrimps, amphipods, bivalves, mollusks (Woods Hole).

Life History: The young "mackerel midges" are silvery, unlike the adults in appearance, as in various other bottom fishes which have pelagic surface young.

Spawning takes place through the summer. The eggs are buoyant, about ¾ mm. in diameter. Newly hatched larvae are slightly more than 2 mm. long. From about 5 to 10 mm. the larvae are characterized by very large black ventral fins, by the presence of one post-anal dark cross band, and by the short stocky body form. After a length of 17 to 20 mm. has been reached, the structure of the first dorsal fin can be made out. These larger fry are silvery, while still swimming at the surface.

Size: Reaches 10 inches in length (Woods Hole), and 16½ inches is reported from Scandinavian waters.

247. **Cusk**
Brosme brosme (Müller)



Distribution: Formerly not uncommon in April and May at Woods Hole, now very rare.

Occurs northward in the North Atlantic, south to Cape Cod (rarely New Jersey in deep water) and Denmark. The cusk is a solitary bottom fish occuring from 10 or 15 down to 500 fathoms (not so deep in American waters) and favoring rocky ledges or gravelly ground. It is a sluggish swimmer and probably wanders or migrates little if at all. A powerful fish, none the less, when hooked it coils about the line in a troublesome way.

Food: It feeds on crustaceans (such as crabs) mollusks, worms, and probably fish to some extent.

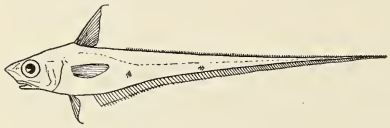
Life History: The spawning season is in spring and summer. More than 2,000,000 eggs have been counted in a female of medium size. The eggs are buoyant, 1.3–1.5 mm. in diameter, with a single oil globule of a brownish or pinkish color, and the entire egg surface finely pitted. The larvae are about 4 mm. long at hatching, the yolk is absorbed at about 5 mm. a week or so after hatching. As they grow the ventral fins elongate like those of young hake and young rockling, and become black, cusk larvae are separable from both of these by the independent ventral rays and presence of 3 black patches, one on top of the head, a second over the gut, a third at the tip of the tail, and 2 vertical black bands which divide

the trunk behind the head into 3 nearly equal sections. The young live near the surface, pelagic, until 2 inches or more long, becoming greenish yellow with blue eyes, not silvery like young rockling and Boston hake.

Size: Reaches a maximum length of 3 feet, and weight of about 30 pounds.

THE GRENADIERS

Fishes found in deep water at the bottom, with broad angular heads, usually pointed snout, large eye, tail region elongate and ending in a point.



248. **Rat-tail**
Macrourus bairdii Goode and Bean

Distribution: This abundant deep-sea fish which ranges to depths of over 1000 fathoms, has been dredged as a straggler in 9 fathoms of water, Vineyard Sound, August 26, 1882.

Occurs from the Gulf of St. Lawrence (rarely), south to the West Indies. A bottom fish usually found on soft mud, and a very feeble swimmer.

Size: Reaches a length of about 2 feet, usually about one foot long.

FLOUNDERS.

Fishes with body flattened from side to side to lie on the bottom. The lower side is more or less (usually entirely) white or colorless, both eyes are on the upper side. Always a pectoral fin in the upper side.

a. Ventrals symmetrical, similar in size, form and position; mouth large, symmetrical (see b).
Ventrals symmetrical; mouth small, twisted; eyes and color on the right side in our species (see d).
Ventrals unlike, that of the eyed side extended along the ridge of the abdomen. Eyes and color on the left side (see e).

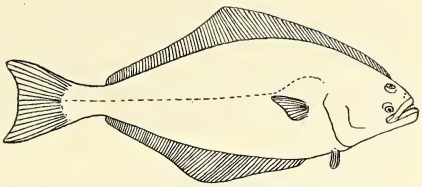
b. Sinestral,—eyes and color on the left side. *Paralichthys*
Dextral,—eyes and color on the right side (see c).

c. Caudal fin lunate, anal rays more than 75. *Hippoglossus*
Caudal fin double truncate or rounded, its median rays longest. Anal rays fewer than 75. *Hippoglossoides*

d. Lateral line with a distinct arch in front. *Limanda*
Lateral line without a distinct arch in front. *Pseudopleuronectes*

e. Lateral line with a distinct arch in front. Scales smooth. Mouth large. *Lophopsetta*
Lateral line with a distinct arch in front. Scales rough. Mouth moderate. *Platophrys*
Lateral line without distinct arch in front. Mouth very small. *Etropus*

249. **Halibut**
Hippoglossus hippoglossus (Linnaeus)



Distribution: Rare in winter, to April, formerly not uncommon near Woods Hole. *Woods Hole*, rare, formerly not uncommon, a few taken regularly in April. *Orient*, one taken April, 1910, another several years previous to that. *New York*, occasional, winter.

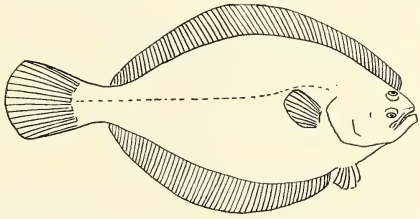
Occurs in northern seas, circumpolar, southward, usually in deep water, to Sandy Hook on our coast. Though once common on the northern New England coast, the halibut is now practically fished out there.

Food: It is a voracious species preying chiefly on other fishes (cods, sculpins, grenadiers, herrings, launce, capelin, flounders a principal item, skates, wolf-fish, mackerel, etc.), also crabs and lobsters, clams and mussels, and even occasionally sea birds (alcidae). The halibut in tern is eaten by seals, and is a staple article of diet for the Greenland shark. Halibut sometimes rove the bottom in bands in search of food.

Life History: The halibut is believed to spawn in February on the eastern side of the Atlantic, ripe fish are reported from spring to early fall on the American side. The eggs of a fish of about 200 pounds have been estimated as over 2,000,000. They are between 3 and 4 mm. in diameter. Young halibut swim near the surface for some months after hatching and take to the bottom at a length of 4 or 5 inches or earlier. At 1½ inches, the larva is still pelagic and the upper eye has not completed its migration from the blind side.

Size: Reaches a total length of slightly over 9 feet and weight of about 700 pounds; but very rarely taken over 450 pounds.

250. **Sand Dab**
Hippoglossoides platessoides (Fabricius)



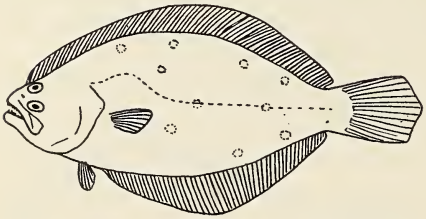
Distribution: Uncommon at Woods Hole, February.

Occurs on both coasts of the North Atlantic, south to Cape Cod and Narragansett Bay. The sand dab occurs in moderately deep water, 10 fathoms or over. It avoids rocky or hard bottom on the one hand and very soft mud on the other, preferring a mixture of sand and mud. It usually lies on the bottom, but on occasion swims some distance up in the water, for just what reason we do not know.

Food: When larval at the surface it feeds first on diatoms, and on copepods as it grows larger and more active. Small ones on the bottom feed chiefly on shrimps and such small crustaceans; as they grow largere chinoderms (sea urchins and brittle stars) are an important item of diet, a great variety of invertebrates is eaten by the sand dab, and small fish occasionally caught by it.

Life History: Spawns in spring, from March to June in the Gulf of Maine, producing 30,000 to 60,000 eggs according to size. The eggs are buoyant, without oil globule, with a perivitelline space so broad that they are not apt to be confused with any other species, averaging about 2.5 mm. in diameter. Incubation occupies 11 to 14 days at a temperature of 39°, and hatching takes place when the larvae are 4 to 6 mm. long, the yolk being absorbed about 5 days later. The period occupied in larval growth varies with temperature; 3 or 4 months a fair estimate for the Gulf of Maine where the pelagic larvae have been taken from May to late summer. The eye commences its migration from the blind side when the larva is 20 to 35 mm. in length and metamorphosis is complete and it commences its life on the bottom at an estimated length of 1½ to 2 inches up to the time of its metamorphosis it lives pelagic, keeping close to the surface at first but sinking deeper as it grows. Like many other pelagic animals it sinks more or less regularly by day, to rise toward the surface again at night. The growth of the sand dab varies with the temperature of the water. It takes some 3 to 5 years to reach a length of 12 inches, some become sexually mature when only 6 inches long, probably all do so by their third year, and an age of 24 to 30 years may be reached.

Size: Reaches a length of about 2 feet and weight of 7 pounds.



251. **Summer Flounder**
Paralichthys dentatus (Linnaeus)[16]

Without definite large dark ocellated spots. 15 or 16 gill-rakers on the lower limb of the first arch.

Distribution: Abundant in summer, April 16 to December 27. *Woods Hole*, abundant, May 10 to October 15. *Orient*, common, April 16, 1913 (average April 28) to December 27, very early and very late ones of large size. *New York*, abundant, May 7 to November 21.

Occurs from Cape Cod (casually Casco Bay) to South Carolina (perhaps Florida). Is found in shallow inshore waters and bays in summer, in the northern part of its range moving out into deeper water in winter.

[16] The closely related southern flounder, *Paralichthys lethostigmus*, with about 10 gill-rakers versus 15 or 16, has been recorded from New York, very likely in error.

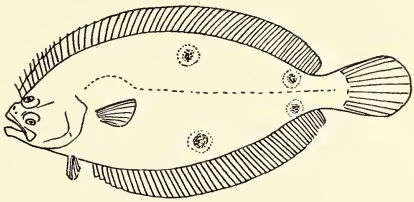
Generally distributed, particularly numerous on sandy bottoms, also found on mud and among eel grass. It takes it but an instant to bury itself in the sand where it is frequently seen lying covered all but the eyes.

Food: Feeds on crustacea, particularly shrimps and crabs, worms, squid, small mollusks and to a considerable extent on small fishes which it sometimes pursues right up to the surface.

Life History: A spent female seined on June 21. Young, 2 to 6 inches in standard length, frequent near shore in the summer months.

Size: Has reached a weight of 26 pounds and estimated length of 46 inches, and one taken off Fishers Island about 1915 by an Orient beam-trawler, weighed 30 pounds . Average run of fish, 2 to 5 pounds. In Sandy Hook Bay they average between 12 and 15 inches in length.

252. **Four-spotted Flounder**
Paralichthys oblongus (Mitchill)



Four large dark ocellated spots on the colored side, one pair in the neighborhood of the middle of the body. and another pair closer together, placed more posteriorly.

Distribution: Common to the eastward in summer and fall, May 18 to December 12, also to the westward in somewhat deeper water. *Woods Hole*, common in May and June, most abundant about June 1. *Orient*, uncommon, May 18 to December 12. *New York*, common in rather deep water (November). One (casual) in Sandy Hook Bay on June 2, 1925.

Occurs on the coasts of southern New England (casually north to Gloucester, Mass.) and New York, on sand and mud bottom usually in from 7 to 17 fathoms.

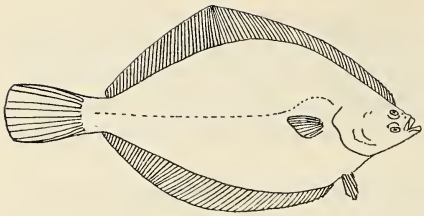
Dr. C. H. Townsend, dredging in Long Island Sound with the U. S. S. *Fish Hawk* between June 20 and July 2, 1914, records (Mss.) frequent captures of the four-spotted flounders at depths of from 6 to 21 fathoms. At the same time he took a few silver hake and shore eel-pout, and the rockling in greater numbers.

Food: Feeds on small crabs, shrimps and other small crustacea, annelids, mollusks and small fish (Woods Hole).

Life History: The spawning season of this species is at its height in May in the northern part of our territory. Buoyant non-adhesive eggs about 1 mm. in diameter are extruded and hatch in about eight days at a temperature of about 53° F.

Young of 2 to 3 inches have been taken at Woods Hole in autumn, showing that this flounder takes to the bottom about 3 months after hatching.

Size: Reaches a total length of 15 inches, weighing 13 ounces (Orient).



253. **Rusty Dab**
Limanda ferruginea (Storer)

Distribution: Common resident in rather deep water. *Woods Hole,* common throughout the year at depths of 10 to 12 fathoms, a few along shore. *New York,* common in rather deep water (November).

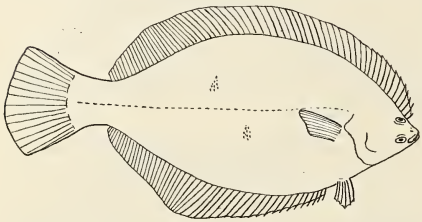
Occurs from Labrador to New Jersey. Partial to sandy bottoms.

The rusty dab is found on sandy or mixed sand and mud bottoms at moderate depths, 5 to 50 fathoms.

Food: Various small crustacea, also annelids, mollusks and small fishes. Fish in breeding condition usually are empty.

Life History: Spawns in spring and summer, the individual females spawning over a considerable period of time. The eggs are buoyant, without oil globule, spherical, very transparent, with a narrow perivitelline space, about 0.9 mm. in diameter. The surface of the egg is covered with very minute striations, and the germinal disk is of a very pale buff color. Hatching takes place in 5 days at a temperature of 50° to 52°. Larvae of 11 mm. are still symmetrical, at 14 mm. metamorphosis is under way, and presumably the pelagic life of this species is short compared to that of some other flounders.

Size: Reaches a length of 21¾ inches.



254. **Winter Flounder**
Pseudopleuronectes americanus
(Walbaum)

Distribution: Abundant resident. *Woods Hole,* abundant resident. *Orient,* abundant from October to May; uncommon in summer, but more common in deep water. *New York,* abundant resident.

Occurs from Labrador to Georgia.

Found on all sandy or muddy bottoms, from the shore (at all seasons) to at least 20 fathoms (in fall). Mud broken by patches of eel grass is perhaps the favorite ground, but it is common enough on sand and even pebbly bottom. It sometimes lies buried in the mud, all but the eyes, and spends most of its time lying motionless, but can dash for a few yards with surprising rapidity, when disturbed, or to seize some luckless shrimp. In-

dividuals living on the flats are usually quiescent over the low tide and become more active on the flood, moving about in search of food.

Sailing across some flats in a light air with every detail of the bottom in a very few inches of water plainly visible, it was interesting to note the behavior of small flounders which darted swiftly away for a very short distance and then settled motionless on the bottom. Unlike animals which are in like manner protected by concealment usually behave thus, for instance the woodcock which flies a short distance and settles again on the brown leaves.

Flounders run very early in the spring in the vicinity of New York and are the first fish caught by rod-and-line anglers from the city. They are abundant in most of our shallow or muddy bays and accessible to many who have no chance to angle for other species.

This species moves off shore to some extent to find deeper cooler water in summer, but is rather common even in the shallow bays and in the warmer months. About August 1, 1917, there was an unusually heavy mortality of *Pseudopleuronectes americanus* in Moriches Bay, Long Island, N. Y. This is a broad, almost tideless bay, but much of it is very shallow (extensive flats having but a few inches of water) and it is decidedly brackish. The channels coming in from the west through the narrows which separate this from Great South Bay, are salt enough, but some of the landward spring-fed "creeks" are pure fresh water, and the water on the seaward side, under the beach, which separates bay from ocean, is surprisingly fresh. This condition is probably due to the fact that the opening of these waters to the ocean is twenty-five miles west at the farther end of Great South Bay, namely Fire Island Inlet.

Pseudopleuronectes is one of the few marine fishes found in the bay in numbers. An exceptional number of dead of this species were noticed on July 28, and on August 4 it was estimated that a thousand dead were seen. They averaged about 8 or 9 inches in total length. This high mortality was probably correlated with a period of unusually hot weather which that section had just experienced. It also should be borne in mind that this is a northern fish, which, though it extends to Chesapeake Bay and beyond, is less numerous, especially in summer, south of New York. Similarly, large numbers of winter-killed *Cyprinodon variegatus* have been seen on Long Island, a fish whose range is southern and extends northward only to Cape Cod.

Unfortunately no data is accessible as regards the temperature which accompanied the mortality of flounders, except the recollection that the locality was, more than it usually is, affected by the heat-waves then present. Data for July and August, 1917, at New York City, kindly furnished by the local office of the United States Weather Bureau gives an idea of the date and severity of these heat-waves. The mean daily temperature was above 75° on July 2 (77); again on July 16 to 17 (76, 78); on July 20 to 27 (76, 76, 76, 78, 78, 77, 78, 82); July 30 to August 2 (85, 89, 89, 84); August 7 (78); August 9 (78); August 13 (76); August 15 (76);

August 17 (77); August 20 to 21 (76, 76); August 24 (76); August 29 (76). —*Copeia, No. 55.*

Winter flounders taken on the coast of Maine in August had numerous small pinkish amphipod 'lice' (*Lafystius sturionis*) crawling on their upper surfaces, notably about the head and shoulders, and particularly the larger, fish, something which does not seem to have been noticed in flounders south of Cape Cod.

Food: Feeds on shrimps and other small crustaceans, annelids, mollusks, squid, and small fishes. Red sea weed recorded as a food (Woods Hole).

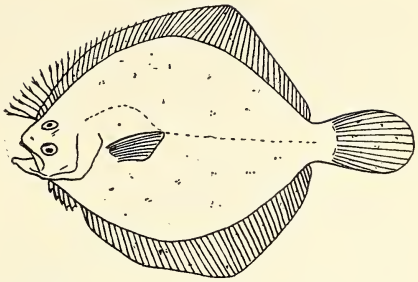
Life History: The winter flounder is a winter breeding fish, spawning usually at the coldest time of the year in rather shallow places of low salinity (often from one to two fathoms). December to March covers the bulk of the spawning. During this time they feed very lightly which fact accounts for the failure of anglers to catch them at this season in quantities. Examination of large quantities of spawning flounders failed to reveal more than mere traces of food.

In the latitude of New York City, angling stops about the middle of December and begins again in the latter part of February, while in New England the off season is from about November to March.

Individual females produce about 500,000 eggs annually and nearly 1,500,000 have been taken from a large one of 3⅜ pounds.

In confinement at least the spawning act is invariably performed at night, usually between 10:00 P.M. and 3:30 A.M. The eggs are minute, adhesive and heavy. They vary in diameter from .71 to .86 mm. The blastodisc is large and of a bright amber color whilst the yolk is colorless. On account of their adhesive nature they compress each other into more or less regular polyhedrons. The incubation is slow, the eggs not hatching in less than 15 days at a temperature of 39° F. Very little motion of the embryo was noticeable at any time. The eggs of this, as well as all other flounders, hatch into perfectly symmetrical fishes which swim in a normal position. On hatching, the larval winter flounder measures about 4 mm. in length. At the end of twenty-two days they are still perfectly symmetrical. They are pigmented with light yellow chromatophores which become darker as time wears on. The metamorphosis is said to be rapid and to take place at a length of about 8 or 9 mm. By the middle of the following summer these larvae have turned over on their side and one eye has passed round to the other side of the head and the typical asymmetrical form of the adult is attained. These little fishes are frequently taken in seines and may have a length of 30 or 40 mm. Maturity is probably reached in about the third year.

Size: Though there is a record of a 20-inch winter flounder weighing 5 pounds it is very rare to find them over 15 inches long and 1½ pounds in weight, particularly in our region, for large ones are more frequent on the coast of Maine. There is a record of one of 3 pounds from near Glen Cove, Long Island, March 30, 1923, which measured 17¾ inches total length. (L. B. Hunt, Jr.)



255. **Sundial**
Lophopsetta maculata (Mitchill)

Distribution: Rather common, March 1 to December 18, rare in winter. *Woods Hole*, common, April to late autumn. *Orient*, resident, rare in winter, rather common March 1 to December 17. *New York*, rather common, spring to December 18.

Occurs from the Gulf of St. Lawrence to South Carolina, rare north of Cape Cod.

In our region almost always found on sandy bottoms in both shallow water (sometimes stranded on sand bars by the falling tide); and deep water (17 to 20 fathoms). On Georges Bank it occurs at depths of 30 or 40 fathoms.

The flesh of the sundial is translucent and when held to the light a shadow may be seen passing through the fish. In spite of this fact it is one of our most delicious species—yet, on account of its comparative scarcity and small size it probably will never be widely known as a table-fish.

Food: Feeds on crustacea (*Crangon* and miscellaneous shrimps, crabs, etc.), worms, mollusks, etc., and small fishes (*Ammodytes*, small herring, silversides, etc.) and squid.

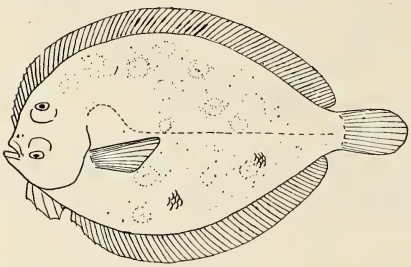
Life History: In Massachusetts this species spawns in May and June. The eggs are spherical, transparent buoyant and non-adhesive, with a single colorless or pale yellow oil globule and the surface of the egg showing faint irregular markings. They average about 1 mm. in diameter and hatch in about eight days at a temperature of about 53° F. At about 10 mm. the migration of the eye from the blind side is completed and the fry ready to take to the bottom.

Young, 1 to 2 inches total length taken mid-December (Orient). They have been described from Rhode Island waters as 2 or 3 inches long in July and 4 inches and upward in December. Probably an average of 6 to 9 inches is reached by the end of the second summer and 10 to 12 inches the third summer when the fish are mature.

In Sandy Hook Bay there is one group which shows an average growth of from 20 mm. in standard length in May to 50 to 60 mm. in the latter part of September. Another group, probably of the next year, grows from about 90 to 110 mm. (4⅜ inches) between the middle of July and the middle of September. It would seem from this that they spawn earlier here than to the east, although ripe females have been taken as late as May 8. If the

20 mm. fish of that month are of the preceding year, their growth has been remarkably slow. Of course we may have gotten only laggards in the bay.

Size: Reaches 15 inches total length, 1 pound weight (Orient), or a maximum of 18 inches, and weight of 2 pounds, but usually only 10 or 12 inches.

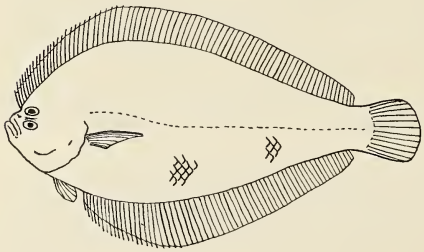


256. **Eyed Flounder**
Platophrys ocellatus (Agassiz)

Distribution: Casual in fall, September to October 20. *Woods Hole*, several specimens, October 4 to 20, 1906. *New York*, accidental, September.

Occurs on sandy shores of the western Atlantic from Long Island to Rio.

Size: Reaches a length of about 8 inches.



257. **Small-mouthed Flounder**
Etropus microstomus (Gill)

Distribution: *New York*, at times not uncommon, recorded from July 26 to October 19, 1923 (Sandy Hook Bay), October 21, 1925 (Rockaway Inlet).

Due to uncertainties of identification, it is impossible to say where this species (doubtless often overlooked) occurs most abundantly.

It is a small, fragile, sinestral flounder; head small; mouth small, symmetrical, oblique; eyes close together; scales rather large, deciduous. Translucent, the vertebral column showing through as a dark, lengthwise streak, with sometimes a few dark marks along it, the only tangible pattern in a brownish grey finely freckled upper surface.

Previous to 1923 the small-mouthed flounder was represented in our field notes by a single record from Sandy Hook Bay (September 28, 1921). During that year it became quite common on a certain stretch of beach in the "Bight of the Hook."

The following growth table was compiled from specimens taken in that year:

Date			*Average Standard Length*	
July	26,	1923	62	mm.
August	2,	"	70	"
"	9,	"	74	"
"	23,	"	78	"
"	30,	"	82	"
September	6,	"	88	"
October	9,	"	82.5	"
"	19,	"	84	"

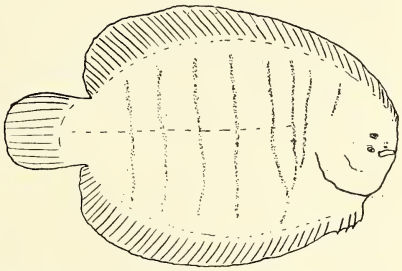
SIZE: Reaches a maximum length of about 6 inches.

SOLES

The most specialized, or degenerate, flatfishes. Eyes very small, mouth small and very crooked. Our species has no pectoral fin on the upper, eyed, colored side.

Dextral, scales well developed, rough. *Achirus*
Dextral, no scales. *Gymnachirus*[17]

258. **American Sole**
Achirus fasciatus Lacépède



DISTRIBUTION: Common to the westward from April to December, uncommon to the eastward. *Woods Hole*, uncommon, taken throughout the year. *Orient*, common in shallow bays, May to October 15. *New York*, common, April to December. Rare in Sandy Hook Bay.

Occurs from Cape Ann to the Gulf Coast. Sandy and muddy bottoms in shallow, and running into brackish waters.

FOOD: Rock weed and eelgrass recorded as food in August (Woods Hole).

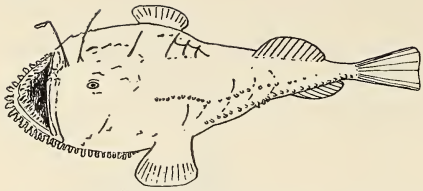
LIFE HISTORY: Eggs apparently rise in latter part of May (Woods Hole).

SIZE: Reaches about 6 inches standard length (Sandy Hook Bay).

ANGLERS

Large depressed scale-less fishes, tadpole-shaped with big heads and narrow tails. Mouth enormous, armed with irregular, formidable, pointed backwardly directed teeth. Pectoral fins on short arm-like bases.

[17] The naked sole, *Gymnachirus nudus*, described from Bahia, Brazil, is reported as accidental at Woods Hole, October 16, 1906. If the genus is correct, the species is in doubt. *Gymnachirus melas* has been more recently described from Carolina.



259. **Angler**
Lophius piscatorius Linnaeus

Distribution: Common resident to the eastward, winter only to the westward, except for a few in deep water. *Woods Hole*, large specimens common in summer and fall. *Orient*, adults in June and July. *New York*, common, October to May 19, a few summer in moderately deep water.

Occurs from Norway and the Gulf of St. Lawrence south along shore to Cape Hatteras and in deep water outside the continental shelf to the West Indies and Cape of Good Hope.

Large anglers sometimes allow themselves to become stranded in shallow water in late fall. These would seem to be aged individuals tired of life in the ocean depth, that have come up to the shore to die. Their bleached jawbones with formidable teeth are frequently picked up along the beaches.

Food: Indiscriminately carnivorous, eating skates, flounders, weakfish, sea robins, butterfish and other smaller fish, squid and other mollusks, crabs and smaller custacea, annelids, etc., diving birds.

Bigelow and Welsh say "In Scottish waters, where the habits of this species are better known than in the Gulf of Maine, its local abundance depends on the supply of small fish, and in spite of their poor ability as swimmers goosefish have been found to congregate near particular shoals of herring. W. F. Clapp, who has often watched the feeding habits of goosefish at low tide in Duxbury Bay, Mass., where they are very plentiful, describes them to us as lying perfectly motionless among the eelgrass with the tag or "bait" on the tip of the first dorsal ray swaying to and fro over the mouth, either with the current or by some voluntary motion so slight as to be invisible. The only fish he has seen them take are tomcod, and when one of these chances to approach it usually swims close up to the "bait" but never (in his observation) actually touches it for as soon as the victim is within a few inches the goosefish simply opens its vast mouth and closes it again, engulfing its victim instantaneously. These observations are the more welcome as no other recent student seems to have seen the feeding habits of this species in its natural surroundings, and they show that it depends mostly on such fish or Crustacea as chance to stray close enough to be snapped up from ambush or siezed by a sudden rush. However, the fact that it has been known to seize and swallow hooked fish as the latter were being hauled up, and even to capture sea birds sitting on the surface, proves that it may make considerable excursions for a meal on occasion."

Life History: Spawns from May to August. Spawn laid in clusters which are often found attached to fish traps or floating in the Sound (Woods Hole).

The eggs are extruded in summer. They form in gelatinous masses violet gray or purplish-brown in color, floating at the surface. These may be as large as a foot or two in width and 30 or 40 feet in length with weight of over thirty pounds.

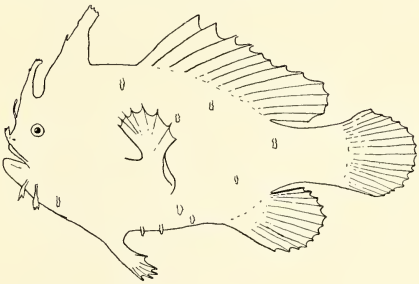
The eggs, which have been estimated as 2⅔ millions for a single female, are spherical or slightly oval about 2⅓ mm. in diameter. The larvae are about 4.5 mm. long at hatching, and float at first with the yolk uppermost. The absorbtion of the yolk and formation of the mouth are complete and the larva rights itself in the water in about 2 weeks. It grows to 50 mm. while still free swimming, and descends to the bottom shortly thereafter; as the fins develop and the head enlarges various picturesque stages having been passed through. The species is mature at a length of 30 inches or more and probable age of upwards of 4 to 8 years, the growth rate varying in different waters.

Size: Reaches a length of 3 or 4 feet, weighing up to 45 pounds, and recorded as heavy as 70 pounds.

FROGFISHES

Small, sluggish fishes of irregular outline, hiding in weed. Mouth large and oblique. Pectoral fins on short arm-like bases. Body scale-less. Color usually spotted and streaked, to render the fish inconspicuous.

260. **Sargassum Fish**
Histrio histrio (Linnaeus)



Distribution: Rare and irregular to the eastward, accidental to the westward, July to November. *Woods Hole*, rare and irregular, July to November. *New York*, accidental, August.

Occurs in tropical parts of the Atlantic, north to Cape Hatteras and occasionally beyond. Confined almost exclusively to floating drifting gulf weed off shore; where its shape and color give it a very low visibility.

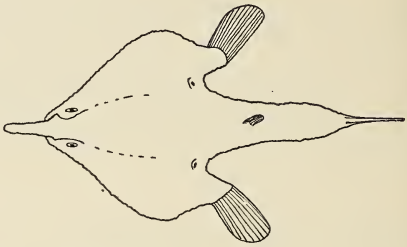
Life History: Has deposited unfertilized spawn in laboratory aquaria, in jelly masses, similar to those of *Lophius*.

Size: Reaches a length of about 6 inches.

BATFISHES

Small, sluggish, bottom fishes, hard exterior studded with small tubercles. Body depressed, triangular forward to the snout which is more or less pointed and produced. Pectoral fins at the side on backwardly directed angles of the broad anterior part of the body. The tail portion narrower ending in a weak squarish or rounded caudal fin.

261. **Batfish**
Ogcocephalus vespertilio (Linnaeus)



Distribution: *New York*, accidental, mid-summer.
Occurs in the West Indian fauna, regularly north to Florida.
Size: Reaches a length of about 9 inches.

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*Species marked with asterisks we consider as very doubtful records. They are not included in the list proper, being mentioned only in footnotes, and are not figured.

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INQUILINISM BETWEEN THE CHEILODIPTERID FISH, *APOGONICHTHYS PUNCTICULATUS*, AND THE UNIVALVE MOLLUSK, *STROMBUS BITUBERCULATUS*

By E. W. Gudger

Bibliographer and Associate in Ichthyology, American Museum of Natural History, New York City

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(Figs. 264–265 incl.)

Symbiosis is, strictly speaking, the living together of two organisms for their mutual benefit, but in a more common and broader sense there are various kinds and degrees of this partnership in which fishes take part. Fishes live symbiotically with colonied hydroids, with medusae, and with sea anemones among the Coelenterates; with sea urchins, starfishes, and holothurians among Echinoderms; with other fishes; and last and possibly most infrequently with mollusks. In the latter category the most common living together is that of the pearlfish, *Fierasfer*, in the mantle cavity of the oyster, especially the pearl oyster, *Meleagrina*. But of symbiosis between a fish and a univalve mollusk one case only has thus far been recorded in the literature.

In 1908, L. Plate[1] published an article on the symbiosis between a Cheilodipterid fish, *Apogonichthys strombi*, and a huge sea snail, *Strombus gigas*, in the Bahama Islands. It seems best to give a careful translation of his interesting account, and to follow this with my own observations.

After reciting various instances of symbiosis in which a fish is a partner, Plate sets forth as follows his observations made in January and February, 1905:—

The giant snail (*Strombus gigas*) is very abundant here and is brought in in great quantities by the market fishermen, as the foot of such "Conchs" finds a market both as food and as fish bait. It is considered a national dish, and the Bahama islanders—white as well as black—jokingly call themselves "Trueborn Conchs."

On the bottom of boats which had held a lot of snails, I often found a little brown fish from 3–6 cm. long. In answer to my questions, the fishermen explained that these animals were ejected by the snail as food waste. That this was an impossibility I proved absolutely on my trips in the vicinity of Nassau (New Providence) and on a longer voyage to the islands of Andros, Green Cay

[1] Plate, L. *Apogonichthys strombi* n.sp., ein symbiotisch lebender Fisch von den Bahamas. Zoologischer Anzeiger. 1908, Bd. XXXIII, pp. 393–399.

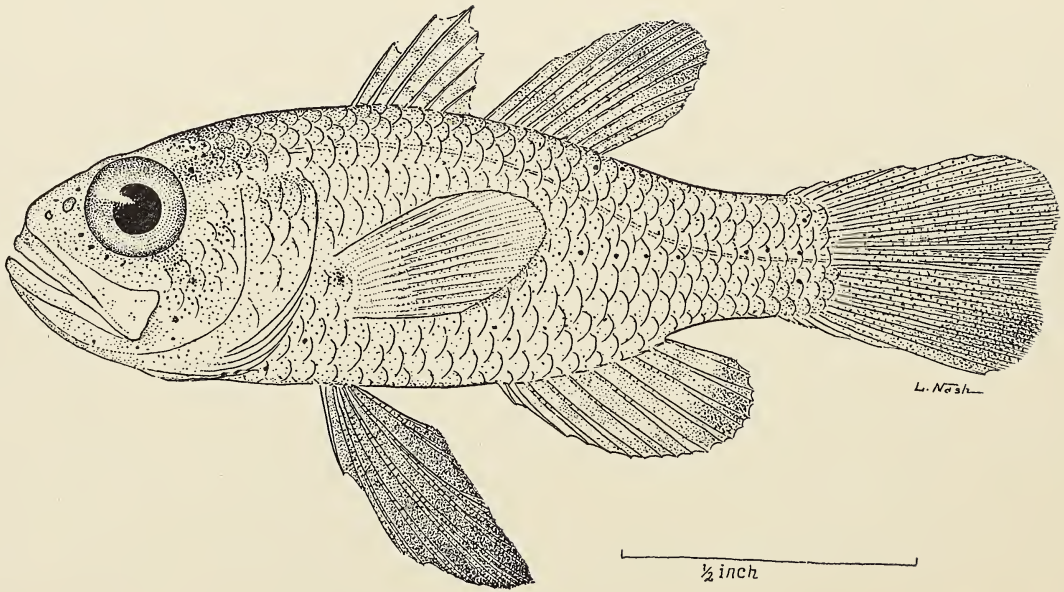

Fig. 264. *Apogonichthys puncticulatus*, the little fish which lodges in the mantle cavity of the sea snail.

Magnification = × 3.

Exuma-Kette, Eleuthera and Egg Island. The small fishes live in the mantle cavity of the snail, but only in large specimens in water, from 2–5 m. deep. The younger *Strombus gigas*, to a size as large as that of a fist, occur frequently in about a depth of 5 m. here and there in the shallow coastal waters (for example, directly off Nassau), but I have never found a fish in one. I have often watched from a boat a large *Strombus* like this, but I have never seen it accompanied by any small fish. Moreover, none of a number of experienced fishermen, who in the course of their lives have captured many thousand snails, can recall any such observation. I conclude from this that the little fishes only abandon the snails at night to go after their food which consists of shrimps, sea-lice, and other crustaceans.

If one pulls up the snails by means of a long hook and lays them in the boat. the animals naturally first draw back into their shelter, but soon venture out a little way again. Whereupon the still living fishes slip out of the mantle cavity and can be kept alive if put into fresh water. If the snails lie in the boat from one to two hours and no fishes appear, one can be reasonably sure that they do not harbor any. I have never come across more than two tenants in one snail. In such cases, they proved to be sometimes a male and a female; sometimes the same sex. However, it was much more often the case that only one fish had sought shelter in the one snail. To be absolutely sure, I repeatedly put a fish and a snail together in a large sheet zinc receptacle and found in some cases that after a couple of hours, the fish had gone into the mantle cavity without my having seen it enter. In other cases, the fish stayed outside even after it had been a whole night in the same receptacle with the snail; perhaps because the water had grown too warm. I had no opportunity to place the creatures in a larger and well aired aquarium and thus to observe them under conditions approaching normal, so I cannot give any information on other peculiarities of this interesting symbiosis.

It still remains to determine the attitude of the snail toward the intruder, especially whether or not its entrance is welcome; moreover, whether the fish spawns inside or outside of the mantle cavity; whether it returns to the same snail which it has deserted in search of food, or whether it uses any snail in the vicinity; whether the fish swims far away from the snail, or always stays in its neighborhood, etc. In my judgment, the snail gains no advantage from its intruders, even as little as the previously mentioned organisms which are utilized by fishes (Holothurians, jelly fishes, sea roses and sea urchins). The question is not one of mutualism, but of a one-sided symbiosis.

The smallest example that I came across in a *Strombus* measured 32 mm. from the tip of the snout to the base of the caudal fin, and was therefore almost full grown. Probably, therefore, the fish under these circumstances deposits its eggs outside the mantle cavity and the young animals do not live symbiotically. It will be easy to clear up all these questions at the biological station at Tortugas.

Shortly after the publication of Plate's article, my attention was called to it and when, in 1912, I began the first of several

Fig. 265. *Strombus gigas*, the huge sea snail. Note the two folds of the mantle, the foot and operculum, and the proboscis and tentacles. When all these parts are drawn inside the shell, there is a cavity between them wherein the fish lodges.

seasons' work at the laboratory of the Carnegie Institution of Washington at Tortugas, Florida, I sought for confirmation of Plate's find. Our engineers and boatmen, Florida- and Bahama-born, knew nothing of this phenomenon. Conchs were not easy to get, and the few examined revealed nothing out of the ordinary. My time and thoughts being concentrated on other work, the matter of this symbiosis presently was practically forgotten.

In 1914, however, the matter was brought sharply to the fore in the following manner. There was at the Tortugas laboratory that summer an investigator (Dr. E. E. Reinke) at work on the problem of sperm formation in *Strombus bituberculatus*. About the middle of July, the 'Dohrn' took the two of us to Key West, where Dr. Reinke hunted for his giant conchs while I fished for sharks. On our return we anchored for part of a day at Marquesas atoll where there was a good hunting ground for *Strombus*. Leaving a ship-keeper behind with the 'Dohrn,' the others of us went out in the launch on a great eel-grass flat to the southeast of the island where these mollusks abounded. The conchologist and I remained in and poled the launch along while the men waded over the flat in water about three feet deep and hunted for *Strombus*.

Presently these began to be handed or thrown into the boat, and little attention was paid to them. One conch, however, was laid on a seat with the aperture upward, and, on noticing it, great was our surprise to find a little fish swimming in the water which filled it. Since all the conchs found in the eel-grass were in the normal position for walking (mouth down), no conclusion was possible other than that the little fish had come up in the mantle cavity of the *Strombus*, that the conch, lying on its back so to speak, had thrust out its foot and operculum and had expelled some water and the fish with it. Then when the foot and connected parts had been retracted, the fish could not return to the deeper part of the cavity and was found swimming in the water remaining in the hollow of the shell outside the foot and operculum. Here then was confirmation of Plate's discovery.

These huge sea snails were taken to the ship and examined as carefully as possible. Next day at Tortugas they were stored in salt-water tanks awaiting Dr. Reinke's convenience. So far as observed, none gave up symbiont fish, and, although careful watch was made as they were dissected, in none were any fishes found.

So, although Plate's discovery was confirmed in this symbiosis between a fish and a conch, both of different species from his forms, yet the questions he propounded in his article were not "easily cleared up at the biological station at Tortugas." Furthermore, though Dr. Reinke dissected considerable numbers of Plate's conch, *Strombus gigas*, from the Tortugas atoll, none were found to be inhabited by fishes. It should be noted, however, that one specimen of *Apogonichthys puncticulatus* has been taken at Tortugas, not in the mantle cavity of a conch but with dynamite at a depth of 35 ft. in West Channel. This at any rate proves that the fish is found at Tortugas, though it is plain that it occurs sparingly.

When classified, my little fish was found to be, as noted above, of a different species, *i.e.*, *Apogonichthys puncticulatus*. It was 46 mm. in total length, and 35 mm. to the end of the spinal column (base of caudal fin). Plate fortunately gives a figure of his fish and from it my specimen differs markedly in a number of particulars, but especially in the size and color of the thoracically placed pelvic fins. *A. strombi* has these fins "darkish, almost black;" mine has them very black. In the first fish the pelvics are not very large and reach only to about the middle of the anal, while in my specimen they are enormously enlarged, and reach to the middle of the anal or even beyond this point. For these points see figure 264.

My little fish was very shy, and, while kept in an aquarium of running salt water, mainly remained in hiding. However, when aroused it was a striking object as it swam around with its fan-like black pelvic fins widely spread.

Undoubtedly these little Apogonichthyids seek shelter and safety in the mantle cavity of their respective molluscan hosts, but it is a one-sided symbiosis for I cannot conceive how the mollusk can possibly benefit therefrom nor can I begin to answer the questions which Plate asked as he studied his specimens. However, it is something to have discovered another species of *Apogonichthys* which practices this habit.

Since the above was written, I have received an article[2] relative to certain Key West fish in which Messrs. Hildebrand and Ginsburg announce the collection of four specimens of *Apogonichthys stellatus*

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[2] Hildebrand, S. F., and Ginsburg, Isaac. 'Descriptions of Two New Species of Fishes from Key West, Fla., with notes on Nine Other Species Collected in the Same Locality.' Bulletin United States Bureau of Fisheries, 1926, Vol. 42, p. 210, fig.

from conchs at Key West. These measure 42, 43 (2 specimens) and 50 mm. long. They were taken Dec. 8, Jan. 1, Feb. 1, and April 27. Now, many of these Cheilodipterid fishes practice oral gestation but, as none had eggs in their mouths, the dates given are presumably not the breeding season and this precludes the idea I once had that possibly the fishes live in the mouth cavity of the conch for protection during the breeding season. The particular species of conch was not determined.

Hildebrand and Ginsburg identify their fishes with Cope's species, *Apogonichthys stellatus*, established in 1869. Cope's description, however, contained a number of errors which Fowler in 1907 corrected, giving an excellent figure. Hildebrand and Ginsburg further compare Plate's figure and description with the above and decide that his fish also is *A. stellatus*. There can be no doubt, however, that my fish is a different species.

The American Museum has a beautiful model of *Strombus gigas* with the anterior part of the animal protruding from the aperture of the shell. This is reproduced herein as Fig. 265. Here may be seen the folds of the mantle lining both sides of the aperture, the contracted relatively small foot with the operculum at its hinder end, in front of this the large black proboscis with the tentacles on either side. When these are drawn in to fill the outer part of the aperture, there is left a water-filled space between the body and the mantle, and in this the fish is contained.

Mr. C. E. Olsen, a skilled preparator in the American Museum, accompanied Dr. R. W. Miner on an expedition to the Bahamas in July 1926, and there observed this phenomenon. He tells me that at one spot off Mangrove Cay, Andros Island, large numbers of *Strombus gigas* were brought aboard and thrown in the bottom of the boat. Presently he noticed many small fishes swimming about in the water. So abundant were they that he believes that each conch must have given up a fish. Conchs from other localities did not happen to have fish. This would lead to the idea that the phenomenon is rather localized. The Bahamans call these fishes "conch-fishes."

In conclusion, it may be said that Mr. L. L. Mowbray, formerly of the New York Aquarium but now head of the Bermuda institution, tells me that he has repeatedly observed this phenomenon in the Bahamas. Unfortunately however, he did not identify the

fishes; but, with two species known to practice this habit, one is lead to wonder if other species of the genus do not do likewise.

Summary

Plate in 1905 discovered, and in 1908 first made known this curious form of association between a Cheilodipterid fish, *Apogonichthys strombi* (*stellatus*) and the sea snail, *Strombus gigas*. Gudger in 1914, discovered a similar relationship between *Apogonichthys puncticulatus* and *Strombus bituberculatus*. In 1922–23, Ginsburg collected four specimens of *Apogonichthys stellatus* from conchs at Key West, and in 1918–1919, three from cavities in sponges in the same locality. Probably other species of this genus will be found to have similar habits.

No explanation is at hand for this remarkable form of association in which the fish gains a sure protection but in which no value for the conch seems possible. It is not a strict symbiosis, nor a commensalism, nor a mutualism. Perhaps the most fitting term is inquilinism (a lodging secured by one party), a term already in use for such a one-sided association among insects and proposed by Emery to describe the relationship between the pearlfish, *Fierasfer* and its bivalve molluscan host, the pearl oyster, *Meleagrina*.

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By C. M. Breder, Jr.

with the collaboration of

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FROG TAGGING: A METHOD OF STUDYING ANURAN LIFE HABITS

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(Figs. 266–277 incl.)

Introduction

As our knowledge of any group of animals increases the desirability of devising new methods or of applying old ones in new ways becomes more evident. This we must do in order to extend our information along an ever increasing front and to avoid degenerating into puttering in comparatively barren fields. This becomes especially patent in the pursuit of experimental zoology and more particularly so in experimental field zoology. Work on the life histories and habits of anurans in tropical America along conventional lines brought this thought home most forcibly to the senior author. While little was done at that time along unorthodox lines, various methods of attack on innumerable fascinating problems constantly suggested themselves. One of the indirect outgrowths of such thoughts, the possibility of applying some methods of marking individual frogs, under natural conditions, in a manner somewhat similar to that employed by ornithologists in "banding" birds has developed into the present studies.

Although the work has been of but a single season the great promise of valuable results prompts us to place on record the efforts of the year in this direction, partly because of their intrinsic value, but more especially in the hope of interesting others more fortunately situated than ourselves for the further pursuit of such problems.

The senior author, has been extremely fortunate in securing the collaboration of Ruth B. Breder and Albert C. Redmond in these studies for parts of the season. Indeed most of the field work has been done by them. As they worked in different localities the paper divides readily into two chief parts accordingly. The interpretation of the data gathered by these two collaborators in which they both took active part entitles them to co-authorship. While assuming responsibility for the assembly of the data, any credit is due to R. B. Breder for the accumulation and interpretation of the data

gathered at Haskell, N. J., and to Albert C. Redmond for that gathered at Palisades Interstate Park.

We are greatly indebted to Mr. James Brooks for his kindness in allowing the use of his camp (Camp Thomas Brooks) and land at Haskell, N. J., for these experiments and studies, and equally so to Dr. Frank E. Lutz of the American Museum of Natural History for the extension of similar privileges at the Station for the study of insects in the Harriman section of Palisades Interstate Park, N. Y., of which he has charge. In addition we are indebted to Dr. Lutz for his generosity in allowing his assistant, Albert C. Redmond, to devote a liberal portion of his time to the problem.

Use of the Method

To crystallize the reasons for developing this method and to point out some of its possible applications there are tabulated herewith a few problems to which it opens a ready lane of approach. None of these are definitely answered in the present paper for the work has not been carried on long enough, but we have every reason to believe that their solution may be in part, if not entirely, attained by this means.

1. Normal rates of growth of specimens under different types of habitat.
2. Speed of color changes and its extent in normal specimens in correlation with seasons and general environmental conditions of a normal sort.
3. Movements to and from spawning areas with reference to mass and individual movement, and its speed as correlated with sex, environmental factors, etc.
4. Movements not directly connected with breeding activity, as correlated with factors of environment; migrations.
5. Homing instinct, extent developed, variation between species and finally how it operates.
6. Learning and memory of paths and routes under normal conditions.

Some of these problems have been attacked in various ways, mostly by laboratory methods, but no work appears to have been done on the behavior of frogs in a ferral condition such as is made possible by the use of this method. Many other problems suggest themselves, such as the number of females a single male will mate

with in one season, the constancy of voice variations and so on. If work can be carried on over several successive seasons many other additional problems at once come to mind that are well worth working out.

Technique

The basic technique for marking, tagging or banding frogs was worked out in 1924 in the jungles of Darien, Panama on a large and interesting tree frog, *Hyla rosenbergii* Boulenger. After various systems and methods were tried with varying degrees of success and failure it became evident that some method employing the circling of the narrowest part of the body, the "waist" of the frog would be the eventual solution. *Hylas* in general are especially suited to this method on account of the extreme narrowness of the region. Other forms, lacking such extreme constriction, as many *Ranas*, are troublesome at times, often being able to slip out of bands so placed. *R. sylvatica* has given particular bother in this regard. However, if the band is properly attached there is scant chance of even this species casting it off.

The marker or tag basically consists of a cord passed around the frog, tied in a square knot below and attached to a symbol of some sort above. Several different types were used successfully. They are described herewith.

Cardboard Tags.—Small cards with numbers and letters were used with considerable satisfaction. Most of them were typed as is indicated in Fig. 266, A and B. The letter forms the basis for the distinction of a series and could serve to keep the frogs of different but adjacent workers distinct. The cards could carry numbers up to 99,999 by placing numbers on either side of the letter, as well as below it. A good durable paper or light card was used which had been waterproofed after punching and lettering. Most of them were dipped in liquid celluloid made by dissolving old photographic film in acetone. Such cards generally lasted up to about three months. While it was not given a really fair trial we believe sodium silicate would prove to be more satisfactory than celluloid for this purpose. A soft light fish line was found to be quite satisfactory for attachment, evidently far outlasting the cards. Several methods of attaching the card were employed as suggested by Fig. 266, A and B.

Metal Tags.—Small squares of aluminum with smooth edges and

rounded corners were stamped with letter punches with the expectation of having them carry over into a second season. They were attached by means of durable enameled trout line. While time is not yet sufficient to report on their durability we have but little doubt that they will serve the purpose well. See Figure 266, C.

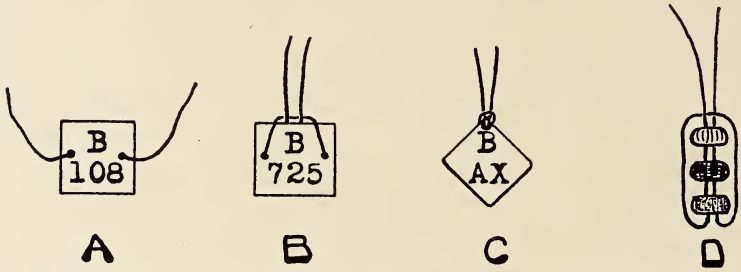

Fig. 266. Types of tages; A and B—Card tags; C—Metal tag; D—Bead tag.

Beads.—Differentially colored glass beads of small size were used on very small frogs. Aside from the fact that they were rather difficult to find in the field they served the purpose very well. Fine bead silk was used to attach them to the frogs. Six different colors gave the possibility of a lengthy series by using up to three beads to a frog. See Fig. 266, D for attachment methods.

Tag Holder.—Holders of light cardboard were provided with holes to take the strings already attached to the tags. Fig. 267 shows the three types of tags in their holders. A heavy open end envelope was provided to hold them. The additional effort of placing the tags in these holders was found to be more than offset by the convenience in the field. The envelope also held a short rule, a small note book a pencil and blunt nosed scissors. The entire equipment could thus be carried in an inside coat pocket.

Records.—A loose leaf note book with a page size of 5″ by 8″ was found to be quite satisfactory for records. Every tagged frog was given a new page, headed with its tag number, species and other primary data. Then followed the data concerning it and its recoveries in chronological order. A sample heading is indicated below.

Fig. 267. Three types of tags in their holders.

B–104

Rana calmatans

Interstate Park

May 6, 1926—male, 50 mm. In pool "A" 11:20 A.M. Gave vent to more noise when handled than is usual for this species.

May 7, same place as when first seen, 9:30 A.M.

This data together with the usual field journal preserved all the required information.

Attaching the Tag.—With two operators working together it is, of course, extremely simple to attach such tags, but when one is working alone it requires some skill to make a satisfactory attachment. There seems to be no especial method to suggest, a little practice soon developing a proper deftness. The loop of string around the "waist" should just be tight enough to prevent it

Fig. 268. Attaching the tag.

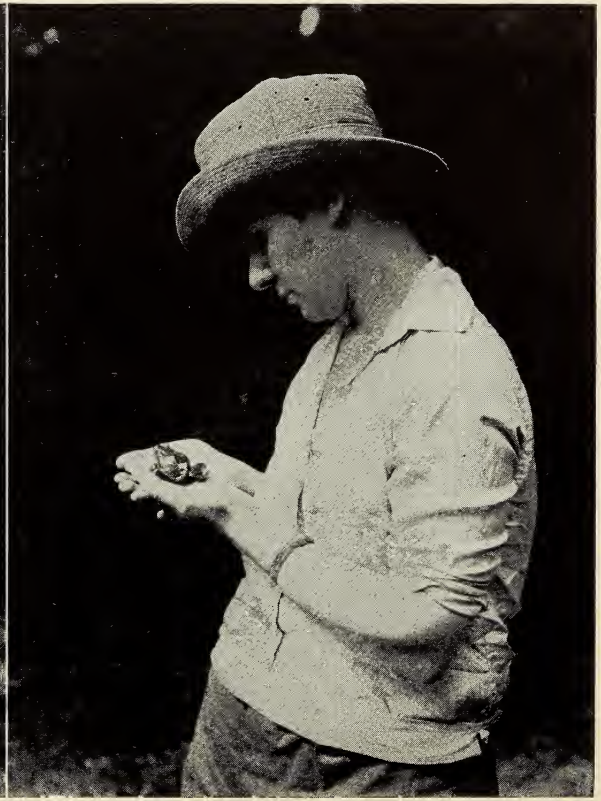

Fig. 269. The card attached.

being slipped off, as some *Ranas* (*R. sylvatica, R. clamatans, R. palustris*) are very apt to do, although they generally desist after two or three unsuccessful trials. In cases where it is too tight it wears through and produces sore spots. However, such injuries heal rapidly and grow over the offending cord shortly burying it with no noticeable ill effect on the animal. This can hardly be avoided in some cases where a frog is growing rapidly and observations are infrequent. It should be recalled, however, that often frogs will puff themselves up when handled so that a tag that appears to be quite tight when being tied is actually relatively loose when the frog returns to normal size. Figs. 268 and 269 show stages in the attachment of a tag.

Recaptures.—After once tagging a frog every attempt was made not to disturb it any more than necessary. Recapture was resorted to only when the tag could not be readily deciphered as it lay, i.e. when hidden by a leaf or covered with mud. A great assistance in such reading was found in the new Bausch and Loumb telemagnifier permitting a reading at distances much further than those which might cause the frog to leap away. However, it was found that a very close approach could often be made, in fact much closer than necessary, as indicated by Figs. 270 and 271.

The Studies in New Jersey

The operations at Haskell, N. J., carried out largely by R. B. Breder, were commenced on July 29 and concluded on September 26, by which date fall weather had set in and the frogs were seeking and for most part finding hibernation, as observations a week later demonstrated. It is to be regretted that it was impossible to begin work here earlier in the season and also that the summer was unusually cool and rainy. As a consequence the stream banks were frequently flooded, often causing even *Rana clamatans* to seek shelter from the pelting rain and the generally disturbed conditions. Doubtless, their behavior was somewhat abnormal for this time of year.

The species and numbers of individuals tagged were as follows: *Rana clamatans* 61, *Rana palustris* 12, *Rana sylvatica* 7, *Bufo fowleri* 9, total 89. *Rana clamatans*, only, was tagged in sufficient numbers and recovered often enough to show any results of value. This is partly because of its dominance as a species here and partly because it was given nearly sole attention.

Fig. 270. Locating a tagged frog. Frog in lower right hand corner; in circle.
Fig. 271. Locating a tagged frog. Frog in lower left hand corner; in circle.

Rana clamatans

As a preliminary to a study of the extent of the homing instinct in *Rana clamatans* all specimens tagged here were released at places other than where taken. Sixty-one were so treated. Of this number three were known to cast their tags shortly thereafter, the loose tags being found the next day. This leaves fifty-eight to be considered. Of this number fifty-one were taken along Post Brook and released at the camp. Of these, twenty-two were seen at some later date along the brook, leaving twenty-nine which were not seen again. The interpretation of the data supplied by these fifty-one frogs is open to some possible divergence of opinion. Such questions as the following naturally arise. As the land sloped from the camp to the brook and as it was the nearest body of water would it not be natural for the frogs to gravitate to it by simply moving down hill? This question is subsequently answered. Of those which were not recovered, how many got back to the brook and were simply not seen again, how many cast off their tags enroute, how many were intercepted by enemies and how many went elsewhere? These questions cannot all be answered satisfactorily at this time, but further work should help to clear the matter considerably. At any event a relatively large number (43%) got back to approximately their "home" region. However, this movement can all be interpreted without calling in any "homing instinct." They moved directly away from camp in most cases and in none tarried into the second day. This was true even in spite of the large amount of rain which one might expect to lessen the urge for them to seek water. Nevertheless, they all retreated from the camp (because of the occupants ?) and it is tempting to suppose that they all started for the nearest water. Why were not more recovered?

Now let us examine another case. Three frogs were taken in the spring and released at the camp. In six and seven days respectively two (B–70 and 71) were back in the spring whilst the third was not recovered. In order to attain the spring it was necessary for them to cross the brook which proved so attractive to the frogs which were originally taken from it and to ascend the opposite bank for an approximately equal distance to reach the rather small hillside spring hole. Here is a clear case where we cannot ascribe their movements to simply tumbling down hill to the nearest puddle.

Take still another case where two frogs from the brook were

released in the spring. One was not seen again but the other (B-22) returned to the brook in six days after resting two in the spring. Why was the spring not satisfactory to these two individuals when it was so desirable to the previous two that they crossed the brook to attain it when at least one of the present went to the brook? As these two experiments were in progress simultaneously we cannot ascribe it to changing conditions. Surely here we have some sort of simple homing instinct.

The statistical data of these experiments is given in Table 1, and Fig. 272 shows the location of the work with the important points indicated. The dates in the first part of Table 1 represent all those on which careful searches of the region were made. The localities indicated represent all those where frogs were released. In other words there were recoveries from each spot of releasing. With further tabulations of this sort we believe that some valuable statistical studies might be made. Sex and size is not indicated for the figures show no correlation. With a larger number of examples

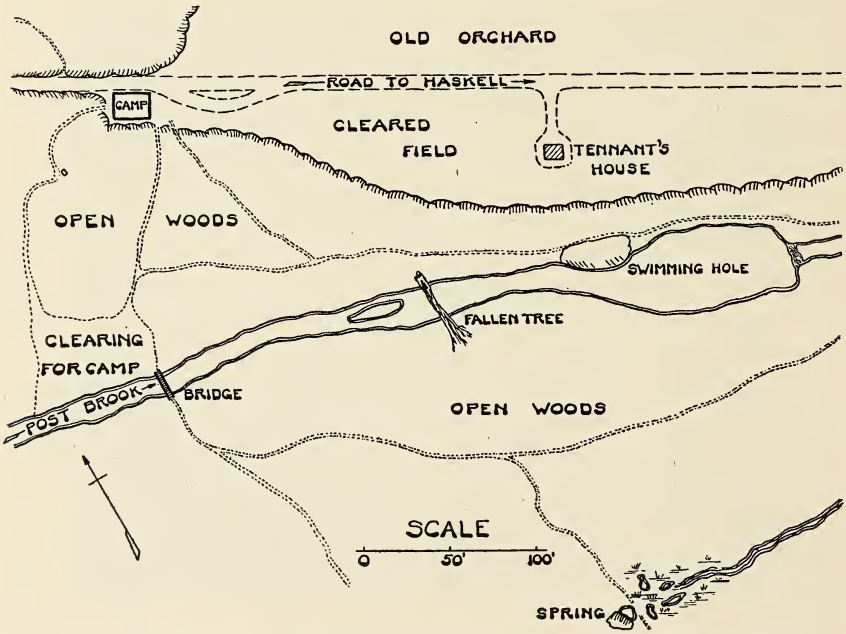

Fig. 272. Sketch map of the camp at Haskell, New Jersey, showing important localities.

TABLE NO. 1—Recoveries of *Rana clamatans*

Tag Number	July			August																					Sept.			
	29	30	31	1	2	3	4	5	6	7	8	9	13	14	15	16	25	27	28	29	30	31	1	6	7	26
B-22	BS	S	S	..	..	..	..	..	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24		BC	...	..	..	..	..	..	..	..	B	B	..	..	..	..	..	..	..	..	B	B	..	..	..	..
30		BC	...	..	..	..	..	..	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
33		BC	...	..	..	..	..	B	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
34		BC	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
36		BC	B	..	..	..	..	..	..	..	B	..	C	..	..	..	..	..	..	..	..	B	..	..	..	B
37		BC	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	B	..
45		BC	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	B	..	..	..	..	..	..
47		BC	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
49		BC	...	..	..	..	..	..	..	..	B	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..
50		BC	...	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	B	..	..	..	..	..	..
51		BC	...	B	..	..	..	..	..	B	B	..	..	..	..	..	..	..	B	..	..	..	..	..	..	..
52		BC	...	..	..	..	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
53		BC	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	B	..
55		BC	...	B	..	..	..	..	..	..	B	..	..	..	..	..	..	..	..	..	..	..	..	..	B	..
61			BC	..	..	..	..	..	B	..	B	..	..	..	B	..	B	..	..	..	..	..	..	..	B	..
63			BC	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
65			BC	..	..	..	..	..	..	B	B	..	..	..	..	..	..	..	..	..	B	..	..	..	..	..
66			BC	B	B	B	..	..	..	..	B	..	..	..	..	..	..	..	..	B	B	B	..	..	B	..
68			BC	..	..	..	..	..	..	..	B	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..
70			SC	..	..	..	..	..	..	S	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
71			SC	..	..	..	..	..	S	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
80			BC	..	..	..	..	..	..	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
81			BC	..	..	..	..	..	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
83			BC	..	..	..	..	..	..	B	B	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..
303																			HC	..	..	B	..	..	..	..
309																				BB	..	B	..	..	..	..

B—Brook. C—Camp. H—Halfway between B and C. S—Spring. Two localities under a date indicate those from which and to which the individual had been moved at the time of tagging.

Number of recoveries of the 61 specimens tagged

Times recovered	0	1	2	3	4	5	8	Average no. of recoveries 2 +
No. of examples	34	14	4	4	2	2	1	Total no. recovered 27

Intervals in days between taggings and last observations

No. of days elapsed	1	2	3	5	6	7	8	9	10	29	30	32	38	39	58
No. of examples	3	1	1	1	2	4	1	2	1	1	3	1	2	3	1

Average number of days.....18—

Extent of observations—25 days of actual field work July 29 to Sept. 26 inclusive

	July			August					
Dates of tagging	29	30	31	6	7	27	28	29	
Remaining no. of days	59	58	57	51	50	30	29	28	Totals
No. of frogs tagged	2	31	21	2	1	2	1	1	Total no. tagged.....61
No. later recovered	1	14	10	0	0	1	1	0	Total no. recovered.....27
No. not recovered	1	17	11	2	1	1	0	1	Total not recovered.....34

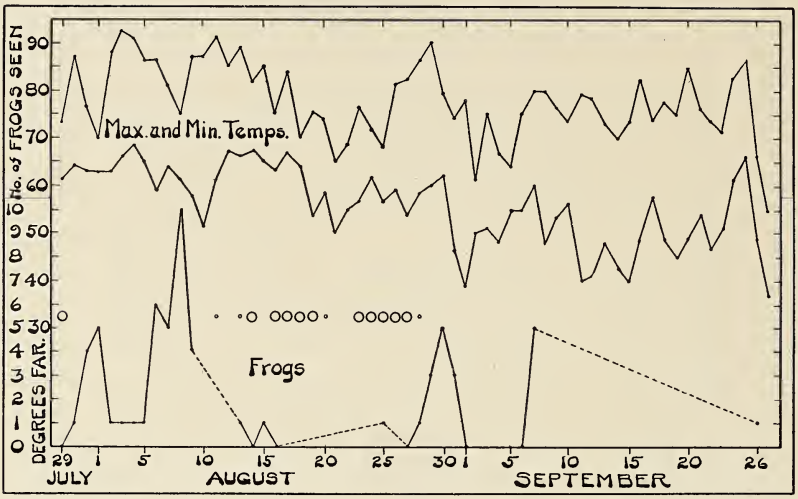

Fig. 273. Temperature (air) and number of tagged *Rana clamatans* seen, by days, at Haskell, New Jersey.

these and other items might be brought in with significance. Figure 273 gives a graphic representation of the maximum and minimum daily temperatures as compared with the number of tagged frogs seen. There seems to be some correlation although, of course, the data is much too slight to prove any point, it being presented more as an indication of what might yield results when further data are collected. Other matters of statistical significance we believe to be present in Table I waiting on a greater array of data to yield results.

Of the twenty-one frogs taken at the brook and released at the camp that found their way back we find from studying Table I that the average number of days between their release and recapture at the brook was 9. This data may be arrayed as below:

Days elapsed	1	2	5	6	7	8	9	30	39
No. of examples	5	3	1	2	4	1	2	1	2

Thus 23% of the individuals we know got back to the brook the next day at the latest. How many more did and were not seen until later is still a question. As the four other recoveries (B-22, 70, 71 and 303) returned to their "home" sites in 6, 7, 6 and 3 days respectively and as the average of the remaining twenty-one, as above

noted, was 9 days it may be that average number of days spent in the return was not far from six. The remaining one B-309 taken at the swimming hole and released at the bridge was retaken two days later at the fallen tree (Aug. 28–30).

Now let us consider the wanderings of the frogs after attaining their apparent objectives. Here a great amount of diversification was met with, some individuals remaining constantly in one place and others scattering about. A tabulation of those specimens which gave more than one record after release may serve to indicate their movements.

MOVEMENTS AFTER RETURNING TO THE BROOK

B-24	Aug.	8, Within a few feet of where first taken (by bridge).
		9, 30 and 31, Same place.
B-36	July	31, By fallen tree.
	Aug.	8, Same place.
		13, Near camp.
		31, By fallen tree.
	Sept.	26, Same place.
B-49	Aug.	8, Far end of fallen tree.
		9, Same place.
B-50	Aug.	1, Below fallen tree.
		29, At bridge.
B-51	Aug.	1, Swimming hole.
		7, 8 and 28, Same place.
B-55	Aug.	1, By fallen tree.
		8, Same place
	Sept.	7, Swimming hole.
B-61	Aug.	6, By bridge.
		8, 15 and 25, Same place.
	Sept.	7, Swimming hole.
B-65	Aug.	7, By bridge.
		8, and 30, Same place.
B-66	Aug.	1, By fallen tree.
		2, and 3, Same place (exact spot).
		8, and 29, Slightly below fallen tree (released at bridge).
		30, Half way between bridge and fallen tree.
		31, Three-quarters way to fallen tree.
	Sept.	7, Swimming hole.
B-68	Aug.	8, Far end of fallen tree.
		9, Same place.
B-83	Aug.	7, Half way between bridge and fallen tree.
		8, and 9, Same place.

Of these eleven frogs, six were subsequently seen only in single

small areas in any case not exceeding a radius of ten feet from where first seen after release. In other words they each stayed in a restricted region. Of the others, one (B-36) traveled up to camp and then returned, of itself, to the spot previously seen, again showing a good sense of direction. Three traveled down stream in late August and early September. One (B-66) after having been carried a short distance up stream took from August 29 to September 7 to travel from the bridge to the swimming hole. Another (B-30) traveled up stream from below the fallen tree to the bridge between August 1 and 29. It is to be noted that of those which moved about at all (the only ones, save one, seen on September 7 and including all of those which had moved down stream) were to be found at the swimming hole on that date and the one which had not moved had been there all along. Only one tagged frog was seen thereafter (September 26). Might this not be interpreted as a movement to the closest pool for purposes of hibernation? This pool is rather quiet and deep in the middle and is the only nearby place that is not in imminent danger of rapid and thorough freezing. The rather scattered data here presented seems all to point the general conclusion that these frogs have a well developed sense of direction, although when left alone are given to rather indiscriminate slight wanderings, five out of eleven moving about of their own volition.

Other Species

A *Rana sylvatica* and *R. palustris* taken in the orchard on August 28, and released at the barn were next seen at the swimming hole on August 29–30 and August 31, respectively.

Three *Bufo fowleri* tagged near the camp were all retaken at no great distance or significant direction therefrom. The dates follow.

B-59	July 30	–August 11
B-60	July 30	–July 31
B-93	August 4	–August 11

The Studies in New York

The operations at Palisades Interstate Park, N. Y., carried out largely by Albert C. Redmond, were commenced on May 6 and concluded August 26. Rain and coolness interfered with activities at this locality also but the larger number tagged and more intensive methods allowed of a proportionally greater record.

The species and number of individuals tagged were as follows. *Rana clamatans* 96, *Rana palustris* 7, *Rana catesbiana* 6, *Rana sylvatica* 1, *Bufo fowleri* 34, *Bufo americanus* 3, total 147. *Rana clamatans* is here also the dominant anuran and although useful data were collected on *Bufo fowleri* the greater mass of it refers to the former.

Rana clamatans

Methods employed here centered not so much on the homing instinct of the species, although of the fifty-six recoveries eight had originally been transplanted to other sites. The data they furnish corroborate the results obtained in New Jersey very well. Exactly half of those found their way back to their "home" localities. In these experiments the frogs were not placed at points lacking water but were transferred from one stream-side pool to another, in all of which frogs were living and were of such a nature that it would be almost humanly impossible to ascribe an advantage of one over the other as far as the "tastes" of frogs are concerned. The days elapsed between their last observation at the site of planting and their return to the "home" puddle may be expressed as below. See also Fig. 274.

B-111 May 8 D to B June 13 D days elapsed 35
B-112 May 6 C to B June 13 C days elapsed 37
B-116 May 6 D to B June 13 D days elapsed 37
B-118 May 7 C to B June 13 C days elapsed 36

It is highly probable that they returned much sooner than the "days elapsed" would seem to indicate as there is a great hiatus in the observations here (May 10 to June 12). It is to be especially noted by comparison with Fig. 274 that the pools "B," "C" and "D" are all in line and for B-111 and 116 to attain "D" they had to pass "C" which was very close and similar to it. Nevertheless, these frogs sorted themselves out according to their origins. When the New Jersey data is compared with this and it is recalled that there the one recovered that had been taken from the brook to the spring lingered two days it seems fair to infer that placing in a relatively unfriendly environment not only gives greater impetus to departure but also increases the urge to go "home" for otherwise how could one account for the two examples crossing the brook in the New Jersey studies so comparatively rapidly? One other frog which was moved later than its tagging date (B-128), June 26-27, returned at once.

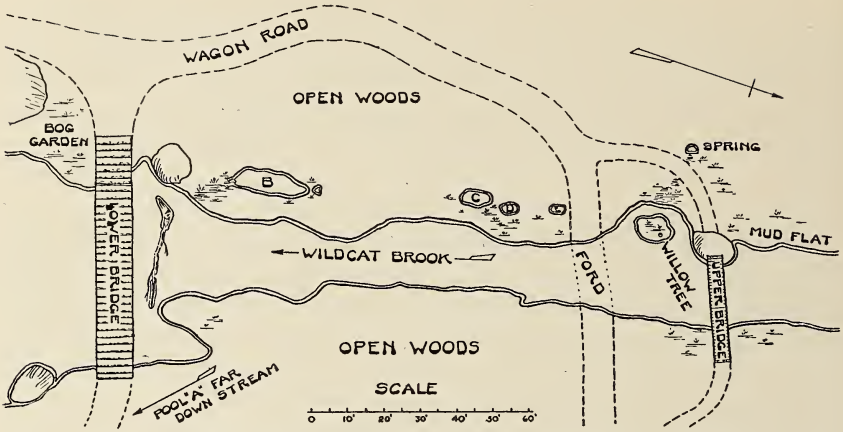

Fig. 274. Sketch map of Wildcat Brook showing important localities.

Considering the voluntary movements of these frogs which was the more special object of study at this locality we again have a great expression of individuality to deal with, more apparent here on account of the greater number of observations. Those which showed voluntary movements (omitting those transported) may be tabulated as follows:

B-105	May 6	In pool "A."
	May 7	Same place. (See Fig. 275-C.)
	June 21	In brook opposite "A."
	July 1	Same place.
B-106	May 6	In pool "A."
	May 7	Same place. (See Fig. 275-C.)
	May 8	In brook opposite pool "B."
B-116	June 18	In pool "C" (had returned to "D" on June 13).
	July 19	At ford, above pool "E" 8:00 A.M.
		At willow tree 11:00 A.M.
B-128	June 12	In spring.
	June 13	In brook opposite spring.
	June 14	In spring (identical to previous position).
	June 15	In brook opposite spring.
	June 19	Ten feet down stream from last date.
	June 20	Same place.
	June 23	In spring.
	June 25	At willow tree. (See Fig. 275-A.)
	June 26	Same place. (Released on other side of brook.)
	June 27	At willow tree.
	July 30	Same place.

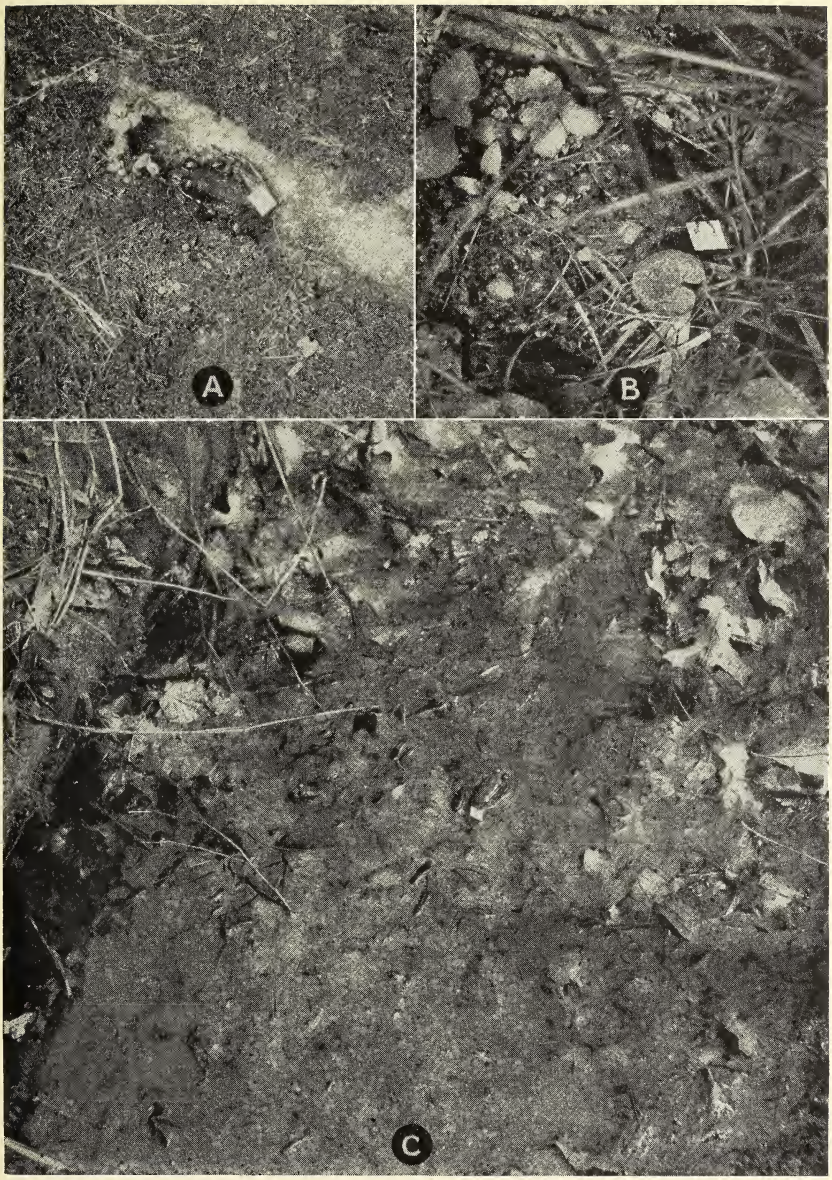

Fig. 275. Specimens of tagged *Rana clamatans* at Wildcat Brook; A—(B-128); B—(B-129); C—(B-105 and B-106).

	Aug. 2	In brook opposite spring.
	Aug. 9	At willow tree.
	Aug. 23	In brook opposite spring.
B-129	June 12	In spring.
	June 13	Same place.
	June 14	Same place.
	June 15	Same place. (See Fig. 275-B.)
	June 18	Same place. (Released 50 feet up road.)
	June 19	In creek opposite spring.
	June 20	Same place.
	June 30	In spring.
B-131	June 13	In pool "C."
	June 14	Same place.
	June 18	In brook opposite spring.
	June 20	Same place.
	June 26	In pool "D."
	Aug. 2	Between spring and ford. (F.L.)
B-132	June 13	In brook opposite pool "B."
	June 14, 18 and 20	Same place.
	July 11	In spring.
B-133	June 13	In pool "B."
	June 20	In brook opposite "B."
	June 22	Across brook from pool "B."
	June 29	In brook opposite "B."
	July 8	Same place.
	July 22	Across brook from pool "B."
	Aug. 2	In brook opposite "B."
B-135	June 13	Above spring on mud flat.
	June 14	Same place.
	June 15	Across brook from spring.
B-137	June 14	In pool "C."
	July 7	In brook about 75 feet below ford.
	July 27	In brook about half way between ford and spring.
B-140	June 14	Below lower bridge opposite bog garden.
	July 22	Under lower bridge.
B-141	June 14	East end of lower bridge. (Right hind foot missing.)
	June 22	Same place.
	June 25 (D.K.) 29, July 8, 19 in brook opposite pool "B."	
	July 22	East shore below lower bridge.
	July 23	In pool "D."
B-142	June 14	Above spring at mud flat on a small branch.
	June 15	Same place except not on branch.
	June 18 and 19.	Same place.
	June 20	In brook opposite spring.
	June 21	Above spring on mud flat.
B-143	June 15	In pool "B."
	June 19	In brook opposite "B."

	June 22, 25 (D.K.), July 4 and 18	Same place.
	July 22, 26, 27 and Aug. 2	Same place.
	Aug. 14	In pool "B."
B-145	June 15	In brook opposite spring.
	June 18	On shore opposite spring.
	July 30 and August 3	At willow tree.
B-146	June 15	Across brook from spring.
	June 18, 19 and 20	Same place.
	July 19	At ford.
	July 23	At willow tree.
	July 27	In brook opposite willow tree.
	Aug. 1	Across brook from pool "B."
B-147	June 15	Across brook from spring.
	June 21	In brook opposite spring.
	June 22	Same place. (D.K.)
	July 26	At willow tree.
	July 27	Same place.
B-150	June 18	In pool "C."
	June 19	Same place.
	July 21	In brook about 50 feet below ford.
B-153	June 20	In brook opposite pool "B."
	July 27	Across brook from "B."
B-162	July 8	In brook opposite "B."
	July 9	Near spring (under a board).
	July 10	Same place.
	July 17	In brook opposite spring.
	July 22	In brook opposite pool "B" 7:00 A.M. About 50 feet above pool "B" and across brook 3:10 P.M.
	July 27	In brook opposite "B."
B-163	July 9	In spring.
	July 21	Same place.
	July 25	At willow tree.
	July 27	Across brook from willow.
	July 30	In spring.
	Aug. 9	At willow tree.
B-171	July 17	At ford, east shore of brook.
	July 25	In brook above ford.
	July 28	At willow tree.
	Aug. 9	Same place.
B-174	July 22	In brook opposite pool "B."
	July 23	In brook opposite spring 9:40 A.M. In pool "D" 8:45 PM.
	July 25	At willow tree.
	July 27	Same place.
	Aug. 13	Same place.
B-175	July 18	In brook opposite pool "B."
	July 22	In brook opposite bog garden.
	July 25	In brook across from bog garden.

	July 27	Same place.
B-176	July 18	In brook opposite pool "B."
	July 22	and Aug. 12 In pool "C."
B-180	July 23	In pool "D."
	July 24, 26,	Same place.
	July 28	Below upper bridge.
	July 30	In pool "D."
	Aug. 2, 9	Same place.
	Aug. 12	In pool "C."
B-181	July 23	In pool "D."
	July 24	Between "D" and "C."
	July 25, 26, 27, August 1, 2, 3, 9, 11, 12, 14 and 20, pool "C."	
B-182	July 25	In pool "C" (had been transported some distance on July 23 from a point well back from the brook).
	July 26	Same place.
	July 27	In brook opposite pool "B."
B-189	Aug. 1	In pool "B."
	Aug. 2	In brook 10 feet above pool "C."
B-190	Aug. 9	In pool "D."
	Aug. 12	In brook opposite pool "B."
	Aug. 13	In brook 15 feet below ford, 8:45 A.M.
		In brook 20 feet below ford 2:30 P.M.
B-198	Aug. 12	In pool "C."
	Aug. 13	At willow tree.
B-206	Aug. 18	In brook opposite spring.
	Aug. 20	Below lower bridge.

F.L. and D.K. refer respectively to records made by Frank B. Lutz and Day Krolick.

A perusal of the above tabulation of activity and an examination of Fig. 274 will show at once that the voluntary movements of these frogs, more or less given to wandering, cannot be considered as a migration or even a seasonal movement induced by changing weather conditions for there is not sufficient unanimity of direction or time of movement to permit of such an interpretation. For example, some stayed in one restricted locality while others were moving up, down or across stream and in some cases must have passed each other. A study of Table II will reveal numerous instances where various frogs were moving down or across stream or staying in one place on consecutive days. For example between June 18 and 19 B-129 moved from the spring to the brook (transverse), B-116 moved from "C" to the ford (upstream) while B-142, 146, 149 and 150 all stayed in one place. This becomes more evident if more than a lapse of

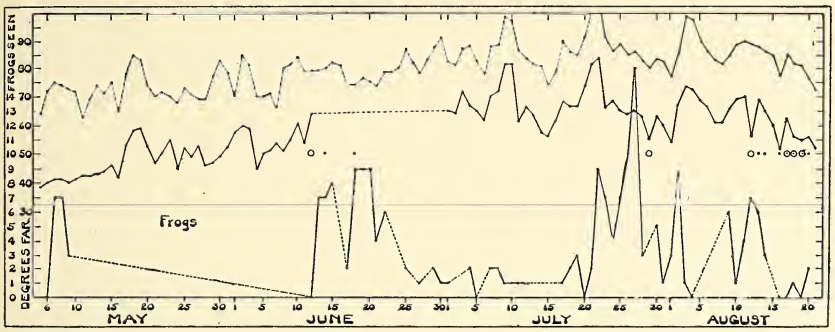

Fig. 276. Temperature (air) and number of tagged *Rana clamatans* seen, by days, at Interstate Park.

one day is included. From this we may tentatively infer, at least, that this species during the growing (non-sexual) period tends to remain in one place as long as its requirements are met with. Factors which may drive frogs from a site include the drying up of a pool, as happened at pool "A" which dried up in late May with the result that the frogs migrated, as far as known, to the stream. What caused one (B-106) to move so far upstream as to be opposite pool "B" we do not pretend to know. Another (B-143) which left pool "B" when it became nearly dry returned later when it was again filled by rain. Other adverse conditions such as a lack of food might cause similar movements but in the localities studied conditions were so uniform that this is hard to conceive of. Fright by enemies might be another, but as the handling incident to tagging failed to produce any such results, as is abundantly shown by the records, it is doubtful if the presence of enemies would do more than cause them to hide close by. Other phenomena of a less violent nature would naturally seem to have even less stimulus. To infer that they move about when they do for the pure desire to change their location is rather anthropomorphic and begs the question. Therefore we disclaim the ability to explain, as yet, these wanderings.

Another point which we are at a loss to explain is that the frogs frequently disappeared from a site for from a few hours to several days without being found elsewhere. Especial attention was paid to this point in pools "C" and "D." Although in other cases we generally avoided disturbing conditions in the case of these two they were generally "dredged" and the absence of frogs or even one

TABLE NO. 2

Recoveries of *Rana clamatans*

Tag Number	May				June														July									
	6	7	8	9	12	13	14	15	17	18	19	20	21	22	25	27	29	30	1	2	4	5	7	8	9	10	11	17
B–104	A	A	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
105	A	A	..	..	..	..	..	..	..	..	..	..	*B*	..	..	..	..	..	*B*	..	..	..	..	..	..	..	..	..
106	A	A	*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
107	A	A	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
110	B	..	B	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
111	DB	..	B	..	..	D	..	D	D	D	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
112	CB	..	..	..	..	C	C	C	..	..	C	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
113	O	..	O	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
114	DB	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
116	DB	..	..	..	..	D	..	..	..	C	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
117	DB	B	B	..	..	B	B	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
118	CB	B	..	..	..	C	..	..	..	..	C	C	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
119	DB	..	*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
121		A	A	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
123		C	..	C	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
127			B	B	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
128					S	*B*	S	*B*	..	..	*B*	*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
129					S	S	S	S	..	S	*B*	*B*	..	..	..	..	..	S	..	..	..	..	..	..	..	..	..	..
131						C	C	..	..	*B*	..	*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
132						*B*	*B*	..	..	*B*	..	*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S	..
133						B	..	..	..	..	..	*B*	..	*B*	..	..	*B*	..	..	..	..	..	..	*B*	..	..	..	..
134						D	D	D	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
135						M	M	*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
137							C	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*B*	..	..	..	..	..
139							O	..	..	O	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
140							*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
141							*B*	..	..	..	..	..	..	*B*	*B*	..	*B*	..	..	..	..	..	..	*B*	..	..	..	..
142							M	M	..	M	M	*B*	M	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
143								B	..	..	*B*	..	..	*B*	*B*	..	..	..	..	..	*B*	..	..	..	..	..	..	..
145								*B*	..	*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
146								*B*	..	*B*	*B*	*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
147								*B*	..	..	..	..	*B*	*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..
149										*B*	*B*	*B*	*B*	*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..
150										C	C	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
153												*B*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
155												*B*	..	*B*	..	..	..	..	..	..	*B*	..	*B*	..	..	..	..	..
162																								*B*	S	S	..	*B*
163																									S	..	..	..
170																												
172																												F
173																												
174																												
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206																												

B—Brook. A—Pool "A." B—Pool "B." C—Pool "C." D—Pool "D." F—Ford. M—Mud flat. N—Across stream from Willow tree. O—Circular spring (not shown in Fig. 9). S—Spring

TABLE NO. 2 (Cont.)

Recoveries of *Rana clamatus*

July												August																	
19	20	21	22	23	24	25	26	27	28	30	31	1	2	3	4	9	10	11	12	13	14	16	17	18	19	20	21	22	23
F																													
			C	C	C		C	C	C	C			C				C	C											
				S		W	WN	W		W			B			W													B
							D						F																
			B										B																
								B																					
			B																										
B			B	D																									
			B				B	B					B								B								
										W				W															
F				W				B				B																	
							W	W																					
		B																											
								B																					
			B					B																					
		S				W		B		S						W													
				C	C		C	C			C							C	C	C									
						B			W							W													
			C				C												C	C									
			B	B		W		W												W									
			B			B		B																					
			C																C										
	B						B	B					B																
				D	D		D		B	D			D			D			D										
				D	D	C	C	C				C	C			C		C	C		C					C			
				BC		C	C	B																					
						B		B																					
							B	B				B						B											
																W			W										
												B	C																
																D			B	B									
																			D	W									
																			D	D									D
																								B		B			

—Base of Willow tree. For further details see text. Two localities under a date indicate those from ich and to which the individual had been moved.

TABLE NO. 2

Recoveries of *Rana clamatans*

Tag Number	May 6	7	8	9	June 12	13	14	15	17	18	19	20	21	22	25	27	29	30	July 1	2	4	5	7	8	9	10	11	17
B-104	A	A																										
105	A	A											B						B									
106	A	A	B																									
107	A	A																										
110	B		B	B																								
111	DB		B			D		D	D	D																		
112	CB					C	C	C			C																	
113	O		O																									
114	DB	B																										
116	DB					D				C																		
117	DB	B	B			B	B	B																				
118	CB	B				C					C	C																
119	DB		B																									
121		A	A																									
123		C		C																								
127			B	B																								
128					S	B	S	B			B	B																
129					S	S	S	S		S	B	B						S										
131						C	C			B		B																
132						B	B			B		B																S
133						B						B		B			B							B				
134						D	D	D																				
135						M	M	B																				
137							C																B					
139							O			O																		
140							B																					
141							B							B	B		B							B				
142							M	M		M	M	B	M															
143								B			B			B	B					B								
145								B		B																		
146								B		B	B	B																
147								B					B	B														
149									B	B	B	B	B	B														
150									C	C																		
153												B																
155												B		B						B		B						
162																								B	S	S		B
163																									S			
170																												
172																												F
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B—Brook. A—Pool "A." B—Pool "B." C—Pool "C." D—Pool "D." F—Ford. M—Mud flat. N—Across stream from Willow tree. O—Circular spring (not shown in Fig. 9). S—Spring

TABLE NO. 2 (Cont.)

Recoveries of *Rana clamatus*

Tag Number	July 18	19	20	21	22	23	24	25	26	27	28	30	31	August 1	2	3	4	9	10	11	12	13	14	16	17	18	19	20	21	22	23
B-104																															
105																															
106																															
107																															
110																															
111																															
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190																															
198																															
199																															
206																															

W—Base of Willow tree. For further details see text. Two localities under a date indicate those from which and to which the individual had been moved.

TABLE NO. 2 (Cont.)

Number of recoveries of the 96 specimens tagged

Times recovered	0	1	2	3	4	5	6	7	8	10	11	13	15	Average no. of recoveries	4—
No. of examples	40	15	10	8	7	6	1	3	2	1	1	1	1	Total no. recovered	56

Intervals in days between taggings and last observations

No. of days elapsed	1	2	3	4	6	7	9	11	13	16	17	18	19	20	22	23	25	26	28	33	37	38	39	40	42	43	44	45	47	49	56	60	74	97
No. of examples	7	6	3	4	1	1	1	1	1	1	1	1	3	1	1	1	1	3	2	1	1	1	1	1	1	2	1	2	1	1	1	1	1	1

Average number of days 23—

Extent of observations

60 days of actual field work — May 6 to August 26 inclusive

	May				June								July									August									Totals
Dates of tagging	6	7	8	9	12	13	14	15	17	18	19	20	8	9	17	18	20	22	23	25	26	1	4	9	12	13	14	16	18	26	
Remaining no. of days	112	111	110	109	75	74	73	72	70	69	68	67	49	48	40	39	37	35	34	32	31	25	22	17	14	13	12	10	8	0	
No. of frogs tagged	18	5	2	1	2	7	6	4	2	3	3	7	1	1	1	5	1	2	3	1	3	1	1	2	6	4	1	1	1	1	Total no. tagged 96
No. later recovered	13	2	1	0	2	5	5	4	0	2	0	2	1	1	1	4	1	1	3	1	1	1	0	2	2	0	0	0	1	0	Total no. recovered 56
No. not recovered	5	3	1	1	0	2	1	0	2	1	3	5	0	0	0	1	0	1	0	0	2	0	1	0	4	4	1	1	0	1	Total not recovered . . . 40

specific one is virtual evidence that they were in reality not hiding in the water or on the nearby banks. Just where they went to is still an open question. Note on Table II such frogs as B-118 in which the times it was absent from pool "C" for the most part actually imply just that, and not simply that by casual inspection they were not seen. Likewise B-170, B-181, etc. The impression was obtained that there was a certain periodicity to the movements of these individual frogs that caused them to hide away in inaccessable places, possibly after an extra large meal to await the processes of digestion. It will be noted that here no uniformity of disappearances or appearances was obtained. Further work alone can aid in the explanation of these phenomena.

Bufo fowleri

Although only thirty-four specimens were tagged and but twelve recovered this species yielded by far the most striking results. As the work was not of a continuous nature it may better be simply discussed by days.

On the evening of June 13, when the males were in good voice in the middle Beaver Pond, eleven were collected along its lower side (B-J to B-T). See Fig. 277. These were placed in a bag as collected and carried to the cabin where they were released about 11:00 P.M. In a few minutes after release they were all actively hopping about near the cabin and calling. This kept up until about midnight and by morning none could be found. At sunset on the 14th four of these appeared from under the cabin, began calling and were very restless. Three were not seen again and two were taken at the middle Beaver Pond not only in its general vicinity but each within a few feet of their original calling site. The remaining two were taken at Beaver Pond on the evening of June 18. This may be more clearly indicated in tabular form as follows omitting those which were not recovered at all.

Frog number	Dates—June					
	13	14	15	16	18	19
B-J		C			B	
B-K		C				
B-L					B	
B N		B				

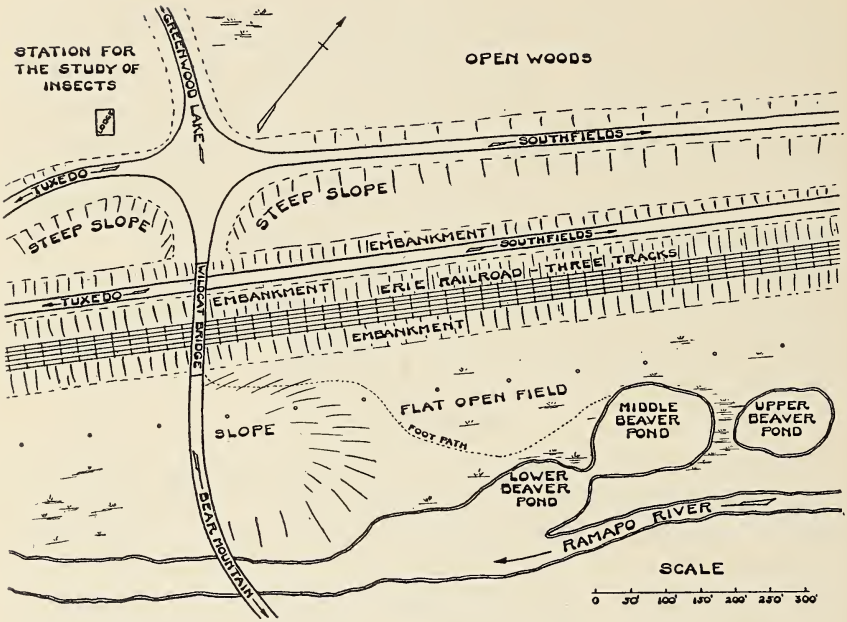

Fig. 277. Sketch map of the Beaver Ponds showing important localities.

Frog number	Dates—June					
	13	14	15	16	18	19
B-P		C				
B-Q		C				
B-T		B			B	

"C"—At Cabin "B"—At Middle Beaver Pond.
June 13—Date of tagging. June 15, 16—Observer absent.
June 17—No toads calling, too cool.

In other words, of the recoveries we know that at least one half got back by the 18th. The remarkable part of this performance is not the fact that it shows a degree of homing instinct for the species but is the great number of obstacles and distractions as well as the length of the journey, as is partly shown by Fig. 277. The most likely route taken by them entails a crossing of three macadam highways overcrowded at night with speeding high-powered cars and comparatively full of traffic at practically all times, the climbing of a cinder railroad embankment, the crossing of three railroad

tracks and finally a descent into an open flat field beset with holes of small size. An alternative route would have been over Wildcat bridge which would eliminate one road crossing and the railroad but which would have lengthened their time in the path of traffic. For these reasons it was feared that possibly those that were not recovered had been crushed by passing cars although a careful search failed to reveal any remains. It is to be especially noted that the toads were headed down the opposite slope of the hill which the cabin tops toward other water where a second colony of toads were calling. These could be heard much more distinctly than those at Beaver Pond but, nervertheless, none of our tagged individuals were ever found there.

On the 14th seven more were tagged and released in a like manner (B-U to B-AA). Unfortunately none of these were recovered as it was impossible to stay at this place on the 15th and 16th. Why none of these were recovered on the 18th we do not know.

On the 17th one was taken and released as before but none were calling—a poor night for *Bufo* on account of low temperature. The next evening this one was still at the cabin.

On the 18th two more were so treated one of which B-AH was seen the next night at the cabin. Nine more were retained until the 19th before release and were not seen again but as the time available for search was slight this probably means little.

One B-184 found on July 26 not far upstream from Pool "A" has the following history.

July 27 —Same place.
July 30 —Opposite shore.
August 2—Crossed brook again further upstream.
August 11—Near where first seen.
August 17—Near cabin.

One June 18th two toads which had made the journey back to Beaver Pond (B-T and B-L) were released at the cabin along with two others which had been brought from the pond for the first time. These had "trailer" [1] attached to them which worked their paths. Although this device interfered with their movements somewhat it is

[1] This device is described in "Turtle trailing: a new technique for studying the life habits of certain testudinata." R. B. Breder Zool., Vol. IX, No. 4. The paths taken by these four toads is there illustrated.

noteworthy that the two which had already made the journey moved toward the end of the cabin away from the pond and in much more direct lines than the other two which actually moved more toward it but with more leaping around. This may mean that the first two had partly learned a path more satisfactory than simply moving in a straight line.

Rana sylvatica

The single *Rana sylvatica* of small size had the following history.

June 19	Tagged at Pool "D."
June 20	Same place.
July 18	At pool "C."
July 22	Same place.

Conclusion

The following table indicates the total number of animals tagged as compared with the returns.

Tagged	Interstate Park	Haskell, N.J.	Millburn, N.J.	Total
Rana clamatans	96	61	10	167
Rana catesbiana	6	..	..	6
Rana palustris	7	12	5	24
Rana sylvatica	1	7	13	21
Bufo fowleri	34	9	..	43
Bufo americanus	3	..	..	3
Totals	147	89	28	264

Recovered	Interstate Park	Haskell N.J.	Total
Rana clamatans	56	27	83
Rana palustris	..	1	1
Rana sylvatica	1	1	2
Bufo fowleri	12	3	15
Totals	69	32	101

None tagged at Milluburn, N. J., were recovered partly because studies were discontinued there early and partly because, no doubt, of its ready accessibility to small boys and because the location was used more as a basis for experimentation with technique. The returns may be expressed in percentage as follows:

Rana clamatans	53–
Rana palustris	05–
Rana sylvatica	25
Bufo fowleri	35–
All species	43

That these percentages are not all that could be expected is patent for our time afield was limited and suffered much interruption and the season was an unusually poor one for frog studies on account of prevailing rains and coolness. However, we are convinced that the method as outlined, although not entirely perfect, is of such a nature that its further pursuit will surely reveal matters of importance. The basic conclusions so far arrived at follow.

1. The tags described herewith apparently inconvenience the individuals little, if at all, and are practically of no consequence in modifying their normal behavior.

2. Tagging anurans is a method applicable to a large number of species and problems.

3. The number of returns to be expected is not much below 50% and under good conditions should be much more.

4. *Rana clamatans* shows a well developed homing instinct during the summer at least.

5. *Rana clamatans* shows such individuality in its voluntary journeys or lack of them during mid-summer.

6. Male *Bufo fowleri* have a well developed homing instinct when in voice at least.

7. Male *Bufo fowleri* will sometimes travel at least one quarter of a mile in less than twenty-four hours over very difficult paths and surmount numerous obstacles to return to their "home" territory.

Herpetological literature contains many references to known individuals of various species of anurans that have displayed a homing instinct. A careful search of it would enable one to compile quite an extensive bibliography but as all those which we know of are comparatively minor notes and none express the results of systematic investigation and would have slight bearing on the present theme we feel that the present paper can dispense with such a list. Finally it is to be noted that although the data here presented is of definite significance it is published chiefly as a basic building block and stimulus to further more extensive and systematic research of this nature.

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TURTLE TRAILING:

A NEW TECHNIQUE FOR STUDYING THE LIFE HABITS OF CERTAIN TESTUDINATA

By Ruth Bernice Breder

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TURTLE TRAILING:

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By Ruth Bernice Breder

(Figs. 278–284)

Introduction

In an effort to obtain detailed data on the general behavior and daily life of certain land turtles it became clearly evident that much could be accomplished if it were possible to make continuous observations on specific individuals. The well tested method of carving characters on the plastron, that has been in use for a long time by both the naturalist, for study, and the layman, for amusement, is sufficient for many purposes entailing long time observations but for others the information it supplies is too general and lacking in detail. In short, for the purposes in mind, it became desirable to find out what the turtles did between the observations that the carving method allowed of.

With these thoughts in mind an apparatus was devised which caused the individual turtle to unwittingly mark its own trail with a fine thread that unreeled from a spool as the turtle moved about. As will be subsequently shown, it is extremely doubtful if such an equipped turtle was aware of the presence of this object which caused him to record his activities that could only be otherwise obtained by a rather impractical sort of continuous observation. Although the work is still in somewhat of an experimental stage, its development this summer and the promise of useful returns that it holds has prompted this placing on record of the details of the technique.

The studies were carried on near Haskell, New Jersey, in 1926 at the camp of Mr. James E. Brooks of Glen Ridge, New Jersey, known as Camp Thomas Brooks. For the use of this camp and the adjoining land I am greatly indebted to the owner. I am also indebted to Mr. C. M. Breder, Jr., of the New York Aquarium, for his encouragement, criticism and the preparation of the accompanying diagrams.

Use of the Method

To make more clear the possible uses of this method of study, there are tabulated herewith a number of problems that might be attacked in this manner with a good expectancy of success.

1. Extent of the homing instinct.
2. Exact route taken to attain the "home" territory.
3. General wanderings on home territory. How differing from day to day as associated with season and weather.
4. Migrations, their extent and routes.
5. Activity during mating periods as compared with that at non-mating times.
6. Methods of search for nesting sites.
7. Significance of water in the lives of turtles.
8. Actions on a natural approach to various stimulae, such as avoidance or search of sunny place.
9. Differences in the behavior of the sexes in any of these respects.

Many others might be tabulated, but the above will suffice to point out the manifold questions of biological significance that an intelligent and systematic application of this method should help to solve. It is to be especially noted that experiments in behavior of a laboratory nature do not duplicate those suggested above for field work, but rather, are complementary in nature.

The Apparatus

The only species worked with so far has been *Terrapene carolina* (Linnaeus). However the apparatus described below should work just as well on our other local terrestrial species *Clemmys insculpta* (Le Conte), and the possibility of applying it to *Gopherus polyphemus* (Daudin) or even larger forms with more elaborate equipment is fascinating.

Large spools of white basting thread holding 150 or 250 yards per spool and weighing about 30 grams were attached to the hind end of the carapace by means of iron wire as indicated in Fig. 278. A hole was bored through the flanging edge of the shell, by a small pen knife blade, to provide attachment. It was bored half way from each side to prevent splitting and undue enlargement and was placed so near to the edge that in time it would break through, releasing the trailer in case the animal came to the end of the line and was not retaken. The wire was hooked through this hole and passed through the spool so that the latter rotated freely on it as an axle. The bending and twisting of this wire is plainly indicated in Fig. 278. A guide was made of a lighter piece of wire attached

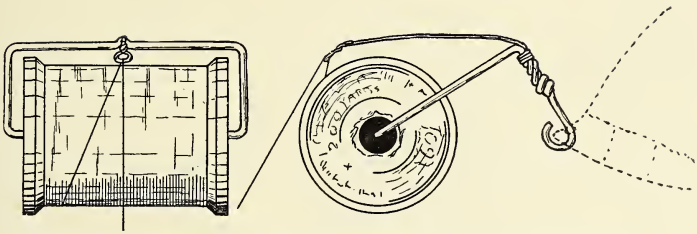

Fig. 278. Diagram of the construction of the trailer as used.

to the heavier wire where the latter was twisted together and provided with a loop, through which the thread passed. This loop was placed directly over the center of the spool so that the thread would play out freely and independently of the turtles activity, regardless of the abruptness of its turning.

The turtle thus provided was then released, the thread being tied to a small stake, and as it began to resume its life activities a complete record was laid out on the forest floor of the places it visited and often what it did until the end of the line was reached. Some time later, if the turtle was not recovered and provided with a new trailer, the thin edge of the shell should break and the device be dropped leaving a small notch as its only indication. For this reason as well as others symbols were always carved on the shell so that a later recovery would allow a continuation of observations as well as give such data as that method provides. Fig. 279 and 280 show turtles in the process of laying down trails.

The question might here be raised as to how much inconvenience this device causes a turtle. As the spools weigh about 30 grams and the average weight of a mature *Terrapene* is about 425 grams, the difference is so great that it can be of small significance, especially as two turtles of equal size will frequently differ much more than that amount in their own weights. The possible dragging effect it might have is also doubtless of no consequence for as a little observation will show such turtles are constantly forcing their way through tight places and continually being held back because of their shells catching on various objects. The resistance such a rolling spool might have is so slight in comparison that it is gravely doubted whether a turtle is at all conscious of the presence of the trailer. In this connection it should be pointed out that the trailer

Fig. 279. Turtle laying down a trail through rather open country.

Fig. 280. Turtle laying down a trail through rough country.

should be placed so as to clear any possible movements of the hind feet or tail and that the thread should be so passed through the guide that it unrolls in the proper direction of rotation for otherwise the spool in unwinding would be rotated against the direction it would naturally roll in which might produce some friction between it and the ground. Also it is important that white thread be used for ease in following the trail after it is laid, as any other color is seen with comparative difficulty afield. This is especially noticeable when passing under low bushes with dense foliage. There is, of course, always a possibility of the device being caught by some obstruction, but this, as is subsequently shown, is comparatively slight if the trailer is neatly made. It might also interfere with copulation but of this there is no data as yet.

Application of the Method

After the method was fairly satisfactorily worked out time was only sufficient to try it on four individuals. These were specifically marked on their plastrons T-16, T-18, T-20 and T-22. The first and third were given three runs each and the second and fourth one each making actually eight trails. In each case T-16 broke its thread due to an imperfection in the trailer as did T-22. This leaves a remainder of four complete and perfect trails. All are indicated on the accompanying sketch map, Fig. 281 which should be consulted in connection with the tabulation of the activities of these turtles given below:

T-16 July 30th. Male. Taken at cabin 8:00 A.M. Plastron length 140 mm. Released without trailer at 9:10 A.M. Went directly to Post Brook and was seen there 11:30 A.M.

August 20th. Retaken about 1000 feet south-east of camp site. Released with trailer and started in direction from which it was brought, thread breaking in a short time.

August 21st. Retaken part way to spot where last seen. Released from same place and again started in same direction and broke thread.

September 2nd. Retaken in same general vicinity.

September 3rd. Released from same place and started in same general direction again breaking thread in each successive trial it moved progressively nearer to the brook.

T-18 August 5th. Male. Taken in open woods almost north of camp site. Retained for 36 hours. Plastron length 140 mm.

August 6th. Released at cabin with a 300 foot spool at 6:30 P.M.

Very active and restless all time prior to release not retracting at any time. When released it made no stops but quickly and directly started away, Burrowed for the night.

August 7th. Came to end of thread a few feet from where taken.

T-20 August 27th. Female. Taken at cabin 8:15 A.M. Retained for 24 hours.

August 29th. Released with trailer. Wandered about toward an open field, but refused to emerge into the bright sun.

August 30th. Retaken at edge of woods a short distance from end of line. Returned to same place for a new start. Went to creek and entered it twice and headed in the opposite direction from yesterday. Dug in about 4:30 P.M.

August 31st. Continued on way crossed creek. Retaken near end of line. Restarted as before. Followed yesterday's path closely but did not bathe and dug in at about 4:30 again near last night's lodging.

September 1st. Continued on yesterday's trail and burrowed early.

September 2nd. Crossed stream and returned and burrowed not far from where it burrowed the two previous nights.

September 3rd. Wandered about in same territory and came to end of thread.

T-22 September 25th. Male. Taken on hillside south east of cabin and across brook from it.

September 26th. Released with trailer at cabin. Headed straight in direction of capture and burrowed early.

September 27th. String broken but pointing to position of capture.

A consideration of the data here presented when compared with the map, Fig. 281, reveals some rather interesting conditions. T-16, T-18 and T-22 all show a direct tendency to go to the point from which they were picked up. As the earlier dates of T-16 show it was apparently at all times on its home territory but nevertheless desired to get back to where it had been last taken from. T-22 would seem to have its home lands across the brook. The trail of T-18 is the most interesting in that it is so complete and perfect. Here an active, strong and apparently fearless specimen sought out and found his "home" territory with great expedition. It was of extreme interest to note that he took the most direct route, avoiding trees and rocks of large size and still continually gaining altitude. That is, he followed the crests of small ridges and carefully avoided gullies. Only in one place, as shown on the map did he descend into one. This gully was so long that a detour would have been less efficient than the descent he made into its shallow depth. It is also noteworthy that he apparently did not travel by dark as

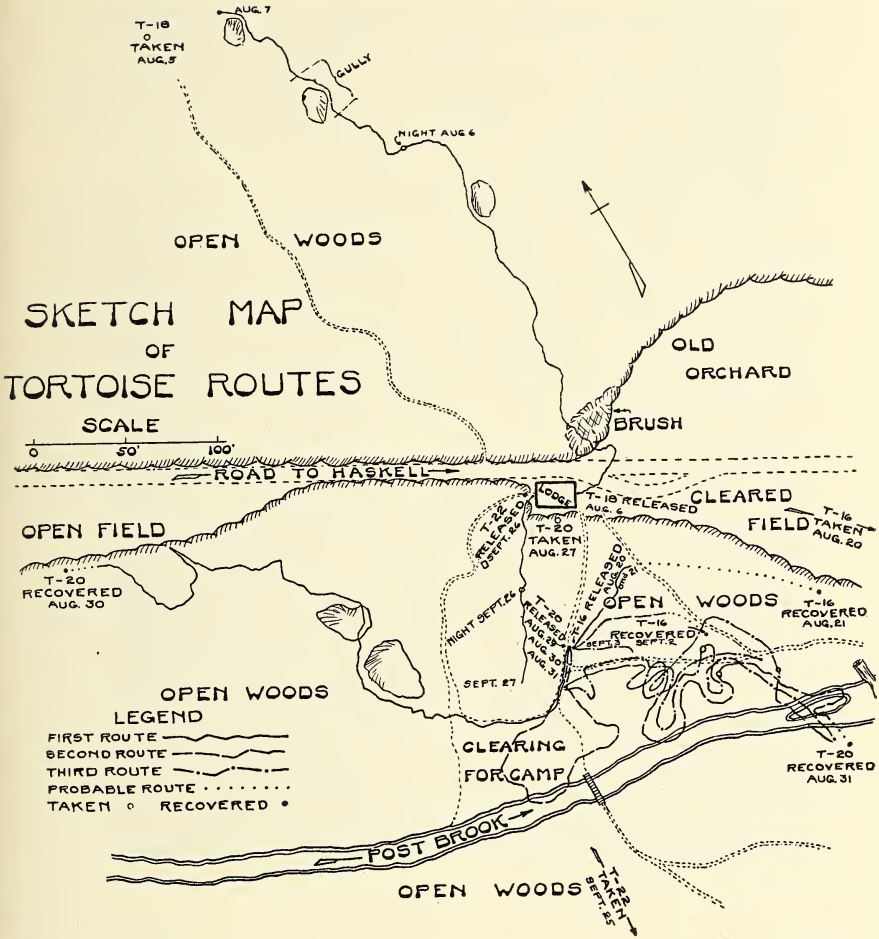

Fig. 281. Freehand sketch-map of Camp Thomas Brooks and environs showing paths taken by the turtles studied as indicated by their trails. The important points are marked and the significant dates indicated.

the thread went underground in a burrow exactly as did others which we know buried themselves for the night. He pushed right on through not backing out of the hole as might be expected. However, this had apparently little to do with the direction he was going in for in all cases they emerged from their burrows in this same manner. This in itself is interesting and would not have been sus-

pected if it had not been for the application of the present method. There is every reason to conclude that the sense of direction is well developed in these turtles and that in an effort to attain the desired location they pick the geometrically shortest route in respect to vertical movements and the avoidance of obstacles as well as the proper horizontal angle.

In the case of T-20 we apparently have a turtle already on "home" territory. Her first trail is much more rambling and as that day was especially warm and sunny it is interesting to contemplate her edging along the hot and dry field and her refusal to leave the shade of the woods. It is noteworthy also that her intelligence was not sufficiently great to prevent her from making a second attempt to go in the direction of the field that so recently turned her back or she may have been edging along under some comparatively strong motive to cross that field. It would be interesting to know what urged her to move in this direction. The second trail on an equally hot day started in the same direction as the first but finally carried her down to the water where two emersions were made before digging in for the night which was done well before sundown. Fig. 282 shows the first part of these two trails where they still ran together along the path. Compare with Fig. 281. The photo was taken looking up the path from the camp clearing. On coming out the next day after sun-up she entered and this time crossed the creek. On retaking and release from the old starting point an almost identical route was covered except that bathing was omitted and the path somewhat shortened. It cannot but remind one of the shortening of routes so common in experiments on animal psychology. After spending another night close to where the last one was spent she continued on her journey again crossing the creek and one might think to continue on her journey on the other side that was interrupted when she was brought back to her starting point. Here we might almost imagine that some objective was in view as is often seen in experiments on behavior in the interruption of animal acts that she had no better discrimination than to repeat nearly all the acts preliminary to attaining this point whether necessary or not. However, this hardly seems to be the case, for on attaining the point at which she was recovered yesterday she doubled back and returned close to the place that the preceding nights were spent before coming to the end of her line. All this is simply

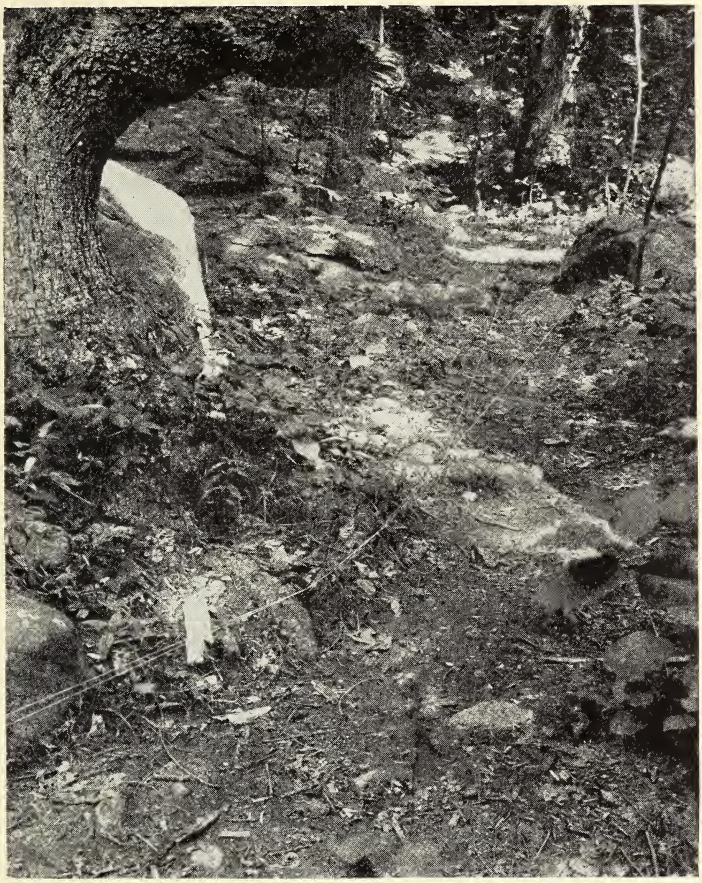

Fig. 282. The start of the first and second trail of T-20.

interpreted to mean that she was on her "home" land and not going any place in particular but wandering around in search of food or what not. It is inferred from these considerations of the preceding data that T-16 has its center of activity somewhat to the south-east of camp and north of the brook, T-18 across the road from camp on the hillside, T-20 between the camp and the brook and T-22 across the brook from the camp at some distance. Continued studies another year should give further data of this nature, such as the normal extent of their range of territory, how close they adhere to it from season to season, and so on. There is a possibility that a differential

behavior of the sexes complicates this for it so happens that the one on "home" territory was a female while the other three were all males. It is also to be noted that on Sept. 2d when male T-16 was recovered for the last time and female T-20 had just emerged from her burrow close by that they were found craning their necks and apparently taking notice of each other.

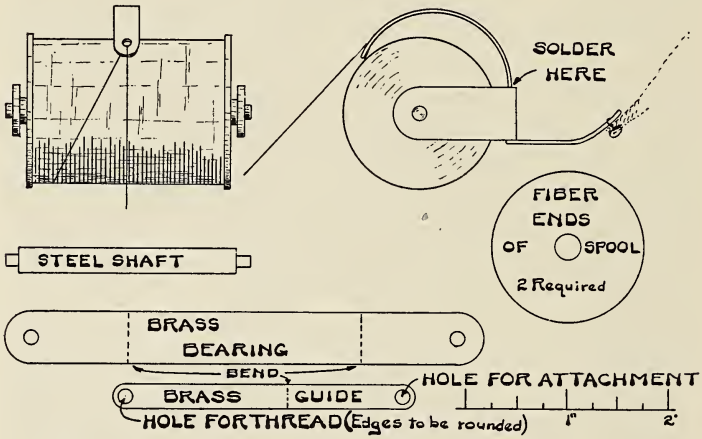

Fig. 283. Diagram of the construction of the trailer as proposed.

Proposed Methods

The chief faults with the present method seem to be that the spools do not carry enough thread and in order to renew the spool it is necessary to take the apparatus apart and that it is a rather crude device. Work is now in progress looking forward to another season on the construction of more refined trailers. These are being built according to the plans given in Fig. 283 designed in collaboration with Mr. Breder.

Supplanting the spool of large diameter is to be a bobbin of small diameter on which the contents of several spools may be wound. This may be done rapidly and effectively by placing the end of the bobbin in the jaws of a breast drill or other similar device. Also the thread may be tied to the bobbin so as to hold the turtle at the end of the line. It is remarkable how often ordinary basting thread will succeed in tethering such a turtle.

As indicated in the sketch the bobbin is held in place between the spring fingers of the bearing clip. Thus a new spool may be

inserted in a moment by simply spreading it apart. It is believed that much greater satisfaction will be had with this improved device.

Other Applications of the Method

It seems likely that this method, with various modifications might be applied with success to other animals that spend most of their time on the ground. While it is almost impossible to devise an apparatus small or light enough for an anuran to carry, in connection with work on tagged frogs in progress at the same time, a little device of a similar nature shown by Fig. 284-A was tried. Of course, the length of line was very slight as compared with that of the turtles and the devices no doubt interfered with the frogs activity although some data of interest in a corollary way to the tagging operations were obtained.

Two *Bufo fowleri* Garman released at the cabin, a male B-90 and a female B-89 made very different tracks. The former moved straight away in a single direction, while the latter zigzagged about as indicated in Fig. 284-B. Without becoming facetious, there may be some differences in the normal behavior of the sexes in this regard. Two trials of a similar nature of a male *Rana palustris* Le Conte, B-92, 1 and 2, showed that it was seemingly not trying to go in any given direction but moved about much more erratically than either of the toads and both times finally came to rest under the cabin. Of course, we already know that this species is more active than the comparatively stolid toad. See Fig. 284-B.

At the Station for the study of insects at Palisades Interstate Park through the courtesy of its director, Dr. Frank E. Lutz, of the American Museum of Natural History, Mr. Breder so equipped four male *Bufo fowleri* during the breeding season B-I, B-T, B-AH, B-AI in one evening. The first two of them had previously returned to their home locality and had been retaken and two were removed from the same place for the first time. It is to be noted that the two that were there for the first time moved much less directly than the two that were apparently on their second journey, and that the first two went to one side of the cabin furthest away from their home site while the other two went more directly toward it. This may have considerable or no significance but it will be discussed in its more proper place in a paper on the results of the tagging of anurans. See Fig. 284-C.

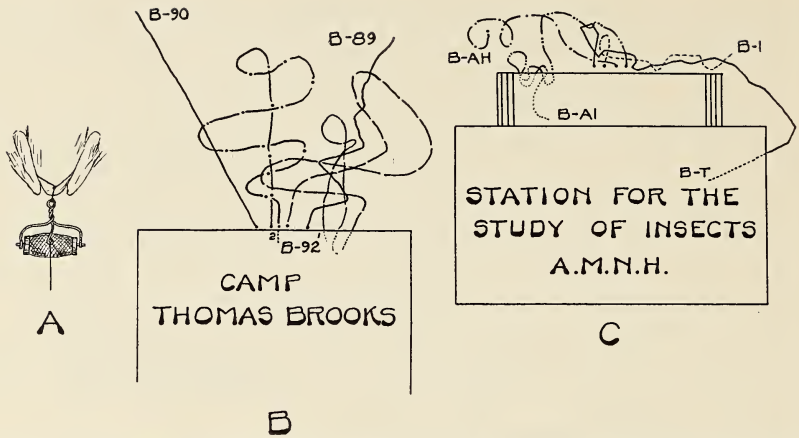

Fig. 284. A—Sketch of a frog trailer attached; B—Routes of *Bufo fowleri* B-89 and 90 and one *Rana palustris* B-92 (two routes 1 and 2) as indicated by trailer at Camp Thomas Brooks; C—Routes of four male *Bufo fowleri* B-AH, B-AI, B-I and B-T as indicated by trailer at the Station for the study of insects.

While it is obvious that this method is primarily best suited to animals of a ponderous sort that are strictly terrestrial in habit, speculation and a little thought might lead to some other device that could cause lighter and more agile animals to record their comings and goings without interfering seriously with their normal life.

Conclusions

Whilst, as previously pointed out, the work is still in an early stage, the following somewhat tentative conclusions are offered as indicative of the data that may be amassed by this method.

1. *Terrapene carolina* has a well developed sense of direction.
2. It takes the most direct route in regard to both the horizontal angle and the vertical and uses discrimination in a choice of paths in avoiding obstacles while attempting to reach a desired location.
3. Each individual has apparently an area of rather circumscribed dimensions which it traverses and which it will attempt to reach if removed a short distance therefrom.
4. It wanders about rather at random when on its "home" territory.

5. It burrows in leaf mold for the night and is most active just after sunrise and before sunset.
6. In emerging from a burrow it proceeds to "plow" through the soft soil, not backing out in any case (5 in all).
7. The device herewith described is not of an encumbering nature and interferes little, if any, in the activity of the animal.

New York Zoological Society

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VOLUME IX. NUMBER 5

ON THE FUNCTIONS AND MORPHOLOGY OF THE POSTCLAVICULAR APPARATUS IN *SPHEROIDES* AND *CHILOMYCTERUS*

By Albert Eide Parr

The Bingham Oceanographic Collection
Formerly of the New York Aquarium

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ON THE FUNCTIONS AND MORPHOLOGY OF THE POSTCLAVICULAR APPARATUS IN *SPHEROIDES* AND *CHILOMYCTERUS*

By Albert Eide Parr

The Bingham Oceanographic Collection[1]

(Figs. 285–293 incl.)

Introduction

While observing the movements of some specimens of *Spheroides maculatus* (Bloch and Schneider) in the tanks of the New York Aquarium the author noticed some very peculiar actions taking place when the fishes descended to rest upon the bottom, usually while they were still a few inches above it. When the fishes were swimming freely in the water their body was seen to be of a fusiform shape, practically circular in transverse section through the region of the belly, with the greatest width between the bases of the pectoral fins. When, on the other hand, the fishes approached the bottom a peculiar change of the outline was observed in dorsal view. The posterior part of the belly was suddenly expanded, becoming laterally produced into rounded angles, thus giving the entire outline of the trunk a somewhat rectangular shape in dorsal view. This change in shape may be more easily understood from an inspection of Fig. 285, where the expanded state is indicated by the broken outline. In

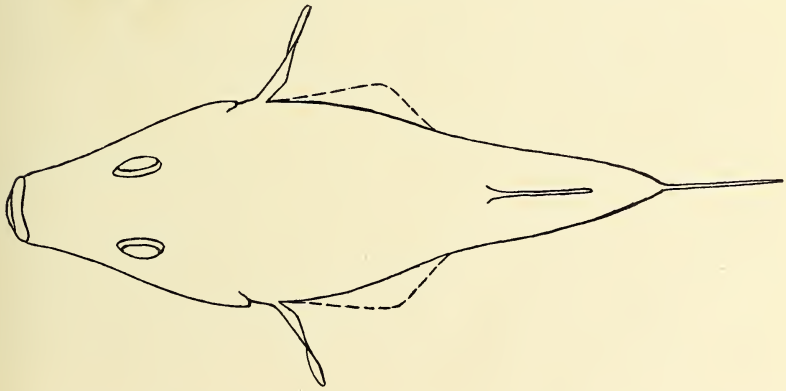

Fig. 285. Dorsal view of Spheroides maculatus. Dashed outline indicates the appearance of the fish when the postclavicles are spread.

[1] Formerly of the New York Aquarium.

this state the ventral surface of the belly is flattened and the greatest width may usually be measured between the posterior corners of the expanded belly.

An anatomical examination of the fishes shows that these corners correspond to the posterior ends of the very large second (inferior) postclavicular bones on each side, the expansion of the belly being brought about by a spreading of the postclavicular apparatus. To the best of the author's knowledge this is the only case in which the postclavicles have been observed to function as independent units with direct external effect. For this reason a closer examination and description seems justified.

In the literature dealing with the anatomy of the Tetrodontidae very little has been said about the finer details of the musculature. Thilo (1899) loosely mentions that in *Tetrodon* "two broad muscles originate from the postclavicles, the anterior of which inserts itself into the lower end of the pectoral arch, the posterior one at the carrier of the anal fin." [2] Rosen (1913) gives a much more thorough description of the body muscles of *Spheroides testudineus* (Linnaeus). Concerning the postclavicular apparatus however he only mentions that "the anterior part of the m. obliquus inferior is attached to the postclavicle," and further that "a small lateral portion (of the rectus) is distinct and is inserted into the free tip of the postclavicle."

The muscular arrangements thus very briefly described by former investigators of the Tetrodontidae seemed insufficient to explain the actions observed by the author in *Spheroides maculatus*. The examination of this species also revealed several rather peculiar, formerly undescribed, muscular differentiations in connection with the postclavicular apparatus.

In an endeavour to trace the possible systematic importance of the characters found in *Spheroides* some specimens of *Chilomycterus schoepfii* (Walbaum) were dissected for a comparison. It then appeared that some very interesting myological features were also exhibited by the latter species, and as the musculature of the genus to which it belongs has formerly not been treated at all, a description of those parts, with which we are here concerned, has been included in the present paper.

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[2] Freely translated from the german text (Die Entst. d. Lufts. b. d. Kugelfischen. Anat. Anz. 1899.)

System of Terminology

Before beginning the description it is necessary to adopt a definite system of terminology for the muscles in question. The author agrees with Rosen (1913) in the view that a terminology based upon the probable phylogenetic homology of the muscles is highly desirable, and would serve to clear the present confusion of purely descriptive names. It would however on the other hand alone be quite insufficient for practical use, because the muscular elements, which are generally recognizable as homologous through all groups of fishes, are so very few and so very broadly defined, as compared with the great number of specialised muscles developed in many smaller groups through differentiation and separation of parts only of the primary elements.

These specialised muscles, when they are developed, generally will be found to be of a considerably greater functional importance to the individual than the primary elements as such, and a purely phylogenetic terminology will necessarily result in more or less vague names for such specialised muscles, or more correctly will give no names to them at all, merely describing them as "the part of the musculus so and so functioning (or inserted) so and so." Such terminology will therefore be just as unsatisfactory to the student of animal behaviour as a purely descriptive one is to the comparative morphologist. To meet the just demands from both sides the author therefore proposes that a double terminology be adopted, giving the specialised parts their definite names according to their specialisation, and at the same time ascribing them to the phylogenetic elements from which they have been developed. Thus for instance the full name of the extensor postclavicularis described on p. 255 stands: extensor postclavicularis musculi obliqui inferioris spheroidi.[3] This name certainly is rather long, but still will be more practical than having to mention the muscle in question as "the part of the musculus obliquus inferior serving to extend the post-clavicles in Spheroides" and so forth, and will also prevent any confusion that might arise from using the name extensor postclavicularis alone. The proposed term also has the advantage of not being a description open to misunderstandings, but a name to which a definite diagnosis may be given once and for all. It will therefore

[3] Or for instance: pars coraco-analis musculi recti spheroidi, see p. 250.

represent to the reader a descriptively and as far as possible, also, phylogenetically well defined muscle. In comparative treatises the name of the species, genus, family or group in which the special muscle under discussion has been recognised and to which the author refers, always ought to be added to the name of the muscle to definitely establish the identity. If the proposed system of terminology is adopted it is of course not necessary always to mention the long names unabbreviated. When dealing exclusively with a special group or species of fishes or with the differentiations of a special primary element of the musculature the corresponding parts of the name may certainly for practical purposes be omitted by its repeated use in the text.

The names applied to the primary elements of the musculature are all adopted from the terminology introduced by Maurer (1899).

The Postclavicular Apparatus of Spheroides Maculatus

Osteological Apparatus

The posttemporals are ancylosed with the epiotics. The supraclavicles are thus directly suspended from the skull. They run obliquely backwards to the upper part of the cleithrum.

Contrary to the general rule the two post-clavicles are firmly attached to each other, the slender upper end of the second (inferior) bone fitting into a groove in the first (superior) one. The connection between the postclavicular apparatus and the cleithrum also is of a very peculiar nature, the superior postclavicle forming a sliding, saddle-like articulation with the convex interior surface of the upper part of the cleithrum as may be understood from Fig. 286. A third

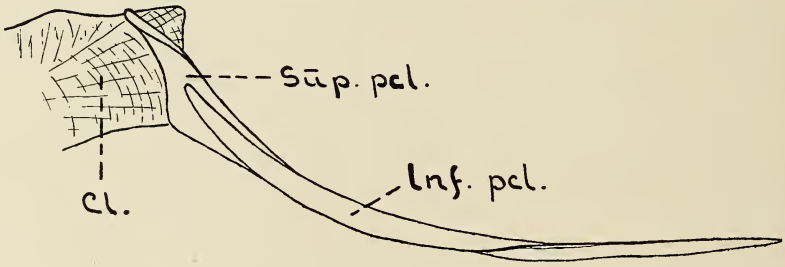

Fig. 286. Ventral view of the right postclavicular bones and the upper part of the cleithrum of *Spheroides maculatus; Cl,* cleithrum; *Inf.pcl,* inferior postclavicle; *Sup.pcl,* superior postclavicle.

peculiar feature of the postclavicular apparatus of these fishes is contributed by the fact that the inferior postclavicular bone is several times as large as the superior one. The superior bone is short and strong, broader than high. The articulating surface (for the cleithrum) occupies nearly half its entire length. The upper part of the inferior postclavicular bone is long and slender, fitting into the groove of the superior bone. The lower part is thin and compressed (broadened vertically), of a lanceolate outline in lateral view. An inspection of the Figs. 286 and 287 will show these relations

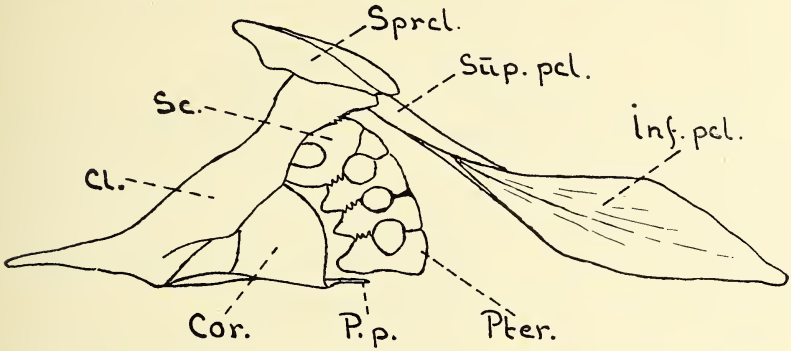

Fig. 287. Lateral view of the left pectoral arch and postclavicles of *Spheroides maculatus; Cl*, cleithrum; *Cor*, coracoid; *Inf.pcl*, inferior postclavicle; *P.p.* posterior process of the ventral lamina on the coracoid; *Pter*, pterygials; *Sc*, scapula; *Sprcl*, supraclavicular bone; *Sup.pcl*, superior postclavicle.

better than a description can do. The total length of the postclavicular apparatus measured from the upper anterior end of the superior bone to the posterior end of the inferior bone equals about half of the entire distance between gill openings and anal fin. The free part of the apparatus i.e. the part not covered by the cleithrum equals about two-fifths of the same distance.

The cleithrums run obliquely downwards and forwards, connecting through cartilage and connective tissue below the throat.

The scapula is rather reduced and united with the likewise reduced first pterygial. The other three pterygials are all connected with the coracoid. The lower pterygial has a more or less well developed, small, mesial, horizontal lamina from the ventral margin. This lamina in some individuals may be produced into a feeble spine-like process, opposed to the posterior process from the lamina of the coracoid.

The posterior part of the coracoid is vertical and rounded with a well developed mesial horizontal lamina from its lower margin. From its posterior mesial corner the lamina forms a backwardly directed spinelike process serving to strengthen and enlarge the margin of insertion for the extensor postclavicularis musc. obl. inf. described on p. 255. Anteriorly the vertical part of the coracoid disappears, leaving a great foramen between the coracoid and the cleithrum, while the horizontal lamina is widened and considerably strengthened.

The first pterygiophore of the anal fin is very large and strong.

The Myological Apparatus

The ventral musculature of *Spheroides maculatus* quite correspond to the features described by Rosen from *Spheroides testudineus*. The "interior parts" of the rectus muscles[4] of the two sides are widely separated by an interspace (Fig. 288) at which the body cavity is not protected by a closed skeleto-muscular wall, the "exterior parts"[4] of these muscles being as in *Spheroides testudineus* differentiated into a set of pseudodermal muscles.

The "interior part" of the rectus runs from the ventral surface of the anterior, horizontal part of the coracoid backwards to the first pterygiophore of the anal fin, and may therefore be called: *pars coraco-analis musculi recti*.[5] The coraco-analis is distinctly but somewhat irregularly segmented. At the third septum the connective tissue sheath of the coraco-analis unites above with the ligament (the facia transversa of Thilo) which is further up attached to the interior surface of the postclavicular bones.

The *retractor postclavicularis musculi recti* is a slender but very well defined muscle running closely along the posterior part of the coraco-analis, partly even imbedded in the latter, still very distinct however by its somewhat yellowish color and its complete lack of segmentation. This muscle has already been mentioned by Rosen as a "small lateral portion" of the rectus (see quotation p. 246). It originates together with the coracoanalis from the first pterygiophore of the anal fin and is anteriorly inserted into the posterior free

[4] See Rosen (1913).

[5] The descriptive term, protractor analis, used by several authors for analogous and probably more or less homologous structures, is rather unsatisfactory as it will change its meaning according to the presence or absence of a pelvis, covering in the latter case the entire part of the rectus anterior to the anal fin, in the former case however only the part between the anal fin and the pelvis.

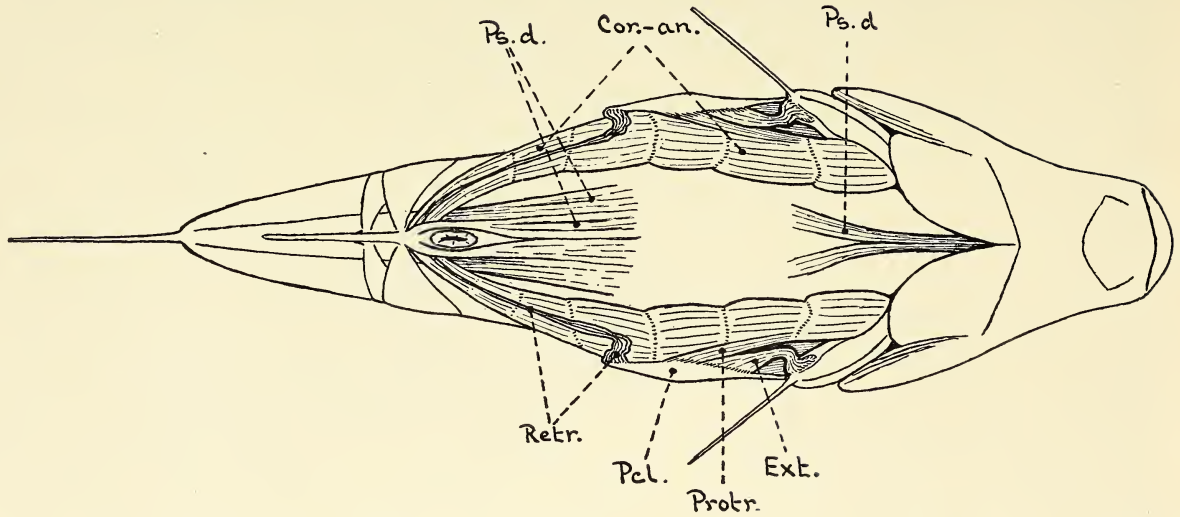

Fig. 288. Ventral view of the musculature of *Spheroides maculatus*. *Cor.-an*, pars coraco-analis musculi recti; *Ext*, extensor postclavicularis musculi obliqui inferioris; *Pcl* postclavicular bone; *Protr*, protractor postclavicularis musculi obliqui inferioris; *Psd*, pseudodermal muscles; *Retr*, retractor postclavicularis musculi recti.

end of the inferior postclavicle. There probably can not be any doubt as to the development of this muscle through differentiation from a part of the primitive rectus (of the teleosts, not of the sharks, see remarks below). The anterior third of the retractor postclavicularis is entirely free from the coraco-analis.

The fibres constituting the *protractor postclavicularis* are inserted into the ventral surface of the coracoid unitedly with the pars coraco-analis musculi recti, and for the first segment are not separated from the fibres of the latter, but shear the first septum with these. Where the protractor postclavicularis and the coraco-analis separate however, behind the first septum, some fibres originate between the two which directly meet the lower posterior fibres of the levator postclavicularis musculi obliqui inferioris at the upper continuation of the third septum of the coraco-analis, which connects the latter with the "facia transversa." The arrangement just described seems to indicate that the fibres of the protractor postclavicularis are homologous with some fibres of the levator postclavicularis musculi obliqui inferioris, being merely separated from the latter through the interposition of the postclavicles. The united first segment of the protractor postclavicularis and of the pars coracoanalis musculi recti on the other hand points to a homologous origin of these muscles. The solution of this problem probably is to be found in the possibility indicated by Rosen and others that the type of musculus rectus present in *Spheroides* has been formed by a part of the musculus obliquus inferior, being at all events not identical with the musculus rectus profundus found in the sharks.

From this point of view all muscles concerned in the present investigation, including the musculus rectus, should be ascribed to the musculus obliquus inferior and named accordingly. The type of musculus rectus in question however seems so well established, that it may conveniently serve as a basis for homologizing the finer details of differentiation in the groups where it is found. The pars coraco-analis and the protractor postclavicularis have therefore in the present paper simply been referred to the musculus rectus. On account of the above described separation of the protractor postclavicularis from the coraco-analis by intermediate fibres, directly meeting fibres of the levator postclavicularis musculi obliqui inferioris, the first mentioned muscle is, on the other hand, directly referred to the m. obliquus inf. as the protractor postclavicularis musculi obliqui inferioris.

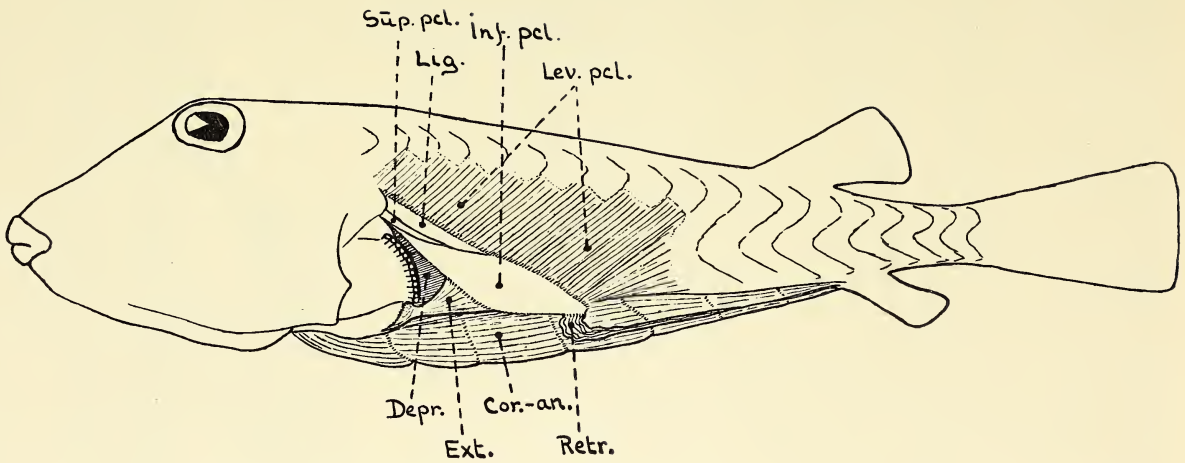

Fig. 289. Lateral view of the musculature of *Spheroides maculatus*; *Cor.-an*, pars coraco-analis musculi recti; *Depr*, depressor postclavicularis musculi obliqui inferioris; *Ext*, extensor postclavicularis musculi obliqui inferioris; *Inf.pcl.* inferior postclavicle; *Lig*, ligament attached to the postclavicular bones as insertion for the levator postclavicularis (see text); *Lev.pcl*, levator postclavicularis musculi obliqui inferioris; *Retr*, retractor postclavicularis musculi recti; *Sup.pcl*, superior postclavicle.

The rest of the muscles attached to the postclavicular apparatus viz.: the levator, the depressor and the extensor probably are also all directly differentiated from the primary musculus obliquus inferior, as their fibres all run, more or less, in a postero-dorsal to antero-ventral direction corresponding to the fibres of the primitive type of m. obl. inferior. The following may therefore be regarded as a description of the direct differentiations of the said muscular element in *Spheroides maculatus.*

The *protractor postclavicularis musculi obliqui inferioris* after separating from the pars coracoanalis musculi recti inserts itself into the mesial surface of the inferior postclavicular bone along its anterior ventral margin (Fig. 290).

The *levator postclavicularis musculi obliqui inferioris* is a broad sheet of muscular fibres originating from the connective tissue sheaths of the epaxial parts of the lateral musculature and running obliquely forwards down to the postclavicular apparatus. The anterior part of this muscle-sheet is attached to the mesial side of a ligament running from the broadened part of the inferior postclavicle to the cleithrum, ventrally attached to the postclavicular bones (Fig. 289). Farther back the levator is inserted into the dorsal margin of the inferior postclavicle, and at the lower posterior part of this bone some fibres run straight across to its ventral margin separating this part of the bone from the formerly mentioned ligament or facia transversa (Fig. 290). Some of the lower posterior

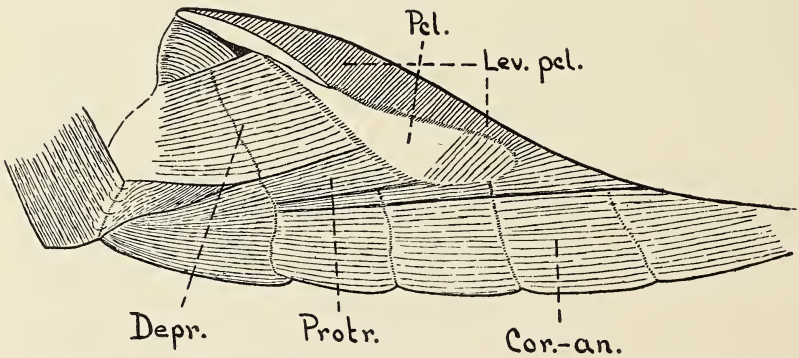

Fig. 290. Interior view of the muscular wall of the body-cavity in *Spheroides maculatus* *Cor.-an*, pars coraco-analis musculi recti; *Depr*, depressor postclavicularis musculi obliqui inferioris; *Lev.pcl*, levator postclavicularis musculi obliqui inferioris; *Pcl*, postclavicular bone; *Protr*, protractor postclavicularis musculi obliqui inferioris.

fibres of the levator, meeting the intermediate fibres between the protractor postclavicularis and the coraco-analis, are more or less horizontal and posteriorly ending in the connective tissue between the lateral musculature and the skin without any definite attachment.

As will appear from the above descriptions and the Figs. 289 and 290 the exact boundaries between the protractor-levator postclavicularis system of the musculus obliquus inferior and the pars coraco-analis of the musculus rectus are nowhere distinct, being more or less effaced by united segments or intermediate fibres. This fact strongly supports the theory that the rectus of the type present in these fishes has been developed from a part of the original musculus obliquus inferior, but does not, however, essentially effect the individual independency of the muscles described.

A most prominent and peculiar feature of the postclavicular apparatus is the well separated and sharply limited *extensor postclavicularis musculi obliqui inferioris* which runs from the antero-ventral margin of the inferior postclavicle forwards to the pectoral arch where it is inserted into the posterior margin of the horizontal lamina of the coracoid, strengthened and enlarged by the posterior process, and into the small lamina of the lower pterygial.

The Functions

The spreading of the postclavicles evidently is brought about by the contraction of the extensor postclavicularis musculi obliqui inferioris, this being the only muscle connected with the postclavicular bones which has its other end inserted at an external antero-lateral angle with the axis of the skeletonous postclavicular apparatus.

The effect of a contraction of the retractor postclavicularis musculi recti is evident, but the use the living fishes make of it is not so clear. In the specimens dissected after they had been killed and fixed in formaldehyde the pars coraco-analis musculi recti was contracted and the postclavicles were gathered close to the sides. In this state the retractor postclavicularis is however not contracted, as should be expected, to keep the postclavicles back and to the side; but is on the contrary quite relaxed, even being folded, and is evidently quite without function under these circumstances. The same also holds good of the extensor and levator postclavicularis

musculi obliqui inferioris. There thus seems to be two different sets of muscles controlling the actions and positions of the postclavicular apparatus, one set consisting of the extensor and the levator postclavicularis musculi obliqui inferioris together with the retractor postclavicularis musculi recti for spreading and operating the apparatus in its active state, another set mainly consisting of the pars coraco-analis musculi recti for gathering the apparatus to the side and fixing its position in its passive state. The depressor and the protractor postclavicularis musculi obliqui inferioris possibly partake of the functions of both sets as they are both found in a state of slight tension in the fixed specimens above described, with the postclavicles in the passive state, while the movements observed in the active state also indicate the possibility of an active depression of the postclavicles during the "squirming" to be described later. These relations will be more easily understood after they have been treated in detail below.

It is convenient for an adequate understanding first to describe the effect of the pars coraco-analis musculi recti. As will appear very clearly from Fig. 288.(showing these muscles in tension already) a contraction of the muscles in question will cause their middle parts to move towards the median plane of the fish. Through the upward connection of the third septum of the p. coraco-analis m. recti with the ligament attached to the postclavicles the latter are forced to join the said muscle in its approach towards the median plane, and will thus be gathered to the side and kept firmly in this position as long as the p. coraco-analis m. recti stays contracted. In the just described state a contraction of the retractor postclavicularis m. recti is therefore entirely unneccessary and we thus understand why this muscle seems not to function under such conditions. At the same time it also becomes evident that the tension of the contracted pars coraco-analis m. recti will prevent the spreading or any movement at all of the postclavicles, we therefore must assume that the active operations of the postclavicular apparatus are preceded by the relaxation of the pars coraco-analis m. recti, after which the above mentioned muscle-set of the active state comes into play.

The function of the retractor postclavicularis musculi recti then will be to act as an antagonistic muscle to the extensor postclavicularis m. obl. inf. thus establishing a control of the operations and positions of the postclavicles in the active state which would other-

wise not have been possible with the pars coraco-analis m. recti out of function. It probably also serves to retract the postclavicles during the squirming, if such retraction takes place at all (see p. 259).

As already mentioned the levator postclavicularis musculi obliqui inferioris also seems out of function (i. e. not even in tonus) when the postclavicles are gathered to the side. When they are spread a contraction of the levator in addition to lifting the apparatus, will also serve to give it an "upward" twist, drawing its dorsal margin towards the median in counteraction with the extensor postclavicularis m. obl. inf. pulling the ventral margin outwards. Thus the levator and the extensor postclavicularis m. obl. inf. between them will be able to produce a perfect shoveling operation of the postclavicular apparatus.

The depressor and the protractor postclavicularis m. obl. inf. both will pull the apparatus forwards and downwards, at the same time on occasion twisting its lateral surface back to the vertical plane. The tension of the depressor probably also serves to keep the postclavicular apparatus in a downwards direction, when the latter is used for support of the resting fish.

We now have an explanation of how the operations of the postclavicular apparatus may be supposed to be effected by the muscles attached to it. The postclavicles are gathered close to the sides and kept in that position, in which they are observed in the freely swimming fish, mainly by contraction of the pars coraco-analis musculi recti which is indirectly connected with the lower part of the apparatus. In this state the extensor, the levator and the retractor postclavicularis are relaxed. To be moved and extended the postclavicular apparatus must first be relieved by a relaxation of the pars coraco-analis m. recti, after which the spreading is effected and controlled by the interaction of the extensor and the retractor postclavicularis. Through the levator postclavicularis the extended apparatus may be given a shoveling twist and movement upwards, and may then be twisted and pulled down again by the protractor and the depressor postclavicularis. The latter muscle, perhaps also the protractor postclavicularis, finally keeps the postclavicles in position when these are serving for support of the body upon the ground.

The Significance Of The Postclavicular Apparatus

As formerly described, the fishes will spread their postclavicular apparatus just before descending to the bottom to rest upon it.

Since the fishes considered have no ventral fins at all and the position and structure of the pectorals is such that these fins are of no value as a support to the resting fish (as may easily be observed in an aquarium), the spreading of the postclavicles may in such cases simply serve to produce a broader basis to rest upon, attained in other fishes by the support from the ventral and pectoral fins. According to Mr. L. L. Mowbray, Director of the Bermuda Aquarium, these fishes generally prefer muddy bottoms to the harder ones, and under such conditions the flattening and enlargement of the ventral surface, stretched between the extended postclavicles, may very well serve to prevent the fishes from sinking too quickly or to deeply into the soft mud. In fishes resting upon the bottom the postclavicular apparatus is not twisted but on the contrary has its lateral surface in the vertical plane.

The very much enlarged postclavicles of *Spheroides* functionally more or less replace the ribs, which are completely lacking in these fishes; as already mentioned by Thilo (1899) in reference to *Triacanthus*. By the absence of ribs and a strong, closed, ventral, muscular body wall it may become important that the weight of the body is kept from pressing upon the body-cavity, thus interfering with the functions of the internal organs. The rather strong musculature for downwardly directing the postclavicular apparatus may therefore probably serve to keep the resting body lifted on the points of the postclavicles, thus relieving the body-cavity from the weight which might otherwise rest upon it.

Mr. L. L. Mowbray further directed my attention towards the sand- or mud-digging habits of the fishes in question. After watching the fishes for some time in the tanks of the New York Aquarium the author has repeatedly had occasion to observe a number of specimens in the act of burying. The fishes generally bring themselves into a slightly inclined position, head downwards with the chin close to the bottom, then with a very short dart forwards they "squirm" themselves into the sand. They may also very often be observed wriggling down, without any forward movement, after having been resting for some time on spread postclavicles on top of the sand.

The "squirming" is to be understood as a very rapid, nearly spasmodic oscillating or similar intermittent movement, transversally to the longitudinal axis of the fish. The effectiveness of the

action is dependant upon the plough-like shape of head and trunk, the flanks being medio-dorsally to latero-ventrally inclined and the belly flattened by the extension of the postclavicles, thus producing a trapezoid transverse outline of the trunk. The squirming of a comparatively heavy, plough-shaped body like this, resting on the bottom, will excavate the sand away from underneath and shovel it up over the flanks, thus digging the fish down and covering it in the same operation. The burrowing starts with a wagging of the head, which more or less imbeds it in the sand. As soon as the head has attained a purchase on the bottom, the activity passes backwards to the postclavicular region, with which we are here concerned. In all the cases observed the squirming in this region appeared to be of a much more violent nature than the preceding wagging of the head, i.e. it had a considerably greater frequency, and from the results produced it seemed to be the main operation in the entire process of burrowing. The initial imbedding of the head may be regarded as probably a preparatory process, fixing the position of the fish before the squirming in the postclavicular region is started and thereby greatly increasing the efficiency of this activity.

The activity in the said region consists in a lifting of the rigidly extended postclavicles alternatingly on the two sides in extremely rapid succession. The lifting seems to be accompanied by an upward twist of the lateral surface of the postclavicles, as should be expected by a contraction of the levator postclavicularis m. obl. inf. (see p. 257), and may thus be regarded as a very efficient shoveling operation. It is very difficult to discern whether the postclavicles in their unlifted state are also more or less retracted and actively depressed. It seems at least as if they are not nearly as rigidly extended as when they are lifted, but they do not on the other hand seem to be gathered close to the sides as by contraction of the pars coraco-analis m. recti. The entire operation under discussion may thus either be described as an extending, twisting and lifting or merely as a twisting and lifting of the, in the latter case already rigidly extended, postclavicles on the two sides alternatingly. In any case the squirming will probably be mainly due to the contractions of the levator postclavicularis m. obl. inf. together with tension or contraction of the extensor postclavicularis m. obl. inf. Whether the depression and the retraction, if any, follows actively

or merely passively upon the relaxation of the above mentioned muscles can not be ascertained.

As already mentioned several times the squirming is very rapid, mainly affecting the flanks and the ventral surface of the fish, the back apparently being essentially quiet but for a quivering unavoidably transmitted to it from the violent motion. The burying operation is often aided by some strokes of the tail and is completed in a few seconds, ten to twenty squirms being performed during this short time. A path to the mouth and from the gill openings is made afterwards by blowing.[6]

Mr. L. L. Mowbray also states in addition to this squirming to have seen the fishes shoveling themselves more quietly and gradually into the bottom. The author has not had opportunity to observe this operation but it may safely be supposed that essentially the same mechanism is employed. It is however probable that by quiet shoveling both sides will be lifted simultaneously and not alternatingly, as the effect would otherwise by slow action merely be a rolling of the fish and not a shoveling of the ground.

It is of interest in connection with the described methods of burying into the ground to remember again that these fishes have no ventral fins to aid their digging.

We thus have found that the postclavicular apparatus of *Spheroides maculatus* serves the fishes for support when they are resting upon the bottom, for preventing pressure upon the body-cavity and for shoveling when the fishes are burying themselves into the ground. Which function is the main or most important one is difficult to make out, in aquaria there are generally more specimens resting on spread postclavicles on top of the sand than there are buried into it.

It finally should be mentioned that in spite of numerous observations on the swelling of live specimens the author has never been able to observe any actions supporting the theory advanced by Thilo (1899), that the very large postclavicles of the Tetrodontidae through their spreading should serve to enlarge the capacity of the body-cavity, this act being among the main factors of the pumping activity producing the inflation of these fishes. The postclavicular apparatus on the contrary seems quite passive during the swelling,

[6] Unlike most fishes *Spheroides* and, in fact, nearly all Plectognaths have a well developed faculty for reversing the respiratory current, ejecting jets of water through the mouth.

and the flattening of the belly, produced by extension of the postclavicles in an uninflated fish, would indeed not occur if the cubic content of the body cavity was increased proportionately with the extension.

The Postclavicular Apparatus of Chilomycterus schoepfii

In *Chilomycterus schoepfii* (Walbaum) the author has not been able to discover any independent functions performed by the postclavicular apparatus. It nevertheless appeared that also in this species there is a very peculiar arrangement of musculature connected with the postclavicular bone. The very fact that the features of this muscular arrangement seem to be functionally "inexplicable," greatly enhances the interest attached to them from a phylogenetic and systematic point of view. The main object of the following treatise therefore is a comparative description of the purely morphological details of the postclavicular apparatus in *Chilomycterus schoepfii.*

Osteological Apparatus

The greatest osteological differences between the pectoral arches of *Chilomycterus* and *Spheroides* are exhibited by the very bones with which we are here mainly concerned viz.: the postclavicles. Except for these bones the pectoral structures are essentially the same in the two species compared, as will appear from a comparison of the Figs. 287 and 291.

The skeletal postclavicular apparatus in *Chilomycterus* is reduced to a single rather small bone, not in any way articulating with the cleithrum, being on the contrary rather firmly attached to the upper mesial surface of the latter bone through strongly developed connective tissue. The said postclavicular bone of *Chilomycterus* may be considered as consisting of two rather different parts, a fact probably indicating that the bone has originated through complete fusion of the two bones normally present. However, no traces of a dividing boundary line are now to be found. The anterior part of the postclavicular bone is strong and rod-like, running steeply inclined along the upper mesial surface of the cleithrum, to which it is attached by connective tissue. The posterior part is free from the cleithrum, compressed, high (broad) and thin, with nearly hori-

zontal upper and lower margins (Fig. 291). The posterior part joins the lower half of the anterior part at an angle of about 120°.

The connection of the pectoral girdle with the skull is of the same type as in *Spheroides*. The ridges and crests of the cleithrum are very strongly developed. Instead of a ventral lamina on the coracoid there is in *Chilomycterus* a crest on the mesial surface of this bone running obliquely antero-ventralwards on its lower part. This crest is at its postero-dorsal end produced into a spine-like process corresponding to the posterior process of the ventral lamina on the coracoid in *Spheroides* The lower pterygial carries from the middle of its inferior margin a well developed, obliquely mesio-dorsalwards directed tapering process, corresponding to the similar but rather inconspicuous process sometimes found in *Spheroides* as a prolongation of the small ventral lamina of the lower pterygial in the latter.

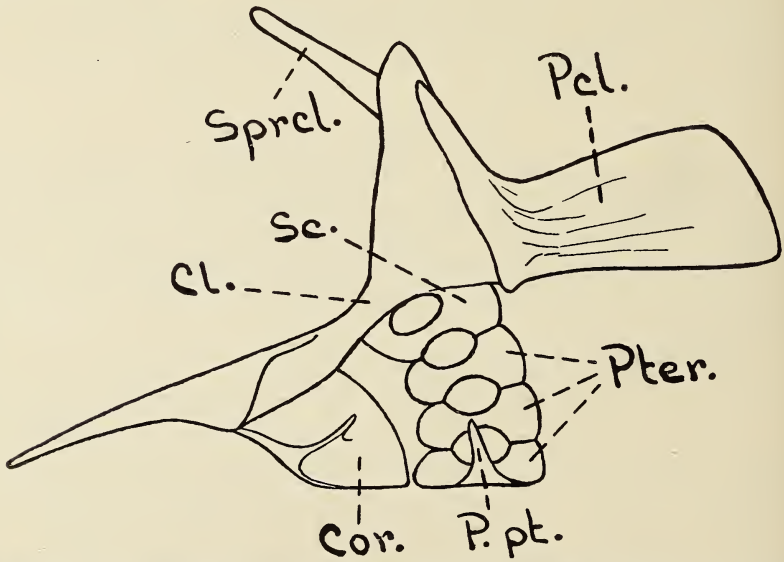

Fig. 291. Mesial view of the right pectoral arch and postclavicular bone of *Chilomycterus schoepfii; Cl*, cleithrum; *Cor*, coracoid; *P.pt*, process from the ventral margin of the lower pterygial (see text); *Pter*, pterygials; *Sc*, scapula; *Sprcl*, supraclavicular bone.

Myological Apparatus

In *Chilomycterus* the ventral skeleto-muscular body-wall is still farther reduced than in *Spheroides*, being in the former altogether extremely vestigeal.

The very thin bundle of muscle fibres inserted into the mesial ventral margin of the cleithrum evidently represents what is left of the anterior part of the *pars coraco-analis musculi recti.* This vestigeal muscle dissolves itself below the postclavicular bone and partly disappears, three strands of fibres may however be traced with interruptions till they also disappear in the lower bundles of the adductores postclavicularis system.

The just mentioned system of musculature is a most peculiar feature of the myology of *Chilomycterus.* It consists of a varying number of fibre-bundles radiating from the postclavicle towards the dorsal, caudal and posterior ventral parts of the fish as will appear from the fig. 292. The bundles are inserted along the dorsal and posterior margin of the postclavicular bone and into its lower posterior corner. The numbers of the bundles may vary even on the two sides of the same specimen, they are however mostly rather well separated from each other, but this separation may in many cases be of a quite occasional nature. At their peripheral ends the bundles are attached to the connective tissue sheaths of the lateral musculature. Apparently the most powerful part of the bundles attach themselves below the base of the dorsal fin (without any connection with the latter however). Anteriorly the bundles are attached along the back of the fish, posteriorly on the sides of the tail and above the base of the anal fin. It is evident that this entire muscle-system has been derived from the musculus obliquus inferior in the broader sense of the term (including also the m. rectus), it is further probable that the system is mainly homologous with the levator postclavicularis musculi obliqui inferioris spheroidi, how far however it may also be partly homologized with the posterior part of the pars coraco-analis and with the retractor postclavicularis musculi recti spheroidi may on the other hand not be ascertained. The author therefore proposes that the entire system be called the *adductores postclavicularis musculi obliqui inferioris chilomycteri,* as a contraction of the bundles evidently will serve to pull the postclavicular bone towards the median of the fish. Though the adductores are covering a relatively very great area of the body, their system is still altogether rather weak as they are all very thin.

Opposed to the adductores only one very small muscle is found, running from the process of the crest on the coracoid obliquely dorsalwards, to be inserted into the posterior ventral corner of the

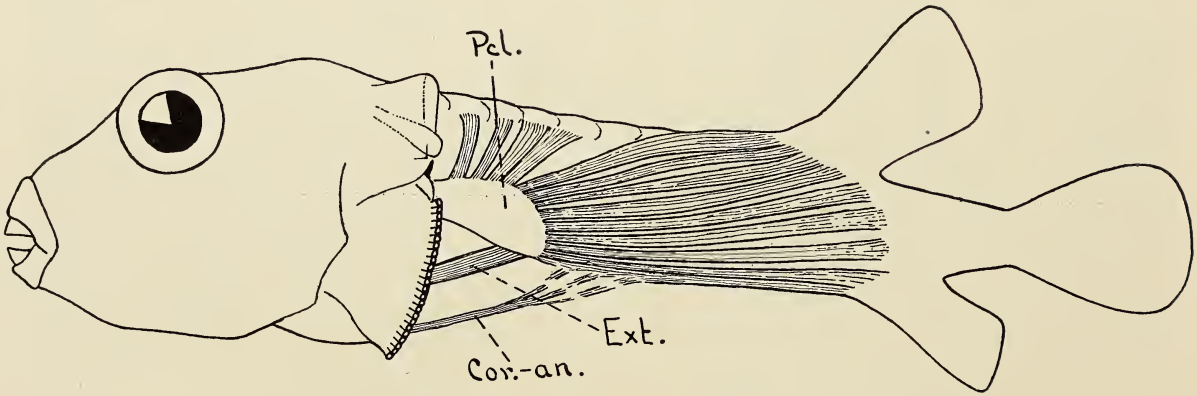

Fig. 292. Lateral view of the musculature of *Chilomycterus schoepfii; Cor.-an*, rudiment of the anterior part of the pars coraco-analis musculi recti; *Ext*, extensor postclavicularis musculi obliqui inferioris; *Pcl*, postclavicular bone. (The apparent strength of the musculature in this figure and in the fig. 293, is merely due to the effect of the black and white drawing, the muscles being in reality very thin and weak.)

postclavicular bone on its mesial surface (Fig. 293). This muscle evidently is homologous with the extensor postclavicularis musculi obliqui inferioris spheroidi, as the anterior insertion of the former is in details identical with that of the latter, and the difference contributed by the fact that the posterior insertion of the muscle is in *Chilomycterus* on the mesial not on the lateral surface of the postclavicle, as in *Spheroides*, may easily be accounted for by the different relative positions of the bones in the species compared, the postclavicular bone of *Chilomycterus* being in normal state so attached and directed that it is exterior to the crest on the coracoid. We thus have here the *extensor postclavicularis musculi obliqui inferioris chilomycteri.*

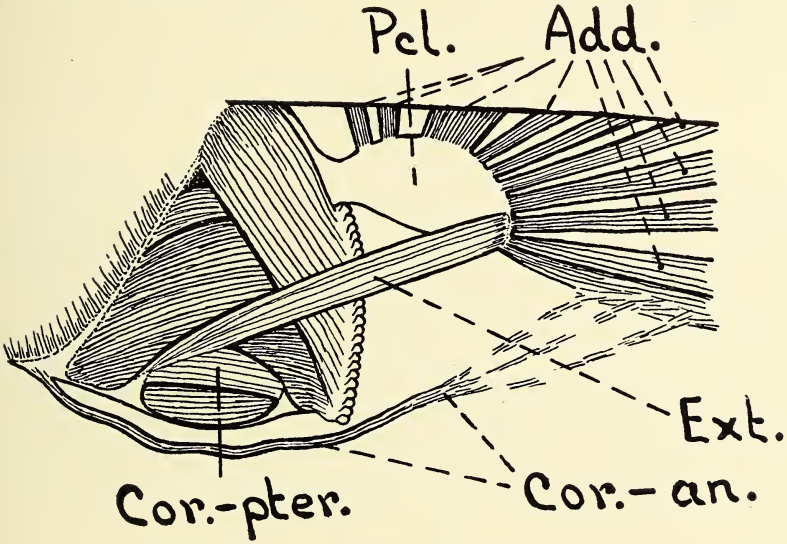

Fig. 293. Interior view of the musculature in the wall of the body-cavity of *Chilomycterus schoepfii; Add*, adductores postclavicularis musculi obliqui inferioris; *Cor.-an*, rest of the pars coraco-analis musculi recti; *Cor.-pter*, pars coraco-pterygialis musculi obliqui inferioris; *Ext*, extensor postclavicularis musculi obliqui inferioris; *Pcl*, postclavicular bone. (See also the explanation of fig. 290).

In *Chilomycterus* we also find another very peculiar muscle connected with the pectoral girdle. This is the *pars coraco-pterygialis musculi obliqui inferioris* which starts from the postero-dorsal process of the crest on the coracoid together with the extensor postclavicularis, then branches off from the latter and posteriorly inserts itself

into the process from the inferior margin of the lower pterygial (Fig. 293). Considering its close relation with the extensor postclavicularis in *Chilomycterus* itself, together with the fact that the anterior insertion of the much more powerful extensor postclavicularis in *Spheroides* also embraces the small ventral lamina of the lower pterygial and occasionally also a process from the same, we may safely assume that the pars coraco-pterygialis m. obl. inf. is also phylogenetically to be regarded as branched off from the extensor postclavicularis. Functionally the pars coraco-pterygialis m. obl. inf. is perhaps even still more puzzling than any other of the peculiar myological features of *Chilomycterus*.

The muscles above described are all that is left of the ventral and lateral wall of the body-cavity. No traces of a protractor or depressor postclavicularis are found in *Chilomycterus*.

Functions And Significance Of The Postclavicular Apparatus

As already mentioned no independent activity of the postclavicular apparatus in *Chilomycterus* has been observed by the author. Separate functions with an external effect as observed in *Spheroides* are moreover not conceivable at all in *Chilomycterus* as the postclavicular bone of the latter is too small, too highly situated, too firmly fixed in its position relative to the cleithrum and is covered by too thick and too heavily armoured skin for such purposes. Nor is it very well conceivable that the postclavicular bone of *Chilomycterus* is serving as a substitute for the ribs as it is too small and too immovable to be of any efficiency as such, and because the dermal plates of the species in question form a practically closed wall around the trunk, when the fish is not inflated, thus making further protection of the body-cavity unnecessary. In the inflated state the protection will in any case be transferred to the skin and the dermal armature. The only significance the postclavicular bone may have thus seems to be as a support and basis of insertion for the muscles attached to it. As for the functions of these muscles it has been quite impossible to show in living specimens that they serve any definite purposes at all. Those of the adductores postclavicularis m. obl. inf. which are horizontal and run caudad might be supposed to partake of the horizontal flexures of the tail. The flexures actually observed however evidently take place behind the posterior

ends of the adductores. The effect of the very weak adductores compared with that of the much more powerful lateral muscles of the tail would moreover in any case be so small as to render the existence of the former still more puzzling if the function of bending the tail were the only explanation of their presence. Such theory would also leave the anterior more or less transverse adductores quite unexplained. The rather unbalanced proportion between the adductores and their antagonistic muscle the extensor is also peculiar and does not indicate a very active nature of the entire system. The conclusion seems inevitable that the peculiar arrangement of muscles attached to the postclavicular bone in *Chilomycterus* is functionally inexplicable,[7] if the functions of an organ, may ever serve to explain its morphology, and may only be understood from a phylogenetic point of view. In this respect the very detailed retention of the extensor postclavicularis musculi obliqui inferioris in *Chilomycterus* is especially conspicuous and interesting.

Summary and Conclusions

A reliable phylogenetic homologizing and a corresponding terminology can not be carried out in sufficient detail to be applicable to many functionally important, specialised muscles in fishes.

A purely descriptive terminology on the other hand is very confusing on account of the great variability of functions and insertions of homologous muscles in fishes.

For the above reasons there is proposed herewith a combined descriptive-phylogenetic system of terminology giving a definite name to each muscle according to its specialisation and at the same time indicating, as far as possible, its phylogenetic origin.

* * *

In the Tetrodontidae and the Diodontidae the muscular walls of the body-cavity are more or less degenerate, leaving an open intermuscular space ventrally, where the cavity is only protected by skin and dermal musculature.

In *Spheroides* there is still a rather powerful part of a rectus left viz.: the pars coraco-analis musculi recti, running from the coracoid to the first pterygiophore of the anal fin.

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[7] The fact that the lateral musculature of the back is considerably reduced above the entire length of the body-cavity seems to have no relation to the adductores postclavicularis as the latter are far too weak to be able, with their insertions, to influence the flexures of the back to any extent worth mentioning.

In *Chilomycterus* the muscular body-walls are still more degenerated than in *Spheroides*. There is in the former only a very vestigeal anterior part of the pars coraco-analis musculi recti left.

In both *Spheroides* and *Chilomycterus* the musculus obliquus inferior is differentiated into a varying set of individual muscles connected with the postclavicular apparatus.

In *Spheroides* there are two postclavicular bones. The inferior one is compressed and high, and is peculiar in that it is firmly and immovably attached to the superior postclavicle, which in turn forms a sliding articulation with the cleithrum.

The musculature operating the postclavicular apparatus of *Spheroides* consists of a set of four muscles viz.: the levator, depressor, protractor and extensor postclavicularis which are directly differentiated from the musculus obliquus inferior, in addition to a retractor postclavicularis which has been developed from the rectus.

The features described enables *Spheroides* to perform locomotor operations with the postclavicular apparatus in the form of burrowing quite independent of activities of other locomotive organs. This, to the best of the author's knowledge is the only case where separate and independent locomotor functions of the postclavicles have ever been observed.

The postclavicular apparatus in *Spheroides* also serves for support for the body, when the fish is resting upon the bottom, and replaces the ribs as a protection of the body-cavity.

The postclavicular apparatus takes no part in the pumping activities whereby the inflation of *Spheroides* is produced.

In *Chilomycterus* there is only one single postclavicular bone, probably developed through complete fusion of the ordinary two. The postclavicular bone does not articulate with the cleithrum but is firmly attached to the latter by connective tissue.

In *Chilomycterus* the part of the musculus obliquus anterior and inferior to the postclavicular bone has degenerated to a single small muscle homologous with the extensor postclavicularis in *Spheroides* and is similarly inserted. There is no depressor or protractor postclavicularis. Dorsally and posteriorly there is a peculiar system of muscles radiating from the margins of the postclavicular bone. These muscles are for the greatest part homologous with the levator postclavicularis m. obl. inf. in *Spheroides*, but may also include the retractor and more or less of the posterior part of the pars coraco-

analis musculi recti; they are therefore simply named the adductores postclavicularis musculi obliqui inferioris. There is no specially developed retractor postclavicularis.

In *Chilomycterus* there is also a small very peculiar muscle connecting the coracoid with the lower pterygial.

In *Chilomycterus* no functions whatever of the postclavicular apparatus have been observed, nor do independent functions of the apparatus in this species seem conceivable. The features of the postclavicular apparatus in *Chilomycterus* are therefore only explainable from a phylogenetic point of view.

In perfect concordance with the other characters of *Spheroides* and *Chilomycterus* a comparison between the myological features of their postclavicular apparatus also reveals *Chilomycterus* as the more specialised of the two.

The present case illustrates how the myology of fishes may, sometimes even within narrow systematic limits, contribute valuable characters for comparison in addition to the more generally considered osteological features.

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THE URUGUAYAN FUR-SEAL ISLANDS

By Hugh M. Smith

(Figs. 294–300 incl.)

In the United States there is a widespread popular notion that fur seals are restricted to the North Pacific Ocean, and the assertion that there are fur-seal herds in the southern hemisphere occasions surprise to many people. In the fur markets of the world, however, seal skins with soft, dense hair have for more than a century been received from antarctic or far southern latitudes; and the fur trade has long been advised that seals with fur scarcely less beautiful than that possessed by the seals of Alaska exist in circumpolar waters of the southern hemisphere and range northward to the mainland of Africa and South America and to various islands of the South Atlantic, South Pacific, and South Indian oceans. A colony of southern fur seals occupied the Galapagos Islands[1] off the coast of Peru; and a still more detached colony resorted to Guadeloupe Island[2] off the coast of Lower California. These colonies were so long separated from the parent stock that they developed peculiar characters which entitle them to recognition as distinct species. Owing to lack of protection and to repeated raids by irresponsible people, the Galapagos and Guadeloupe seals are in danger of total extinction.[3]

Of the once mighty bands of fur seals that frequented the lands and waters of the far south, the principal remnants are now found on the coasts of Argentina and Uruguay. The largest existing herd and the only established sealing industry are off the northeastern shores of Uruguay. Very little has been written about the Uruguayan fur seals and fur-seal islands. Having had an opportunity to visit these islands and observe the seals, and being probably the only North American who has been to all the islands, I may be able to present some information of interest. The staunch little cable-laying steamer *Salvor* was made available by the Uruguayan government, and the visit was made in December, 1922.

The Antarctic Fur Seals

The southern fur seals have not received the comprehensive and long-continued study that has been given to the northern fur seals

[1] Arctocephalus philippi. [2] Arctocephalus townsendi.

[3] The Guadeloupe seal was first described by Dr. C. Hart Merriam in 1897 and named by him for Dr. Charles H. Townsend, formerly naturalist on the Fish Commission steamer *Albatross* and now director of the New York Aquarium.

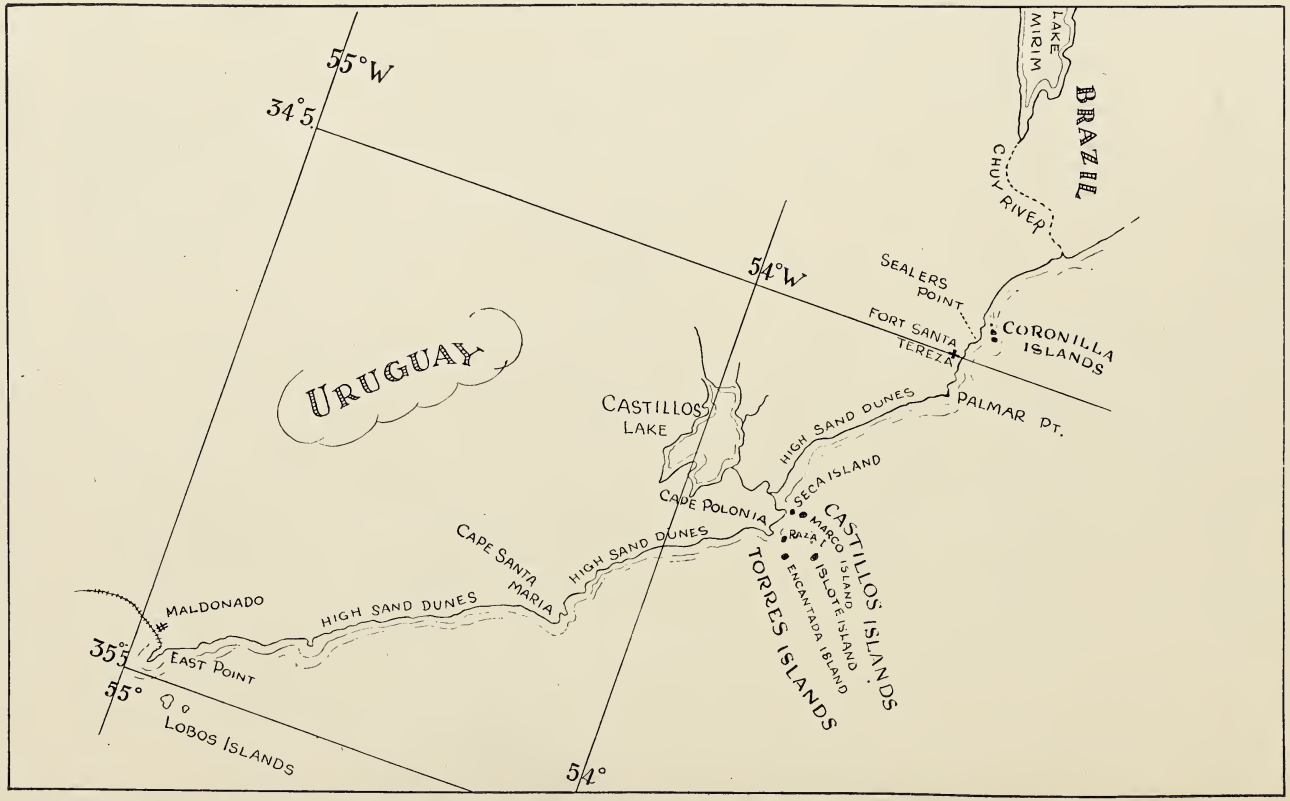

Fig. 294. Sketch map of the coast of Uruguay showing the location of the seal islands. Re-drawn from a sketch by the Author.

by zoologists. A person in quest of detailed facts regarding any important phase in the life of these creatures will look in vain in works of travel and reference. It is lamentable that the countries claiming ownership of the southern fur seals have not sought to acquire even the fundamental biological data as a prerequisite to the proper administration and utilization of the seal herds—their chief concern seems to have been to kill as many seals as could be killed, without regard to age, sex, or breeding requirements. It is true that much of the slaughter in earlier years was on remote islands easily raided by the sealers of foreign nations; but even under modern conditions, with the gruesome history of unrestricted sealing so well known and so often cited, and with the seals readily susceptible of protection, the countries most concerned have seemed indifferent to the present or future welfare of one of their most valuable resources.

The extensive north and south range of the antarctic fur seals and the wide separation of the different bands that used habitually to resort for breeding purposes to the shores of Africa and South America and to various remote islands led early zoologists to assign distinct names to the members of the different herds, and at least twenty-five nominal species were recognized. Even at the present time the early nomenclatural tangle has not been straightened out, owing to the deficiency of anatomical material at the disposal of zoologists. There is general agreement, however, that the fur seal found on islands off the east coast of South America should bear the specific name of *australis* first applied by Zimmerman in 1782 to the fur seal of the Falkland Islands. While the southern forms are true fur seals, they differ in cranial and other characters from the North Pacific fur seals (Callorhinus), and are given a distinct generic name Arctocephalus.

The southern fur seals have a rich, soft, luxuriant fur that for beauty is scarcely if at all inferior to that of the North Pacific fur seals. Even those branches of the tribe that frequent subtropical or tropical waters, where a thick coat is not needed for warmth, have a fur that is remarkable for its softness and denseness.

Ruthless Slaughter of Early Days

The recognized commercial value of the pelts of the southern fur seals early attracted hunters from North America and Europe, and in the wholesale destruction that ensued the seals underwent

almost total extinction in certain places. Thus, in 1798, the ship "Betsy" of New York took a full cargo of skins from the island of Masafuera, on the coast of Chile, and Captain Fanning reported that when he left the island there were 500,000 to 700,000 seals there. In the next few years a million seals were killed on that island. Captain Scammon reported that in 1801, 30 vessels, many of large size and nearly all under the United States flag, resorted to the island and killed without restraint. In 1815, when Captain Fanning again visited the island, he found only a few seals remaining.

At the island of South Georgia, discovered by Captain Cook in 1775 and found to possess extensive herds of fur seals which he very aptly called "sea-bears," the sealing business began early and reached its height in 1800, and not less than 112,000 skins were taken in one season, 57,000 of these by a single American vessel, the "Aspasia." This slaughter continued for 20 years and left only a small remnant. Dr. Robert C. Murphy (National Geographical Magazine, April, 1922) notes that in 1907 between 300 and 400 fur seals were slain illegally and since that time scarcely an animal has been reported from South Georgia. It is recorded by Captain Weddell that at the South Shetland Islands over 300,000 fur seals were killed in 1820 and 1821, and that at the end of 1821 the species was almost exterminated; not less than 100,000 newborn seals were starved to death because of the killing of their mothers, and the destruction was so ruthless that whenever a seal landed it was immediately dispatched.

Similar slaughter occurred at Antipodes Island, off New South Wales, where not less than 400,000 seals were killed in 1814 and 1815. A single ship carried in bulk to London 100,000 skins which on arrival were found to be spoiled and were sold as manure.

By 1830 the fur seals of the southern seas had been so reduced in numbers that sealing vessels generally had a losing business. The known places that were the last resort of the seals had been abandoned by them; but owing to the considerable numbers of seals still observed at sea it was the belief of sealers that there were undiscovered grounds to which the seals were going for breeding purposes.

Early Sealing in Uruguay

Commercial sealing on the Uruguayan coast was carried on prior to 1820; and it is a matter of record that in 1823 the government, ap-

Fig. 295. Lobos Islands: Fur seals on a rocky ledge.

parently desirous of deriving some revenue from fur seals, leased to an individual for the sum of $80,000 the sealing privileges for a term of ten years. The leasing system continued until 1910. During the 35 years ending in 1907, the lessees placed on the London market 524,120 salted skins, an average of 15,000 annually. The largest numbers of seals taken in single seasons were 21,150 in 1888, 20,150 in 1890, 20,763 in 1894, 23,639 in 1896, and 21,253 in 1902. The smallest take was 5,633 in 1905. It is reported that when the last lease expired, after the government had announced its intention henceforth to do its own sealing, the islands had been swept clear of every available seal. The only seals left were those on inaccessible islands and rookeries, or on the high seas beyond the local jurisdiction.

Sea-lions Associated with Fur Seals

Everywhere on the Uruguayan coast the fur seal has associated with it a related seal which, for lack of a better name, is called sea-lion (*Otaria jubata*). It belongs to the same family as the fur seals, the two having external ears and various other anatomical characteristics in common and the same bear-like movements on land. The sea-lion, however, has no fur, its body being covered with stiff hairs like those constituting the "guard" hairs of the fur seals. The old males develop a very conspicuous mane, and a local Uruguayan name for the creature is *peluca* (i. e., one who wears a wig). A book name is "Patagonian maned sea-lion."

This sea-lion, ranging on the entire coast of Uruguay and Argentina, extends up the west coast of South America as far as the Galapagos Islands. It was not listed by Dr. Murphy (National Geographic Magazine, April, 1922) among the seals inhabiting South Georgia Island.

The sea-lions appear to live amicably with the fur seals on the Uruguayan islands. Some stretches of the rocky shores are practically monopolized by them, while in other places small groups of sea-lions may be observed intermingled with fur seals. The largest sea-lions are larger than the largest fur seals, but it is said that the full-grown bull fur seals are able to maintain themselves against the sea-lions.

The most numerous group of sea-lions is to be found on the Lobos Islands. The principal rookery is quite near the village. I approached quite close to a part of this rookery, took photographs,

and inadvertently stampeded about fifty old males that were sleeping at the water's edge, regularly lined up on a shelly beach. They took to the water with a tremendous splash, plunged through the surf, and then faced about and contemplated the stranger who had disturbed their slumber. Some of these were of huge proportions, weighing at least 1,000 pounds.

A singular feature of many of the old male sea-lions is the presence of large granite stones in their stomachs. The stones, of which 3 are often found in one animal, are sometimes 4 to 5 inches long and 2 to 3 inches thick, with well rounded ends and smooth sides. The sealers think the stones are deliberately taken in for ballast! A more plausible explanation, however, is that the stones are swallowed with the octopuses on which the sea-lions are known to feed and which attach themselves tightly to stones when in danger of capture.

Sea-lions are killed along with fur seals on the Uruguayan coast. Their skins are preserved by salting, and are sold for manufacture into an excellent grade of durable leather suitable for making shoes, traveling bags, and numerous other articles. The fat beneath the skin is rendered into oil which is used as elsewhere mentioned. The large canine teeth are shaped, polished, drilled, mounted with gold or silver, and thus converted into cigarette holders which are popular in Uruguay and Argentina. In 1922, the Lobos Islands yielded 3,037 sea-lion skins and other islands 1,252 skins. In the previous year only 683 sea-lions were killed on the Lobos Islands, while in 1919 the figures were 4,401 for the Lobos Islands and 2,652 for other islands.

Nomenclature of the Antarctic Seal

There are no wolves in the countries of South America on whose coasts fur seals and sea-lions occur. There is no equivalent of the word seal in the Spanish language of those countries. The name *lobo* (wolf) has in consequence come to be generally applied to seals in Argentina, Chile, and Uruguay; and a glance at a detailed map of the coast of those countries will disclose various islands and promontories designated by the name of *lobo*. The term is not a particularly happy one, as, aside from the circumstance that these animals go in herds, there is nothing about them to suggest the predatory wolf. By far the best name for the seals, from the stand-

Fig. 296. Lobos Islands: Loading skins of fur seals and sea-lions.

point of anatomy, is sea-bears, which name the antarctic fur seal is entitled to share with its cousins of the North Pacific.

In Uruguayan usage, the fur seal is specifically designated the "lobo fino" and the sea-lion the "lobo ordinario" or "lobo comun." The young are called "chicos," the females "lobas," the males "machos," and the old males or bulls "machos grandes." The trade designation of the skins of the old male seals, whether from Alaska or Uruguay, is wigs.

The Lobos Islands

The Uruguayan seal islands are popularly but erroneously regarded as being synonymous with the Lobos Islands; and in the fur markets of the world all fur-seal skins from Uruguay are designated "lobos" to distinguish them from the pelts from Cape of Good Hope and other southern regions. As a matter of fact, while the Lobos Islands are the largest, best known, and most accessible, there are several other distinct groups of islands to which fur seals resort, and the numbers of seals taken on the minor islands have at times exceeded those killed on the Lobos group.

The Lobos Islands, lying 10 kilometers off Punte del Este, Department of Maldonado, are usually cited in works of reference as located in the mouth of the Rio de la Plata. The trend of the coast from Montevideo to Maldonado is in general a continuation of the left bank of the estuary of the Plata, but it does violence to the physical and biological facts to regard the Lobos Islands, with their typical marine littoral fauna and surrounded by water of high salinity, as being in the mouth of the Plata.

The Lobos group consists of a main island, an outlying low islet, and a number of small detached rock masses over which the surf breaks. Lobos Island proper is about one kilometer long and half a kilometer wide, with a maximum height of 20 meters, and is composed mainly of exceedingly rugged granite ledges, boulders, and cliffs, in places left in fantastic shapes by the volcanic upheaval of which evidences remain in small smooth laval areas and outcropping honeycombed laval rocks in the interior of the island. A shallow soil of sand, shells, and humus supports a sparse stunted vegetation of which conspicuous elements are a harsh brake and a diminutive cactus. Sandy beaches are few in number and of limited extent, the principal beach, at the northwest end, being the only safe boat

landing and having determined the location of government houses connected with the sealing industry, a lighthouse, and a wireless station. There are no harbors, and landing is at times difficult, if not precarious, owing to the heavy swell and strong currents. The southern part of the island has the most elevated and broken shore, a striking feature being a huge, semi-detached castle-like buttress, with precipitous sides and numerous ledges and crevices to which the seals resort, the base being surf-beaten.

Seals were observed on nearly every rod of the shore, and a few were found well back from the water on the steep slopes of the cliffs or on the topmost boulders. Even at the landing place where men were on the shore and boats were constantly going and coming there were a few seals sleeping or basking on the boulders or sleeping in the surf. At some places where the configuration of the shore appeared attractive or favorable, there were large accumulations of seals, some thousands being in a more or less compact mass.

The most striking feature of the seal life on Great Lobos Island is the heterogeneous mixture of seals of all ages and both sexes. Whereas on the seal islands of Alaska, Kamtchatka, and the Kuriles there is a definite organization of the herd on land, it is difficult on any of the Uruguayan islands to recognize that segregation which the fur seals naturally maintain. The family unit, the harem, in command of a single male always vigilant and ready to give battle to an intruder, was rarely to be seen. The almost invariable condition at all points on the shore was the absence of groups of cows in harem formation. There was a general preponderance of old bulls, constantly engaged in fierce fights. The normal harems that were noted could have been counted on the fingers of one hand. Usually any semblance of a small harem was marred by the presence of pugnacious bulls that sometimes outnumbered the cows. In the incessant fighting, helpless pups were crushed or injured, and in many cases that came under personal observation the young were killed within a few minutes of their birth by being caught beneath the huge bodies of the struggling bulls. The young males and females, which normally haul out by themselves, occupying areas back from the rookeries and never entering the harems, were mingled with the adults throughout the island. The disorganized condition that prevails at the Lobos Islands exists also on the other seal islands and is to be attributed to the reckless sealing methods which have long been followed.

Old sealers estimated the number of seals at the Lobos Islands in December, 1922, at 20,000, including 5,000 new-born pups. The difficulties in the way of making even an approximately accurate census of the seals under present conditions are formidable, if not insuperable. The opinions of persons who have spent years on the group are entitled to weight, but the writer's feeling is that the above estimate is too large, by possibly 50 per cent.

Other Animals of the Lobos Group

The larger of the Lobos Group is the only island of sufficient size and remoteness from the mainland to have acquired much individuality in the matter of its fauna.

When I landed there and inquired what animals besides seals and sea-lions one would be likely to find, I was told that among other things there was a "bicho colorado," which being interpreted means simply red beast. Request for more specific information evoked only smiles and the statement that no visitor had ever failed to find it among the ferns. By lunch time a few bichos colorados had been detected and by evening they were greatly in evidence. They proved to be merely chiggoes, with the same insinuating ways that North American chiggoes have.

The most conspicuous land mammal is a rabbit or cony—locally known as *conejo de la India*—said to have been brought here many years ago by sailing ships that touched at Lobos on their way home from the orient. It is nearly as large as a jack rabbit of the western plains of the United States, and occurs in some abundance among the grass and ferns, ambling off leisurely when disturbed.

The most interesting of the land mammals is a tailless rodent about the size of a common gray rat and identified as a native "guinea-pig" (Gaira). It is found all over Uruguay, and bears the Spanish name of *quis*. It lives in holes in the laval rock and in the densest vegetation, and is a prey of various predatory birds living on the island but its principal enemy is a large owl (*buo*) that comes from the mainland at night. The *quis* is now comparatively rare on Great Lobos Island.

The Torres Islands

The northern coast of Uruguay is sadly in need of attention from a modern geographer and surveyor. Many of the geographical names are confused and uncertain, and will remain so until a com-

plete official survey is made. Consultation of a dozen available Uruguayan maps (some issued by the government, some by private persons) reveals a hopeless lack of uniformity in names. The British Admiralty chart for the Rio de la Plata, many of the data thereon obtained over 60 years ago, is in general use among the local navigators on this coast and affords the best information as to depths, shoals, and general hydrographic features, but it is necessarily obsolete in various respects and many of the names employed are not recognized in modern local usage. The chart, republished in 1869, embodies some detailed surveys made by the French in 1861. The United States Hydrographic Office chart for the Rio de la Plata and approaches (No. 930, 1886) covers this coast but is on too small a scale to be useful in clarifying the nomenclature of the seal islands.

The first islands north of the Lobos Islands to which fur seals now resort are off Cape Polonia and are designated Torres Islands on American, British, and Uruguayan charts. The separate islands are unnamed on the American chart but on the British chart they are called Encantada, Islote, and "H. W. rock" (the largest). On another edition of the British chart the islands are designated Seca, Encantada, and Islote. The local usage, however, applies the name Raza to the first of these islands and places Seca in another group.

All of these islands are small, rocky, and difficult to reach owing to the prevalence of heavy surf and the absence of beaches. It is only in the calmest weather that sealers are able to land, and it is to this circumstance that the seals obtain almost the only protection they have. The local waters are infested with large sharks which prey on the seals and interfere with the operations of the seal hunters.

Very few seals were found on Raza Island, owing doubtless to its nearness to Cape Polonia and its easy accessibility to sealers. Encantada Island, on the other hand, had its shores well lined with seals, which occupied also parts of the interior and the highest rock masses toward the center. Not less than 500 seals were observed on this island, but this number may have been much less than the actual total, as the extreme ruggedness of the shore precludes the possibility of seeing all the seals. One model harem of 16 cows and one bull was observed, but elsewhere the old males were unduly numerous and several were engaged in fierce combats. One small table rock at the water's edge had as its sole occupants a new-born

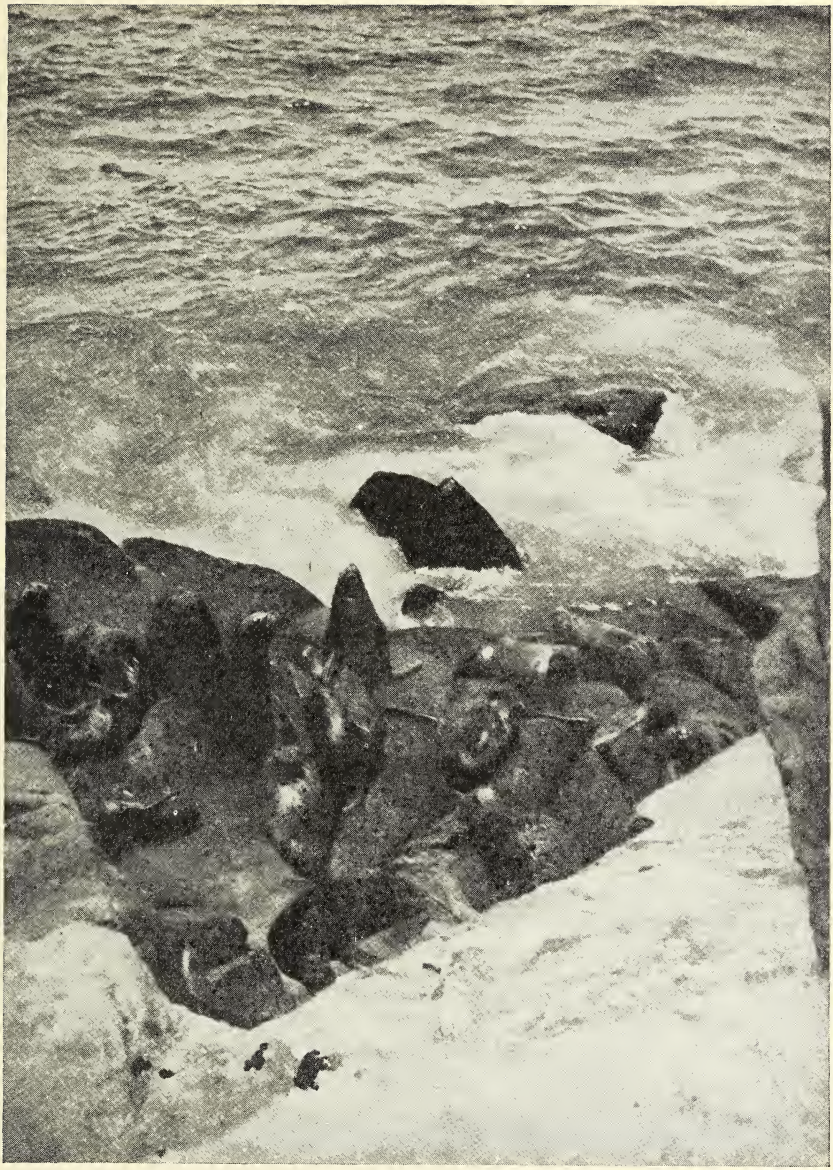

Fig. 297. Lobos Islands A protected pocket on the surf-washed shore. About twenty-five fur seals, mostly mature females, are crowded in the V-shaped pocket, taking refuge from the surf.

pup of perhaps 10 pounds weight and a patriarchal male of 750 pounds. Islote, the most remote and most exposed of the group, contained a fair number of seals, probably in excess of those on Encantada.

Cape Polonia and the Sand Dunes

The northern sealing headquarters are at Cape Polonia, in the Department of Rocha. Clustered near the base of a modern high-power light-house are the residence of the government sealing agent, huts occupied temporarily by the sealing force, houses in which the seal skins are salted and stored, and an oil-reduction plant.

Cape Polonia is a conspicuous rectangular promonotory of colossal granite ledges and boulders, flanked by broad sandy beaches that slope evenly backward and merge into high sand dunes. The sand dunes, reaching a height of 40 meters or more, are the salient feature of the coast of Uruguay, and in the vicinity of Cape Polonia are particularly striking on account of their height and their continuation for mile after mile without interruption. Interest in the sand dunes is increased by the fact that they contain fulgurites—fragile tubes of vitrified sand formed by bolts of lightning. These fulgurites came under the observation of Charles Darwin, and in his "Journal of researches into the natural history and geology of the countries visited during the voyage of H. M. S. *Beagle* round the world," he records on July 26, 1832, that in a sand-hillock near Maldonado he dug out by hand a fulgurite 5 feet 3 inches long.

After our steamer had come to anchor half a mile offshore in a shallow bay behind the cape, it gave several long blasts from its siren. These had no significance to me at the time, but in the course of 15 or 20 minutes their meaning became clear when horsemen, solitary or in small groups, began to appear on the sky line of the dunes headed for the beach and the settlement; and in an hour about 40 men, summoned from their ranches lying behind the dunes, had gathered to participate in the annual loading of seal skins and oil on the government vessel.

The local waters abound with excellent food fishes several of which are identical with, while others closely resemble, species occurring on the east coast of the United States. Schools of sea mullet and menhaden were observed, and on two occasions five-pound bluefish were caught by trolling. In tidepools and potholes among

the surf-washed granite rocks there were found specimens of a large toad, first met with at Montevideo.

The Castillo Islands

To the north and within sight of Cape Polonia is another cluster of small islands lying off a low, sandy tongue of land designated as Coronilla Point on the British Admiralty charts but called Punte de Castillos Grandes on a chart issued by the Uruguayan director-general of public works in 1893. To complicate the situation, the latter chart gives Islas Castillos Chicos as the name of the group, which contains two main islands. One of these, rather close inshore, called Seca (dry, that is, seal-less) in current Uruguayan usage, is designated Little Castillo Island on the British Admiralty chart. It is a confused mass of granite boulders and ledges reaching a height of 12 meters and appears to be well suited for seals, but in recent times at least has been entirely avoided by these animals.

Lying about 1.5 kilometers due east of Little Castillo or Seca Island is the second member of the Castillo group, an island with several names. The British Admiralty chart designates it Great Castillo and assigns to it a height of 100 feet; the U. S. Hydrographic Office chart calls it Castillo Grande Island and gives it an elevation of 102 feet; but the Uruguayan navigators and local residents know this bit of land as Isla del Marco, following an Atlas Geographico de la Republica Oriental del Uruguay published at Montevideo in 1891. Marco now ranks second in importance among the Uruguayan seal islands, and is the most rugged and least accessible to man of all of them. To the circumstances of its comparative inaccessibility may be attributed the fact that it is now resorted to by more seals than any other island except the larger Lobos. It rises directly from the open sea, without beaches, and is composed entirely of granite boulders, ledges, and massive blocks, those near the water being wave worn, while those further back are as sharply outlined as though fractured and piled up by recent volcanic action. Toward the center of the island, great granite blocks standing on end form an elevated mass that is a conspicuous landmark for sailors. Extending into the island are deep fissures and long, low caverns into which the seals go. There are also huge pot-holes to which the seals resort.

Sealing at Marco Island is attended by thrills and dangers. In following the seals into the caverns, the hunters are in very close

Fig. 298. Lobos Islands: A group of female fur seals on a granite ledge far above the water

quarters, and a number of them have been bitten by the seals. The principal excitement, however, comes from sharks. These waters abound in large, predatory sharks that are easily able to capture and devour seals at sea and are attracted to the island by the carcasses and blood of the slain seals. There being no landing places, the sealers have to leave their boats and wade ashore. It frequently happens that before the hunters can land and begin operations they have to fight off the sharks. If the hunters can be believed, the sharks will seize the dead seals on the rocks near the water's edge; and it is a fact that freshly-taken skins, while being washed in sea water, have been literally torn from the hands of the sealers by the ravenous sharks.

The Coronilla Islands

The most northern islands on the coast of Uruguay are the Coronilla group, lying in latitude 33° 56′ S., about 17 kilometers to the southward of the Chuy River which marks the boundary between Uruguay and Brazil. These islands are resorted to by both fur seals and sea-lions, and are the northern limit of the range of these animals on the east coast of South America. The group consists of two main islands and several islets, and lies about 2½ kilometers offshore, off a promontory sometimes designated as Punte de los Loberos but unnamed on most charts.

The larger island is landward and eight-tenths of a kilometer long. The low northern end is composed of granite ledges and boulders, with a considerable soil-covered area planted with cane and oats about an abandoned sealing plant. The higher southern end is very rugged, with extensive fissured granite ledges and huge boulders. The shore has no landing places but inside the surf-washed boulders there are half a dozen flat sandy or shelly areas. In some places the shells, washed in by the storm waves, are in great variety and of exquisite beauty and are in beds several meters thick. Wherever there is vegetation and in and about the abandoned buildings, there exist untold thousands of large land snails, including two edible species introduced into Uruguay from Europe many years ago and now found all over the country. Conspicuous birds resident on the island were a black-backed gull, abundant and nesting, a few eggs observed, many downy young running about; a small tern, nesting; the teru-tero, or lapwing, a number of old birds

observed and several young caught by the Uruguayan sailors who stated that the birds are easily tamed and make interesting household pets; the black oyster-catcher, several adults seen and a nearly grown bird and two downy young brought aboard the vessel; a black cormorant, numerous; a red-breasted grebe, a nearly full-grown young of the year caught in tall grass; and a colony of orioles nesting in the cane-brake.

The other island is exceedingly rugged, and its entire surface is covered with granite boulders and fissured ledges, so that vegetation is sparse. Owing to the absence of landing places and the prevalence of heavy surf and ground swell, the island is difficult to reach.

The Coronilla Islands were once the resort of large numbers of fur seals, and upwards of 2,000 skins have been taken on one island in one season. For several years, however, owing to the scarcity of seals, the government has made no effort to obtain skins, and in 1922 not a single seal was observed on the principal island, although in 1922 and 1923 considerable numbers of seals were noted on the outer, less accessible island. There is little doubt that, in the absence of a government guard, private sealing has occurred and has hastened the decline in this section.

On the main island, seven large sea-lions were the sole occupants of the portion of the shore where the sealers found it possible to land through the surf. As our boat approached, they took to the water and disappeared for a few moments, and then the entire band came to the surface and in a regular line swam fearlessly to within a few rods of the boat, apparently moved by an inordinate curiosity.

The geographical status and the names of the Coronilla Islands are hopelessly confused on Uruguayan charts and maps, no two of which are in agreement. Thus, an *Atlas Geographico de la Republica Oriental del Uruguay* published at Montevideo in 1891 does not show the group of seal islands but represents in a different position a group of three islands of uniform size designated Coronilla, Castillos Chico, and Santa Tereza; while an *Atlas Escolar de la Republica Oriental del Uruguay* published at Montevideo about 1910 shows, on the special map for the Department of Rocha, a single island (Coronilla) north of Sealers Point and a single island (Verde) south of that point, no other islands being represented on this part of the coast.

A Rare Uruguayan Seal

There occasionally wanders to the Uruguayan coast and is observed on the seal islands a straggling example of the leopard seal, more properly known as Weddell's seal (*Leptonychotes weddelli*), which is at home among the ice and snow of the far south. Its hair is short, stiff, and of a tawny color, its neck is short, its body is very wide in proportion to its length, and its short flippers are not used as walking limbs as in the fur seals. This species has been made known to American audiences and readers through the lectures, motion pictures, and writings of Shackleton and Scott. In 1921 a few of these antarctic strays appeared at the Lobos Islands. Several of them were of enormous size—as large as the largest sea-lions. The creature is observed at rather long and irregular intervals at the islands off Cape Polonia, and one that was killed at Raza Island in 1921 was of noteworthy bulk; its salted skin was over 3 meters long (without head and posterior flippers) and nearly as wide. Among old sealers of the Uruguayan coast this seal is known as the "morsa." A specimen two meters long from the Lobos Islands was secured by the writer and is now in Washington.

Seal Oil for Consumptives

There was a time, not so long ago, when the use of any kind of oil except that from cod livers in the treatment of tuberculosis would have been scouted. The writer's personal investigations in Norway some years ago showed that while cod livers yielded most of the medicinal oil for which Norway was justly famous, the fishermen and manufacturers had no hesitation in mixing with cod livers the livers of other members of the cod family; and further inquiries indicated that some of the cod-liver oil of commerce was mixed with the excellent oil derived from the blubber of the Newfoundland hair seal. From the standpoint of therapeutics, this mixing, that some might call adulteration, was unobjectionable, for the medicinal virtues of the cod, pollock, and seal oils are essentially identical, depending on their iodine content, on their fuel value, and, as we now know, on their vitamines.

It should, therefore, occasion no surprise but rather be taken as evidence of a changed viewpoint and practice that the Uruguayan government should make a high grade of oil from the blubber fat of fur seals and sea-lions and should utilize this oil in the treatment

of incipient and developed cases of tuberculosis at hospitals all over the country. The refined oil is supplied gratis by the government, and is sent out in glass jars and carboys. The oil is in great demand; the hospitals keep sending back the empty vessels to be refilled; and some remarkable cures of apparently hopeless cases are recorded. No distinction is made and no appreciable difference is known between the oil of fur seals and the oil of sea-lions; the oils are mixed indiscriminately. In 1921 the production was over 28,000 kilograms.

Remains of the Aborigines

While historical data are deficient, there is ample archeological evidence that the Uruguayan Indians resorted to the seal islands and made use of the seals. Stone spear-heads and arrow-heads have been found in the wave-washed recesses of some of the islands. At what must have been Indian camp or village sites, on the coast east and north of Maldonado, among remains of fires and primitive utensils, there may still be uncovered charred bones and teeth of seals. On the shores of the Lobos Islands, at Cape Polonia, and at the most remote of the islands now resorted to by fur seals, off Sealers Point, there have been found *boleadoras*—small, rounded, grooved stones of which a set of two or three, tied at the ends of sinews of the rhea or other wild animals and used by hurling at the quarry, constituted a *bola*, the characteristic and most effective weapon of the Uruguayan aborigines.

The *boleadoras* have been found at points where, in historical times, practically the only animals of noteworthy size have been seals and sea-lions, but these creatures are not of a form and habit that would readily permit capture by such means. It is possible, however, that the *bolas* were sometimes thrown to stun or confuse the seals until the Indians could approach near enough to employ their spears or clubs.

The Indians who resorted to this coast and made and used the stone weapons referred to were the warlike Charruas, whose extermination began soon after the arrival of the Spaniards and was relentlessly pushed during three centuries. Drawn into one of the innumerable revolutions with which Uruguay has been afflicted, the pitiable remnant of the once formidable tribe suffered annihilation in 1830. According to local authorities, the *boleadoras* here collected by the writer were last used probably not later than 1750.

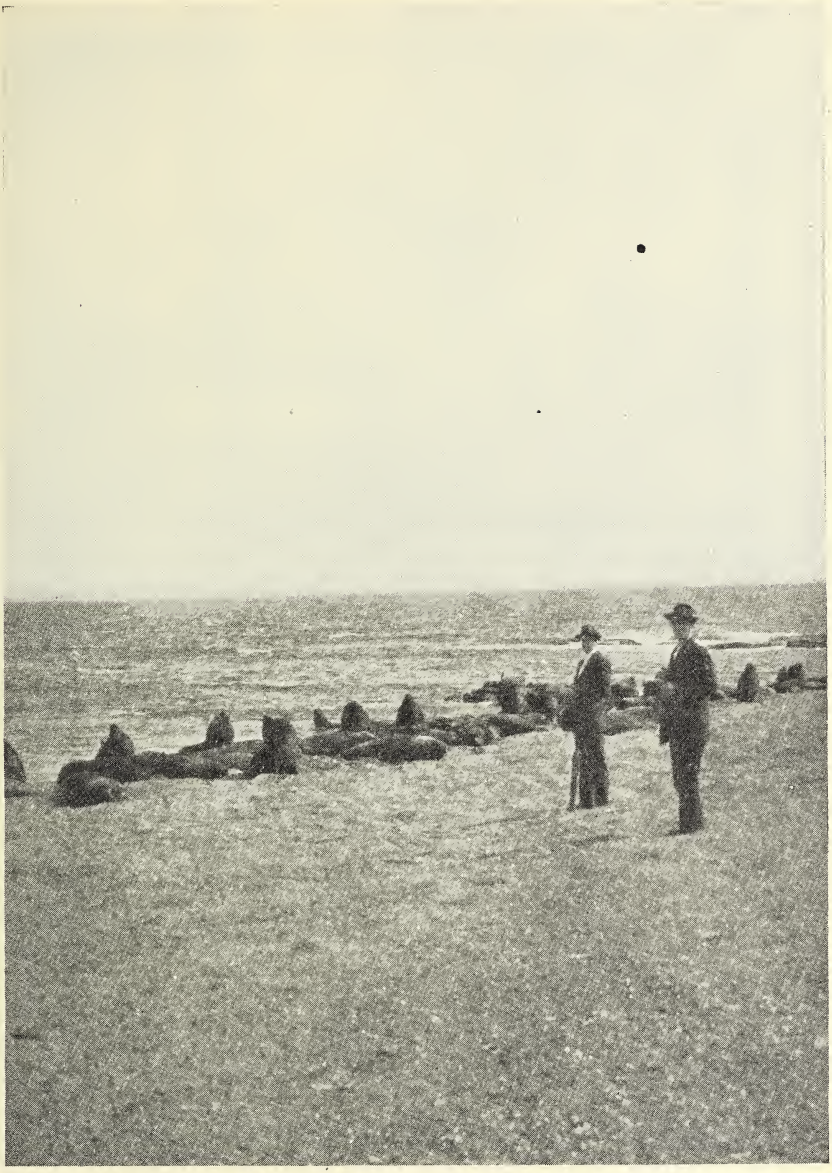

Fig. 299. Lobos Islands: Sea-lions resting on beach of Great Lobos Island. Unless harrassed they are comparatively tame and fearless.

The Plight of the Penguins

A curious freak of geographic distribution is the occurrence on the most northern part of the Uruguayan coast of such characteristic antarctic birds as penguins. Penguins have been known to occur as stragglers on the Brazilian coast as far north as 32° south latitude, but their annual appearance in numbers about the northern seal islands of Uruguay occasions surprise, especially in view of the extraordinarily unfortunate plight in which the birds find themselves.

Every year in winter, that is, in July and August, large numbers of penguins swimming from the south arrive at the seal islands in the vicinity of Cape Polonia. The compelling cause of this northward migration is unknown. Whether the birds are impelled by a perverted instinct, whether they are carried involuntarily by ocean currents, or whether they follow their food supply along with seals and flying birds, is uncertain. The all important point is that the birds resort by thousands to the extensive sandy beaches at Cape Polonia, and that as the season advances and the air and water become warmer they sicken and die. Not one penguin survives until the next fatal migration occurs. Many of the penguins are skinned by the local sealers, who make up the skins into various articles of wearing apparel, but no use is made of most of the carcasses.

Numerous penguin remains were noted by the writer in the shifting beach sand at Cape Polonia in December, and it was learned that as many as 3,000 birds had been known to succumb at that place in a single season. The species was identified as the "johnny" penguin (*Pygoscelis papua*), which attains the size of a mallard duck, and was entertainingly described and well figured by Dr. Murphy in his most readable article, "South Georgia, an Outpost of the Antarctic" (National Geographic Magazine, April, 1922). The birds nest on South Georgia Island, lying 1,500 miles southeast of Cape Polonia and 1,000 miles east of Cape Horn, and were met with by Murphy "in the wide sea some hundreds of miles north of South Georgia."

Future of the Uruguayan Seal Herd

The present Uruguayan seal herd is a mere remnant fast approaching commercial extinction under existing conditions. During the thirteen years ending in 1922 the number of seal skins taken by the government was 19,151, an average of less than 1,500 yearly,

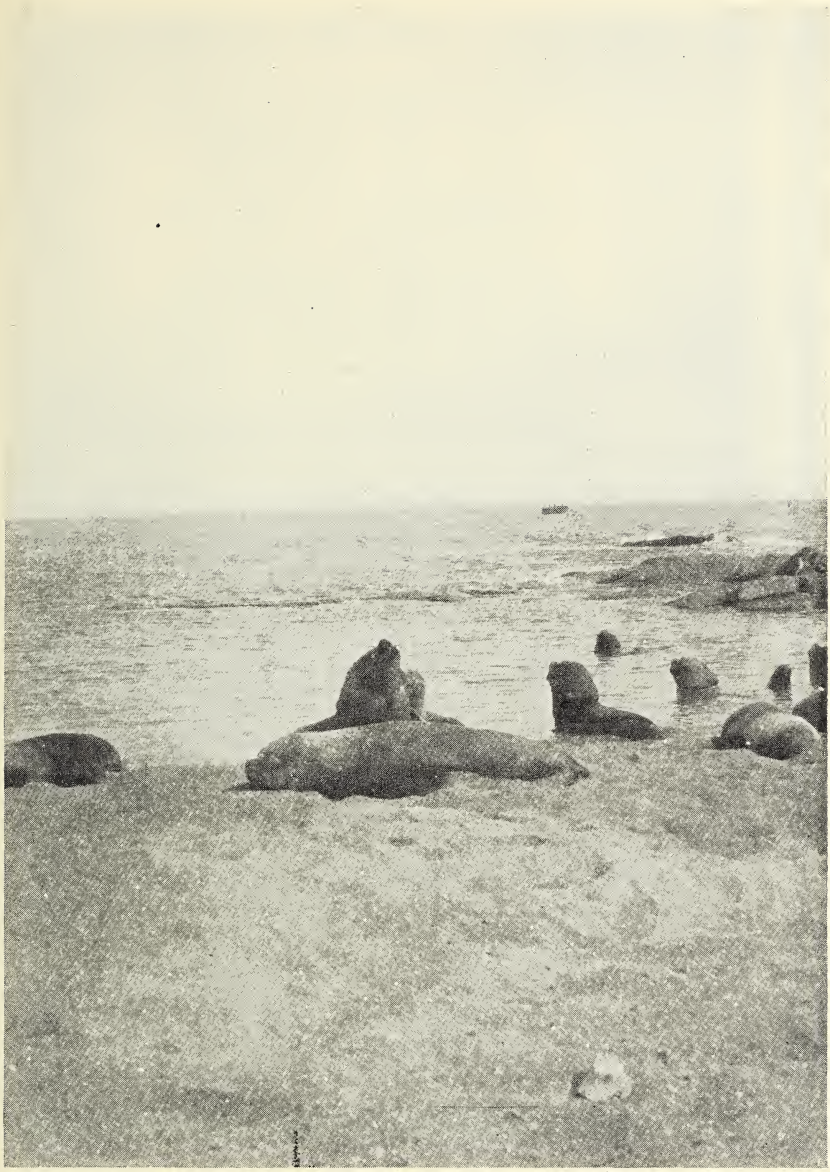

Fig. 300. Lobos Islands: Male sea-lions in a sandy cove.

against a yearly average of nearly 15,000 in the thirty-five years ending in 1907.

There is little doubt that these seals will quickly respond to an opportunity to reëstablish themselves, and it is confidently expected that so progressive a country as Uruguay will take the steps necessary to restore and maintain this valuable resource.

These seals are not without their international relations, differing in degree but not in kind from those to which the fur seals of the North Pacific Ocean have given rise. An important question may sometime arise between Uruguay and Argentina involving jurisdiction over the seal herd. Inasmuch as the fur seals and sea-lions migrating to and from their breeding grounds on the Uruguayan coast pass along the coast of Argentina and at times within the territorial jurisdiction of that country, it would be an easy matter for vessels under the Argentine flag to intercept, harass, and kill the seals and thus materially impair the herds to which a sister republic makes claim by virtue of their resorting to her land for breeding purposes. Similarly, it would be easily possible for Uruguayan sealing vessels to operate along the entire coast of Argentina and prey on the seals passing to and from the various islands on that coast.

There would thus be created a situation like that which developed in the North Pacific Ocean and Bering Sea when pelagic hunters, under American, British, and Japanese flags, closely followed the herds of migrating seals and carried on such a ruthlessly destructive industry that the heads resorting to the Alaskan, Kamtchatkan, and Japanese islands were soon sadly depleted, and protracted international controversy ensued before an agreement was finally secured that prevented further decimation and almost certain extinction of the respective herds, and has resulted in a noteworthy recuperation.

Uruguay has as yet not entered into any coöperative arrangement with Argentina for the protection of fur seals and sea-lions, but the time is ripe for international action to supplement national regulation that will save the shattered seal herds from total extermination.

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FIELD OBSERVATIONS ON FLYING FISHES; A SUGGESTION OF METHODS

By C. M. Breder, Jr.
New York Aquarium

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FIELD OBSERVATIONS ON FLYING FISHES; A SUGGESTION OF METHODS

By C. M. Breder, Jr.
New York Aquarium

Introduction

(Figs. 301–305 incl.)

Ichthyologists and laymen alike when aboard ship frequently make passing observations on the various species of flying fishes that dart away from the prow of their vessel. Aside from speculations on the mechanism of the Exocoectid flight most of these observations have been exceedingly desultory and likely few persons have considered that a little systematizing of them could be of scientific value.[1] As opportunities for such studies come at a time when it is often impossible to pursue other matters of interest they become useful adjuncts to practically any one for whom it is necessary to travel on the high seas. The purpose of this paper is to call attention to the kind of data that would be valuable to gather and to describe a systematic method for gathering it. The suitability of this method is demonstrated by results obtained on a single short trip. These results are recorded more for their suggestiveness than otherwise as only by repeated observations of this sort can a proper answer be given to the questions they reopen or originate.

Methods

The observations that may be made from the deck of an ordinary commercial carrier divide themselves roughly into three interrelated parts. For our purposes here they may be described separately, as follows.

Distribution

Data of value concerning the distribution of the family Exocoetidae may be augmented by statistical counts of the numbers set into flight by the vessel carrying the observer. A suitable place

[1] Scientific literature contains many incidental references to observations on flying fish but for our purposes here it is thought superfluous to refer to them in any detail for none shows any attempt to make systematic observations which is the method under consideration.

on the vessel should be selected where all set in flight on one side of the ship may be seen. This will be found, usually, to be some place along the top deck about one-quarter of the ship's length from the prow. Incidentally it has the advantage of being fairly out of the way of over-talkative fellow passengers who usually crowd ahead of that point to wonder at the flying fish or the play of porpoises. At such a point the observer stations himself for a stated period and counts the number of fish raised. Then immediately following he stations himself on the other side of the ship for an identical period to remove any possible bias. The importance of making such bilateral counts will be brought out later. In counting, it is well to write down the numbers seen in a school and the single fish separately. For convenience it is worth while to have some sort of a form that can be filled out as the observations are made. Such a form is illustrated (Fig. 301, A). For all this work it is necessary to have certain data abstracted from the ship's log. Officers of the vessels are usually highly interested in accommodating one in such a matter. For this purpose another form is advisable. This is shown (Fig. 301, B). It is desirable, but not essential, to have a chart of the waters being navigated so that the course may be taken directly from that of the ship.

The data accumulated by this method throws light on many interesting questions besides those of distribution. These will be illustrated by the studies used for a basis of the present paper.

Identification

The field identification of flying fishes is not always an easy matter but when they can be determined, it, of course, greatly enhances the value of any such observations. The wing patterns, naturally, are of considerable significance in this connection. It was found to be a help to have outlines prepared on which patterns could be sketched for future reference. Colored pencils should be a help. Figure 301, C illustrates the forms used in this connection. High-powered field glasses proved to be of little value in this connection as the time elapsed in bringing them to bear on the object generally was so long that the distance the fish covered more than compensated for the advantage of the glasses. Possibly greater skill in their manipulation would prove them to be of very definite value.

Flight

Any data on the length of time elapsed, distance covered, etc., in flight is always of interest, especially when made in regard to weather and other conditions. A good stop watch is a necessary instrument to have with one for such observations. Figure 301, D illustrates a form used for tabulating flight data. In all cases the size of the fish should be estimated as carefully as possible.

The above bare outline gives an idea of the type of observations that may be made aboard ship without any elaborate preparations and whereby otherwise idle time may be rendered of scientific value.

The suggested complete equipment is as follows:

One good time piece
One good stop watch
One pair of field glasses
Forms for distribution count
Forms for ship's log data
Forms for sketching wing patterns
Forms for timing flights
One loose leaf notebook for holding above and spare sheets for miscellaneous notes
Colored and black pencils
One good chart of area
One ruler and protractor for plotting chart

The forms if made out in accordance with the accompanying figures will help prevent the omission of important data and it is strongly recommended that they be of some standard sized loose leaf pocket note book. Those illustrated measure 3¾″ x 6¾″. An ordinary mimeograph may be employed to prepare them.

Analysis of Data

The data obtained in the manner described is of cumulative value and subject to various analysis. Its arrangement has consequently been so planned as to allow of its fullest analytical utilization. Some of the questions it is hoped that this method will shed light on follow:

Distribution of the Exocoetidae in reference to temperature, season, current, latitude and longitude, size of fish, etc.

Length, direction, height, etc., of flight of Exocoetidae in reference to wind direction and force, temperature, sea, size of fish, etc.

Field identification of Exocoetidae and eventually distribution of species.

Sizes of Exocoetidae and eventually supplementary data on growth.

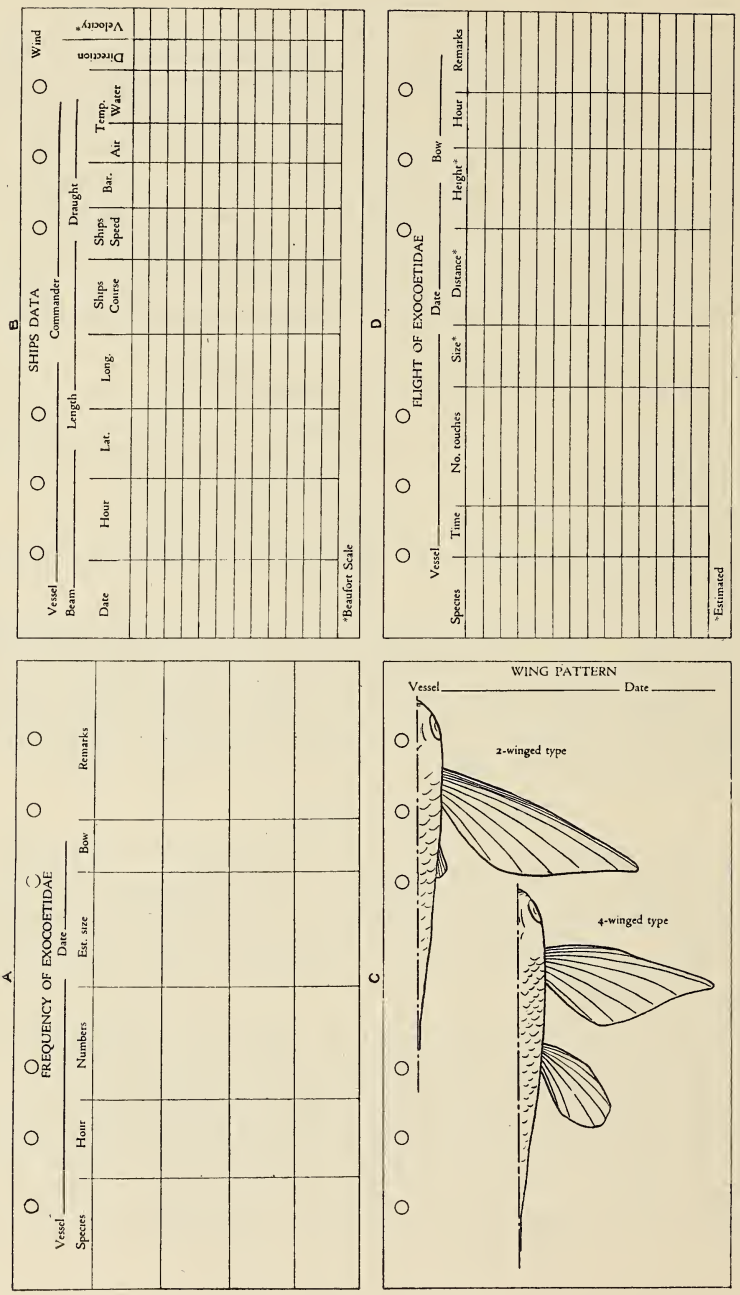

Fig. 301. Forms for collecting field data on Exocoetidae; A, Form for frequency data; B, Form for ships data; C, Form for sketching wing patterns and other field identification data; D, Form for flight data.

The following sections concerned with the actual data collected suggest various methods of analysis.

Exocoetid Distribution in the Gulf Stream

Observation stations to the number of 21 were made in various places between Latitudes 30° 56′ to 37° 14′ N. and Longitudes 80° 57′ to 74° 40′ W. The basic data derived therefrom is given in Table I. The columns covering wind velocity and direction, barometer, temperature, ship's course and ship's speed were all taken from the logs of the vessels.[2]

The wind direction is given in reference to the course of the ship, its angle of incidence in degrees being given under the side of the ship that was to the windward. The latitudes and longitudes are taken from the chart plotted from ship's log data, time and the ship's speed from the last observation locating the point. The periods of observation were all one-half hour and the time given is that when the change was made from port to starboard (*i. e.* the middle point of each full observation period). The observations No. 4 to 10 inclusive were made by two observers[3] jointly so they represent actually twice as long an interval (*i. e.* one man-hour of continuous observation). This must be taken into consideration in the calculations.

From this data an index of the number of fish inhabiting a given stretch of ocean water may be obtained. After some consideration it was decided that for most purposes the Exocoetid population might best be expressed in number per square nautical mile. These figures are given in the last column, "calculated population." It might be objected that only a certain percentage of fishes fly. While we have no way of determining what this percentage is at present it is reasonable to assume that under similar conditions similar percentages do fly. Just what this number bears to the actual population we of course do not know, but at the very least we have accurate figures of the flying population which of itself is of significance. The manner in which these figures are calculated follow.

---

[2] Appreciation is here expressed to Commander B. W. Leek and Chief Engineer C. P. Kennedy of the S. S. *Algonquin* and to Commander F. G. Avery and First Officer J. A. Ohlund of the S. S. *San Jacinto* for their coöperation in supplying this data.

[3] I am indebted to Mr. J. J. Shea for assisting in this matter as well as others bearing on the field work.

TABLE I. DISTRIBUTION OF EXOCOETIDAE

Observation number	Date	Hour (Middle of half hour observation period)	Latitude (north)	Longitude (west)	Wind			Barometer	Temp.		Specific gravity[2]	pH value	Ship's course	Ship's speed (knots)	No. of fish counted		Estimated lengths of fishes (inches)		Calculated population[3]
					Vel.[1]	Direction													
						Port	Star.		Air	Water					Port	Star.	Port	Star.	
1	Aug. 26	5:15 A. M.	36° 15′	75° 7′	2	6°	—	30.41	77	—	—	—	186°	15.50	0	0	—	—	<1
2	" 26	9:15 A. M.	35° 37′	75° 12′	2	6°	—	30.42	80	—	—	—	186°	15.50	0	0	—	—	<1
3	" 26	12:00 M.	35° 10′	75° 16′	2	6°	—	30.42	82	85	—	—	186°	15.50	0	0	—	—	<1
4	Two observers 26	2:30 P. M.	34° 45′	75° 20′	2	6°	—	30.41	83	85	—	—	186°	15.50	51	18	8–10	8 –10	349.6[4]
5	26	5:15 P. M.	34° 18′	75° 23′	2	6°	—	30.41	84	82	—	—	186°	15.50	48	6	2–10	8 –10	273.6
6	27	7:30 A. M.	31° 13′	76° 55′	3	120°	—	30.39	81	85	—	—	210°	15.50	51	12	8–10	8 –10	319 2
7	27	3:00 P. M.	29° 18′	78° 9′	3	59°	—	30.37	83	84	—	—	210°	15.50	23	28	4–10	4 –10	258.4
8	28	8:15 A. M.	25° 34′	79° 59′	4	55°	—	30.32	86	—	—	—	200°	15.00	10	3	4–10	4 –10	77.0[5]
9	28	10:45 A. M.	25° 4′	80° 13′	3	90°	—	30.34	86	—	—	—	225°	15.00	14	5	3– 4	1½– 4	97.9[6]
10	28	3:35 P. M.	24° 35′	80° 57′	2	110°	—	30.36	86	—	—	—	251°	14.00	1	0	8	—	5.6
11	Sept. 11	8:55 A. M.	25° 29′	79° 54′	2	—	120°	30.10	84	86	1.026	8.4	10°	15.13	0	5	—	6 – 8	28.2
12	" 11	11:00 A. M.	25° 58′	79° 49′	2	—	85°	30.12	86	88	1.026	8.4	6°	15.13	0	7	—	6 – 8	39.5
13	" 11	2:00 P. M.	26° 41′	79° 47′	2	—	90°	30.11	86	87	1.026	8.4	0°	15.13	1	7	6– 8	6 – 8	45.1
14	" 11	5:35 P. M.	27° 8′	79° 42′	2	—	86°	30.09	85	86	1.026	8.4	3°	15.13	0	2	—	6 – 8	11.3
15	" 12	6:35 A. M.	30° 56′	79° 20′	2	—	65°	30.18	82	86	1.026	8.4	28°	17.30	1	7	6– 8	6 – 8	72.9
16	" 12	8:35 A. M.	31° 22′	79° 3′	2	—	45°	30.20	84	86	1.026	8.4	45°	17.30	2	4	6– 8	6 – 8	54.7
17	" 12	11:50 A. M.	31° 57′	78° 23′	2	—	45°	30.24	85	86	1.026	8.4	45°	17.30	4	1	6– 8	8	45.6
18	" 12	3:45 P. M.	32° 31′	77° 43′	2	—	31°	30.18	83	86	1.026	8.4	45°	17.30	0	1	—	½	9.1
19	" 12	6:15 P. M.	32° 52′	77° 20′	2	—	35°	30.20	82	84	1.026	8.4	45°	17.30	3	0	6– 8	—	27.3
20	" 13	6:45 A. M.	35° 44′	75° 6′	2	55°	—	30.15	76	79	1.024	8.3	12°	17.30	0	0	—	—	<1
21	" 13	12:00 M.	37° 14′	74° 40′	2	93°	—	30.16	78	78	1.024	8.3	12°	17.30	0	0	—	—	<1

[1] Beaufort Scale. [2] At 60° F. [3] All *Parexocoetus mesogaster* (Bloch) except as noted in the following footnotes. [4] Two specimens, possibly *Exonautes rondoletti* (Cuvier & Valenciennes). [5] One *Cypselurus monroei* Nichols & Breder (?). [6] One *Halocypselus* sp.

Let:

Speed of ship in knots per hour	= K
Time of observation in decimals of an hour	= T
Beam of ship in feet	= B
Width of area of disturbance on one side of ship in feet	= D
Number of fish observed	= F
Population per square nautical mile	= X

Since there are 6080.2 feet in a nautical mile the following formulae may be used.

Then:

$$\frac{6080.2 \cdot F}{(2D + B) \cdot T \cdot K} = X \text{ for two observers.}$$

$$\frac{6080.2 \cdot F}{\left(D + \frac{B}{2}\right) \cdot T \cdot K} = X \text{ for one observer.}$$

Below are given the actual calculations involved.

The beam of the ship plus the area disturbed on either side is the width of the area scanned. The latter is estimated by observation of the ship underway and is located at the curl of the bow wave (see Figure 302). In average large vessels this is usually situated about 50′ from their side.

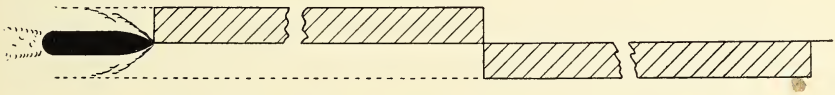

Fig. 302. Diagram of areas of observation for frequency data. The ship is in the position for the initiation of an observation period. The hatched area just ahead of the ship represents the port watch, say of 15 minutes, and the succeeding area the starboard watch of identical length. With two observers both sides of the ships course would be under observation. The width of the area is determined by the lateral extent of the disturbing bow wave as indicated.

Fishes arising at a distance greater than this from the vessel are considered as flying from other causes and are not counted. In other words the width of the area considered is 2D + B for two observers or $D + \frac{B}{2}$ for one. Time of observation in decimal fractions of an hour multiplied by the knots per hour multiplied by 6080.2 gives the length of the band scanned in feet. Multiplying

these the resulting figure divided into the square of 6080.2 gives the number of such parts contained in a square nautical mile. This multiplied by the number of fish observed in the sample area gives the estimated population per square nautical mile. The full formula would read.

For two observers

$$\frac{36968832.04}{(2D + B) \cdot T \cdot K \cdot 6080.2} \cdot F = X$$

or for one

$$\frac{36968832.04}{\left(D + \frac{B}{2}\right) \cdot T \cdot K \cdot 6080.2} \cdot F = X$$

This is reducible to the following formula with which an example (the first calculation) is given.

$$\frac{6080.2 \cdot F}{(2D + B) \cdot T \cdot K} = X$$

$$\frac{6080.2 \cdot 69}{(2 \cdot 50 + 54) \cdot 15.5 \cdot 0.5} = 349.6$$

Although no especial effort to analyze in full the data here presented is attempted, reference is made to (Fig. 303) which gives the population density as calculated above. It will be noted that the greatest concentration is east of the axis of the Gulf Stream, that the greatest concentration is just south of Cape Hatteras and that in the Straits of Florida there are relatively few. The inner edge of the Gulf Stream is similarly barren, that is very few find their way north or west of it. West of the axis the counts are all less than 100 per square mile and east of it (south of Hatteras and north of the Florida straits) all over 250. This of course may vary considerably from season to season, with prevailing winds, etc. It is for just this reason that continued observations of this nature are desirable.

While these distributional figures may not hold absolute accuracy or present any startling contribution to the present knowledge of Exocoetid distribution the value of the method, the extension into detail of their distribution and the following data is considered ample justification for the present paper.

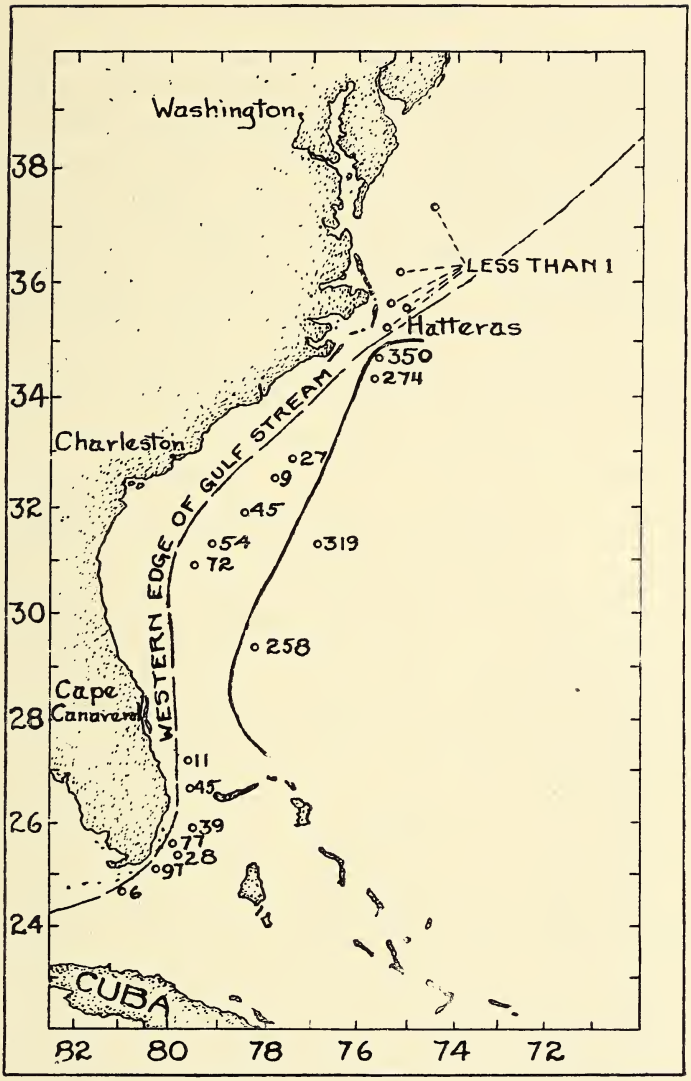

Fig. 303. Calculated population of Exocoetidae in the Gulf Stream, September 26th to August 13, 1928. See table I for details; the figures given at each station are the nearest whole numbers of fish per square nautical mile as calculated from Table I. The heavy solid line separates the areas with a population of over 250 fish per square mile from those of under 100. This line in its northeast trend approximates the axis of the Gulf Stream. Past the western edge of the Gulf Stream none were counted during periods of observation. Consequently these are calculated as less than one per square mile.

Species Observed

By far the greatest number of fish observed were without any definite pattern on their wings. Consequently they may be *Parexocoetus mesogaster* (Bloch), *Cypselurus vitropinna* Breder or *Cypselurus bahiensis* (Ranzani) on a basis of wing pattern, although most of these stations were too far north to expect either of the latter in abundance, and the pectoral appeared to be too short and the ventrals too small for a *Cypselurus*. Furthermore the dorsal seemed rather high but some specimens were unusually large for *Parexocoetus*. (See Table II.) One *Halocypselus* was

TABLE II. FLIGHT OF EXOCOETIDAE

Date	Hour	Wind vel.	Temp.		Flight time in seconds	No. of touches	Average single flight	Est. size of fish in inches
			Air	Water				
Aug. 27	10:00 A. M.	3	82	84	1.0	1	0.5	2
" 26	6:00 P. M.	2	84	82	1.2	0	1.2	8
" 27	10:00 A. M.	3	82	84	1.2	1	0.6	3
" 26	5:30 P. M.	2	84	82	1.8	0	1.8	8
" 26	5:30 P. M.	2	84	82	2.6	1	1.3	6
" 26	5:30 P. M.	2	84	82	2.6	1	1.3	12
" 27	10:00 A. M.	3	82	84	3.2	1	2.6	3
" 27	10:00 A. M.	3	82	84	4.8	3	1.6	12
" 26	5:30 P. M.	2	84	82	5.0	2	2.5	12
" 27	10:00 A. M.	3	82	84	5.0	2	2.5	4
" 27	10:00 A. M.	3	82	84	5.8	3	1.9+	4
" 27	10:00 A. M.	3	82	84	5.8	3	1.9+	4
" 27	10:00 A. M.	3	82	84	6.2	4	1.5+	6
" 27	10:00 A. M.	3	82	84	7.0	4	1.7+	12
" 27	10:00 A. M.	3	82	84	7.2	3	2.4	4
" 26	5:30 P. M.	2	84	82	7.4	4	1.8+	12
" 27	6:30 A. M.	3	81	85	7.6	2	3.8	12
" 27	10:00 A. M.	3	82	84	7.7	6	1.3−	4
" 27	10:00 A. M.	3	82	84	9.2	4	2.3	3
" 27	10:00 A. M.	3	82	84	9.9	5	2.0−	4
" 27	6:30 A. M.	3	81	85	10.2	4	2.5+	12
" 27	7:00 A. M.	3	81	85	10.2	5	2.0+	12
" 27	10:00 A. M.	3	82	84	10.4	5	2.1−	6
" 26	5:30 P. M.	2	84	82	10.8	3	3.6	12
" 27	6:30 A. M.	3	81	85	11.0	3	3.7−	12[1]
" 27	6:30 A. M.	3	81	85	12.0	4	3.0	12
" 27	12:00 Noon	3	82	84	15.2	4	3.8	6
" 27	10:00 A. M.	3	82	84	15.6	8	1.9+	6
" 27	10:00 A. M.	3	82	84	21.2	8	2.6	6

[1] Possibly *Hirundichthys rufipinnis* (Cuvier & Valenciennes) (Pectorals dusky, ventrals plain). Refer to Table I for other data.

seen. Those which were not apparently *Parexocoetus* are indicated in the two tables. On August 26th, 11:10 A. M., a little north of Hatteras, before entering the Gulf Stream a single specimen was seen, believed to be *Cypselurus heterurus* (Rafinesque). The first two observation periods before this were blanks as was the next one which followed. The Gulf Stream was entered at 12:05 P. M. and the first Exocoetid in it was seen at 1:50 P. M. This was what we here consider as *Parexocoetus*. From then on they became common as Table I shows.

A key was prepared to aid in identifying flying fishes on the wing. It was based in part on preserved material, on the literature and from previous field experience. It includes material from the western Atlantic only and in its present form is purely tentative and is given here as a basis on which to construct a more satisfactory one and for whatever else it may be found useful.

TENTATIVE FIELD KEY TO ADULT EXOCOETIDAE OF THE WESTERN ATLANTIC

BASED LARGELY ON WING PATTERN

A. Two wings only, evident in flight.
B. Wings dusky, with a light area on posterior edge, darkest at anterior edge. *Halocypselus evolans* (Linnaeus)
BB. Wings clear, with a dark spot on the anterior edge and a band near distal edge, widest anteriorly, tapering to a point near the posterior edge, parallel to the distal edge. *Halocypselus obtusirostris* (Gunther)
AA. Four wings evident in flight.
C. Pectorals without any distinct pattern.
D. Pectorals transparent or very light.
E. Ventrals transparent or very light.
F. Pectorals very light dusky; ventrals small or large.
G. Ventrals transparent or sometimes reddish on anterior edge; ventrals small. *Parexocoetus mesogaster* (Bloch)
GG. Ventrals entirely transparent; ventrals large. *Cypselurus bahensis* (Ranzani)
FF. Pectorals entirely transparent, also ventrals; ventrals large. *Cypselurus vitropinna* Breder
EE. Ventrals dusky, darkest at tip and lightest at base; pectorals light dusky; ventrals large *Prognichthys gibbifrons* (Cuvier & Valenciennes)
DD. Pectorals gray or darker for most part; ventrals large.
H. Ventrals transparent, pectorals darkest distally, lightest proximally. *Hirundichthys rufipinnis* (Cuvier & Valenciennes)
HH. Ventrals dark.
I. Ventrals uniform dusky; pectorals dusky.

J. Pectorals darkest mesially and with a vague transparent margin on the posterior edge; 2 long mandibular barbels.
Cypselurus monroei Nichols & Breder

JJ. Pectorals and ventrals uniform dusky; no barbels.
Cypselurus lineatus Cuvier & Valenciennes

II. Ventrals darkest mesially, with a light axil and a light tip; pectorals uniform dusky except for a scarcely evident distal edging of transparent. (Young = *E. exsiliens* Muller?)
Exonautes rondeletii Cuvier & Valenciennes

CC. Pectorals with a distinct and sharply defined pattern of black and transparent.

K. Pectorals dark with a broad transparent band running diagonally entirely across fin.

L. Ventrals dark, with a broad transparent band similar to pectorals; pectorals also with a scarcely evident transparent distal edging.
Cypselurus furcatus Mitchill

LL. Ventrals transparent except for a dark axil; pectoral tip also transparent.
Cypselurus heterurus Rafinesque

KK. Pectorals dark, with a broad transparent band running diagonally from the posterior edge of fin but not entirely across it.

M. Ventrals uniform dusky, pectoral bar reaching less than half way across fin. *Hirundichthys vinciguerrae* (Jordan & Meek)

MM. Ventrals transparent, except for dark axil.

N. Pectorals uniform dusky except for a transparent bar which reaches about ¾ way across fin and a very narrow transparent edging.
Hirundichthys affinis (Gunther)

NN. Pectorals darker distally than proximally, transparent bar not reaching more than half way across fin, no transparent edging.
Cypselurus lutkeni Jordan & Evermann

Factors Influencing Flight

As has been noted a shift from one bow to the other was made in all cases to prevent any possible bias. The importance of this method of procedure is brought out by the fact that in practically all cases there was a marked difference in the numbers counted on either side both in consecutive counts by a single observer and in simultaneous counts by two observers. If we consider the factors that may act differently on one side of a ship than the other it at once becomes evident that wind, wave motion and sunshine are about the only ones that can be readily dealt with. As in mid-ocean generally, in fair weather, the wind and the sea ran together. When these observations were made the "ground swell" was practically absent and could not be correlated with any observed phenomena. If we consider the wind and wind-impelled wave action

we find that the flying fish flew in a very direct response to it. Totalling those from the windward side we get 230 and those from the lee 85 or in other words nearly three times as many flew into the wind as with it. A comparison of the angle of incidence with the ship's course failed to bring out any more exact relationship, nor did the numbers flying show any correlation with that angle. A greater amount of data might well be expected to show a close connection.

It seems natural enough for flying fish to fly into the wind, but how are these figures to be interpreted? Do they fail to fly if "chased" with the wind? Do they know before leaving the water what direction the wind is blowing and orient themselves accordingly, if possible? Is this from recent memory? If so, it would seem that they fly a great deal more than one would gather from observations aboard ship. Those that do fly with the wind generally do not have such long flights as those against or across it. This observation is in direct contradiction to that of Hubbs[4] who writes as follows of *Cypselurus californicus* " . . . when flying with the wind, distances of about a quarter mile are occasionally made." This difference may be due to weather conditions or specific habits as this paper is one of the few recent ones on the subject that carries the conviction of careful and accurate observation with it.

Frequently they do little more than plunge out and in again. The only directing influence the wind above could have on the submerged fish is from motion imparted to the water by it. Considering the directive effect that wind-produced waves might have on flying fish about to immerge we may better contemplate the conditions by reference to (Fig. 304). Here is shown the emergence of a flying fish against and with the wind. The waves move in the direction of the horizontal arrow but the water as a mass is stationary except for a moment of the particles in an elliptical path somewhat as shown by the curved arrows. Thus the surface layer moves actually with the wind under the crest of a wave and against it in the trough. Hypothetically a flying fish coming up from relatively still water below could orient itself to swim with the flow of water and then cut into a reverse flow immediately before breaking the surface. This might explain choice in flight, especially as

[4] Hubbs, C. L. Copeia No. 62, 1918, pp. 85–88.

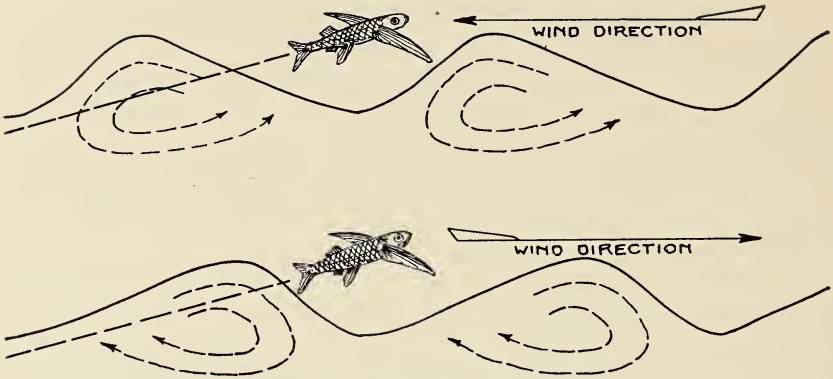

Fig. 304. Wind direction and Exocoetid flight. The upper diagram shows immergence from the windward side of a wave indicating motion of water particles, form of wave, direction of wind and wave motion. The lower diagram shows immergence from the leeward side of a wave indicating the same factors.

flying fish probably normally inhabit a stratum not far below the surface. In the opposite case a reverse flow might discourage attempts to fly. That this manner of exit is advantageous there can be little doubt. In the first case the rear side of a wave is usually the point of taking off (a matter of observation) and allows the fish to be suddenly left suspended in air in a clean-cut take-off. In the other case the wave follows along and the speed of leaving the water is slower. They may be compared as follows:

Into the wind; Speed of fish + speed of wave = speed of clearing water.

With the wind; Speed of fish − speed of wave = speed of clearing water.

Coupled with this is the advantage in the first case of such an object (rather comparable to a toy aeroplane) taking off into the wind.

While the above hypothetical considerations are not necessarily true in their minutest detail it follows on evidence quite *a priori* that some such effect must exert its influence to cause the observed difference in counts from side to side of a vessel.

Hubbs *l. c.* writes as follows of *Cypselurus californicus.* "They appear never to leap directly into the air, as some species are said to do but, on emerging from the water with greater or less velocity

they immediately spread their wide pectoral 'wings' and move forward on the surface like tiny aeroplanes, for a distance averaging perhaps twenty-five feet." The species considered in this paper, supposedly *Parexocoetus*, certainly do not average twenty-five feet of skittering on their emergence.[5] Many probably average about five feet and a large number leave directly as discussed above. Considering those which do not leave directly there is not as great a difference as might first appear. With the forepart of the body emergent they skull along with the tail in the water and follow the curved surface of the moving waves but the eventual take-off is normally from just beyond the crest of some wavelet in about the position shown (Fig. 304) or a little nearer its crest. It is here that the ventrals are spread, raising the tail clear of the water.

During this period of skulling much greater velocity is acquired than these fish could possibly be expected to gain under water for, as pointed out by Breder[6] " . . . the pectorals raise the weight of the head and forepart of the body into the air, leaving the tail submerged. The bulk of the fish being in the air reduces head resistance considerably, while the tail still has the advantages of operating in the denser medium."

What then becomes of the fish that do not fly to the leeward? Two possibilities can be thought of. They may simply swim out of the way as do other fish. If so they would be expected to be seen more often in the clear Gulf water that does not obscure other fishes of similar size. The other possibility is that they may scatter considerably in advance of the moving noisy hull and tend to the windward side so that when they are overtaken most are already on that side. If observations from a relatively silent sailing vessel do not show such marked differences this thought would be much strengthened. It is for the above reasons that the statistical population is considered merely relative and that no attempt is made to weigh the observations for a more absolute determination.

We may now consider the effect of light; in this case sunshine. During all of these observations the sun shone brightly and as flying fish are known to throw themselves at lights at night as do other fishes, the possibility of the sun as a direct source of directive

[5] This is very probably associated with the average size of the two species.

[6] Breder, C. M., Jr. The Locomotion of Fishes. Zoologica Vol. IV, No. 5, 1926, p. 159–297.

influence must be considered. As the wind blew continually across one bow and the days split between having the port and starboard alternately illuminated it should become relatively easy to separate the two influences. If we total those observed on the sunny side we get 155 and those on the shady side 160. This of course is very little difference with a slight suggestion of their flying away from the light. This, however, is hardly a fair way to analyze this data, as in cases where the sun is high little influence could be expected. This is a point which the present data is inadequate for and which further observations should clear up.

If a stop watch is held on the length of time flying fish stay aloft it will be found that they vary from the shortest possible aerial excursions to those of considerable length. The sixth column of Table II gives the flight time in seconds of the 29 observations made. As usually flying fishes drop their tail into the water to gain an added thrust these drops are given in the seventh column. The eighth column gives the result of dividing the second into the first. These figures give an index of the time between hops. They include, however, such time as is spent in skittering over the surface for the next rise. It is evident from these figures without the necessity of graphic plotting that, on the average, the longer the flight the more often the tail drops for added momentum but that these do not increase at as fast a rate is shown by the seventh column in which the time between tail drops average longer in the longer flights. The exact meaning of this is not entirely clear but suggests that size of fish and initial momentum has something to do with it. The correlation between estimated size and length of flight is not very great but that one exists is evident if the average of the first half of the column is compared with that of the last splitting between 7.2 and 7.4 seconds. Those flying less than 7.4 seconds averaged 6.66+ inches in length and averaged 1.68+ seconds per single flight while those above that average 8.5 inches and 2.8 seconds per single flight.

Captain B. W. Leek of the S. S. *Algonquin* stated that he had often held a stop watch on flying fishes and although he had not recorded the results that at one time he had clocked one at 42 seconds in a light breeze and calm sea. This is probably near the maximum for fishes of this general locality.

A study of the present data in regard to schooling indicates

merely that where flying fish are most abundant they tend to form the largest schools. Naturally enough the largest schools were noted to the windward side. The largest was composed of 25 fish. On the lee side but one school included more than 5, one of 15. On the windward were noted 8 schools of more than 5, of from 6 to 25. These notes refer only to observations during the stated intervals. About 34 per cent. of fishes so observed flew singly, 14 per cent. in twos, 6 per cent. in threes and so on. In other words about twice as many flew in company as alone.

A caution is here given concerning observations on the direction of flight in reference to that of the wind. Viewed from aboard a moving ship it is very easy to forget the complicating effect of the observer's own motion. The solid curved line of flight (Fig. 305)

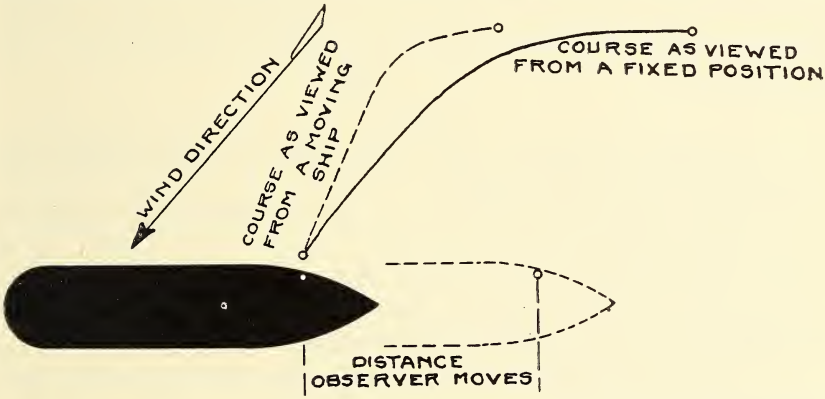

Fig. 305. Diagram showing a typical exocoetid flight with regard to wind direction and the apparent differences due to the forward motion of the observer which must be considered in the study of the relationship to flight and wind direction.

represents a typical course, starting directly into the wind and finally ending at an angle to it. Due to the observer's motion however the course will more nearly resemble that of the dotted line at no time parallel to the wind direction.

In conclusion it is pointed out that only a suggestion has been given here of the possible analysis that these figures may be given. This is partly because the data so far collected is inadequate and partly because this paper is intended primarily to lay a method of study before ocean travelers. A list follows of the more evident types of analysis that an adequate number of observations might be given.

- Species
- Sizes of individuals
- Flight characteristics
  - length
  - height
  - speed
  - direction
  - form
- Geographic locality
- Time of day
- Season
- Meterological conditions
  - Temperature
  - Wind
    - direction
    - velocity
  - Sunshine
    - direction
    - intensity
- Water conditions
  - Temperature
  - Current
    - speed
    - direction
  - Wave action
  - Salinity
  - pH value

Each of the above items and their sub-items could be compared with one another in various ways leading to a better understanding of the distribution, habits and habitat requirements of the Exocoetidae.

Summary

1. Valuable statistical and other data on flying fishes may be gathered from ocean vessels.

2. Such data is susceptible of various types of analysis and its value is cumulative.

3. The flying fish population of the Gulf Stream in late summer is most dense east of its axis, and north and south, denser near Cape Hatteras than in the Florida Straits.

4. The flying fishes of this region fly into the wind in the ratio of about 1 to 3.

5. The only directive influence from the wind they are able to feel is that due to the underwater disturbance of wind-impelled waves.

6. The direction of sunlight may have secondary influence on their flight.

7. The larger the fish, on the average, the longer the fligth will be and the fewer the dippings of the tail into the water for added power.

8. About twice as many flying fish fly in schools of two or more as fly alone.

9. *Parexocoetus mesogaster* is the predominant form in the Gulf Stream.

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ON THE EXTINCT GALAPAGOS TORTOISE THAT INHABITED CHARLES ISLAND

By R. Broom, F.R.S.

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ON THE EXTINCT GALAPAGOS TORTOISE THAT INHABITED CHARLES ISLAND*

By R. Broom, F.R.S.

(Figs. 306–309 incl.)

The discovery by Dr. C. H. Townsend of a large number of specimens of the Charles Island tortoise is an event of considerable importance in herpetology. Up till 1832 giant tortoises were abundant in Charles Island, but in that year the island was colonized by several hundred settlers from Ecuador, and within a very few years the tortoises became so rare that the colonists sent hunting parties to the other islands for supplies, and even the few small ones that may have remained were probably soon killed off by the dogs and pigs that had been introduced by the settlers. Almost certainly the native tortoises of Charles Island were extinct by 1850; and any specimens collected there after this date are most likely to have been specimens brought from neighboring islands by the settlers.

Owing to the early extinction of the Charles Island tortoise there was for long considerable doubt as to what species it was and even till now there has been uncertainty as to the name that ought to be given it.

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* It would be difficult to imagine a more effective trap for tortoises than the well-like entrance to the cave on Charles Island from which the skeletons were taken.

It must have operated automatically as a death-trap for centuries. The brushy half-concealed entrance is merely a hole in the ground a dozen feet in diameter and twenty feet deep. With a steep slope at one side, the unlucky tortoise that tumbled in did not necessarily strike bottom with a fatal crash, but rather rolled down an incline it could not ascend.

The rocky floor of the cave is not wide but leads into a few low passages under the lava, all strewn with dry bones of tortoises that had crept everywhere in search of an outlet. The brittle remains of the earlier victims had been crawled over repeatedly and gradually broken up by those that were entrapped subsequently from time to time.

It is not likely that the latest and best preserved of these entered the cave less than ninety years ago. According to the log-book records of seventy-nine whaleships examined by the writer, the last tortoises were taken from Charles Island in 1837.

The bleached and bony remains of those not too antiquated and fragile to be removed, had long lost their dark horny plates which lay curled and twisted beside them. In a dozen of these, both carapace and plastron were practically intact, while skulls and leg bones had usually been disturbed and scattered. A considerable amount of broken tortoise remains had long since become mixed with the soil of the cave floor. The later arrivals lay where they died, their large white carapaces showing conspicuously as our flashlights were turned in their direction. *Townsend, Bulletin N. Y. Zool. Soc. Sept.–Oct. 1928.*

We have a few interesting references to the tortoises in the works of some of the early voyagers.

In 1812 Captain Porter of the U. S. Navy spent some time in the Galapagos Islands and as he was a good naturalist he has given us some interesting observations on the tortoises. He was apparently the first to recognize that there were different species on the various islands. He visited Hood, Narborough, James, Charles and Indefatigable Islands and found tortoises abundant on all of them.

The following is his reference to the Charles Island species: "Those of James Island appear to be a species entirely distinct from those of Hood and Charles Islands. The form of the shell of the latter is elongated, turned up forward in the manner of a Spanish saddle, of a brown color and of considerable thickness. They are very disagreeable to the sight, but far superior to those of James Island in point of fatness, and their livers are considered the greatest delicacy. Those of James Island are round, plump, and as black as ebony, some of them handsome to the eye . . . The tortoises of Hood's Island were of a quality far superior to those found on James Island. They were similar in appearance to those of Charles Island, very fat and delicious."

In 1833 Commodore John Downes visited the Galapagos Islands in the U. S. Frigate "Potomac" and collected a large number of tortoises. He is known to have landed only on Charles Island. Mr. T. N. Reynolds who voyaged with Commodore Downes gives a short account of the tortoises in his voyage of the Potomac. He says: "From the last of May to December, embracing the rainy season, the Terrapin leaves the mountains and high grounds and may be found spread in all directions over the plains and low grounds near the sea, where they feed principally upon prickly pear, and find water in the little lakes in the crevices of rocks. From January to May, as the dry season advances, they return again to the high ground where the trees are larger, vegetation more abundant and where springs may be found issuing from the sides of the mountains. These watering places became much frequented and paths leading to them may be traced for a great distance along the sides of the hills; and I have seen in many places the roads worn away more than six feet in depth, and just sufficiently wide to allow them room to pass. At these springs hundreds of them are often

seen at a time waiting their turns to drink, or, becoming impatient, pile themselves one upon another, in their efforts to obtain water. When satisfied, they again return by the little roads hewn through the soft rocks and again disappear amid the thick underwood."

On his return to Boston in the summer of 1834 Commodore Downes presented to the Boston Society of Natural History the two largest of the tortoises he had brought home with him. One of these was dissected by Dr. J. B. S. Jackson who published in 1837 a description of both the external characters and the internal anatomy. He believed that there was only one species of Testudo on the Galapagos Islands and naturally assumed that his tortoise belonged to the species described by Harlan in 1827 as *Testudo Elephantopus*.

Jackson gives the color of the upper shell as "deep brown, almost black" and the under shell he says has a light shade of the same color, and the surface is more rough than that of the upper. The color of the female he states was similar to that of the male.

Harlan's specimen of Galapagos tortoise described in 1827 has apparently been lost, and we can now judge of the species by his rather poor figure. His description and figure do not enable us to identify his species and it seems wisest to regard *Testudo Elephantopus* as an indeterminate species. In any case it is almost certainly not the Charles Island species. This was the opinion of Baur who in 1890 gave to Jackson's Charles Island specimen the name Testudo galapagoensis, and Gunther, one of the greatest herpetologists who has ever lived, confirmed Baur's opinion.

Van Denburgh, who in 1914 published a most exhaustive report on the tortoises of the Galapagos Islands, believed Jackson's specimen to be the same species as Harlan's and retained the name *T. Elephantopus* for the Charles Island form.

In 1917, S. Garman also published a large paper on the Galapagos tortoises, but as it regards Baur's *T. galapagoensis* as a synonym of *T. nigra* of Quoy and Gaimard 1824; and under *T. elephantopus* which he considers entirely different he places as synonyms *T. ephippium, T. abingdoni, T. becki, T. bedsi, T. hoodensis* and *T. phantastica*—all saddle-backed types though Harlan's specimen judging by the figure was not a saddle-backed type at all.

While agreeing with most of Van Denburgh's conclusions, I

believe Baur and Gunther were right about the distinctness of the Charles Island form, and the large series of specimens discovered by Dr. Townsend not only gives us an excellent idea of the Charles Island species but confirms Baur's view that it is a distinct species.

Most of the specimens got by Dr. Townsend are between 50 and 60 centimeters in length. One is a very large one—unfortunately imperfect—and one is comparatively young.

The largest specimen which is evidently a male probably when perfect measured 85 centimeters in greatest length from front to back as it stands on the plastron or probably about 96 centimeters in oblique measurement. It probably measured about 105 centimeters over the carapace from front to back but as all the posterior half of the carapace is gone the posterior end can only be estimated roughly from the position of the back of the plastron. The circumference of this large specimen round the widest part is about 170 centimeters.

As will be seen from the photographs given the front of the carapace is high, and the sides much pushed together, giving the well known Spanish saddle-back, though the degree of constriction is less than in *T. abingdoni, T. phantastica,* and *T. becki,* the agreement being more close to *T. ephippium* and *T. hoodensis.* The height of the anterior opening from the upper part of the plastron to the inner border of the upper part of the carapace is 346 mm. and the greatest width of the opening 404 mm.

The plastron measures in greatest length in the middle line 650 mm. and the length of the bridge between the limbs is 310 mm. on one side and 318 mm. on the other. The plastron is much hollowed out, especially in the posterior half. The anterior process is long and narrow and truncated in front. Posteriorly the plastron is also transversely truncated.

The only epidermal shields preserved in this specimen are the 1st marginal of the right side and the 2nd marginals of both sides. All are a dark brown, but where weathered or rather perhaps rubbed in front they are of a dirty light brown color. In the collection are numerous detached shields of specimens and while some are a very dark brown—almost black—many of the shields of the plastron are quite light brown—almost yellow.

A smaller specimen is nearly perfect. It measures in curved length over the carapace 730 mm. and in greatest circumference

Fig. 306. Tortoise of Charles Island, Galapagos. (*Testudo galapagoensis*) Bauer. Side view.

1060 mm. The plastron measures in the middle line 483 mm. and the bridges measure 243 mm. on the one side and 245 mm. on the other.

The views given will show the general arrangement of the shields and bony plates. Though this is a young specimen, the anterior end of the carapace makes a distinct approach to the Spanish saddle, but only in a very slight degree as compared with the large specimen. The bones of the carapace in this specimen as in all the others are thin and easily broken and the whole carapace is rather loosely attached to the marginals, narrow fontanelles being very often present between the costals and the marginals, and even where the fontanelles are the union is delicate.

There are in the collection eight skulls and three mandibles. The skulls differ somewhat from that figured by Gunther. The jugal arch, as will be seen from the figure given, is considerably narrower and placed lower on the side of the skull. This character is constant in all the skulls in which it is preserved. The posterior muscular process formed by the ex- and basi occipitals is much less developed than in Gunther's specimen but in all other characters the agreement is fairly close.

There are preserved many bones of the skeleton but for the most part not in association with the carapace.

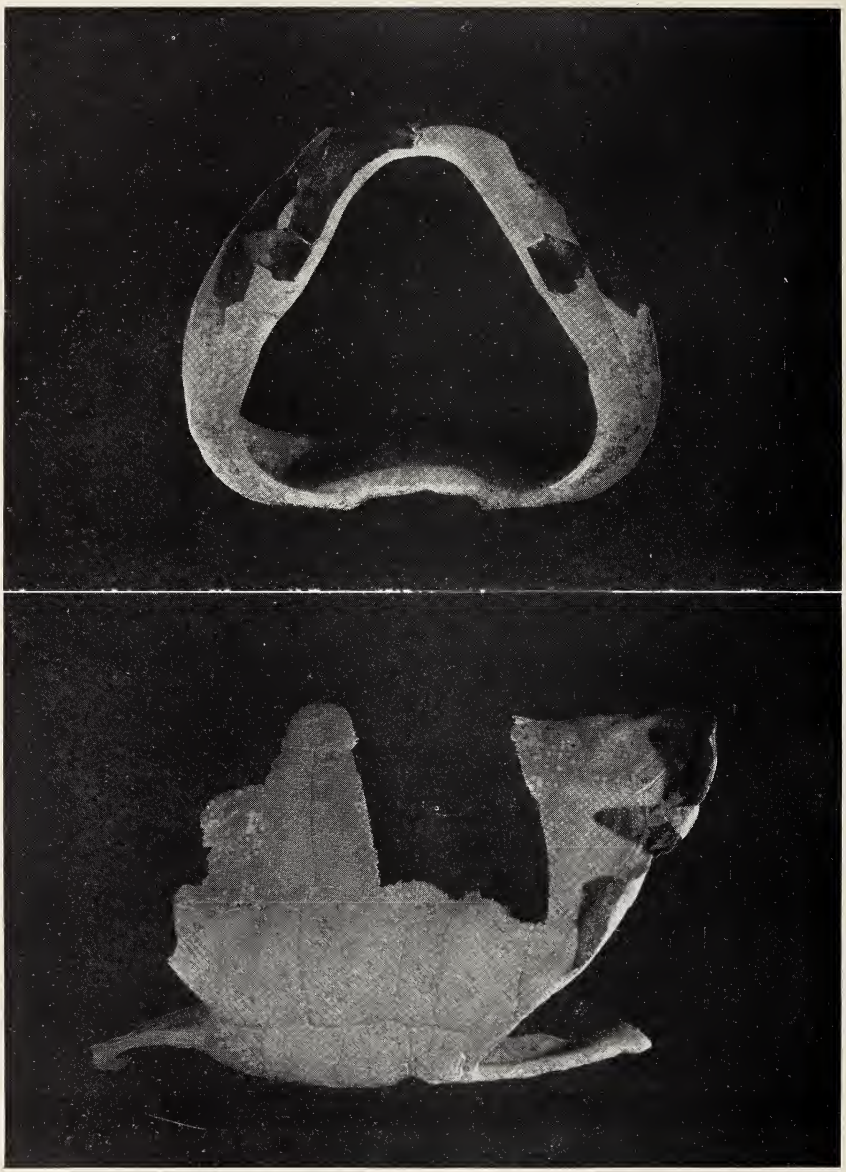

Fig. 307. Tortoise of Charles Island, Galapagos. (*Testudo galapagoensis*) Bauer. *Upper:* anterior view. *Lower:* side view.

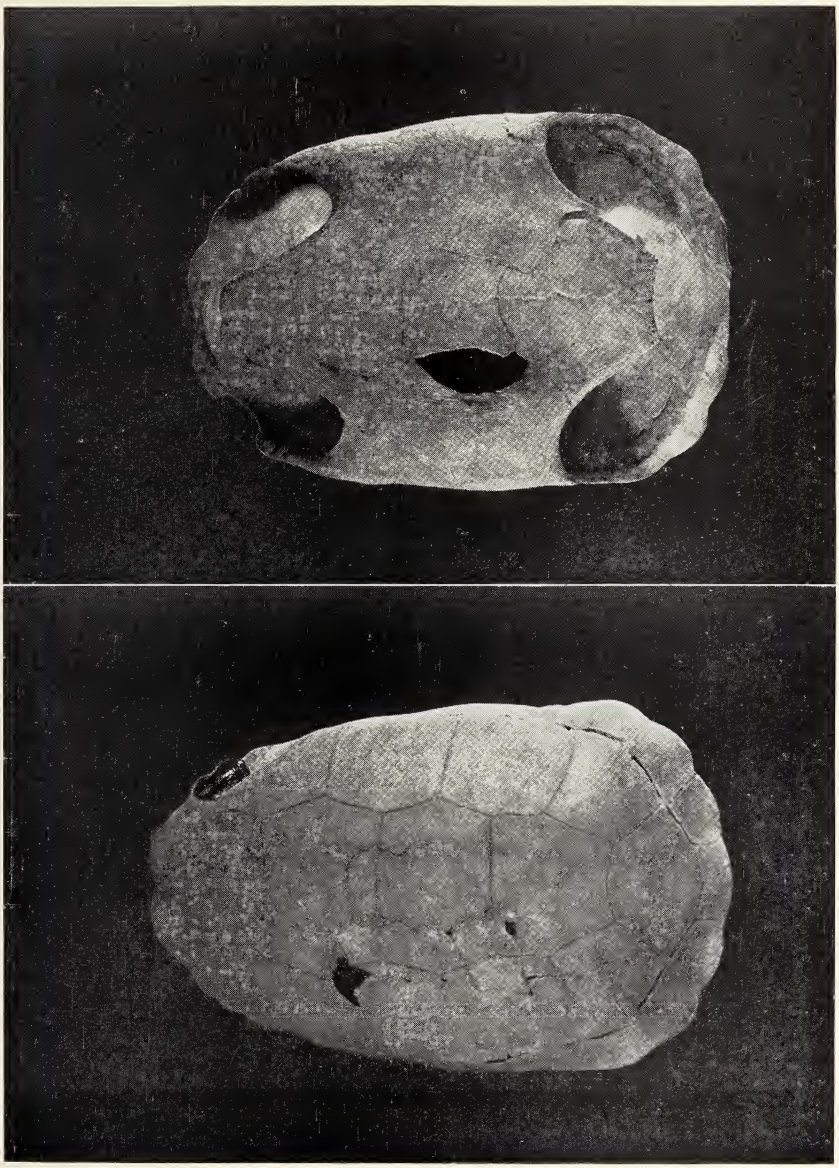

Fig. 308. Tortoise of Charles Island, Galapagos. (*Testudo galapagoensis*) Bauer. *Upper:* carapace from above. *Lower:* plastron.

Fig. 309. Extinct Tortoise of Charles Island, Galapagos. (*Testudo galapagoensis*) Bauer. *Upper:* side view of skull. *Lower:* upper surface of skull.

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RECORDS OF CHANGES IN COLOR AMONG FISHES

By Charles Haskins Townsend

Director of New York Aquarium

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RECORDS OF CHANGES IN COLOR AMONG FISHES[1]

By Charles Haskins Townsend
Director of the New York Aquarium.

Introduction

(Figs. 310–321 incl., Plates 1–27 incl.)

Most of the tropical fishes on exhibition in the New York Aquarium have the capacity of making instantaneous changes in color according to their moods or to artificial excitements.

The men who feed and care for these fishes become acquainted with their different phases of coloration and detect them readily, while the casual visitor passes by unaware that the black and the white and the showily colored specimens in a certain tank are all of the same species and may all look alike a quarter of an hour later.

We did not realize at first the extent of the color changes going on in the tanks. When it became apparent that the tropical fishes indulged in many more changes than was supposed, observations were commenced with a view to recording all the changes practiced by each species.

Changes in color and pattern are caused by the contraction or expansion of color cells or chromatophores, which contain black, red, blue, yellow or other pigments. The movement of color granules in the color cells is controlled by the nervous system. The stimulus to color change is received through the eye; blind tropical fishes make no response to disturbance or to changes in environment, their color cells remaining inactive. Blind fishes from Mammoth Cave and blind salamanders from an artesian well in Texas, that were kept for months in the Aquarium, were pale and colorless, entirely lacking development of color cells.

The chameleon, the dolphin and the octopus are celebrated for their capacity to make changes in color, but fishes inhabiting

[1] In the preparation of these records the writer has drawn freely upon his three earlier papers on the same subject. The supply of such papers being exhausted, the present one will supplant them on the list of publications emanating from the Aquarium.

coral reefs possess color cells which enable them to surpass the performances of their eminent rivals. Their abilities in color change have been made known more recently because the public aquarium, where they can be observed more readily than in nature, is an institution of comparatively recent development. Tropical fishes being easily captured, transported and retained in captivity, the New York Aquarium exhibits many kinds from the coral reefs of Florida and Bermuda. Their colors are usually brilliant, whatever phases the various species may assume momentarily. Tropical birds and butterflies are no more showy than these inhabitants of the reefs. The changes in color which these fishes make in conformity with their moods or surroundings are, or at least can be, made instantaneously. A fish having little color may greatly alter its appearance by a mere change in the pattern of its markings.

The New York Zoological Society authorized the preparation of a series of paintings and photographs of tropical fishes, showing the various changes in color of which each species in the collections of the Aquarium is capable. Written descriptions of the various liveries assumed were prepared whenever the behavior of the fishes permitted but the work of photographing and painting the color changes was necessarily slower and more difficult. The camera and the artist are available when arranged for but the subject poses or performs to suit his own moods. Both the photographer and the artist endured tedious delays before the record for each species was completed. To avoid loss of time the artist kept outline drawings of two or three species in readiness so that he could turn promptly from one tank to another and apply the color without delay as the fishes under observation became active or quiescent.

The paintings which have been prepared showing from three to seven different phases according to the species may not even now after long continued observation be complete. Occasionally some fish furnishes a surprise by appearing in a guise not previously noticed. We have indeed found that with most species an additional color phase can be produced by stopping the flow of water until the fish becomes distressed, when it assumes colors or markings different from any of those displayed under normal conditions.

Such experimentation produces colorations that might be named distress phases. Similar appearances are assumed by fishes that are sick or injured. The display of markings or colors not previously recorded in the Aquarium we now regard as symptomatic of discomfort and the attendants take action accordingly. It is not easy to name the colorations appearing normally but experiment and observation have shown that certain well-known changes can be attributed to fright, to anger and to distress.

In our observations in recording normal changes in color and our experiments in producing others by artificial means, twenty-eight tropical species were closely watched. All of these were proved to have the capacity of making instantaneous changes from one set of colors or markings to another, while from three to seven guises each, according to the species, were clearly distinguished. It is possible that each kind is capable of additional transformations in its natural habitat, but as yet we know little of the habits of animals in the sea.

One is at first inclined to a feeling of surprise that the ability of fishes to assume half a dozen different costumes within the space of a few moments was not earlier understood, but many kinds of observations are scarcely possible in the natural state. It is necessary that certain details of animal behavior be studied under conditions involving captivity and the continuous observation of each individual, such as may be arranged in the large tanks of a well-equipped aquarium.

Reighard, who studied these fishes on the coral reefs of the Tortugas, concluded that their conspicuousness is without biological significance and that their agility affords them ample protection. It is true that the reef fish, like the chipmunk and the woodchuck, is seldom more than a few jumps from home. It finds security in proximity to the nooks and crannies of the reefs with their varied coral growths. The reef itself being a refuge, its conspicuousness is, according to Reighard, an expression of race tendency, independent of natural selection, the conditions of life permitting a suspension of selection so far as colors are concerned.

Longley, who also studied reef fishes at the Tortugas, rejects

the hypotheses of "warning and immunity coloration, signal and recognition marks and sexual selection" as applicable to reef fishes, but concludes that color and pattern have an "obliterative" function, their evolution having been guided by natural selection.

The study of gaudily hued fishes on coral reefs has as yet progressed little farther than the stage of reconnaissance. At the time when Reighard's investigations were made ('07), the great extent to which reef fishes alter their coloration was not known, their behavior in captivity not having been recorded.

We are not yet prepared to accept the conclusions arrived at by those who have confined their observations to the generally grayish reefs of the Tortugas, which lie near the margin of the tropic belt. After experiences on the coral reefs of more than forty islands in various parts of Polynesia, where the fishes are more gorgeous than in sub-tropical Atlantic waters, we are prepared to affirm that the abundance and variety of the invertebrate life alone is sufficient to give areas of the reefs such splendors in color that the most brilliant fish could soon find an environment to match without changing its own color in the least. Wallace,[1] in describing the harbor of Amboyna, says: "The bottom was absolutely hidden by a continuous series of corals, sponges, actiniae and other marine productions of magnificent dimensions, varied forms, and brilliant colors. In and out among them moved numbers of blue and red and yellow fishes, spotted and banded and striped in the most striking manner."

Hickson,[2] in referring to the marine fauna of Talisse in the Celebes, says: "This general account of a ramble on the reefs of Talisse is perhaps sufficient to indicate the immense variety of form and color of living corals that may be observed in many places, but it would take a separate volume to describe in detail all the different creatures, their marks and colors, their movements and their habits, which are to be found upon a hundred yards of such a coast." . . . "The brilliant colors of the reef fishes were first noted by Captain Cook and form one of the most striking features of the fauna of the tropical shores."

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[1] Malay Archipelago.

[2] A naturalist in North Celebes

In Polynesia we found that the colors displayed by fishes were vastly more brilliant and varied than those of fishes in any part of the Atlantic.

The pictorial and other records made in the Aquarium show that a reef fish can no longer be regarded as a creature having some permanent life color but must be considered as having several colorations, any one of which may be assumed instantly. Provided with such records, the investigator in the field should be better equipped for his efforts toward interpreting the colors of fishes.

Fishes given to wandering among grayish reef heads, clumps of purple or yellow sea fans, settling on brownish rock surfaces or whitish sandy patches, must be benefited by the ability to adjust their colorations of body instantly to environments varying widely in color. That most of them, both in nature and in captivity, practise color change in moving about is beyond question. While mere immobility in a living animal lessens its visibility, its simulation to some extent of the background contributes also to the reducing of its conspicuousness.

Since our records have shown that reef fishes have from two to seven distinct normal color phases according to the species, attention should be called to the fact that colored plates of fishes as published in standard works on ichthyology show but one of several phases which the species is capable of assuming. Seen in some other phase the color plate might be useless for purposes of identification except in the hands of the expert acquainted with its structural characters. The color of a reef fish disappears when the specimen is preserved in spirits and a colored plate showing a single phase is obviously an imperfect color record. When similar records of color phases of many more species become available the specific names of a good many fishes will be relegated to the lists of synonymy.

The studies made in the New York Aquarium are, of course, based on the behavior of fishes in captivity, where the conditions of life are necessarily different from those encountered in nature They are neither preyed upon nor compelled to seek prey. They

associate only with such other species as may be placed in the same tanks with them. Even when a large tank is fitted with rock work, patches of sandy bottom, purple and yellow sea-fans and clumps of sea weed, their surroundings at best are monotonous as compared with the diversified backgrounds to be found on their native coral reefs.

It is difficult under such conditions to determine the meanings of their color changes. Perhaps some of them have no serious meaning but are merely emotional like sudden flushing or pallor. The principal motive in changing color must be the impulse to conform with environment. If the fish rests among dark-toned rock-work, it is disposed to show its more banded or blotched phases. If it settles down upon a patch of grayish bottom it quickly assumes paler tones more in keeping with its change in position. Then there are the colors and markings displayed when under some excitement, as when food is thrown into the tanks, artificial light turned on, or the air-compressor started. Where several species are kept in a single tank there is more activity and a noticeable increase in the color changes of all of them.

If all of the many species under observation could be installed in tanks equipped with more varied backgrounds of rock-work, sandy bottom, sea weed, etc., their color changes, as they settle down in different situations, would doubtless be brought into play with even greater frequency. It is difficult to arrange surroundings that closely approximate nature and the work of providing reef-like environments has necessarily been slow. The gradual enlargement of exhibition tanks in the Aquarium is proceeding and each improvement of the kind affords opportunity for the placing of accessories which in the end will give our ocean rainbows greater inducements to show what they can do as they move from one position to another.

We know as yet little of the extent to which color change is practiced by fishes amid their natural surroundings on the reefs where observation is difficult. They may assume colors or markings useful in warning off enemies or revealing themselves to their own kind, which are not displayed during their sheltered lives in the tanks.

Certain feeding experiments conducted by Reighard at the Tortugas showed that the gray snapper (*Neomaenis griseus*) recognizes certain colors. Specimens of its favorite food fish, a species of Atherina, were artificially colored red, blue, yellow, etc. The snappers took them all readily, but when the red fishes had been rendered unpalatable by treatment with various substances, they soon learned to avoid them altogether, continuing to feed on those of other colors which had not been so treated. Such experiments indicate that perception of color by reef fishes exists.

So far we have been able to do little more than record the numerous changes they are capable of making in captivity, but these are striking and the tendency to make them is very strong. Certain color performances can be evoked at the will of the experimenter. It may be possible to produce others under the conditions of captivity, by introducing species of which they have an inherent fear. As the artificial conditions under which they live are apparently not conducive to breeding, it is possible that there are special color changes brought into play during their spawning periods.

We are loath to believe that the sudden flashing of a dozen regularly distributed white spots by the red parrot-fish is meaningless. While it may be so in the humdrum round of life in the tanks, in nature, surrounded by enemies, it may be a recognition signal to its mates. Some of our showy fishes feed at night as certain brightly colored reef fishes are known to do; there may be "obliterative coloration" in the ghostly whiteness sometimes assumed by the blue tang as the tanks become dark in the evening. In the wild state it may do this habitually at night and move quite away from the reefs to feed.

Observations on the color changes of fishes under normal conditions such as prevail on coral reefs will throw more light on this subject, but they are naturally more difficult to make and will require long-continued research. We are still far from satisfactory interpretations of the gaudy hues of most animals.

The common pig-fish (*Orthopristis chrysopterus*) has four liveries which it may put on and off within a few moments. One of these consists of seven or eight irregular, vertical, dark bands, not

unlike those of the northern tautog. When a number of heavily banded tautogs (*Tautoga onitis*) were placed in the tank with the pig-fish the latter wore its vertical bands habitually. It changed its habit of swimming about and usually rested on the bottom among the tautogs, from which a casual glance did not distinguish it, so nearly perfect was the mimicry.

A spade-fish (*Chaetodipterus faber*) was taken from its mates and placed in a tank with black angel fishes which have little power to change color, being habitually so dark as to be almost black. The spade-fish soon adopted the color of its new associates and remained nearly black for several weeks. When finally returned to the society of the spade-fishes, it took to the black and white bands which is their usual dress for every-day wear. The black coloration having become habitual while with the black angels, it evidently had to make some effort to maintain the customary livery of the spade-fishes and for several days there were frequent lapses into black. The experiment was repeated with another specimen with similar results. As both species inhabit the reefs and are at times associated, the behavior of the spade-fish in assuming the coloration of the black angel may be regarded as mimicry.

The Bermuda chub (*Kyphosus sectatrix*), a fish having little color, changes quickly from its striped to its spotted phase and back again in play, as the fishes chase one another from place to place. At times the change is made slowly enough to show a combination of both phases, as may be seen in the photograph on page 343. The photographer was unusually fortunate in this case, exploding his flash powder at the critical instant. Work of this kind has generally been done at night by flashlight, as the building is too dark for instantaneous photography in the daytime.

When the flow of water is stopped and the air-pump started, all of the chubs in the tank at once assume the spotted phase, which is retained an hour or more until the flow of water is restored. The white spots are unusually sharp and distinct at such times, over the entire body except on the head, but all the fins remain very dark. A pure white band develops across the top of the head, with longitudinal white bands along the jaws. All the fishes keep

swimming actively and are excited over the fountain of white bubbles escaping from the air tube at the bottom of the tank.

Two small red-mouthed grunts (*Haemulon flavolineatum*) were placed in a small photographic aquarium built so narrow that they could neither get out of focus nor turn around. They were carried out of doors where bright daylight permitted quick work and were photographed in the midst of their color attempts at concealment. Badly frightened, they turned very dark and remained so, the specimen on the right as shown in the photograph on page 344 turning light and showing two longitudinal black lines only after considerable prodding with a stick. The customary coloration of this species when undisturbed is a pale golden yellow with diagonal silvery stripes, as shown (lower) on page 344. When alarmed, the whole school bunches together at the bottom, all immediately assuming a dark-mottled appearance, the ground color becoming so dark that the fish is completely changed. The dark blotches disappear when the disturbance ceases, the specimens one after another assuming their ordinary coloration.

The fact that some fishes are nocturnal in their feeding habits must not be overlooked. In the dark their obscurer colorations may serve to make them indistinguishable.

The power of camouflage among fishes and some other animals must have its uses or it would not have been developed. It is well known that conspicuously marked or colored mammals, birds, reptiles and insects lacking the capacity to make such changes in appearance, often render themselves inconspicuous when at rest, by seeking positions where their colors or broken markings merge with their surroundings. Readily visible on close view, the sharply marked animal may practically disappear at longer range, or if nocturnal in habit, be more indistinguishable in the dark than if uniformly colored.

It should not be assumed that the different aspects caught by the artist are all that the species under observation can present. The responsiveness of the color cells to the transient excitements of the fish are such that no two artists portray well known guises absolutely alike. No two photographs are quite the same even if

the fish in front of the camera has not moved. While certain general changes in appearance are identifiable by any one, it soon becomes evident that intensity of color or pattern depend upon the individual fish under observation. In the coney, the graysby, the red hind, the hog-fish and most of the groupers, we are confronted with such activity of the chromatophores that no two of a species are ever completely identical in appearance.

Among the more active species, the duration of the colors assumed from time to time is uncertain until the fish comes to rest, when it may be greatly prolonged.

It is evident that the amazingly varied appearances possible to tropical fishes, so readily observable under the conditions of captivity, have not been fully appreciated by those who have studied them at longer range. No other creatures can compare with the fishes in this respect. All impulses, reactions, movements, find instant reflection in the kaleidoscopic color cells.

The visitor at the Aquarium need not expect to see in a short time many of the colorations of which a species is capable. The records and pictures presented here are the result of long-continued observation by the recorder and the artist, both by day and in the dusk of evening. Some of the recorded changes in appearance were brought about only by experimentation.

The writer is indebted to Hashime Murayama, Herbert B. Tschudy, Olive Earle and Charles R. Knight for painstaking efforts in portraying the behavior of their capricious subjects. Mr. L. L. Mowbray, curator of the Bermuda Aquarium, demonstrated for me the relationship between the yellow-finned grouper and the so-called "princess rockfish." Each has its own colorations, the differences being due to depth of habitat. Both are *Mycteroperca venenosa.*

Species as Illustrated by Colored Plates and Photographs

Shark-suckers habitually cling to the bodies of sharks by means of an air disk on top of the head. One of these (*Echeneis naucrates*) has for many years been exhibited at the New York Aquarium, where one or more individuals may be seen clinging to a shark or swimming close beside it. Three of its phases of coloration are shown in plate 1.

The shark-sucker often changes from black with white stripes to gray or even jet black. While clinging to or swimming close beside the shark, the darker costumes are usually worn. When kept in a tank by itself it often clings to the glass front and becomes uniformly gray. It may even assume a position on the bottom of the tank, turning over and applying the sucking disk on the top of its head to the concrete floor, so strong is the inclination to make fast to something. The color changes practiced by this fish are usually made instantaneously. Those shown here are the ones usually displayed, but frequently when the upper surface and the black stripe along the side remain black the fish may turn entirely white beneath.

It inhabits warm seas in association with sharks, porpoises, whales and turtles.

A hardy fish that lives many years in captivity is the Spade-fish (*Chaetodipterus faber*). Its usual appearance is silvery with five or six heavy cross-bands of black, but at times some of the specimens become either entirely white or dull black. These changes are generally of brief duration. If frightened all the specimens in the tank instantly assume their black cross-bands. There is a decided tendency in this species to become dark in the evening. The black bands have a tendency to become obscure in very large specimens. Having perhaps ceased to be concerned about enemies, the large fishes may have less inclination toward changes in color.

The Spade-fish is a tropical species, found from Brazil to our South Atlantic coast, sometimes extending its summer range to the latitude of Massachusetts. We have taken late summer stragglers in New York Bay. It is reported to feed on the "Portuguese man-of-war" (*Physalia*) and that fishermen at Trinidad capture it with that jelly fish as bait.

Eight phases of coloration are sometimes observed in a tank containing specimens of the Nassau Grouper (*Epinephelus striatus*). In one the fish is uniformly dark; in another creamy white. In a third it is dark above, with white underparts. In a fourth the upper part of the body is sharply banded, the lower pure white. A fifth phase shows dark bands, the whole fish taking on a light

brown coloration. While in a sixth the fish is pale, with all dark markings tending to disappear. The seventh phase shows a light colored fish with the whole body sharply banded and mottled with black. (See photograph p. 345.) This is instantly assumed by all specimens when they are frightened and seek hiding places among the rock-work. The banded phase shown here is no more the normal appearance of the fish than the uniformly dark, the uniformly white, or any other phase. Singularly enough, no two photographs of this banded phase are quite alike, the extent of the markings being dependent apparently upon the degree of disturbance to which the fish has been subjected.

The artist has not shown a rarer guise when the body is dusky above, white below, with a median black band from head to tail. This is an important food fish of Bermuda, Florida and the West Indies. Specimens have been taken weighing as much as fifty pounds.

The Red Grouper (*Epinephelus morio*) assumes nearly as many colorations in the course of the day as the Nassau Grouper. One of these is dusky black; another brownish with blotches of white; a third, still lighter, has broad brownish bands. The others show various shades of fawn color without markings on the body.

The red grouper is an important market fish, common along our South Atlantic and Gulf coasts and in the West Indies. Large specimens often exceed twenty pounds in weight.

The Black Grouper (*Mycteroperca bonaci*) has no showy colors but frequently makes changes varying from white to black. In the first there may at times be black edging on dorsal, anal and caudal fins. An intermediate rather light phase shows four vertical rows of dark brown rectangular blotches, the lower half of the body being closely covered with brownish dots. In a third change, both dots and blotches slowly disappear as the fish becomes practically black. Between these rather common colorations there are variations which the artist does not portray. The photograph shows one of these phases.

Distribution—From Florida and Bermuda to Brazil.

The usual appearance of the Yellow-finned Grouper (*Myctero-*

perca venenosa) with the body sharply mottled is shown at the top of plate 6. When the fish turns white as it sometimes does, all color disappears except the black border of the soft dorsal and caudal fins. Even the minute red dots which ordinarily cover the whole body are lost.

In the phase shown below, the markings become dim. They are often lost entirely in a deep brown coloration which the artist has not shown. Specimens observed in March, 1929, at the Bermuda Aquarium displayed two other phases not shown on plate 6: one pale with dark blotches on back, while another had the upper half of body crimson, with blotches showing faintly, the lower surface being very pale crimson.

An important food fish ranging from Florida and Bermuda southward.

The colored plate of the dainty Princess Rockfish (*Mycteroperca venenosa**) needs little explanation. The artist has shown its three principal guises perfectly: white, with the evenly distributed black spots reduced to the minimum; second with the always present black spots at their maximum intensity; and third a similar phase with the underparts crimson. This fish is so rarely brought to the Aquarium that it was never placed in the photographer's portable tank. What markings it might display if subjected to that alarming process are still unknown. The three colorations shown here are all assumed as the fish moves about unmolested. A fourth phase is shown in the photograph p. 346.

Distribution—Florida and Cuba.

The visitor looking at the 200-pound Giant Grouper (*Promicrops guttatus*) and interested chiefly in its large size may occasionally have a chance to marvel at something else than its bulk. The usually dark fish may suddenly shift its position and appear as a nearly white fish with heavy black blotches from head to tail. It may change its position again and assume a creamy-white coloration while the dark blotches or bands slowly fade out. The artist has not shown this fish in a fourth phase, in which it becomes uni-

* Recent observation of many specimens in the Bermuda Aquarium (March 1929) shows this fish to be a shallow water variety of *Mycteroperca venenosa*.

formly dusky black. The behavior of the two giant groupers, which are kept in separate tanks, is interesting: one has lived ten years in the Aquarium without ever disturbing any of the dozen kinds of smaller fishes living with it, while the other has promptly swallowed all fishes placed in its tank, one of these being a young brown shark two and a half feet long. The mouth of the giant grouper measures ten inches across.

Range in the Atlantic—From Florida and Bermuda to Brazil.

The Coney (*Bodianus fulvus*). Groups of this species as received at various times in the past have varied more or less from those collected in 1927, the principal colorations of which the artist has shown here. The color phases described by the writer in 1908[1] do not correspond in details with those of coneys now in the Aquarium. Few fishes are capable of as many intergradations. Between the two phases showing solid color—the red, at bottom and the dark, at upper right of plate 9—there are three other distinct phases that are assumed naturally. Persistent annoyance by the observer's assistant such as driving the fishes from one hiding place to another will also produce them in varying degrees of intensity.

Individual coneys indulging in frequent changes when first placed in the tanks may later take to a single coloration and maintain it habitually with but little temporary alteration. Such fishes are inclined to select a comfortable situation among the rockwork, sometimes head downward in a crevice and may be found there day after day. Others may be more active, some of them fighting until their jaws are lacerated and unsightly. Hostile coneys hang bulldog-like to each other's jaws, and after exhausting struggles return to fight again. Their colors when fighting are different from those displayed at other times and the artist did not feel equal to the task of recording them.

In the afternoon of September 15, 1927, we observed that all of the coneys in the tank had temporarily assumed the pale coloration of the specimen shown at the top of plate 9. At another time a coney that had maintained the dark red coloration persistently was placed in a separate tank for observation when it

[1] 13th Ann. Rept. N. Y. Z. S.

assumed and retained the pale phase. The coneys that have been described as *Bodianus fulvus* and its two subspecies *ruber* and *punctatus* are all color phases of one species, as may be seen in plate 9. An additional coloration observed in the Bermuda Aquarium in March, 1929, is like that of figure at top of plate 9, but with the back, from snout to end of soft dorsal, bright vermilion.

Range—Florida and Bermuda southward to Brazil.

Graysby (*Petrometopon cruentatus*). The various colorations and markings assumed by this fish presented serious difficulties to the painter. He has shown only the four phases which are most distinct: the palest with four or five evenly placed black spots below dorsal, the darkest with similar spots of white instead of black, the red with pale blotches and the dark with white blotches. While all of these may often be seen as shown on plate 10, they are varied at times until they intergrade. Occasionally the black dots flash out in both red and the dark blotched phases. The white blotchings at times unite into vertical bands on the body and horizontal bands on the head. The fish can turn so dark that the numerous brownish dots, more or less persistant in the usual colorations, practically disappear.

Range—Florida and Bermuda to Brazil.

Red Hind (*Epinephelus maculosus*). This fish has three principal color phases—red, banded and pale—all of which may be seen at any time in a tank containing numerous specimens. The different colorations appear as the fishes move about, come to rest on the bottom or seek shelter among the rocks. The numerous red dots covering all of the body except the fins persist at all times with little change. In the red phase the ground color of the body reddens and all fins except the pectoral and spinous dorsal become very dark. The ground color is less red when the fish assumes the heavy dark bands, while the dark fins become lighter. (See photograph, page 347.) In the pale phase the red ground color and the dark cross bands disappear, while the fins lose nearly all color except on their margins. Between these principal colorations there are several gradations.

The color changes of the Rock Hind (*Epinephelus adscensionis*)

come quickly and are hard to follow. The artist has not caught them in their most contrasting aspects. Like the red hind it usually stays among the rock-work of the tank. Its frequent changes in position are always accompanied with changes in color and pattern. The red dots which cover the body and most of the fins remain unchanged at all times. Numerous small white spots on the body may instantly give way to large dark blotches, or the fish may assume wide pale cross bands.

The rock hind is an excellent food fish, reaching a length of about eighteen inches. It is found in southern Florida and throughout the West Indies.

Blue-striped Grunt (*Haemulon sciurus*). This species when moving about undisturbed is of uniformly pale golden color, with numerous longitudinal stripes of blue. Under temporary excitement, as when being fed, the dorsal and caudal fins turn black. If alarmed, a few heavy cross bands appear. These may be on the upper part of the body, as shown on plate 13, or lower as in the photograph, page 348.

A valuable food fish ranging from Bermuda and Florida southward to Brazil.

The Gray Grunt (*Haemulon plumieri*) is usually gray, as shown in the lower figures of plate 14. At times it becomes dark brown. If alarmed it attempts to hide, when the body becomes mottled gray and brown except beneath.

Most of the species of grunts have the habit of pushing against each other with their snouts in play, when their red mouths are opened widely.

This is one of the most important food fishes among the numerous species of grunts found along our south Atlantic coast. It does not usually exceed a foot in length.

The Grass Porgy (*Calamus arctifrons*) varies its appearance rapidly when under excitement, the changes ranging from a pale unmarked phase to one not unlike that of the sheepshead, with about the same number of heavy black cross bands. Between these extremes we often see a fish with the cross bands broken apart into evenly placed dark blotches, usually four to the row

(see photograph on page 348), or a still darker coloration in which the bands and blotches tend to fuse together. When placed in the small photographic tank the frightened fish often becomes darker than any shown on plate 15 with minute white dots scattered over most of the body.

Range—Coasts of south Atlantic and Gulf states.

The Glass Eye (*Priacanthus arenatus*) has color cells well stored with vermillion pigments but the rich color is under perfect control and may be restrained to produce mottled or banded effects or actually reduced until the fish is almost white. When the brilliant color is displayed to its greatest extent even the white of the large and conspicuous eye is suffused. All of the colorations shown here may occasionally be seen among the fishes at one time.

This species is probably nocturnal in its habits as its very large eyes seem to indicate. Specimens in captivity are disposed to seek the darker or shaded parts of the tank during the day.

The Glass Eye belongs to the West Indies region, occasionally wandering northward, possibly with the aid of the Gulf Stream, to Massachusetts in summer. The specimens in the Aquarium are from Florida. It is a food fish reaching a length of a little more than a foot.

The Sergeant Major (*Abudefduf saxatilis*) wears five vertical black bands, the body color usually being yellow, but this often gives way to bright silvery between the black bands. Both of the lighter colors are lost at times in a general darkening of head, body and fins. A very dark phase is often assumed, when the bands disappear entirely and the fish is uniformly black. The artist failed to show this coloration.

This fish inhabits both coasts of tropical America. Its range in the Atlantic is from Florida and Bermuda to South America. It is usually to be seen in schools in the vicinity of wharves.

Brown Parrot-fish (*Pseudoscarus guacamia*). This is the largest and hardiest of the parrot fishes. The paler and the more colorful phases are shown in the upper figures of plate 18. In both of these the green color of the large scales persists with varying intensity, but disappears in the heavily blotched phase shown

below. The fish when hiding in the rock-work of the tank may assume a still darker coloration than that seen in the lower figure and if frightened is certain to do so. All the changes are made quickly as the fishes move about the tank. We have shot specimens two feet in length with the rifle, on the shallow reefs at Swan Island in the Caribbean Sea, that had the reddish brown color which gives this species its name. This coloration is seldom seen in the smaller specimens in the Aquarium. The brown parrot-fish is found from Bermuda and southern Florida to South America.

The Red Parrot-fish (*Sparisoma abildgaardi*) is one of the most interesting among the species subject to sudden changes in color. In the brightest phase (figure at upper right in plate 19) there is a nearly uniform red on the under surface and lower fins. The sides and upper surface turn dark. In the first, third and fifth rows of scales, each third, fourth or fifth scale in the row turns pure white, giving the fish about sixteen regularly distributed white spots, while the dorsal and caudal fins become pink. In another change the head, dorsal and tail become pale, while white spots appear on the second row of scales and tend to disappear on the fifth. In this phase the head may become yellowish (figure at lower left).

Between these colorations are two variations, pale with little color (upper left) and half-spotted (lower right).

In still another phase there is a pure white band along the side from head to tail which was not observed by the artist. The palest and the darkest phases are shown in the photographs on page 349. The Red Parrot is found from Florida and Bermuda southward to Brazil.

The color changes of the Blue Parrot-fish (*Scarus caeruleus*) are so varied that they range from a greenish blue with the upper half of the body quite dark, to a paleness in which the coloration is more suggestive of light green than blue. Between these the ever changing fishes display shades and patterns difficult to describe. At times the darkness of the upper parts is broken by three or four light cross-bands, or the fish may become a uniform greenish blue. In the reproduction of plate 20 the generally bluish coloration of this fish was unfortunately lost in a greenish tinge.

Range—West Indies northward to Bermuda and Florida.

Two striking phases of coloration are assumed by the Blue Tang (*Teuthis caeruleus*), one a dark blue, the other a creamy white. The blue phase is the one usually seen, since it is assumed whenever the fish is in the least disturbed by visitors passing the tank and this lasts all day long. The other phase is seldom seen until evening when the fish may settle down toward the white sand bottom and take on a ghostly whiteness, the blue color remaining only as a narrow border on the fins. Any disturbance instantly brings back the blue color. Sometimes under temporary excitement the fish displays three or four vertical pale bands across the upper half of the body, as shown in the middle figure of plate 21. The intensely blue coloration which the blue tang frequently assumes was not observed by the artist when this species was painted.

Range—Florida and Bermuda to Brazil.

The Surgeon-Fish (*Teuthis hepatus*) gets its name from the sharp-edged, erectile spines which occupy sockets on each side of the tail. With these innocent-looking lancets turned out at sharp angles it can inflict serious wounds. We have had a finger cut to the bone as neatly as if slit with a knife. The fish changes color with great frequency; from light brown with numerous cross bands it turns a dark brown with cross bands scarcely showing, or becomes quite pale except for momentary tinges of pale greenish blue.

This fish lives well in captivity. Although largely herbivorous, the Aquarium has kept specimens as long as five years on a fish and clam diet varied occasionally with seaweed. It is used for food and reaches a length of about a foot. Its distribution is from Florida and Bermuda southward to Brazil.

We are scarcely prepared to discover changeable color cells in that hard-shelled tortoise of the sea, the trunk-fish, so different from ordinary scaled fishes, but it has the capacity to change its appearance, although its chromatophores contain no pigments producing showy colors. The buffalo trunk-fish (*Lactophrys trigonus*) changes from black to white or to a mottled condition varied with minute white spots. (See also photograph on page 350.) In this species all changes in color are made slowly.

Range—West Indies, Florida and Bermuda, occasionally northward to Massachusetts.

The Cowfish (*Lactophrys tricornis*), like the other members of the trunkfish family, is encased in a hard tortoise-like shell, absolutely inflexible but perforated where the lips, eyes, fins and tail protrude. Its name is naturally suggested by the pair of horn-like spines on the head. It has a strong tendency to masquerade in different guises, its magical color cells responding to the impulse for a change in appearance. Pure white perhaps at first, it may later be found in three darker costumes, each decorated with reticulations of blue.

The cowfish is common throughout the West Indies and is found northward as far as the Carolinas. It is rather slow in movement, the three-angled body being propelled by the dorsal and anal fins. The tail is ordinarily used as a rudder but is brought into rapid play when the fish is disturbed. Although it will live an hour or two out of water it does not survive in captivity longer than two years.

The picture of the Queen-Trigger-fish (*Balistes vetula*) shows four color phases of this marine chameleon. The brightest and the lightest shown above are both normal: the dull color of the fish shown in the middle at the left is assumed when resting and also in case of fright; the fourth phase, at the bottom, indicates distress when the flow of water in the tank is cut off.

Range—West Indies, occasionally northward to Massachusetts.

File-fishes newly arrived at the Aquarium are always dark colored—usually more uniformly dark than the one shown in the center of plate 26. The pale phases seldom appear until several days later when they are assumed and sometimes retained indefinitely. Body and fins alike may take on a milky whiteness. The color changes are always made slowly, except when one of the white fishes is captured in a dip net. It then changes quickly, first to a mottled condition and then to the very dark phase. The file-fish (*Monacanthus hispidus*) is of small size, never exceeding ten inches in length. It has a wide distribution, being found from Massachusetts southward to Brazil. It is often taken in lower New York Bay in summer.

A fish that plays the harlequin so frequently that it can be depended upon to perform color tricks "before company" at almost any time is the hog-fish (*Lachnolaimus maximus*). When moving about the tank it has a pale brownish coloration, which gives place instantly to a heavily mottled phase when it comes to rest. (See photograph (top) page 351.) The pale coloration is at times varied to a marked degree when the entire front of the head becomes bright reddish-brown, while more or less blue appears on the tail. Any disturbance of the fish in the pale condition results immediately in the mottled guise. The hog-fish is lively and its color changes are all the more noticeable by reason of its size, large specimens weighing as much as twenty pounds. Its distribution is from Florida and Bermuda southward throughout the West Indies.

FIGURES FROM PHOTOGRAPHS

Fig.	310	Bermuda Chub (*Kyphosus sectatrix*).
"	311	Red-mouthed Grunt (*Haemulon flavolineatum*) Red-mouthed Grunt (*Haemulon flavolineatum*)
"	312	Nassau Grouper (*Epinephelus striatus*)
"	313	Black Grouper (*Mycteroperca bonaci*)
"	314	Yellow-finned Grouper (*Mycteroperca venenosa*)
"	315	Coney (*Bodianus fulvus*)
"	316	Red Hind (*Epinephelus maculosus*)
"	317	Blue-striped Grunt (*Haemulon sciurus*)
"	318	Grass Porgy (*Calamus arctifrons*)
"	319	Red Parrot-fish (*Sparisoma abildgaardi*) Red Parrot-fish (*Sparisoma abildgaardi*)
"	320	Buffalo Trunk-fish (*Lactophrys trigonus*)
"	321	Hog Fish (*Lachnolaimus maximus*) Hog Fish (*Lachnolaimus maximus*)

COLOR PLATES

Plate	1	Shark-sucker	Olive Earle
"	2	Spade Fish	Hashime Murayama
"	3	Nassau Grouper	Herbert B. Tschudy
"	4	Red Grouper	Herbert B. Tschudy
"	5	Black Grouper	Olive Earle
"	6	Yellow-finned Grouper	Herbert B. Tschudy
"	7	Yellow-finned Grouper (var.)	Herbert B. Tschudy
"	8	Giant Grouper	Hashime Murayama
"	9	Coney	Olive Earle
"	10	Craysby	Herbert B. Tschudy
"	11	Red Hind	Olive Earle
"	12	Rock Hind	Olive Earle
"	13	Blue-striped Grunt	Olive Earle
"	14	Gray Grunt	Hashime Murayama
"	15	Grass Porgy	Hashime Murayama
"	16	Glass Eye	Hashime Murayama
"	17	Sergeant Major	Hashime Murayama
"	18	Brown Parrot-fish	Olive Earle
"	19	Red Parrot-fish	Hashime Murayama
"	20	Blue Parrot-fish	Hashime Murayama
"	21	Blue Tang	Hashime Murayama
"	22	Surgeon Fish	Herbert B. Tschudy
"	23	Buffalo Trunk-fish	Hashime Murayama
"	24	Cowfish	Hashime Murayama
"	25	Queen Trigger-fish	Charles R. Knight
"	26	File-fish	Hashime Murayama
"	27	Hog Fish	Herbert B. Tschudy

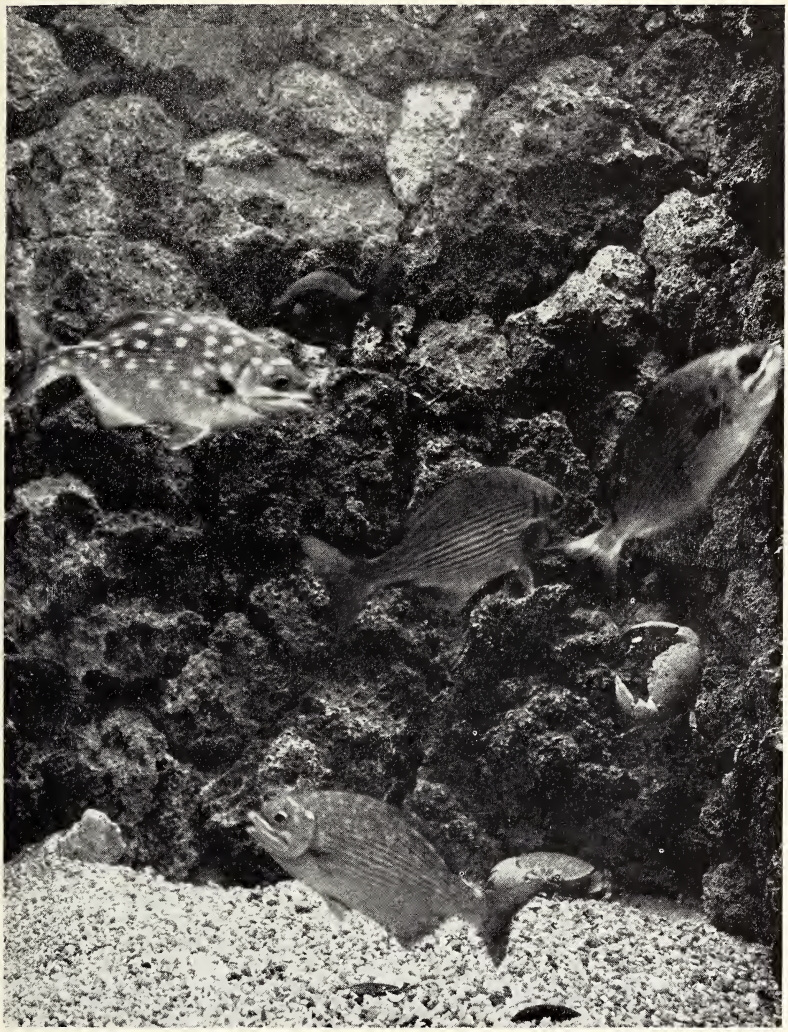

Fig. 310. Bermuda Chub (*Kyphosus sectatrix*). Striped and spotted phases.

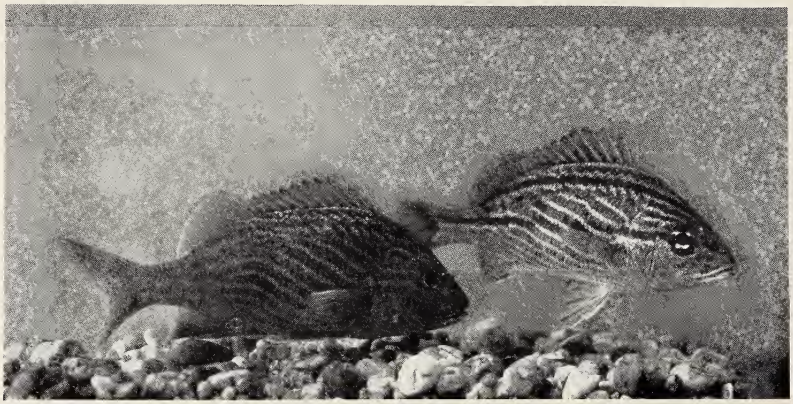

Fig. 311. Red-mouthed Grunt (*Haemulon flavolineatum*). Striped and dark phases.

Fig. 311. Red-mouthed Grunt (*Haemulon flavolineatum*). Usual coloration.

Fig. 312. Nassau Grouper (*Epinephelus striatus*). Heavily banded phase.

Fig. 313. Black Grouper (*Mycteroperca bonaci*). Heavily blotched phase.

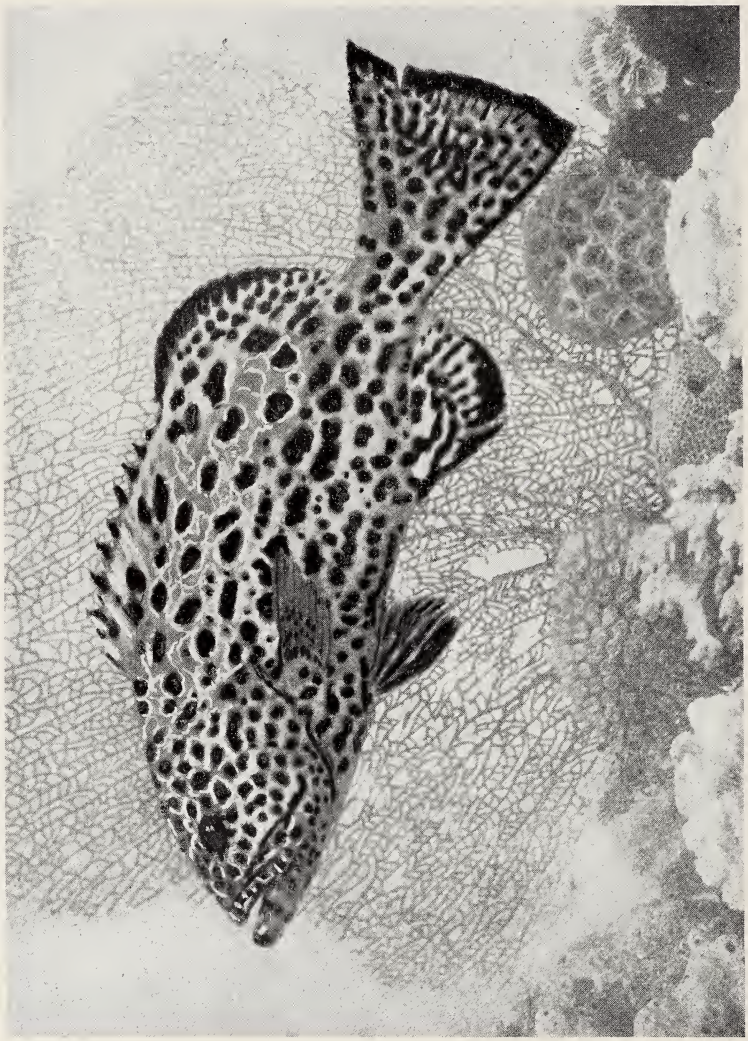

Fig. 314. Yellow-finned Grouper (*Mycteroperca venenosa*). Shallow water variety known as "Princess Rockfish."

Fig. 315. Coney (*Bodianus fulvus*). Darkest phase.

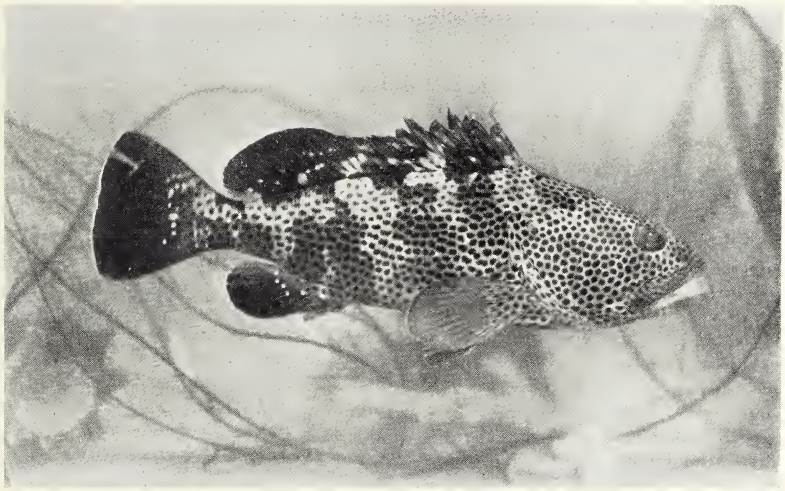

Fig. 316. Red hind (*Epinephelus maculosus*). Heavily-blotched phase.

The blotched appearance as shown in the photograph is often seen when the fish is at rest. It may be produced among all the specimens instantly by frightening them.

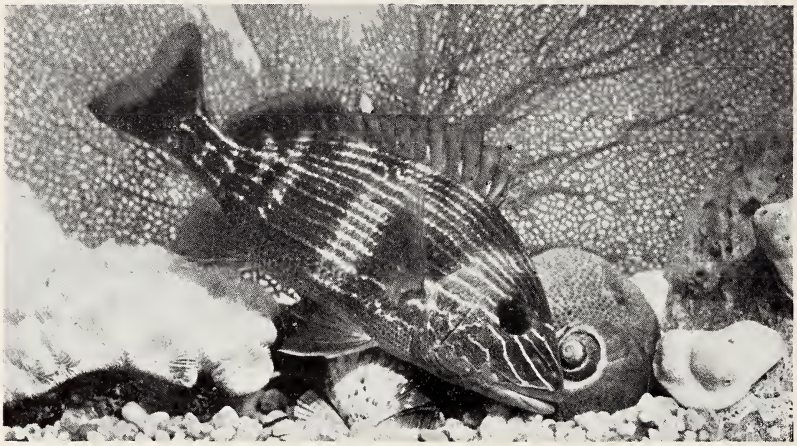

Fig. 317. Blue-striped Grunt (*Haemulon sciurus*). Blotched phase.

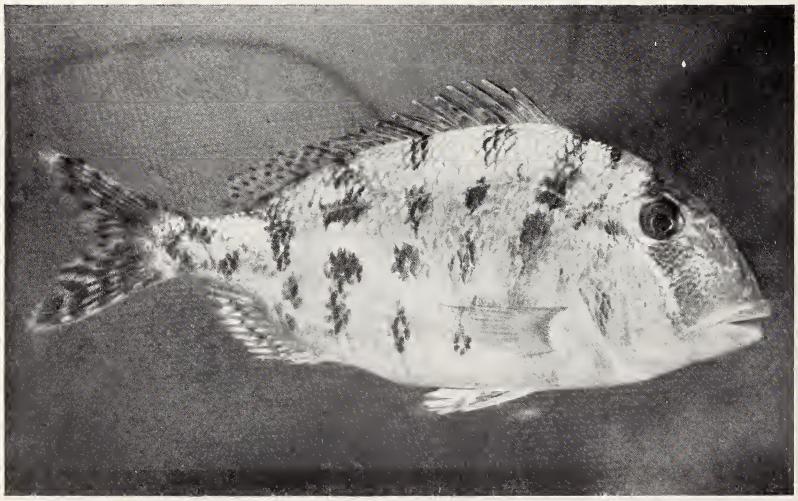

Fig. 318. Grass Porgy (*Calamus arctifrons*). Light spotted phase.

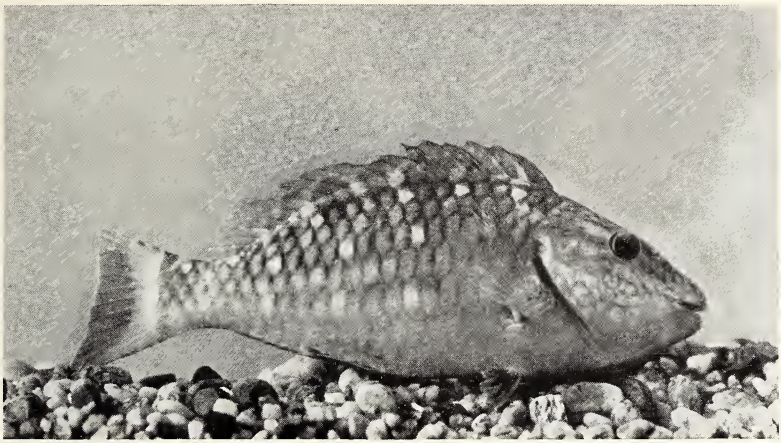

Fig. 319. Red Parrot-fish (*Sparisoma abildgaardi*). Light spotted phase.

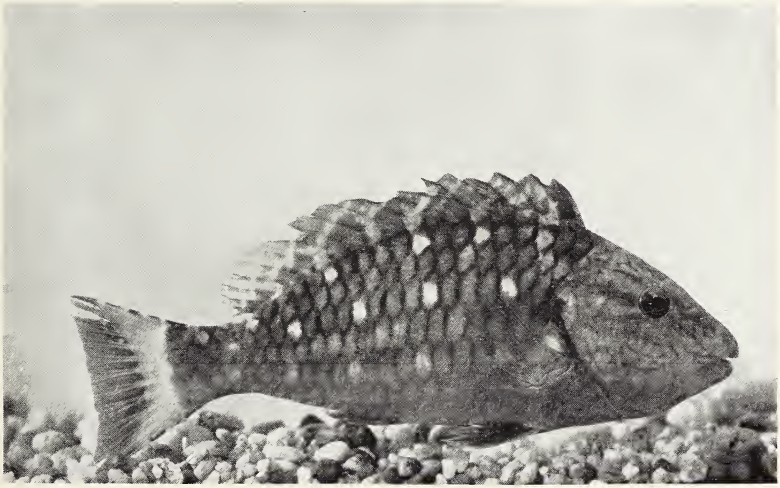

Fig. 319 Red Parrot-fish (*Sparisoma abildgaardi*). Dark spotted phase.

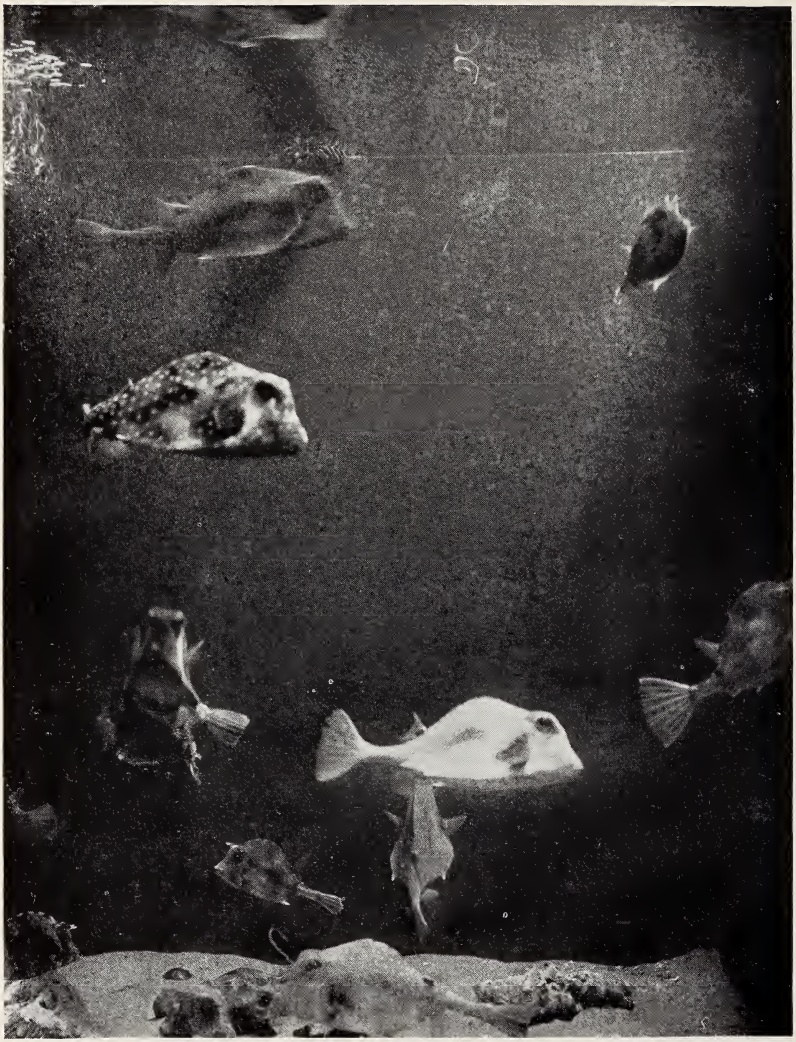

Fig. 320. Buffalo Trunk-fish (*Lactophrys trigonus*). Three phases.

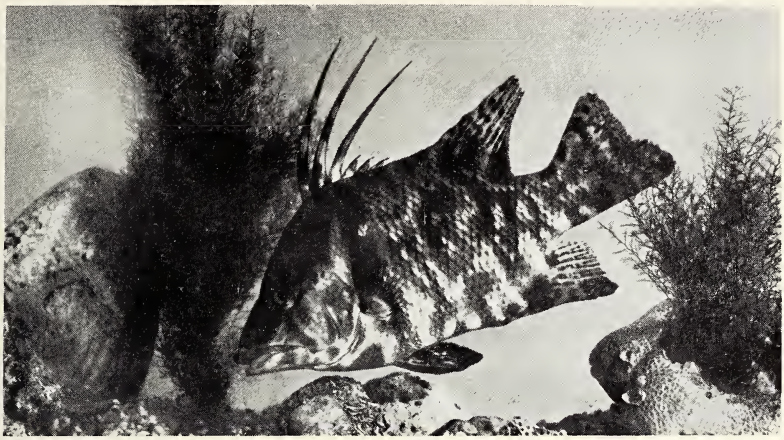

Fig. 321. Hog Fish (*Lachnolaimus maximus*). Heavily blotched phase.

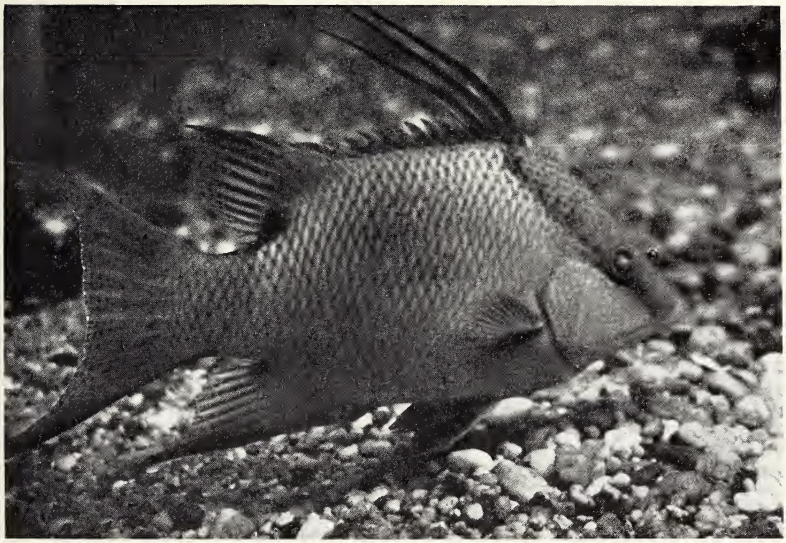

Fig. 321. Hog Fish (*Lachnolaimus maximus*). Red-fronted phase.

Plate 1. Shark-Sucker (*Echeneis naucrates*). Three color changes.

Plate 2. Spade-fish (*Chaetodipterus faber*). Three color changes.

Plate 3. Nassau Grouper (*Epinephelus striatus*). Seven color changes.

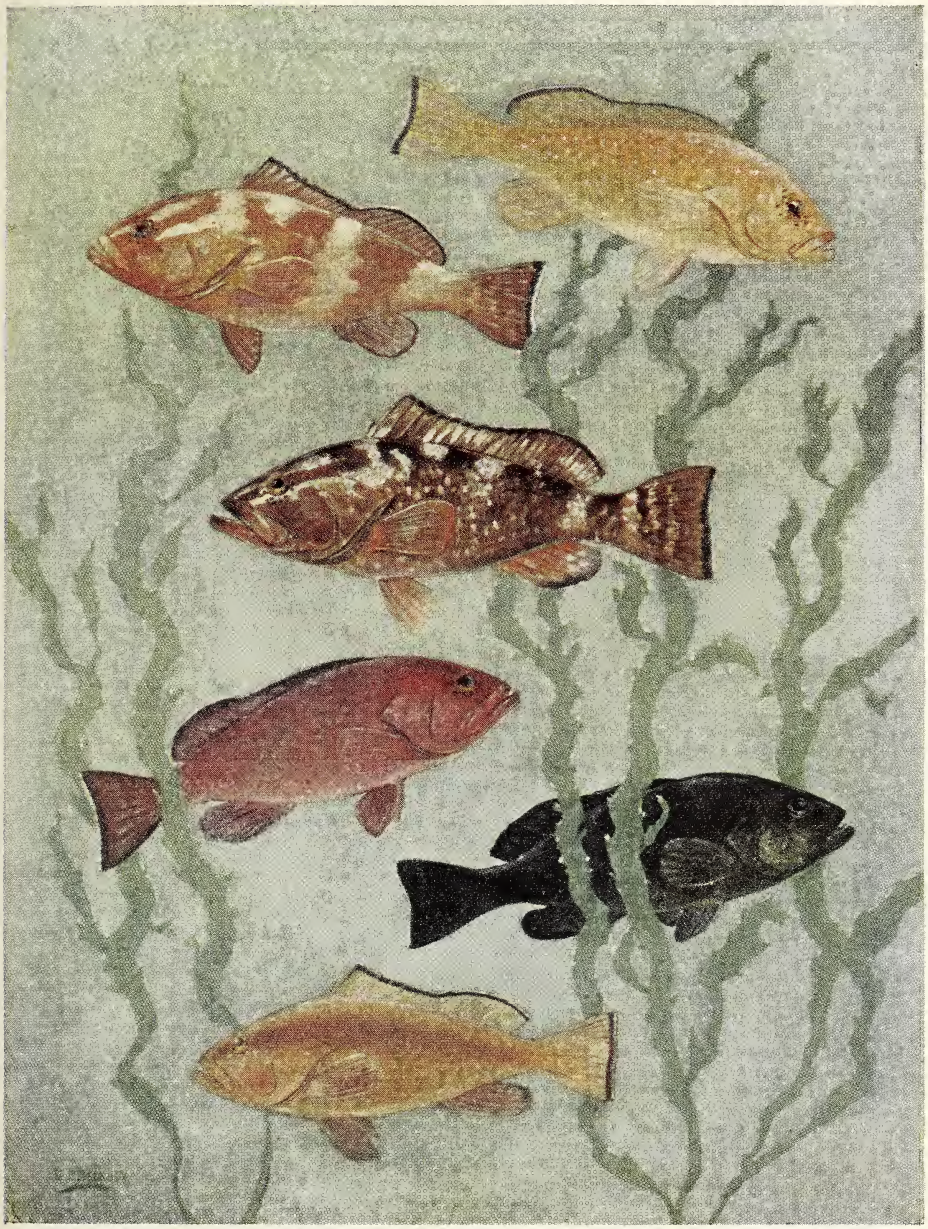

Plate 4. Red Grouper (*Epinephelus morio*). Six color changes.

Plate 5. Black Grouper (*Mycteroperca bonaci*). Four color changes.
See also photograph—p. 345

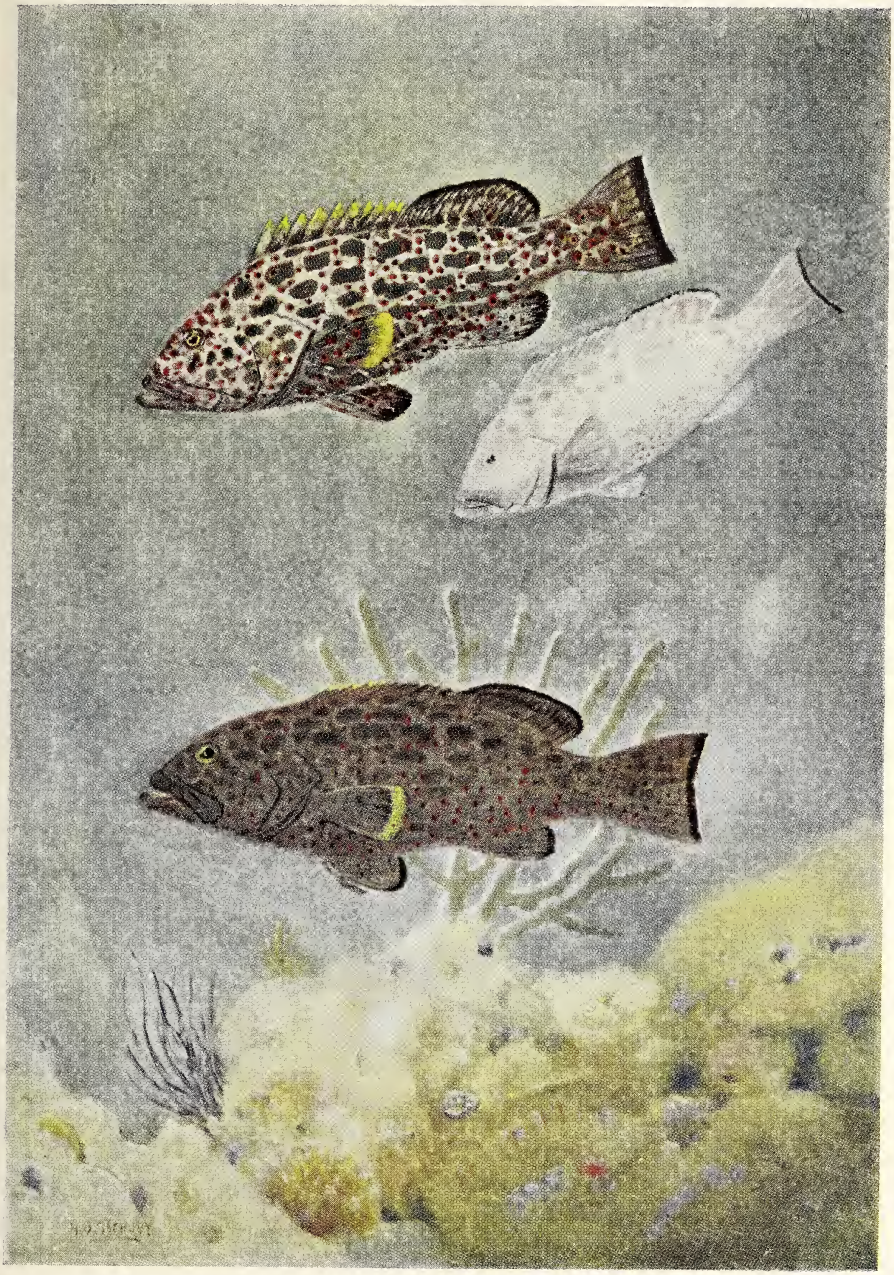

Plate 6. Yellow-finned Grouper (*Mycteroperca venenosa*). Three color changes. Deep water variety. See also plate VII, shallow water variety.

Plate 7. Yellow-finned Grouper or "Princess Rockfish." Three color changes (*Mycteroperca venenosa*). Shallow water variety. This plate supplemental to plate VI.

Plate 8. Giant Grouper (*Promicrops itiara*). Three color changes.

Plate 9. Coney (*Bodianus fulvus*). Five color phases.
See also photograph—p. 347

Plate 10. Graysby (*Petrometopon cruentatus*). Four color changes.

Plate 11. Red Hind (*Epinephelus maculosus*). Three color changes.

Plate 12. Rock Hind (*Epinephelus adscencionis*). Four color changes.

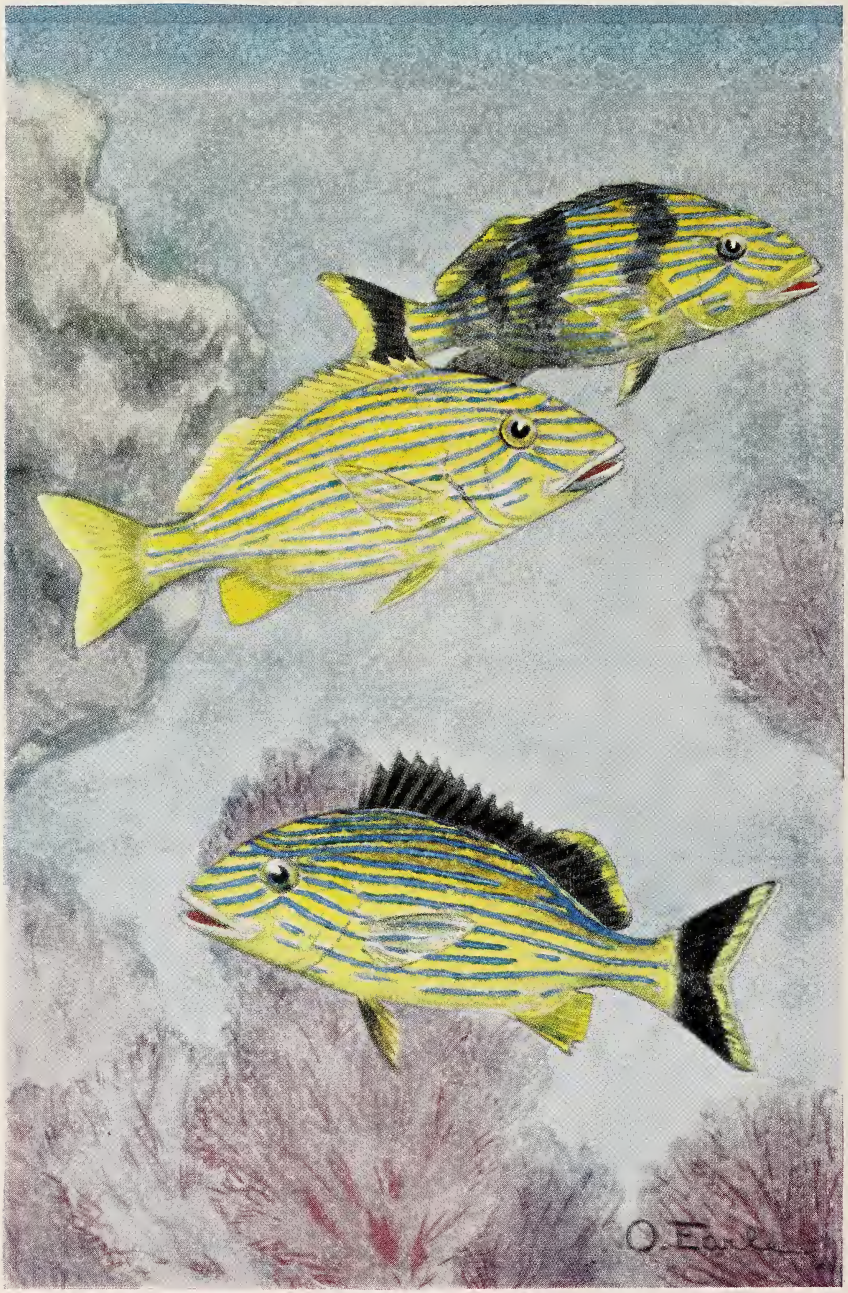

Plate 13. Blue-striped Grunt (*Haemulon sciurus*). Three color changes.

Plate 14. Gray Grunt (*Haemulon plumieri*). Three color changes.

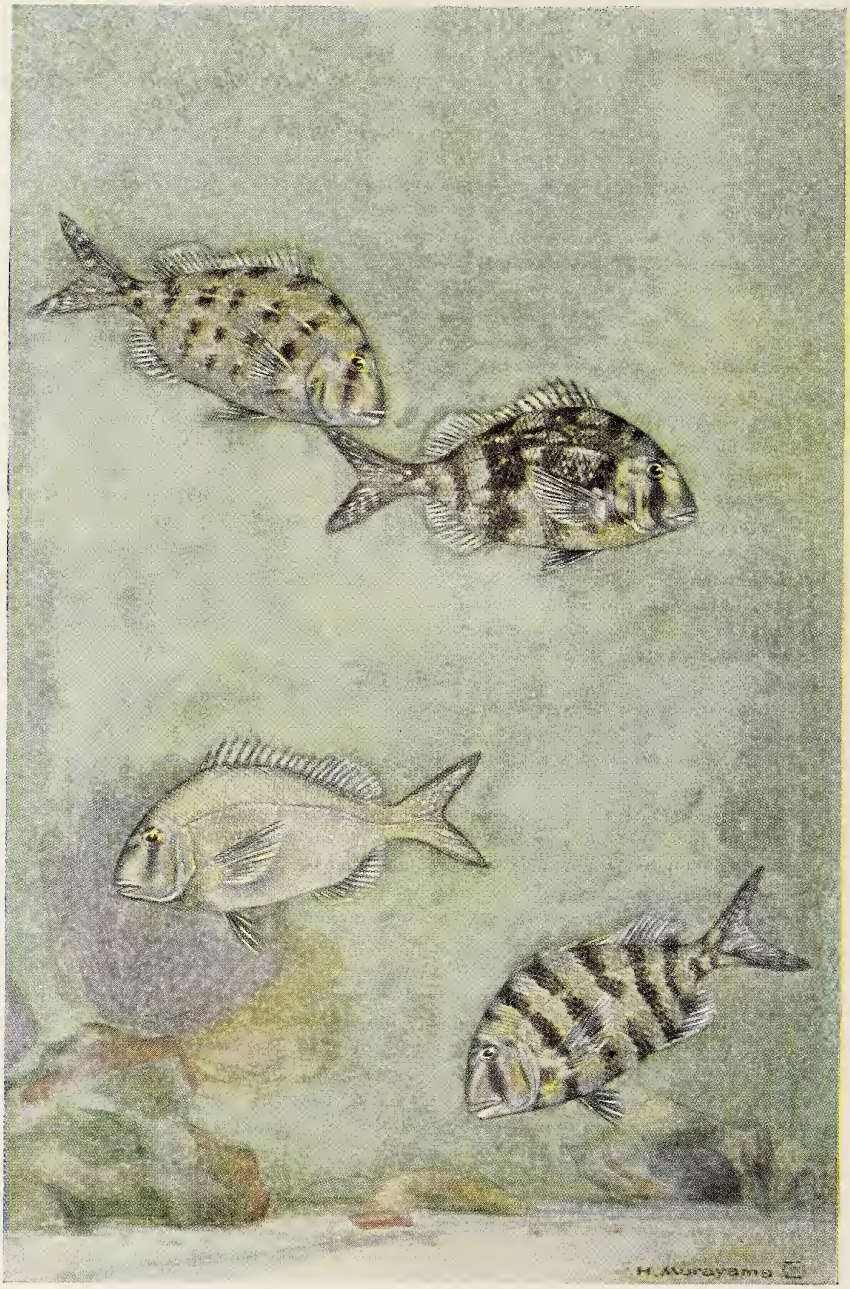

Plate 15. Grass Porgy (*Calamus arctifrons*). Four color changes.

Plate 16. Glass Eye (*Priacanthus arenatus*). Four color changes.

Plate 17. Sergeant Major (*Abudefduf saxatilis*). Three color changes.

Plate 18 Brown Parrot-fish (*Pseudoscarus guacamia*). Three color changes.

Plate 19. Red Parrot-fish (*Sparisoma abildgaardi*). Four color changes.
See also photographs on p. 349

Plate 20. Blue Parrot-fish (*Scarus caeruleus*). Four color changes.

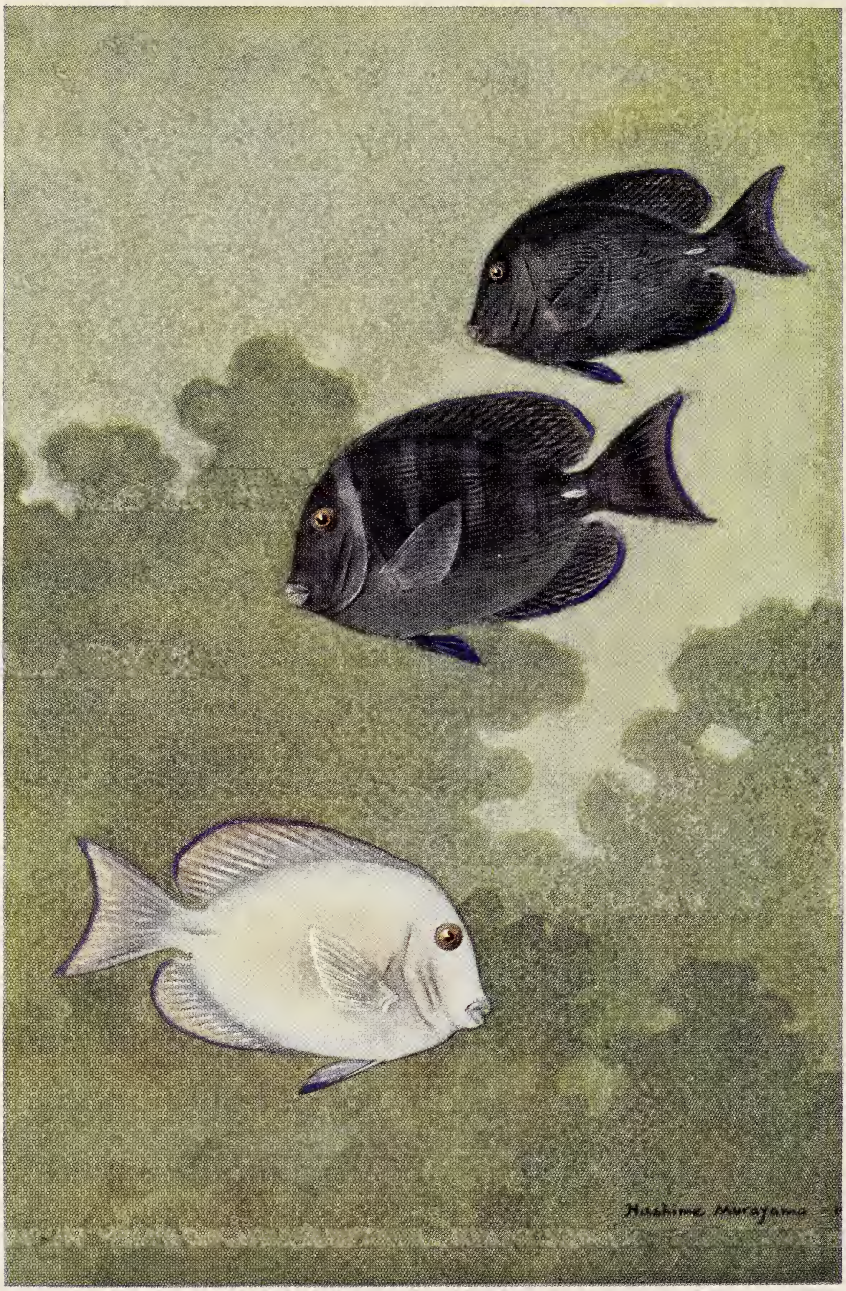

Plate 21. Blue Tang (*Teuthis caeruleus*). Three color changes.

Plate 22. Surgeon-fish (*Teuthis hepatus*). Three color changes.

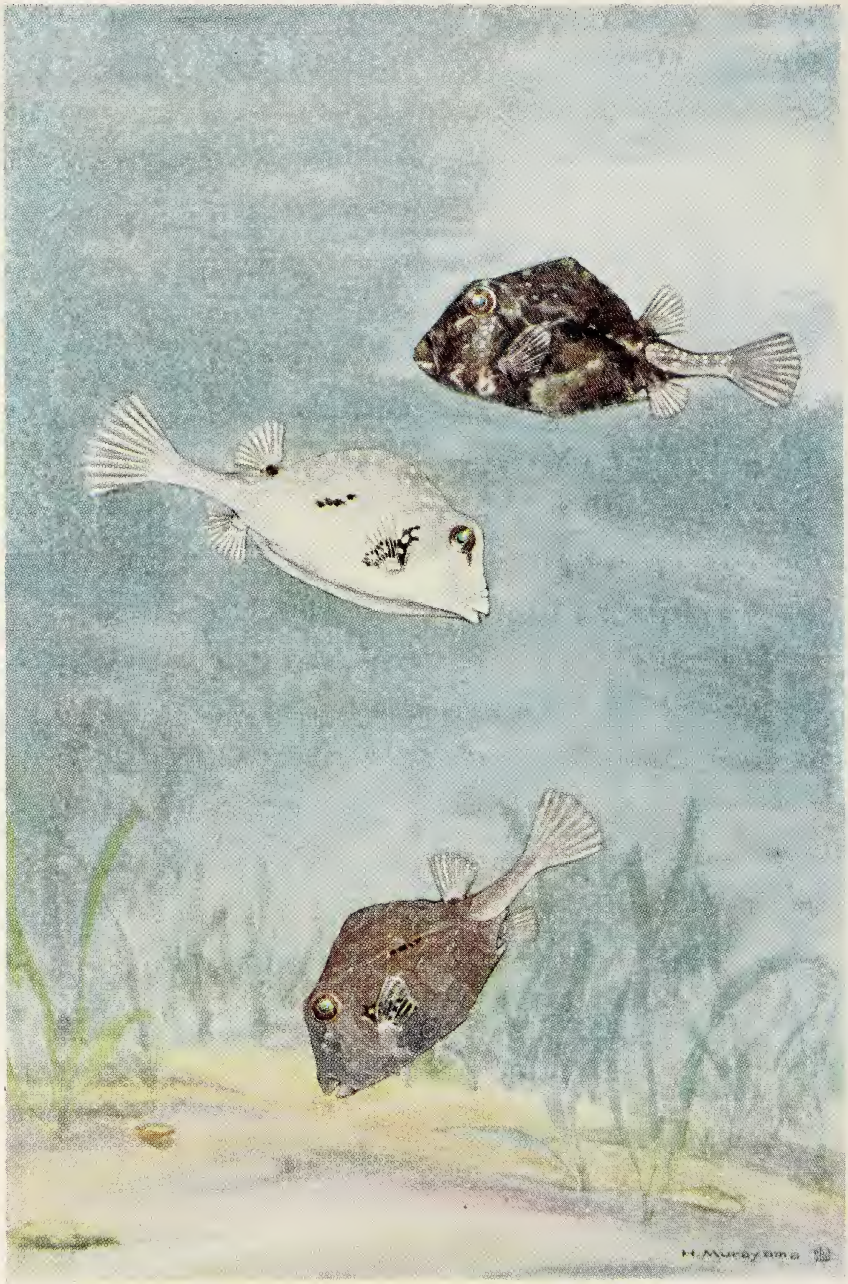

Plate 23. Buffalo Trunk-fish (*Lactophrys trigonus*). Three color changes.

Plate 24. Cowfish (*Lactophrys tricornis*). Four color changes.

Plate 25. Queen Trigger-fish (*Balistes vetula*). Four color changes.

Plate 26. File-fish (*Monacanthus hispidus*). Three color changes.

Plate 27. Hogfish (*Lachnolaimus maximus*). Three color changes.
See also photographs—p. 351

New York Zoological Society

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ZOOLOGICA

SCIENTIFIC CONTRIBUTIONS OF THE NEW YORK ZOOLOGICAL SOCIETY

VOLUME IX. NUMBER 10

THE BLUE-SPOTTED SUNFISH

A CONTRIBUTION TO THE LIFE HISTORY AND HABITS OF *ENNEACANTHUS* WITH NOTES ON OTHER LEPOMINAE

By C. M. Breder, Jr.
New York Aquarium

AND

A. C. Redmond
Hamilton College

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Introduction

(Figs. 322–331 incl.)

Considering how well known most of the lesser sunfishes are it is surprising that little of a detailed nature concerning their life histories has found its way into scientific literature. Therefore, when the opportunity arose to make some connected field observations, chiefly on *Enneacanthus* advantage was taken of it. The field work was carried on at the Wyanokie Zoological Station, located at Haskell, New Jersey about thirty miles north-west of New York City. Most of the actual work of collecting and the making of field observations was done during 1928 by Redmond.

Specific Status

Although it is not the purpose of the present paper to consider the relationships of *Enneacanthus gloriosus* (Holbrook) and *Enneacanthus obesus* (Baird) if indeed these two species are distinct, to prevent confusion it is obviously desirable to clearly define the species to which this study refers.

From an examination of the rather large series both living and preserved, which we handled, it became evident that we were concerned with a single species of a rather variable nature, part of which appeared to be individual, part sexual and part age. On a basis of this material alone references to the literature gave us reason to believe that the two species were synonymous as Palmer & Wright 1920 suggest. However, Dr. C. L. Hubbs, while at the Museum of Comparative Zoology, kindly compared samples of our material with specimens there and doubts that they

are the same. Without going into the matter further it is clear that our material is referable to *Enneacanthus gloriosus* (Holbrook) whether the two are eventually synonymized or not.

The Environment

At first glance, the body of water in which the present studies were made appears to be rather different than a closer inspection proves it to be. It is a small stream, possibly averaging about eight feet in width, known as Post Brook, that for long stretches gurgles over and under great broken chunks of basaltic rock through fairly dense woodland (Fig. 322*a*). Here and there are quiet pools of various sizes up to about 200 by 500 feet. In places there are clearings that allow meadow land to reach to the waters edge. In such places the banks are lined with alders, birches, willow, choke cherries and various other shrubs (Fig. 322*b*). The bottom is usually either rocky or sandy but in some places there is a considerable amount of alluvial silt accumulated. The current and height of water is exceedingly variable. Pickerel weed, arrow-head, *Fontinalis*, *Elodea* and similar aquatic plants grow for the most part rather sparsely in the quiet pools when these occur in clearings. Throughout the more rapid and usually wooded portions there is little but a sparse growth of algae.

In brief, the stream would be designated as a typical trout stream and such it was in not very remote historic times. Today, however, not only are trout absent therefrom but they are replaced practically entirely by the typical pond fishes. Probably only one of its species, *Boleosoma olmstedi*, which is rare, could be considered as a stream preferring species. A list is given (Table 1) of three years of more or less systematic collecting in this stream and we believe it to be complete for the length covered.

This change in the fish fauna of Post Brook is doubtless associated with the change in environmental conditions brought about by the building of artificial lakes. One immediately above the Zoological Station, Lake Iosco, of some sixty-five acres, allows of considerable warming of the water entering the stream below it. Also this lake purges or "blooms" in the heat of summer to such an extent that the brook itself becomes a thick suspension of *Anabena* and related organisms. The oxygen content drops to a low concentration at times, especially when the cycle of these organisms

TABLE I

Fishes inhabiting Post Brook

1. *Ameiurus nebulosus* (Le Sueur)
2. *Catostomus commersonii* (Lacépède)
3. *Erimyzon sucetia oblongus* (Mitchill)
4. *Abramis crysoleucas* (Mitchill)
5. *Notropis bifrenatus* (Cope)
6. *Anguilla rostrata* (Le Sueur)
7. *Umbra pygmaea* (De Kay)
8. *Esox reticulatus* (Le Sueur)
9. *Pomoxis sparoides* (Lacépède)
10. *Acantharchus pomotis* (Baird)
11. *Ambloplites rupestris* (Rafinesque)
12. *Enneacanthus gloriosus* (Holbrook)
13. *Lepomis auritus* (Linnaeus)
14. *Eupomotis gibbosus* (Linnaeus)
15. *Micropterus salmoides* (Lacépède)
16. *Micropterus dolomieu* (Lacépède)
17. *Perca flavescens* (Mitchill)
18. *Boleosoma nigrum olmstedi* (Storer)

is on the wane and they are oxidizing rapidly. The pH values of the stream do not show any marked changes, probably not enough to be inimical to trout. The factors involved that have rendered this stream unfit for trout and similar fishes we believe to be referable indirectly to the raising of the temperature by the construction of artificial lakes, and to the oxygen consuming agency of the organisms which reduce the oxygen concentration at times below that necessary for trouts. See Breder 1927 for further discussion of this interrelation. A graph (Fig. 323) gives such data on temperature et cetera as was gathered during the work.

As was to be expected, these properly pond fishes were concentrated in the quiet pools and the gurgling stretches between were relatively barren of fish life. Most of the work was carried on in a pool just opposite the Haskell Railroad Station. This point also marked our lowest point of study, while the dam retaining Lake Iosco marked our upstream limit. Unless otherwise specified all data refers to this lower pool represented by Fig. 322*b*.

On several occasions systematic collections were made in this pool from which the relative frequency of the various species was calculated. This is given in Table 2. The figures were obtained by dividing the number of individuals of a species by the total number of hauls made. A forty foot seine of ¼″ square mesh was used and in all cases it was operated in a similar manner.

This pool is shored to a considerable extent by cinders from the nearby railroad embankment. This cinder floor runs out into the pond for some distance where it is replaced by the natural rather clayey soil of the region. A variety of vegetation lines the banks

TABLE II. FREQUENCY OF SPECIES

LOWER POOL. JUNE 21

Species	Seine Hauls								Total	Frequency
Micropterus dolomieu	0	1	0						1	.33
Acantharchus pomotis	0	1	0						1	.33
Enneacanthus gloriosus	2	0	0						2	.66
Erimyzon succeta oblongus	3	0	0						3	1.00
Ameiurus nebulosus	3	0	3						6	2.00
Esox reticulatus	0	3	5						8	2.66
Abramis crysoleucas	100	0	12						112	37.00

LOWER POOL. JULY 21

Species	Seine Hauls								Total	Frequency
Catostomus commersonii	0	0	0	0	0	0	1	0	1	.13
Umbra pygmaea	0	0	1	0	1	0	0	0	2	.25
Erimyzon succeta oblongus	0	0	0	1	2	0	0	0	3	.28
Abramis crysoleucas	0	4	1	0	1	0	0	0	6	.75
Mycropterus salmoides	0	3	1	0	1	1	1	0	7	.88
Acantharchus pomotis	1	3	2	2	0	1	4	0	13	1.63
Esox reticulatus	2	0	2	1	5	7	3	2	22	2.76
Enneacanthus gloriosus	4	4	2	4	1	7	11	1	34	4.25
Ameiurus nebulosus	1	0	0	0	1*	1	2	0	5	.62

UPPER POOL. JULY 16

Species	Seine Hauls								Total	Frequency
Catostomus commersonii	1	0	0	0					1	.25
Eupomotis gibbosus	1	0	1	0					2	.50
Erimyzon succeta oblongus	1	0	1	0					2	.50
Ameiurus nebulosus	0	0	3	0					3	.75
Esox reticulatus	2	0	4	1					7	1.75
Abramis crysoleucas	75	10	15	20					120	30.00
Enneacanthus gloriosus	Only 3 specimens all summer									

*Also a school of very young. These would bring the total to 72 + and the frequency to 9.0 +. Note that *Eupomotis gibbosus* was absent from the lower pool on both these dates.

while parts of the pool are fairly choked by submerged aquatics. An indication of the types and locations of the various species is given in Fig. 324. A black muck of decaying vegetation covers the pond bottom in places.

The chief habitat of *Enneacanthus* here was in a fairly dense stand of *Potomogeton epihydrus* about fifteen feet off shore in a depth of three or four feet. This area is indicated in Fig. 324 by the dotted line. Further off shore the pool descended to a considerably greater depth (possibly six feet on the average) and here there was not much shelter of this sort. In this open water *Abramis* disported itself.

The current under the railroad bridge was measured as being ten feet per minute and eight feet per minute at the lower outlet, but there was no appreciable current in the cove that *Enneacanthus* found suitable as a habitat. These figures varied with each local rain storm.

This pool at the beginning of these observations contained large numbers of *Abramis* but these later disappeared, possibly by the inadvertent destruction of their cover. These centered in the more shallow places where there was but a sparse growth of *Potomogeton* just below the railroad bridge.

Food

There is little definite data on the food of *Enneacanthus*. Abbott 1883 reports, "In every case the stomach was empty, but the intestine contained tracheae, eyes, elytra, heads and chitinous parts of small aquatic beetles. These were very numerous, also *Psidium* sp. occasional; several small univalve mollusks; a few Chironomus larvae; a few fragments of insects; many *Cyclops;* a few very small univalve mollusks and a single water mite." This data refers to southern New Jersey.

Hildebrand & Schroeder 1928 record the following from the brackish affluents of Chesapeake Bay. "The food of this fish, according to the contents of thirteen stomachs examined, consists largely of small crustaceans—that is, copepods, amphipods, and isopods. Insects and worms, too, were present in a few stomachs; also fragments of plants."

The following data (Table 3) gives the results of the examination of the stomach contents of a series of specimens from Post Brook.

TABLE III. STOMACH CONTENTS

Enreacanthus gloriosus					Foods						
S. l. mm.	Sex	Condition	Stomach	Intestine	Nemathel-minthes	Gaster-opoda	Daphnia	Ostracod	Cyclops	Asellus	Amphipod
58	M	Mature	....	....	..	..	..	..	..	..	..
57	M	"	....	....	..	..	..	1	..	..	..
56	M	"	....	....	..	..	..	..	..	..	..
55	M	"	....	....	..	..	..	20	..	..	..
53	M	"	....	....	..	..	..	..	..	5	5
53	M	"	Empty	....	..	..	..	..	..	..	..
52	M	"	....	Empty	..	..	..	..	..	..	80
49	F	"	....	....	..	5	+	35	..	..	30
49	F	"	....	....	..	..	..	..	..	..	..
48	F	"	Full	....	..	..	..	..	..	..	25
48	M	"	Empty	....	..	..	..	+	..	15	+
47	F	"	....	....	..	..	2	5	..	..	30
47	F	"	....	....	..	..	..	+	..	..	+
46	M	"	....	....	..	..	..	..	..	..	50
43	F	"	....	....	..	..	..	..	..	..	..
42	F	"	....	....	..	5	..	10	..	..	..
41	M	"	....	....	..	..	..	5	..	15	..
41	M	"	....	....	..	..	..	..	..	..	85
40	M	"	....	....	..	..	..	..	..	..	70
40	M	"	....	....	..	..	+	+	..	+	10
40	M	"	....	....	..	50	..	10	..	..	10
40	M	"	Empty	Half full	..	..	..	+	..	..	..
38	M	Immature	....	....	..	..	..	..	..	..	15
37	F	"	....	....	..	..	+	..	..	..	70
				Average	..	2.4	+	3.4	..	1.5	19
Eupomotis gibbosus											
68	F	Immature	....	....	..	..	..	10	..	40	35
65	M	"	Empty	Empty	..	..	..	..	..	..	..
62	F	"	....	....	..	1	..	70	..	5	..
58	M	"	....	....	..	..	..	..	..	1	1
57	F	"	....	....	..	..	..	80	..	..	5
56	F	"	Empty	....	..	..	..	50	..	..	..
56	F	"	....	....	..	..	..	60	..	..	20
55	F	"	....	....	..	..	..	5	..	..	5
54	M	"	....	....	..	..	..	..	..	..	..
53	F	"	Full	....	..	+	..	15	..	..	25
52	F	"	....	....	2	..	..	15	..	..	35
52	M	"	....	....	..	..	..	+	..	+	25
52	F	"	Empty	....	..	..	..	..	..	..	..
51	F	"	....	....	..	..	..	25	1	..	..
51	M	"	Half full	....	..	..	+	..	..	..	..
50	F	"	....	....	..	..	1	80	..	5	5
50	M	"	....	....	..	..	..	60	..	..	10
45	F	"	....	....	1	..	..	90	..	2	..
43	F	"	....	....	..	..	..	5	..	..	..
43	F	"	....	....	..	..	..	5	..	..	50
42	F	"	....	....	..	..	..	..	..	..	45
41	F	"	....	....	..	..	..	+	..	..	..
41	—	"	....	....	..	..	..	5	..	..	..
38	F	"	....	....	..	..	..	5	..	..	..
38	F	"	Full	Full	..	..	..	..	..	..	..
36	?	"	Full	....	..	..	..	70	..	..	..
33	F?	"	Empty	Full	..	..	..	10	..	..	..
				Average	+	+	+	22.2	+	2	9.2

TABLE III. STOMACH CONTENTS—*Continued*

Foods—*Continued*												Remarks
Odonata	Plecoptera	Corixia	Coleoptera	Diptera	Chironomous	Ant.	Arachnid	Nydrachnida	Anabaena	Potomogeton	Unrecognizable	
..	..	100	..	..	..	..	..	..	..	..	..	About 30 per cent. full.
5	75	..	..	..	..	..	..	..	..	..	19	Triturated animal matter.
90	..	..	..	..	..	..	..	..	..	+	10	Triturated plant matter.
..	..	..	..	..	15	..	..	..	..	..	60	Veg. and animal remains.
40	..	30	..	..	15	..	..	..	..	..	5	Animal remains.
+	..	..	..	..	+	..	..	..	..	..	..	Stomach nearly empty.
..	..	..	..	..	..	..	..	..	+	..	20	Nearly empty.
..	..	..	..	..	10	..	..	..	..	..	20	Animal remains.
80	..	..	..	..	5	..	..	..	..	..	15	Animal remains.
60	..	..	..	..	10	..	..	..	..	..	5	Animal remains.
..	..	..	..	..	+	..	..	..	..	+	85	Animal and plant remains.
30	..	..	..	..	10	..	..	+	..	..	23	Animal remains.
50	..	..	25	..	20	..	..	..	..	..	..	
40	..	..	5	..	+	..	..	..	..	..	5	Animal remains.
..	..	97	..	..	3	..	..	..	..	..	..	Much digested.
..	..	..	..	..	30	..	..	..	..	..	55	Animal remains.
..	..	70	..	..	..	..	..	..	..	..	10	Full.
..	..	..	..	..	..	..	..	..	..	..	15	Animal remains.
10	..	..	..	+	10	..	..	..	..	..	10	Animal remains.
..	..	..	..	..	..	..	..	..	..	..	80	Crustacean remains.
..	..	..	..	..	10	..	..	..	..	..	20	Animal remains.
..	..	90	..	..	..	..	..	..	..	..	8	Animal remains.
..	..	..	..	20	50	..	..	..	..	..	15	Animal remains.
..	..	..	..	..	15	..	..	..	..	..	15	Animal remains.
16	3	16	1	.8	8	..	..	+	+	+	20	
..	..	..	..	..	5	..	..	..	..	..	10	Animal remains.
..	..	..	..	..	..	..	..	..	..	..	..	
..	..	..	..	..	..	..	..	..	..	..	24	Veg. and animal remains.
..	..	6	..	..	30	..	..	..	..	..	8	Mostly crustacean remains.
..	..	..	..	..	5	..	..	..	..	..	10	Probably ostracods.
..	..	..	..	..	1	..	..	..	..	..	50	Veg. remains.
..	..	..	..	..	5	..	..	..	..	..	15	Veg. remains.
..	..	..	..	..	10	..	60	..	..	..	5	Veg. and crustacean remains.
..	..	..	..	..	100	..	..	..	..	..	..	3 Chironomids only.
..	..	..	..	..	60	..	..	..	..	..	..	
3	..	..	..	..	40	..	..	..	..	..	5	Veg. and
..	..	..	..	10	..	15	..	..	..	..	50	Animal remains.
..	..	..	..	..	100	..	..	..	..	..	..	2 Chironomids in intestine only.
..	..	..	..	5	55	..	..	..	..	..	14	Veg. remains.
..	..	..	..	..	+							
..	..	..	..	..	2	..	..	..	..	..	7	Probably ostracods.
..	..	..	..	..	5	..	..	..	..	..	25	
..	..	..	..	..	+	..	..	..	..	..	7	Probably ostracods.
..	..	..	..	..	..	..	..	..	..	..	95	Too far digested to identify.
..	..	..	..	..	10	..	..	..	..	..	40	Too far digested to identify.
..	..	..	..	..	45	..	..	..	..	..	5	Animal remains.
..	..	..	..	..	+	..	..	..	..	..	80	Too far digested to identify.
..	..	..	..	..	40	..	..	..	..	..	55	Too far digested to identify.
..	..	..	..	..	80	..	..	..	..	..	15	Unidentifiable algae.
..	..	..	..	..	100							
..	..	..	..	..	20	..	..	..	..	..	10	Too far digested to identify.
..	..	..	..	..	80	..	..	..	..	..	10	Veg. and animal remains.
+	..	2.2	..	1	35	1	1	..	..	..	22	

It is evident from the nature of the bulk of this food that *Enneacanthus* must spend considerable time in picking around the dense foliage of its chosen habitat. Although in an aquarium they will dart out from cover to take almost any small organism offered them they quickly return. Also as net hauls in open water, not dragged through such weeds, were usually barren of these fishes we infer that they never normally wander very far from such shelter. Other observations in a thickly planted aquarium showed that they would cruise about amid the weeds until they saw some motion on the part of a small organism clinging to the plants, and then rush up and snatch it. These weeds in the pond were usually lightly covered with fine silt brought down by rains which doubtlessly accounts for such material and fragments of plants found in the stomachs. Very likely such material was accidentally ingested along with the other foods, proper. At times in the aquarium they showed no aversion to feeding at the surface. This was probably a more or less acquired habit for at first they would not rise but later did so freely when accustomed to having food always introduced from above.

Compared with *Eupomotis gibbosus* of similar size their feeding habits seem to be somewhat different. A collection of twenty-five each of similar size made on September 10 showed *Enneacanthus* to be the more voracious of the two. It was also found that they "masticated" their food to a much finer degree than did *Eupomotis*. In all but six *Enneacanthus* the stomachs were found to be empty and material could be found only in the intestine, already well digested, whereas in *Eupomotis* both stomach and intestine usually contained food. As this collection was made about three days after a heavy rain and subsequent high water it is possible that the *Enneacanthus* had gorged themselves on organisms washed out by the downpour. This would suggest some difference in reaction to swollen streams by the two species. It is also related to the relative speed of digestion, efficiency of peristolsis *et cetera* in the two.

Sexual Differences

The mature males average a little deeper bodied and longer finned than the others. Their usual ground color is a very pale olive and there is a bright greenish spot in the center of nearly each scale. These spots along the sides form a series of dotted lines.

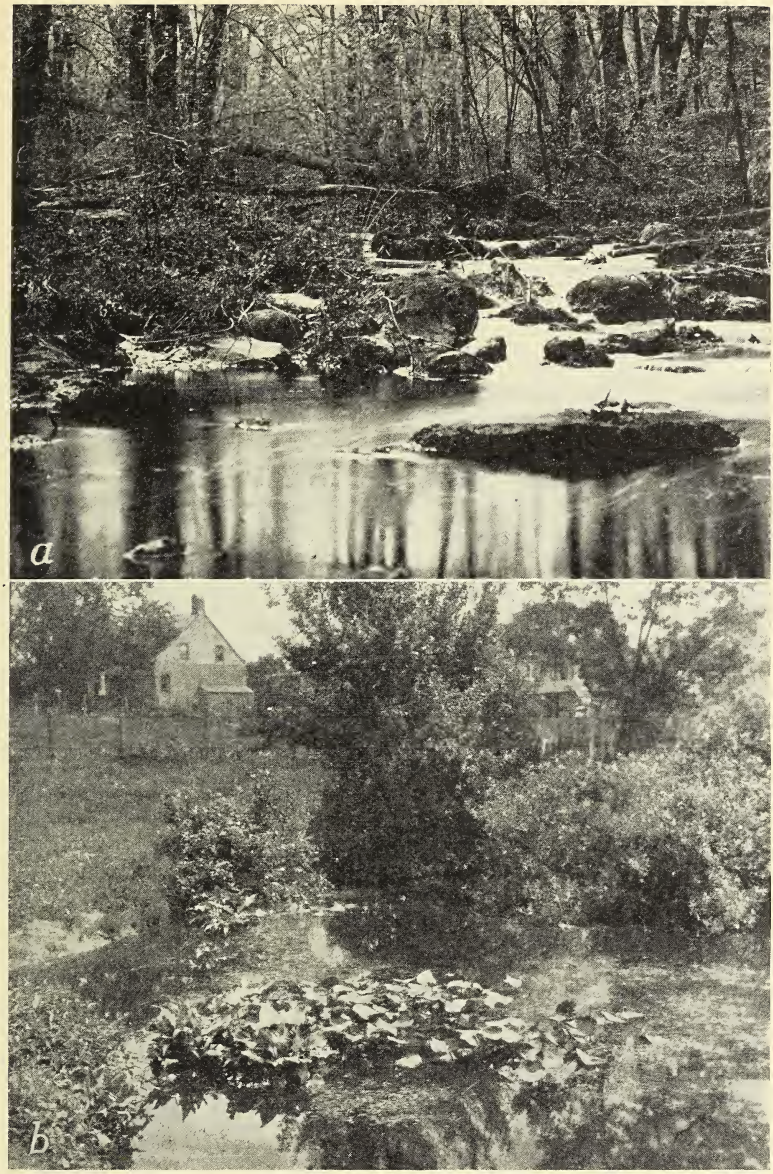

Fig. 322. *a.* Scene along Post Brook passing through woodland. *b.* Pool where most of the studies were carried on.

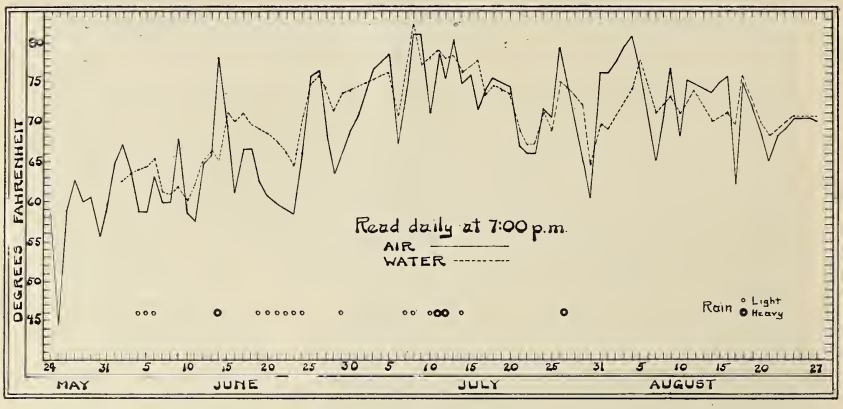

Fig. 323. Chart showing temperature and rainfall.

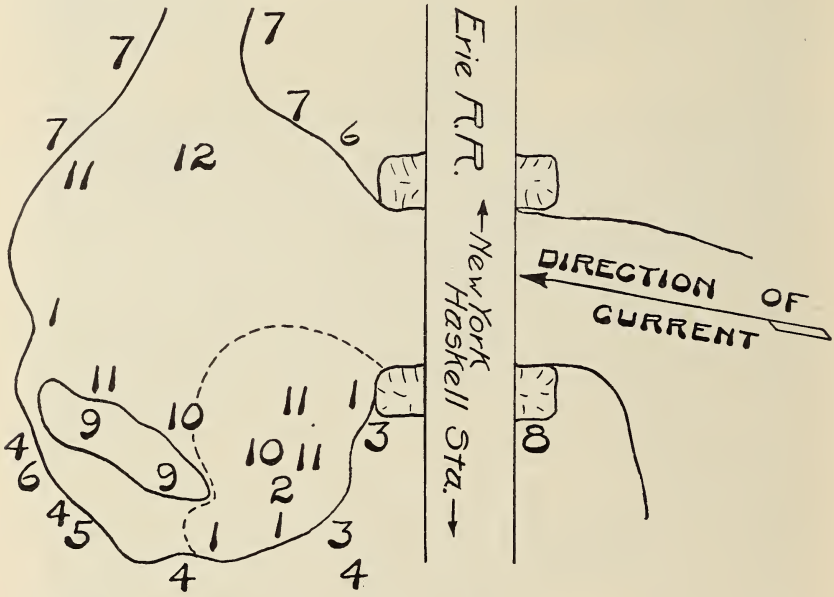

Fig. 324. Plant associations in pool shown in Figure 2. The dotted line encloses the area which was the chief habitat of *Enneacanthus*. The numbers refer to clusters of various plants as follows: 1. *Pontederia cordata* Linn.; 2. *Nymphaea advena* Aiton; 3. *Cephalanthus occidentalis* Linn.; 4. *Alnus incana* Willd.; 5. *Pyrus malus* Linn.; 6. *Acer rubrum* Linn.; 7. *Salix alba* Linn.; 8. *Cornus amomum* Mill.; 9. *Salix nigra* Marsh.; 10. *Philotvia nuttallii* (Plauch); 11. *Potomogeton epihydrus* Raf.; 12. *Valiseneria spiralis* Linn.

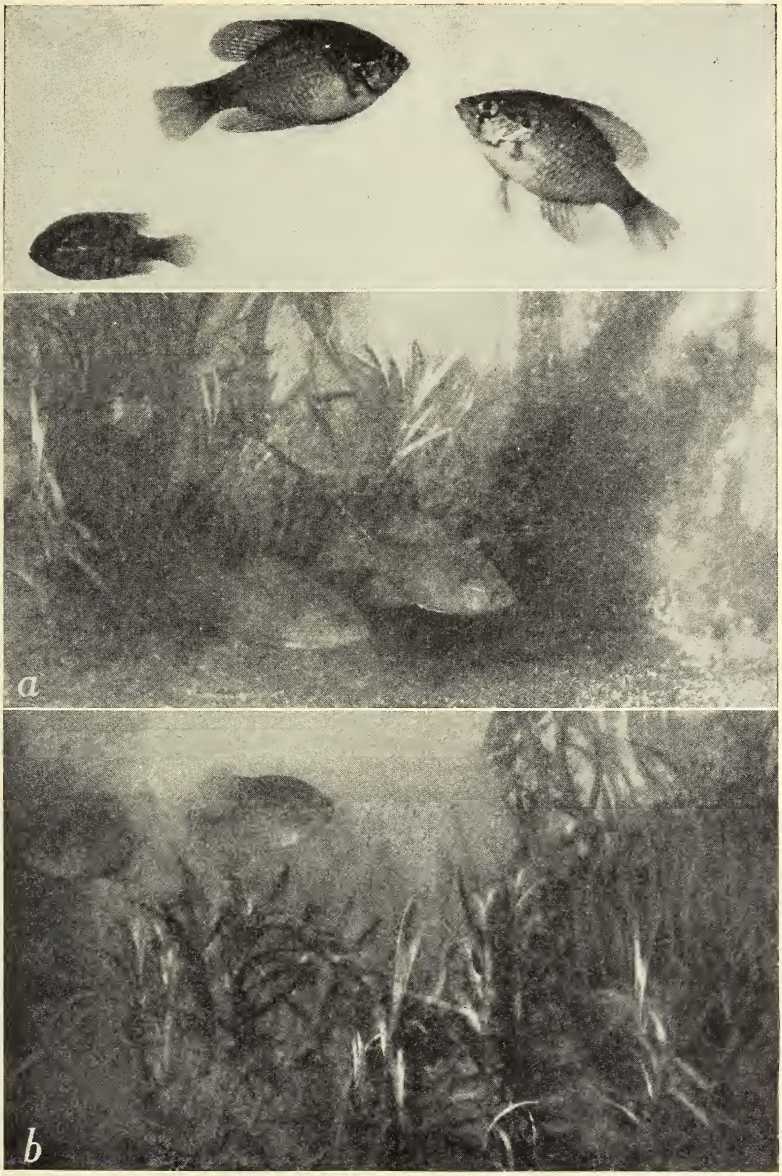

Fig. 325. *a*. Adult female and young on same scale. Photo E. R. Osterndorff.
Fig. 326. *a*, *b*. Males in an aquarium with a transplanted habitat.

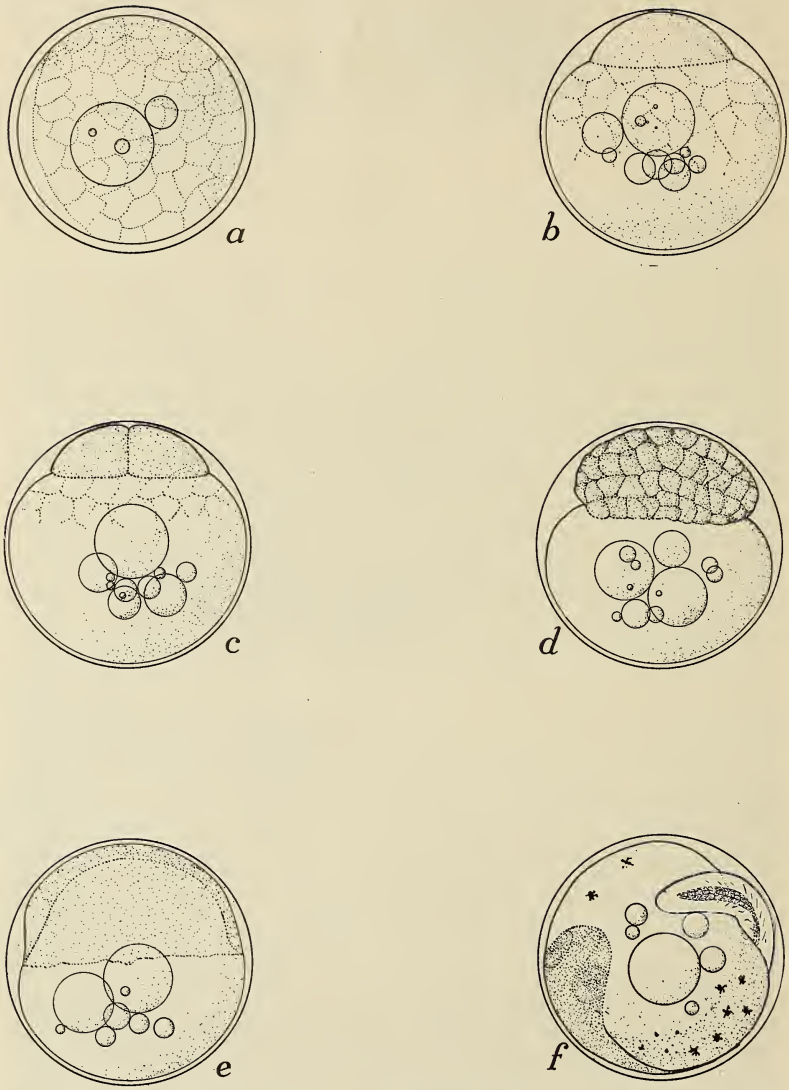

Fig. 327. Eggs of *Ennaecanthus; a.* Unfertilized egg; *b.* Blastodisc just formed; *c* 2-cell stage; *d.* Blastula in advanced stage; *e.* Egg showing advanced anterio-posterior differentiation; *f.* Egg just before hatching.

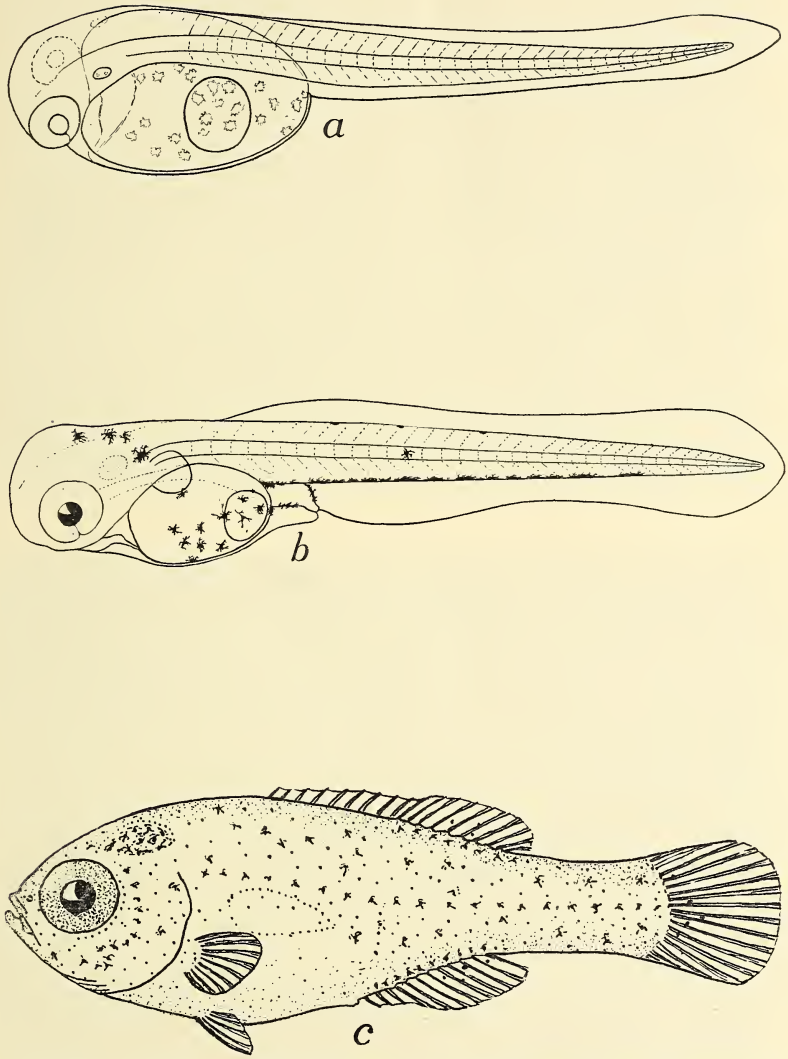

Fig. 328. Development of *Enneacanthus; a.* Newly hatched larvae, total length 3.25 mm.; *b.* Advanced larvae, total length 4.15 mm.; *c.* Advanced post larvae, standard length 9.0 mm.

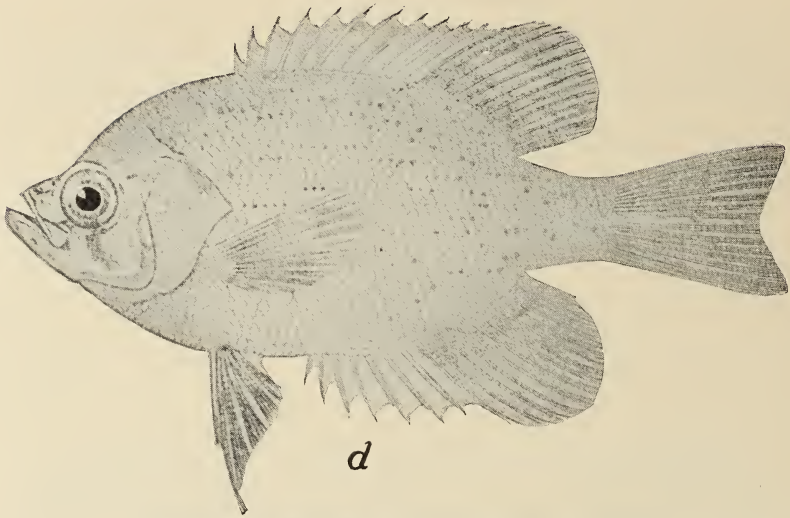

Fig. 328. Development of *Enneacanthus; d.* Adult fish.

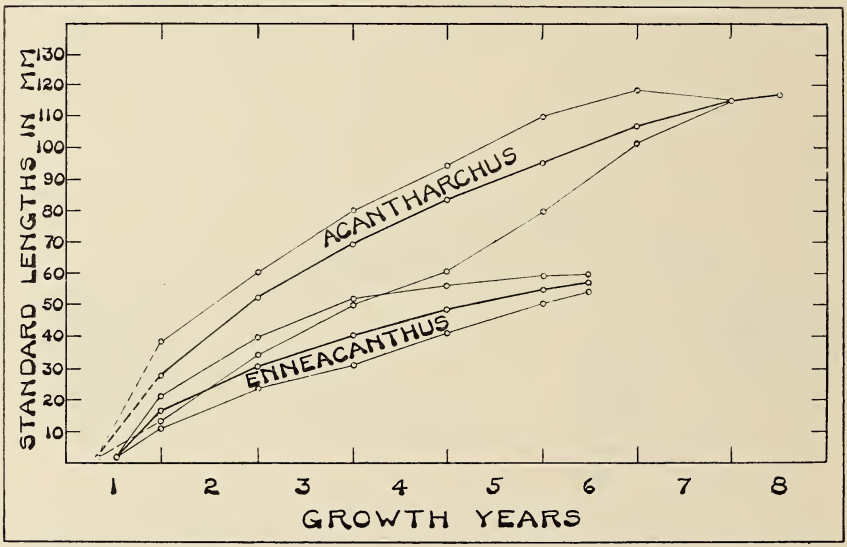

Fig. 329. Growth curve of *Enneacanthus* and *Acantharchus* based on scale examination. The heavy line represents the modal growth, and the light lines the extremes. The dotted lines in the *Acantharchus* curve represent the projected probable growth of the very young. The *Enneacanthus* curve is based on fourteen individuals, and that of *Acantharchus* on ten individuals.

Fig. 330. *a*. Nest of *Eupomotis gibbosus* with parent on guard; *b*. Nest of *Lepomis auritus* with parent on guard.

They are less distinct over the light peritoneum, which shows through the semi-translucent flesh. This is probably of purely mechanical causes as these colors are doubtless due to light interference and not pigment and are consequently considerably dimmed by light coming from the opposite side. The ventrals and anal and to a slight extent the other fins and thoracic region are suffused with pink. When excited the general coloration becomes darker. When roughly handled as when caught in a seine they become a very deep olive blue and the lighter spots are glitteringly brilliant by contrast.

Mature females are a pale olive, preceptably more drab than their consorts. There are light spots on the scales but they lack the greenish tint of the males. Consequently their pattern of spots blends with the ground color and is all but lost in the general effect. There was one exception noted. The fins of this fish were suffused with pink in manner characteristic of the males. This color description of both males and females agrees in its essential aspects with that given by Hildebrand & Schroeder 1928.

Young fish up to and into their second year are a dusky olive and have about seven broad black bars on their sides. They have the conspicuous greenish spots on their sides, but these are not as bold as in the mature males nor do they form such distinct horizontal rows of dots. These fuse to make one large area of silver-greenish and blue on their cheeks. When these fish become disturbed their ground color gets lighter, particularly on the ventral surface which becomes practically white. Viewed from above they range from a dull sand color to steel blue. In an aquarium set with as near a natural bottom as possible this coloration rendered them all but invisible when viewed from above. The darker phase matched the color of decaying *Potomogeton* and the lighter that of a sandy bottom. The light and dark vertical bands of the immature blends well with a background of *Potomogeton epihydras*. Fishes up to 17 mm. s. l. are strongly barred and they do not begin to lose it before they are about 45 mm. Even the larger specimens, at times, show suggestions of these juvenile bars. Fig. 325*a* shows an adult female and a juvenile, and Fig. 326*a*, *b* represents two males in an aquarium with as near natural surroundings as could be arranged.

Spawning Habits

There must be considerable rivalry among the males as is evidenced by the somewhat ragged condition of their fins, principally the caudal, during the mating season. In other local sunfishes much time is spent in nest building and while there is considerable rivalry it seldom seems to come to actual combat. Bade states that *Enneacanthus* does not build a nest of gravel in an aquarium at least. Our observations, although the evidence is purely negative, leads to the same conclusion. In the absence of nests *Potomogeton epihydrus* was suspected of harboring the adhesive eggs. None could be found however, but this is not surprising when the irregularity with which the females develop roe is considered. Although we made collections for the purpose of stripping from July 3 to September 9, at no time did we obtain a large number of ripe females. There were always numerous green fish and usually some spent. In other words, the season is exceedingly protracted and does not come to a sharp peak. Judging from the appearance of the ripe females they probably release all of their eggs at one time. It would be interesting to determine whether this is the retention of a primative spawning habit or represents the loss of the nest building habit or a modification of it, on account of special conditions. A further study and observation of the actual spawning act should be well worth while together with a careful comparison with the more available nesting species.

The Eggs

The eggs of *Enneacanthus* are demersal and fairly adhesive. They are spherical and very constant in size scarcely varying from a diameter of 0.9 mm. The yolk is a very pale amber and contains a variable number of lemon yellow, highly refractive oil globules. These vary in diameter from 0.325 mm. down to a point where they are barely visible under the usual magnifications. A count of the oil globules of fifty-three eggs show the average number to be 7 + with a range of from 2 to 16. There seems to be no absolute correlation between size and number of oil globules. Usually each egg has several rather large globules (0.075 mm. or over) and a variable number of minute ones.

The development of the eggs is rapid. At a temperature of 73° F. they harden within twenty minutes after fertilization. By

this time the germ disk is clearly delimited and the fragmentation of the yolk at first very pronounced has disappeared at the opposite pole. By thirty-five minutes a distinct groove has formed about the edge of the blastodisk. The first cleavage is completed in forty-five minutes, the second by eighty and the third by one hundred. Within three and one-half hours after fertilization the rapid growth of the animal pole has made the egg somewhat ovoid. The long axis averages about 0.096 mm. and the short about 0.090 mm. A distinct germ streak is visible at eight hours, with evident anterio-posterio differentiation. The blastopore closes within eleven and one-half hours. By twenty-one hours the embryo shows segmentation. They are occasionally moving and show cardial pulsations by forty-five hours. Some black chromatophores are also present by this time. Hatching occurs at about fifty-seven hours after fertilization. Fig. 327 shows six stages in the development of these eggs. As they are so typical of the group they represent, little need be said by way of further explanation.

Larvae and Post Larvae

The larvae average 2.3 mm. in length on hatching. The oil droplets consolidate shortly thereafter to form one large globule, which is situated on the ventral surface just a little forward of the posterior end of the yolk. Chromatophores are present on the yolk sac at hatching. They spread rapidly as development progresses. Larvae thirty hours old have a patch of them over the brain and the ventral artery is heavily pigmented for most of its length. Red corpuscles are evident in the blood. The pectoral fin appears at forty hours, the yolk shrinks noticeably and they are very active. They are positively heliotropic and swim up to the top of the water where they hang suspended from the surface film. By thirty-six hours the mouth is open and the yolk sac is nearly gone, but the fish usually still hang from the surface film.

Up to this time almost none died but at this point, as is usual with such fry under laboratory conditions, the mortality was sudden and nearly complete. The smallest specimen collected measured 8.2 mm. From the rate of growth of the laboratory specimens it was judged to be about a little more than two weeks old. At this size the caudal fin had distinct rays and was rounded. The spines and soft rays of the dorsal could be distinguished and counted,

TABLE IV. COMPARISON OF EGGS, INCUBATION TIME, AND EARLY GROWTH OF *ENNEACANTHUS* WITH OTHER SPECIES

PHYSICAL ATTRIBUTES OF EGGS

	Average Egg dia. mm.	Oil Globules		Yolk Color	Adhesion
		Number	Average dia. mm.		
Enneacanthus....	0.90	2 to 16 (average 7 +)	0.325 and less	Pale amber	Slight
Eupomotis.....	1.20	1 + some very small	0.40	Pale amber	Slight
Lepomis.....	1.80	1 + various smaller	0.60 and less	Bright yellow	Strong

INCUBATION AND AVERAGE LENGTH OF FRY AT VARIOUS TIMES

	Incubation in hours	Lengths in mm. hours after hatching			
		0	24	48	120
Enneacanthus....	57	2.30	3.22	3.43	4.50
Eupomotis.....	96	2.60	3.64	4.20	5.30

but it still had a vestige of a urostyle. Another specimen of 10.5 mm. showed none of these larval characteristics and was fundamentally similar to the adults except in the proportions of the body, depth, eye, head, etc. Fig. 328 shows four stages in the development of this species. Table 4 indicates the average rate of growth of the larvae.

Counts of the pulse were taken. It was at first high and showed a definite downward trend to the critical period. After

TABLE V. LEPOMINAE OF NORTHERN NEW JERSEY

	Acantharchus pomotis	*Enneacanthus obesus*	*Enneacanthus gloriosus*	*Mesogonistius chaetodon*	*Ambloplites rupestris*	*Lepomis auritus*	*Lepomis pallidus*	*Eupomotis gibbosus*
3	..	A	A	A	..	A	A	A
4	..	..	..	..	..	..	..	..
5	A	..	..	..	..	..	..	..
6	..	..	..	..	A	..	..	..
7	..	..	..	..	..	..	..	..
8	..	..	..	..	..	a	..	..
9	..	D	Da	..	..	a	..	..
10	da	da	Dd	Dd	da	Da	Da	Dda
11	D	..	..	..	..	d	da	da
12	D	..	..	a	D	d	da	d
Average no. scales.....	39	32	30	28	43	46	47	43
Caudal fin.....	Convex				Concave			

A—Anal spines. a—Anal rays.
D—Dorsal spines. d—Dorsal rays.

that it was naturally very erratic and doubtless abnormal. On hatching the heart beats ranged from 174 to 228 per minute with a mode at 218. They fell regularly to a mode at 124 on the fourth day. After this they became erratic so that on the sixth day they ranged from fifty to 200. On the seventh the larvae showed a heavy mortality.

Rate of Growth

Scales from almost all of the fish collected were examined for growth rings and the results when plotted gave a very reasonable curve. The fish apparently attain a length of about 15 mm. in the summer of hatching and are still of a very pale color when they winter over for the first time. They become barred early the next summer and attain a length of about 30 mm. by the end of that growing season. In the following season they are still barred but become sexually mature that season. Well developed gonads are regularly found in fish of this class and eggs obtained from two of them were successfully fertilized by a male of the next year class. No males in this class could be stripped however so males of the next year were regularly used as they could be at once recognized by their marked secondary characteristics. By the time their third winter is reached they measure from 40 to 50 mm. Only three fish larger than this were taken. They measured 55, 60, and 71 mm. and according to the scale markings were in their sixth year. The curve based on scale examination is given in Fig. 329.

Comparison with other Species

For purposes of comparison and identification of the Lepominae of this region various other data as collected is here recorded.

Eupomotis gibbosus.—The nest building of this species is too well known to need repetition. Figure 330*a* shows a typical one with the fish on it as viewed through the surface. Locally, nest building is in progress as early as the latter part of May and continues usually well into August.

The eggs average about 1.20 mm. in diameter and usually contain a single large oil globule and a few extremely minute ones scarcely discernable under ordinary magnifications. This large globule averages about 0.40 mm. in diameter and is a bright lemon yellow.

The eggs develop much slower than *Enneacanthus* requiring four days to hatch under similar conditions.

The larvae on hatching average about 2.60 mm. in length; 3.64 in twenty-four hours, 4.20 mm. in forty-eight hours and 53 mm. in five days.

Lepomis auritus. The period of nest building of this species practically coincides with that of *E. gibbosus.* Such a nest with its guarding parent is shown in Fig. 330*b*.

The eggs are extremely adhesive, much more so than either *Eupomotis* or *Enneancanthus* and are of a very bright yellow color which almost equals that of the oil globules. There is usually a single large one (about 0.60 mm. diameter) and a variable number of smaller ones of different sizes. These eggs are relatively large, averaging about 1.8 mm. in diameter. A comparison of these three types of eggs is given in Table 4.

Acantharchus pomotis. Although some attempt was made to obtain data on this species little of value was determined. No fish were found to be ripe at any time and no nests could be discovered. However, this is the least common species of the family in Post Brook. A curve of growth based on scale examination is given in Fig. 329. This does not appear to be entirely satisfactory but is consistent although it suggests a rather unusual type of growth.

This species appears to be largely nocturnal in habits. During the day time it was frequently found hiding under stones or submerged logs.

No data was collected on other species found in this region but the data given was found to be of value in connection with the standard keys in the differentiation of the post larvae.

Summary

1. Pond fishes may successfully invade old trout streams when the building of lakes further upstream renders such unsuitable for trout by raising the temperature and thereby reducing the limiting factor, oxygen, both by the direct effect of temperature and the indirect effect of encouraging the growth of oxygen consuming micro-organisms.

2. Such invading fishes naturally select the most pond-like area leaving the intervening rapids relatively barren of fish life.

3. *Enneacanthus gloriosus* selects the denser stands of aquatic plants for its habitat from which it seldom wanders very far.

4. It feeds largely on organisms to be found climbing about on these plants.

5. Males mature at a length of about 40 mm. and in the breeding season are very brilliant colored.

Females mature at a length of about 42 mm. and are usually barred vertically but are otherwise rather plain drab. The immature resemble the females.

6. *Enneacanthus gloriosus* apparently does not build a nest of gravel but deposits its adhesive eggs amid the weeds of its habitat. There is considerable fighting among the males.

7. The spawning season is protracted and reaches no distinct peak.

8. The eggs are typical of the sub-family Lepominae and average about 0.9 mm. in diameter and hatch in about 57 hours at a temperature of 73° F.

9. The larvae are about 2.3 mm. long on hatching and recognizable at a length of about 10 mm.

10. Maturity is attained by the second summer and the species may reach an age of six years probably spawning each year.

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THE CHEMICAL CONTROL OF CLOSED CIRCULATING SYSTEMS OF SEA WATER IN AQUARIA FOR TROPICAL MARINE FISHES

By C. M. Breder, Jr., and T. H. Howley

New York Aquarium

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Introduction

(Figs. 332–344 incl.)

The present paper[1] is intended as the first of a series concerning the control of aquatic environments based on studies carried on in the laboratory of the New York Aquarium. Considering for how long a period of years both public and private aquaria have been maintained, little has been done in attempting to maintain the water in a suitable chemical condition. In a measure, at least, this is due to ignorance of the chemistry involved on the part of those in charge. In the present case, for example, the authors have for the most part been involved with matters of ichthyology and fish culture respectively. It was necessary for them in this instance to practically abandon their ordinary pursuits and delve into the intricacies of modern chemical practice. In this we have been aided by Dr. Homer Smith and Mr. N. Farnacci of Bellevue Medical College, New York University.

The chemical data set forth herewith has been purposely written in language as non-technical as possible for the group it is intended to reach is one of naturalists. While the paper is intended primarily for those concerned with care of aquaria, it is hoped that it may also be of use to individuals holding fishes under experimental conditions in laboratories. The discussion is purposely confined to large systems of circulating water, but obviously the principles set forth also apply to small, standing aquaria of salt water. It is planned, however, to discuss the latter in a subsequent paper of this series.

[1] A preliminary note is given by Breder, 1930.

Principles Involved[1]

Any system for the maintenance of salt water fishes for exhibition, study or experimental purposes such as considered herein consists essentially of a series of aquaria which drain through a filter to a storage reservoir from which the water is pumped to a distributing tank which feeds the aquaria. Figure 332 illustrates the basic elements of all such systems and is a schematic representation of the one employed at the New York Aquarium. To this is added a suitable heating plant for winter use at this institution. Such systems usually contain a negligible quantity of plant life other than a little unicellular algae, whereas they do contain a vastly greater number of aquatic animals than a similar volume of water in the open sea. If it were possible to maintain a proper amount of plant life in such a system, interactions would take place that would largely obviate the methods herewith discussed.

Effects of Fishes on Water

With the conditions so stated we may consider what happens to the sea water in such a system. The animals, usually mostly fishes, bring about the following changes:

Respiration

1. The oxygen dissolved in the water decreases as it is consumed by the fishes.
2. The dissolved carbon dioxide (CO_2) increases as it is produced by the fishes and by hydrolysis forms carbonic acid (H_2CO_3) which tends to make the water more acid.

Excretion

The excreta of fishes may be either solid or fluid as in other animals. The fluid wastes usually immediately go into solution and react with substances already present, while the solids for the most part dissolve slowly. Those wastes that are removed by filtration do not concern us here. The dissolved substances are of course not removed by filtration and tend to accumulate in the sea water. These waste products all primarily derived from the food fed to the fishes, include organic metabolites such as urea, ammonia,

[1] See Harvey 1928 for a recent comprehensive treatise on chemical conditions in the open sea.

uric acid, creatine, creatinine or inorganic salts such as calcium, magnesium, sulphates, phosphates, etc. Some of these substances are excreted in the urine and some by way of the gills (Smith 1929 and 1930).

The experience of others and numerous observations of our own lead us to conclude that the most important changes in sea water resulting from continued use involve the acid-base equilibria. The continued excretion of acid metabolites (principally sulphates) leads on the one hand, to a reduction of the normal bicarbonate content while the continued production of CO_2 by the fish on the other hand increases the free CO_2 in the water. Both of these changes tend to increase the acidity. The accumulation of free CO_2 can be prevented by thorough aeration of the water but the depletion of the bicarbonates cannot be prevented and consequently this change can only be rectified by the artificial addition of bicarbonates from time to time.

The fate of the nitrogenous substances is unknown, but it appears that they are quickly oxidized to ammonia, which escapes from the water during aeration. No more than traces of ammonia or organic nitrogen have been found in our aquarium sea water after twenty years of use (Townsend 1929). There is a gradual accumulation of nitrates but it is probable that in the quantities present these innocuous salts are not deleterious.

Food

The quantities as above mentioned are primarily introduced indirectly as food whereas the protein sulphur etcetera in the food oxidize to produce sulphuric and other non-volatile acids which react with the bicarbonates forming neutral sulphates and other salts.

Tank Fittings

The rock and cement work if properly seasoned affect the system no more than the natural rocks and corals of the sea bottom. If the calcium rocks are attacked, this is in itself an indication of a too acid system. The metals employed in the piping and pumps should not influence the general run of aquarium fishes.[1]

[1] The long discussed toxic effect of certain metals on aquatic animals usually appears to be of significance only in waters that are much less buffered than sea water.

Density

The evaporation of water and the addition of salts introduced in the foods, increase the specific gravity and osmotic pressure above the normal.

Concluding this brief outline we may list the most important changes occurring in a closed system of sea water as:

1. Oxygen decreases.
2. Carbon dioxide increases.
3. Bicarbonates are displaced by acid metabolites. (2 and 3 lead to increased acidity).
4. Density increases.

Methods of Correction

Methods of correcting these changes will now be described.

Oxygen and carbon dioxide

The invasion and evasion of oxygen from air to water is rapid and a very small amount of aeration will nearly saturate the water with oxygen. A slight degree of undersaturation is apparently without effect on the majority of fishes. But a slight accumulation of free CO_2 is sufficient to make the sea water perceptibly more acid and to render it deleterious. Ocean water contains little CO_2. It is our experience that the ordinary aeration system is inadequate to keep the free CO_2 down to the normal level and consequently an increase in the quantity of this substance present in poorly aerated water accounts in part for its increased acidity. This accumulation of free CO_2 tends to make the water more acid but this result is also brought about in part by a decrease in the bound CO_2 or bicarbonate.[1]

As previously pointed out, the oxidation of protein sulphur etcetera in the food fed to the fishes leads to the formation of sulfuric and other non-volatile acids which on being excreted into the sea-water react with the bicarbonates and displace the bound CO_2 forming neutral sulphates and other salts. In view of the above chemical relationship this displacement of bicarbonates is very

[1] The hydrogen ion concentrate (pH) of a solution is determined by the ratio between the free CO_2 and the bound CO_2. According to the equation

$$log \frac{1}{K} + log \frac{[HCO_3]}{[CO_2]} = pH$$

where k is the dissociation constant of carbonic acid. The pH will decrease if either HCO_3 (related to bound CO_2) is decreased or CO_2 (related to free CO_2) is increased.

significant because it not only leads to increased acidity of the water but it reduces the most important buffering salt of the water itself and deprives the living fish of chemical protection afforded by the buffer. From all considerations it would appear that a reduction in bicarbonate content would be just as deleterious as an increase in free CO_2.

Simultanous action

$$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2CO_3$$
$$H_2CO_3 \rightarrow CO_2 + H_2O$$

As remarked above, the excess free CO_2 can be removed by adequate aeration,[1] but the depletion of bicarbonates can only be corrected by adding the salt in sufficient quantities from time to time to hold its concentration in the water at a normal level. This can be done most suitably by adding Sodium bicarbonate ($NaHCO_3$) since sodium is the most abundant base in sea water (about 80 per cent of the total base).

Normal sea water contains about 2.1 millimols of bicarbonate per liter. In order to keep the salt at this level we have found it necessary to add to our aquarium system, holding about 50,000 gallons or 227.000 liters of sea water, 73.19 kilograms of $NaHCO_3$ in a period of six months. A very long period would be required before an increase in Na would be significant.[2]

After the present method of treatment had been in operation for six months Mr. N. Farnacci kindly made the following analysis (Table 1) as a further check against any inherent difficulties not apparent by the analytical methods employed at the Aquarium. A sample of water brought from Nassau, Bahamas, was analysed at the same time for comparative purposes.

How closely our water resembles that of West Indian coral reefs

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[1] At this writing the New York Aquarium system is not entirely adequate in this regard, but work is under way to remedy this remaining defect.

[2] Dec. 19/29 to June 19/30 = 6 months
73,191 g. $NaHCO_3$
50,000 gals. water = 227,000 liters
= .322 g/L

.84 g. = 0.4 millimol per liter added

$\frac{0.4}{2.2}$ = about 20% of original bicarbonate replaced in 6 months. With 440 mM of Na present this added $NaHCO_3$ increases the Na by 0.1 per cent. It would require five years to increase Na by 1 per cent, at the rate of 0.1 per six months.

is evident from this table. For comparison with a large number of analyses see Olsen 1926 and Harvey 1928.

Density

The density is not only increased by evaporation but also by the addition of sodium bicarbonate, the former being by far the more important. The correction of this is simply a matter of dilution with the proper amounts of fresh water.

The changes from which such sea water suffers may be relisted here (Table 2) with the methods for their control.

While it is not claimed that other factors are of no consequence we believe that the most important are proper aeration, density and bicarbonate content.

After a considerable period of laboratory trial the entire warm salt water system was treated as above described with results that were even more satisfactory than we had hoped for. Some of the outstanding achievements are listed below, although this program has been a matter of routine for only six months, at this writing.

The only other Aquarium that we know of that attempts a systematic chemical control is that attached to Plymouth Biological Station in England. In a personal communication, Dr. W. R. G. Atkins, Deputy Director, states that they maintain the pH of their water between 8.0 and 8.3 by the weekly addition of lime. For their circulation of about 50,000 gallons they find about a pound a week sufficient. However, they refresh their system with new sea water about every six months. Such treatment maintains the pH and accomplishes buffering but disproportionately increases the calcium content.

Mr. R. Dorn on a recent visit to the Berlin Aquarium learned that they refreshed their supply at similar intervals in quantities about equal to half their needs making up the difference with water in which had been dissolved the principal salts found in sea water in their natural proportions.

With the present data available it might well be possible to synthesize a fluid sufficiently like sea water to be satisfactory, for inland aquaria. However, it is doubtful if such would be as useful as natural sea water when obtainable.

Results Obtained

As evidence of the validity of the present method of treatment,

the following list is given of the partial and more evident improvements in the condition of the fishes.

Appearances

The colors of the fishes all showed a rapid and decided improvement, especially notable in the case of the more brilliantly colored reef fishes which formerly faded out rapidly to ghost-like shadows of themselves in a few months. For example, the Nassau groupers, *Epinephalus striatus* Bloch, instead of becoming blanched whitish fishes with a simple black peduncular saddle, now always show a variety of their striking natural color phases. The matter of color change is also very marked, fishes which normally display such changes responding on much slighter stimulus than was heretofore necessary and with greater frequency. Squirrel fish, *Holocentrus adscensionis* (Osbeck), retain their brilliant red color in a fashion unknown to us before. The silvery fishes such as pompanos, *Trachinotus carolinus* Linnæus, and *glacus* (Bloch), mullet, *Mugil cephalus* Linnæus, etcetera instead of fading to a dead whitish as formerly, show the argenteus flashing characteristic of their kind to a marked degree. The more somber colored fishes such as black drum, *Pogonias cromis* (Linnæus), channel bass, *Sciænops ocellatus* (Linnæus) striped bass, *Roccus lineatus* (Bloch), jewfish, *Promicrops itiaria* (Lichtenstein) all show a sparkle and clearness of color rare or unknown formerly after a month's confinement.

Feeding

The appetites of the various fishes became strongly marked. Many species formerly of delicate appetites requiring much coaxing to feed at all became ravenous.

The sand sharks, *Carcharias littoralis* (Mitchill) have to be fed with care, so rapid is their strike for food. Several times the attendant came close to having his hand caught in their ravenous maws. Various grunts (*Hæmulidæ*), usually light feeders, take food freely.

Activity

Fishes formerly of very quiet habits became much more active, greatly enhancing their exhibition value. Among those showing these characteristics are the squirrel fish, jewfish, morays (*Lycodontis*), groupers, hinds and toadfish, *Opsanus tau* (Linnæus).

Mortality[1]

During this period of six months referred to, the mortality has been exceedingly low and many species which we were never able to keep for any length of time now thrive. Among the latter are listed bluefish *Pomatomus saltatrix* (Linnæus) and shellfish, *Lactophrys bicaudalis* (Linnæus). It must be remembered that these fishes were kept for nearly as long as they were able to stand the system prior to the establishment of the method here described. Thus they built themselves up from a much weakened condition. Of the few losses during this period, about 90 per cent of these were due directly to fighting which is discussed below.

Fighting

One of the results not anticipated was the development of excessive fighting in many cases. The fishes have always been placed according to their ability to get along with one another and this was an entirely new development. Of course this cannot be considered as desirable, but it is a splendid evidence of the health of the fishes which formerly lacked the exuberance to quarrel.

For example, losses of Squirrel Fish were entirely due to fighting, as they would literally stab each other in their large eyes with the sharp opercular spines. Formerly we considered this species entirely peaceful. Green morays, *Lycodontis funebris* Ranzani, fought more violently and savagely than ever before and several losses were so exacted. The savageness of the sand sharks was marked as was that of the surgeon fishes, *Acanthurus biahans* Castelnau. Probably the most striking was the case of the shark suckers, *Echeneis naucrates* Linnæus, formerly a most innocuous fish. They began attacking

[1] Unfortunately the mortality and other records are impossible of direct statistical comparison as there are various factors inherent in them that vitiate the significance of the figures arrived at. In brief, they could be used to prove anything, dependent on their interpretation. For example, there is nothing to show the size of the specimens by "counting noses" or to give even an approximate idea of the bulk of fish life in relation to the volume of water in circulation or the actual condition of the water at the time. For example, 100 triggerfish might mean 100 two-inch fish or 100 fourteen-inch fish; 10 groupers might mean 10 six-inch or 10 two-foot specimens. Of this much we are certain, however. In the nine years that the writers have been employed at the New York Aquarium, each spring found us in the position of trying to "spread" the collection to make the best possible showing and looking forward to the first new shipment anxiously. This of course has been the unfortunate, but common, experience of all those charged with the care of marine aquaria employing a permanently closed system. This spring found us in the reverse position with tanks full. When a shipment of rare Pacific fishes arrived, the problem was one of what could be done to display them without overtaxing the system. That the fishes received last year were not of any unusual vitality is borne out by the fact that the losses were normal until checked by the introduction of appropriate treatment.

sting rays, *Dasyatis centrura* (Mitchill) inserting their long lower jaws in the spiracular pit and raking upward and downward with their sharp teeth thus leaving ugly scars. These are not single cases but were all repeated from time to time or until a rearrangement of species could be made.

Injuries

Injuries due to fighting or other causes healed with remarkable speed. Formerly a fish sustaining any but the most trifling wounds was as good as dead. Now cow-nosed rays, *Rhinoptera quadrilobata* (Le Sueur) and sting rays attacked by sand sharks heal the most surprising gashes as do the surgeon fishes after quarreling. Sea bass, *Centropristes striatus* (Linnæus), and spiny boxfish, *Chilomycterus schœpfii* (Walbaum) always subject to broken tails which sloughed away, eventually killing the fish, no longer present this problem. Those which displayed such lesions when the corrective measures were applied have healed and regenerated their lost caudal appendages. Lesions on the heads of certain groupers caused by removing parasites also healed beyond all expectations.

Growth

The growth of many fishes has been startling. A bluefish, a species we could not even keep formerly, nearly doubled its length in this time. Sea bass formerly just "hanging on" show a good increase in size.

Parasites

Although parasites are present in apparently increased quantities, they are not nearly so disastrous as formerly and have not exacted any particular toll. Probably the fishes are much more resistant to their inroads. Their effective control is probably now, nevertheless, our most important problem concerning tropical marine fishes.

It is for the totality of the above reasons that we are so well satisfied with the results of this method of procedure.

TECHNIQUE

The technique by which the preceding results were obtained is described in full detail below.[1] While it may be subject to various improvements it has shown itself to be exceedingly simple and

[1] Shelford 1929 gives numerous useful suggestions.

satisfactory as described. The application of the technique divides into two parts, that of analysis of the sea water and that of the application of corrective measures. It is, of course, impossible to intelligently apply the correction until we know how much is required and how often to apply it, all of which is to be determined only by proper analysis of the water. As this will vary with each system and within the system from day to day depending on the number of fishes, their activity etcetera, it is necessary to make such analysis from time to time. At the New York Aquarium, after the system was working properly and the corrective apparatus functioning, we have found once a week to be sufficient with supplementary observations when new fishes were introduced or other changes made. As analysis necessary for setting the machines should take not over an hour when the operator has acquired some skill, it is not costly of time.

Analysis of Sea Water

Directions for making the necessary analysis are given below.

Oxygen

A determination of this quantity is *not* necessary for the present purposes, for in the correction of the carbon dioxide oxygenation is amply provided for. In other words if the carbon dioxide is proper the oxygen *must* be in such a system. The Winkler method has been used at the New York Aquarium to check this statement as well as for other purposes not significant here. It is fully set forth elsewhere (American Public Health Association 1925).

Carbon dioxide

Tropical ocean water contains almost no free carbon dioxide. The addition of a few drops of phenolpthalein to a 10 cc. sample in a test tube will yield a pale pink color. If it fails to do this it means that aeration has been insufficient to reduce it to a normal quantity and indicates the establishment of a more efficient aeration system. In taking this sample care must be exercised to avoid aerating the sample and obtaining a false reading. When working on such an aeration system it is desirable to obtain a quantitive measure of how much free carbon dioxide is present for the presence of more than four or five p. p.m. is undesirable and should be corrected. This may be done as follows:

Collect sample by syphoning into a glass stoppered bottle of about 500 cc. in such a manner that there are several changes of water obtained. Figure 333 illustrates a sample collector adequate for such purposes. This should be done with as little disturbance as possible as agitation of the water reduces the amount of dissolved CO_2. Use immediately. Carefully pour into a 100 cc. Nessler tube up to the engraved mark. Add 10 drops of 0.5 per cent phenolphthalein solution and insert a glass stirring rod. Stir without withdrawing the rod, but raising and lowering it rapidly to insure a vertical distribution. Titrate with sodium hydroxide N/44 from a 25 cc. burette until a faint but permanent pink color is produced.[1] Figure 335 illustrates the apparatus necessary.

The free carbon dioxide in parts per million is equal to 10 times the number of cc. of N/44 sodium hydroxide used.

Alkalinity

A measure of alkalinity is necessary, chiefly as a check against the preceding and following readings.[2] Each read in a different manner, and although calculation is possible it is best to make all three as the possibility of error is reduced to the vanishing point because of their interrelation. While it is not necessary to go into the explanation the scale of measurement of this quantity as here employed, it may be said that it is an indirect expression of the number of free hydrogen ions present and is known as the pH scale. Such water as we are dealing with should not vary beyond 8.0 to 8.4. Preferably it should be about 8.2 to 8.3. Colorimetric methods are entirely sufficient for the present purposes and devices may be bought in sets for such use with complete instructions. They are as simple to operate and read as an hydrometer and require no technical skill.[3] Figure 334 shows an elaborate equipment covering the entire range of natural waters, both fresh and salt.

Bicarbonates

This is by far the most important measure and also the least

[1] For purposes of comparison a few drops may be added to plain sea water and shaken until pink.

[2] Reiss and Vellinger 1929a and b show changes in such readings at another institution in comparison with the open sea.

[3] Any chemical supply house will offer a number of makes. At the New York Aquarium we have used both the La Motte and Helige-Klett comparators covering the range included above.

simple to make. Two methods are described, the second far superior to the first.

Titration method: 100 cc. of sample is placed in an Erlenmeyer flask to which is added five drops of brom-cresol purple.

This is titrated with N/100 hydrochloric acid until the purple color disappears. It is then boiled, which will cause a reappearance of the color. Titration is continued alternating with boiling until the purple color fails to reappear. Figure 336 illustrates the necessary apparatus.

The burette reading in cc. multiplied by 0.0001 gives the results in per cent of concentration. As normal sea water requires from 23 to 26 cc. of acid to reach its end point, it consequently varies from 0.0023 to 0.0026 normal or 2.3 to 2.6 millimols per liter of bound CO_2 or bicarbonate.[1]

Gasometric method: For more accurate work a Van Slyke manometric apparatus may be used. Such a device is illustrated (Fig. 337). It takes some little skill to operate, but where great accuracy is essential or where small amounts of fluid are only available (as in small balanced aquaria) it is particularly valuable. Details of operation for the estimation of CO_2 as used at the New York Aquarium, follow:[2]

With the apparatus in readiness 1.3 cc. of distilled water is introduced in the graduated cup "A." Exactly 2 cc. of sample is admitted to it from a Van Slyke pipette by means of its glass stop cock. The tip of the pipette is placed below the surface of the distilled water. This prepared sample is introduced into the evacuating chamber by means of cock "B." Four drops of 10 per cent lactic acid are dropped in cup "A" and admitted to the chamber the same way and washed in with mercury the last of which is left as a mercury seal in the "neck" of the cup. Reservoir "C" is then lowered until the mercury meniscus in the evacuating chamber stands at the mark near its base. The cock "D" is closed and "C" returned to its rack. The mixture is then shaken by means of the motor for two minutes. The chamber is brought to a vertical position if necessary and cock "D" opened slowly until the meniscus of the sample

[1] There is an inherent error in this method causing the reading to be a little high. Thus 2.3 to 2.6 mM corresponds to about 2.0 to 2.3 by the more accurate Van Slyke method. Accordingly, proper allowances should be made.

[2] General instructions come with the instrument. See also Van Slyke 1927a, Van Slyke & Neill 1924, Barrington & Van Slyke 1924, Hawk & Bergeim 1927 and Shelford 1929.

reaches the uppermost mark. A reading is then taken on the manometer tube and cock "D" opened. Three drops of 5 N sodium hydroxide are added to the cup "A," drawn into the chamber and washed in with mercury again allowing some to remain in the cup as a seal. Reservoir "C" is lowered until the level of the mercury reaches about the middle of the chamber and cock "D" closed and "C" returned to its rack. The meniscus of the sample is again brought to the uppermost mark and a second reading taken and the temperature noted.

The following calculation gives the total CO_2 in millimols (mM).

Reading 2 is subtracted from reading 1. This figure is multiplied by the appropriate temperature factor which is given in the accompanying table (Table 3). The result is divided by 2. From this is deducted a similar result previously determined for the distilled water used.[1]

As the sea water we are concerned with should contain practically no free CO_2 by first aerating the sample in a shaker (Fig. 337) until it turns phenolphthalein pink direct comparisons may be made with ocean water.[2]

After taking any measurement the chamber should at once be emptied. About 2 cc. of lactic acid should then be introduced, evacuated, shaken and washed into the waste bottle by means of cock "B."

Density

Density is measured by an ordinary hydrometer most conveniently marked in degrees specific gravity. This is usually made to read correctly at 15° C. or 60° F. The water may be brought to that temperature or the chart shown in Fig. 338 may be used. The latter is quite accurate enough for all practical aquarium purposes.[3] The recommended form of hydrometer and cup is shown in Fig. 339. We consider such a glass cylinder preferable to a metal cup with a

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[1] This figure is determined in the same manner using 2 cc. of distilled water instead of a sea water sample and in calculating dividing by 3.5 instead of 2 because the total quantity of fluid is concerned.

[2] Although open to criticism on theoretical grounds this reading deducted from a similar one on an unaerated sample serves to separate bound from free CO_2. However, it is amply accurate for the present purposes and much easier and more satisfactory in the hands of anyone not experienced in chemical methods than is the titration method. A small chemical aspirator will be found equally suitable for this purpose.

[3] Based on figures in Schureman 1929.

built in thermometer because greater accuracy in reading is possible.[1]

Sea water suitable for tropical marine fishes shows characteristics similar to those given in (Table 4), based on samples collected at various places. Those of Bahama waters were made possible by the generosity of Mr. Daniel Bacon and those of the Pacific by Mr. Vincent Astor. The latter were collected by W. S. Bronson especially for this purpose while the former were one of the objectives of an expedition by the senior author. Dr. J. N. Gowanloch kindly collected the Florida samples while at the Carnegie Station at Dry Tortugas.

Application of Corrective Measures

The technique of applying the suitable corrective measures are given below. They are three in number and interrelated to the extent that are the factors they control.

Carbon dioxide

By far the most suitable method for controlling the free CO_2 concentration is by any means of agitation which will insure its evasion to the point at which a few drops of phenolphthalein will turn pink. That amount, however, is much more than usually provided in aquaria. Open troughs with baffles, drops through open air, sprays into air, and air pumped through tanks, any or all may be employed to obtain the desired effect. Sea water left standing, after filtering, in a reservoir either in light or darkness, will correct itself in a time dependent on the size, shape and ventilation of the reservoir and the condition of the water when introduced. This method is not important, however, as the water returns with surprising rapidity to the normal high level of a system, taking usually less than two days. If it were not for this fact, a divided reservoir allowing part of the supply to be recuperating at all times, would be useful.

Of methods applicable to aquaria probably the most rapidly effective is that of a stream of water thrown into the air acting as a fountain. Following this in efficiency, we would place an open trough with suitable baffle or riffle boards and free drops from a

[1] See Service 1928. Titration with silver nitrate, a more accurate method for open sea water, loses its value here owing to the possibility of a larger variation in the proportions of the dissolved salts. As it is the osmotic pressure that concerns us chiefly in this regard, where greater accuracy is required, freezing point determinations should be used.

higher level. One of the most misunderstood methods is that of introducing a fine spray of air bubbles into the water. This method gives a considerable visual effect but is *measurably* less efficient than generally supposed. Buswell (1928) has shown that bubbles rising freely through the water carry a film with them that greatly decreases the apparent efficiency. No attempt will be made here to outline structural methods of devices for aeration, as the proper design depends on the particular needs of each institution. The amount required depends on the following factors:

1. Amount and kinds of fishes in relation to the amount of water in circulation.
2. Surface of water exposed to air in relation to volume.
3. Specific gravity in relation to pH value and bicarbonates in solution, used in the system.

In the above discussion, it is supposed that where the water is in contact with air the latter is normally pure. Conditions in closely confined places do not allow a rapid evasion of CO_2 and should be appropriately ventilated.[1]

The possibility of supersaturation, principally with nitrogen and its attendant difficulties, may be guarded against by having the aerating device relatively remote in the system from the fishes, thus allowing the water to reach equilibrium before entering the aquarium tanks.

Another method might be employed but due to the danger it brings it is considered unwise. If in treating for the bicarbonate balance sodium hydroxide be used instead of sodium bicarbonate, the subsequent reactions make use of the free CO_2 in the water ($NaOH + CO_2 = NaHCO_3$). In the sodium bicarbonate ($NaHCO_3$) the union has already been made and the free CO_2 of the water is untouched. Thus the use of sodium hydroxide would be a very satisfactory means of effecting two desired results by one method, but for the following reasons. The drawback is associated with the possibility of adding a little excess of the correcting substance. In the case of the sodium bicarbonate nothing worse happens than that the bicarbonate quantity rises in proportion to its amount, pro-

[1] In localities high above sea level due to the lower barometric pressures at a given temperature, less gases will remain in solution. Under such conditions, the evasion of CO_2 should be more rapid, although offsetting this, the dissolved oxygen would be correspondingly small. We do not know if there would be a practical upper limit due to this in mountain regions.

portionately increasing the pH and the specific gravity. In the case of the sodium hydroxide as soon as all the CO_2 has combined the further addition of NaOH remains in solution in that form causing a very rapid and dangerous increase in pH easily passing out of the range it is possible for fishes to exist in. This danger is also inherent in the use of Ca which is employed in the Plymouth Aquarium, as previously mentioned.

$$NaOH + H_2CO_3 \rightarrow NaHCO_3 + H_2O$$
$$Ca(OH)_2 + H_2CO_3 \rightarrow CaCO_3 + 2H_2O$$

While it is recognized that further study may show a way to automatically check such a catastrophe, it is considered safest at the present time to aerate for the removal of free CO_2 and correct the bicarbonate balance by adding $NaHCO_3$.

Bicarbonates

When the bicarbonates read too low as determined by the analysis previously outlined they may be brought back to their proper range by the simple addition of sodium bicarbonate to some point in the system, such as a duct leading to the reservoir, where it will become thoroughly mixed before coming in contact with the fishes themselves. This of course will cause a rather sudden return to the desired condition and it is much better practice to add it steadily in small quantities in such a manner that it holds the bicarbonate at a constant and normal level, this avoiding the shock of spasmodically varying the chemical quantities. For this purpose the device shown (Figs. 340, 341, 342) was found to be highly satisfactory.[1]

The vital part of the machine consists of a glass tube bent as shown (Figure 341). This is run through a square brass tube rocking on an axel. The cup at the far end when filled with water automatically tips it up. When the cup empties, the tube returns to its original position. The frequency of this tipping action is regulated by a valve controlling the amount of water employed as does the adjustable counterweight on the other end of the brass

[1] This device was primarily designed for use in conditioning fresh water in an open system or applying medications to fishes unable to be moved or to endure standing water. In its description it will be noted that in such use it will maintain a constant concentration of any solution employed irrespective of variations in flow. Although this feature is of little consequence in its present use, in the event of a shut down in the water supply it automatically stops, a feature of some importance. The machine's other uses will be discussed in another paper.

tube. The glass tube dips into a glass pan of solution and draws in a few drops holding it there by capillary attraction. When the tube lifts, this amount runs down and discharges. The glass pan is kept full by an inverted bottle very much after the fashion of the common poultry drinking fountain. No dimensions are given as the proportions may be varied to suit individual needs. Since writing the above, an improvement has been made in which the supply bottle is carried in a swinging cradle. By this means the bottle may be swung neck up for filling, thereby avoiding the handling of the full bottle with its consequent possible breakage or spilling of solution.

After setting the apparatus in place, the flow is increased or decreased by regulating the cock controlling the water supply. At the New York Aquarium it was found that a bottle full of saturated solution of sodium bicarbonate would last two or three days and in a short time the flow could be so regulated as to need no other attention than to renew the supply for long periods.[1]

Density

When the specific gravities read too high as determined by a hydrometer, good fresh water may be added as a dilutant but here again it is much more suitable to add automatically and so keep the density at a constant level comparable to that of the habitat of the fishes concerned.

The device shown (Figs. 343, 344) is rather complicated in appearance but is based on very simple principles. A hydrometer is so arranged that it floats in a bath of the water to be controlled. When the water becomes a little too dense, the hydrometer rises and closes an electric circuit which opens a solenoid valve turning fresh water into the system. With the consequent lowering of the density, the hydrometer drops and opens the circuit. As hydrometers operate truly only at a definite temperature, it is necessary to bring that of its water supply to a constant figure. This part of the apparatus accounts largely for its complicated appearance. A water bath of constant temperature, through which the supply flows, controls this.

[1] It might be thought that a common drip would be just as satisfactory. In actual practice, such was not found to be the case as it proved extremely difficult to adjust to satisfaction.

The dimensions are immaterial but the important details of construction[1] and the wiring diagram are given (Fig. 343).

The apparatus is so made that it will not operate in the case of a failure of any part thus obviating the danger of flooding the system with fresh water. An additional precaution could be installed to ring an alarm bell in the case of the hydrometer dropping below its normal lower level.

If the Control Line Fails

The fresh-water relay will not operate.

The temperature of the water bath will rise and lower the position of the hydrometer.

If the Power Line Fails

The fresh-water valve will remain closed.

The temperature of the water bath will lower, raising the hydrometer but it will be inoperative.

Adjustment and Operation

The adjusting knob (Fig. 343) is so set that the mercury cup on the hydrometer floats just below the contact prongs at the desired density. Any increase closes the circuit allowing fresh water to reduce the density. Fresh water also enters the supply regulating chamber. This lowers the density in the salinostat chamber more rapidly than that of the main supply and the electric valve consequently closes in a period dependent on the amount of fresh water so diverted. By making use of this detail, fresh water is added in small intermittent quantities insuring a smoother and more gentle reduction of density than by allowing it to enter in a single continued flow. Thus the electric valve closes and opens continually while the water is being added until the entire system is properly reduced.

Routine Procedure

The routine procedure now employed at the New York Aquarium is described below.

Analysis

The apparatus absolutely necessary for making the essential analysis may be listed together with the required reagents.

[1] The following parts of this appliance were obtained entire from various sources: Hydrometer, C. J. Tagliabue Co.; Thermoregulator, relays and resistance, American Instrument Co.; special glass ware, Eimer and Amend Co.

1. 3 dropping bottles with pipettes (about 30 cc.)
2. 1 test tube (about 50 cc.)
3. 1 Comparator of ample range
4. 1 Van Slyke constant volume manometric apparatus
5. 1 Van Slyke pipette with stop cock (2 cc.)
6. 1 hydrometer marked in degrees Sp. G. 1.000 to 1.030
7. 1 engraved glass thermometer about 0° to 50° C. (or its equivalent in Fahrenheit)
8. 1 glass hydrometer jar.

If it is desired to titrate for bicarbonates instead of measuring them gasometrically, omit items 4 and 5 and 1 dropping bottle and substitute the following:

1. 1 50 cc. burette
2. 1 200 cc. Erlenmeyer flask
3. 1 Electric hot plate (or other heat source)
4. 1 100 cc. graduate.

If it is desired to titrate for the amounts of free CO_2 present add the following:

1. 1 25 cc. burette
2. 1 100 cc. Nessler tube
3. 1 500 cc. bottle with glass stopper.
4. 1 glass stirring rod.

The reagents necessary follow:

Phenolphthalein solution 0.5%
Lactic acid solution 10%
Sodium hydroxide 5N.

For titrating for bicarbonates add:

Brom-cresol purple 4%
Hydrochloric acid N/100 (exactly).

For titrating for free CO_2 add:

Sodium hydroxide N/44 (exactly).

With this equipment, the procedure should be as follows:

Take pH of sample on comparator.
Test presence of free CO_2 with phenolphthalein.
Measure total CO_2 on Van Slyke apparatus.

Measure bicarbonate CO_2 of aerated sample on Van Slyke apparatus.

Take specific gravity and temperature.

These items should be recorded as taken, on some such form as suggested below which becomes part of the permanent records of the institution.

Date	pH	mM total CO_2	mM bound CO_2	mM free CO_2	Sp. G. at 15° C.	Temperature.
May 15, 1930	8.2	2.254	2.201	0.053	1.0261	72

The pH is read directly from the comparator. The total CO_2 is calculated from the Van Slyke readings. The bicarbonate reading is practically identical and need not be taken if the sample turned pink on the addition of phenolphthalein. If it did not, a sample aerated until it shows this reaction will read less. The free CO_2 is obtained by deduction of the bicarbonate CO_2, in such a case, from the total CO_2. The specific gravity and temperature are taken together. The former is corrected to 15° C. by means of Fig. 338.

If free CO_2 is present in a measurable quantity, it will modify the figures as follows:

The bicarbonate CO_2 will be considerably less than the total CO_2 and the free CO_2 will be relatively high. (This will follow only when phenolphthalein does not turn the unaerated sample pink.) The pH will be lower for the untreated sample than for the aerated sample.[1]

If the bicarbonates are too low the bicarbonate CO_2, will read less than 2.100 mM and the pH will be low. The presence of relatively large amounts of free CO_2 goes along with too little bicarbonate. (Free CO_2 is normally present in larger quantities in waters of low salinity.) The specific gravity should not be above 1.0265. If the salinostat is operating, this will automatically be maintained. A recording thermometer is a valuable adjunct as it shows at once any vagaries in temperature and affords a complete check of this factor.

[1] The relations are not as here described if the water is seriously out of its normal range. Such a condition shows a badly upset system.

Corrective measures

With this knowledge at hand, the control applicances may be adjusted to the needs. The complete apparatus is listed below:

1. Sufficient aeration apparatus to reduce the free CO_2 nearly to zero.
2. A bicarbonate corrector as herein described.
3. A salinostat as herein described.

The only reagent necessary is an ample supply of sodium bicarbonate.

If the bicarbonate CO_2 of the aerated sample reads too low the valve above the tipple bar of the bicarbonate corrector is opened a little more; if it reads too high, it is closed a little. Finer adjustment is obtained after approximately the correct figure is secured by regulating the second valve which "bleeds" the line running to the tipple cup.

If the specific gravity is either too high or too low, the adjustment screw is turned down or up accordingly. When once adjusted, this should remain constant indefinitely.

With these three control measures correct, the pH should be within proper range. A decided variation in this or any of the others not bearing the correlation outlined, indicates that something is radically wrong either with the readings or that the sea water is being modified by some source of contamination or other cause. If it is the latter, the actions and appearances of the fishes themselves, especially the more sensitive ones will also show modification.

It is hardly necessary to remark that although both the analytical and corrective equipment require little attention, a periodic cleaning is necessary as well as an occasional check on the functioning of the moving parts in the apparatus.

In such systems of water there is always some loss due to leakage. If it were not for this, the bulk of water in circulation would actually increase as the addition of fresh water is in excess of the loss by evaporation because of the increase in density due to the addition of sodium bicarbonate and the soluble substances introduced directly or indirectly by foods.

SUMMARY

1. The major chemical quantities in a closed system of sea water containing fishes may be readily controlled by direct chemical treatment.

2. Such treatment provides the fishes with a very close simulation of natural sea water and they consequently show a marked improvement in health and general well being over that displayed in an untreated system.

3. The accumulation of carbon dioxide may be reduced by adequate aeration.

4. The normal bicarbonates which are destroyed by reactions with the fishes' waste products may be replaced by sodium bicarbonate suitably administered.

5. The increasing density may be reduced most satisfactorily by the automatic addition of fresh water.

6. The items not provided for increase in quantities not exceeding traces. At the rate of application necessary at the New York Aquarium, the sodium concentration should not increase more than about 1 per cent in five years.

7. Full instructions are given for the use of the analytical and corrective apparatus described, two of the latter appliances being new.

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TABLE I. ANALYSIS OF TREATED AQUARIUM WATER

Water	Δ	mM per liter									
		Cl[1]	SO_4	Σ A—	CO^2 H_2CO_3[2]	K	Na[3]	Ca	Mg	Σ B+	Fixed Residue
Circulation..	2.029	553	30.0	613	2.1	10.84	499	14.97	42.3	622	——
Nassau.....	2.111	596	31.4	659	2.1	11.39	537	12.95	45.0	664	——
	atm.	parts per thousand									
Circulation..	24.55	19.65	2.88	22.53	.088	.423	11.48	.579	10.03	13.51	36.04
Nassau.....	25.58	21.18	3.02	24.2	.088	.444	12.34	.519	10.95	14.40	38.6

[1] Cl — 0.35 for Br_2 and I_2 gives slightly lower values.
[2] Includes traces of $'NO_2$, $'NO_3$, and 0.2 mM of PO_4.
[3] Na obtained by difference.

TABLE II. CHANGES AND RECTIFICATION OF AQUARIUM SEA WATER

Changes	Methods of Control
1. Oxygen decreases.	Follows on treatment 2.
2. Free Carbon dioxide increases.	Aeration.
3. Bicarbonates destroyed. (2 and 3 lead to increased acidity).	Sodium bicarbonate added. (acidity is decreased by treatment 2 and 3).
4. Density increases.	Dilution with fresh water.

TABLE III. VAN SLYKE FACTORS[1]

Thermometer Reading	Factor	Thermometer Reading	Factor
15	.0313	23	.0300
16	.0311	24	.0299
17	.0310	25	.0297
18	.0308	26	.0296
19	.0306	27	.0294
20	.0305	28	.0293
21	.0303	29	.0291
22	.0302	30	——

Table to be used with a total volume of 3.5 cc. (Sample 2 cc. + distilled water 1.3 cc. + lactic acid 4 drops and sodium hydroxide 3 drops).

[1] From Van Slyke 1927b

TABLE IV. SEA WATER ANALYSIS

Locality	Date	Free CO_2* p. p. m.	CO_2 as bicarbonates mM	pH	Sp. G.
1 mile E. of Nassau harbor, Bahamas...	Feb. 10, 1930	0.0	2.0807	8.3	1.0265
1 mile E. of Nassau harbor, Bahamas, 8′ bottom.....	Feb. 10, 1930	0.0	2.1542	8.3	1.0262
Nassau harbor, Bahamas.....	Feb. 12, 1930	0.0	2.2643	8.3	———
North Cay, Bahamas..	Feb. 12, 1930	0.0	2.0962	8.3	1.0261
North Cay, Bahamas 10′ bottom.....	Feb. 12, 1930	0.0	2.0617	8.3	1.0261
Berry Islands, Bahamas, Frazer's Hog Cay.....	Feb. 14, 1930	0.0	2.0872	8.4	1.0258
Nassau harbor, Bahamas.....	Feb. 19, 1930	0.0	2.2117	8.3	———

*By phenolphthalein sodium hydroxide titration. A more accurate measurement would show this figure to be about 0.04 p. p. m.

TABLE IV. SEA WATER ANALYSIS (*Cont.*)

Locality	Date	Free CO_2* p. p. m.	CO_2 as bicarbonates mM	pH	Sp. G.
1 mile E. of Nassau harbor, Bahamas...	Feb. 20, 1930	0.0	2.1097	—	———
1 mile E. of Nassau harbor, Bahamas, 8′ bottom.....	Feb. 20, 1930	0.0	2.1572	—	———
Perlas Island, Panama.	———	0.0	2.0948	8.3	1.0265
Black beach, Galapagos	———	0.0	2.1830	8.2	1.0265
0′ 27 S. 90′ 20 W, Galapagos.....	May 1, 1930	0.0	2.1681	8.1	1.0261
Academy Bay, Galapagos.....	Apr. 3, 1930	0.0	2.1232	8.1	1.0263
Darwin Bay, Galapagos	———	0.0	2.1217	8.3	1.0265
Tagus Cove, Galapagos	———	0.0	2.1471	8.1	1.0261
Loggerhead Key, Tortugas, Fla.....	June 8, 1930	0.0	2.0599	8.2	1.0270
Garden Key, Tortugas, Fla.....	June 8, 1930	0.0	2.1570	8.2	1.0272
White Shoal, Tortugas, Fla.....	June 8, 1930	0.0	2.0380	8.2	1.0270
Bird Key, Tortugas....	June 8, 1930	0.0	2.0314	8.3	1.0269
Rebecca Light, Florida.	June 9, 1930	0.0	2.0547	8.2	1.0272
Marquesas, Florida....	June 9, 1930	0.0	2.0449	8.3	1.0270
	Maximum	0.0	2.2643	8.4	1.0272
	Minimum	0.0	2.0314	8.1	1.0258
	Average	0.0	2.1165	8.2	1.0265

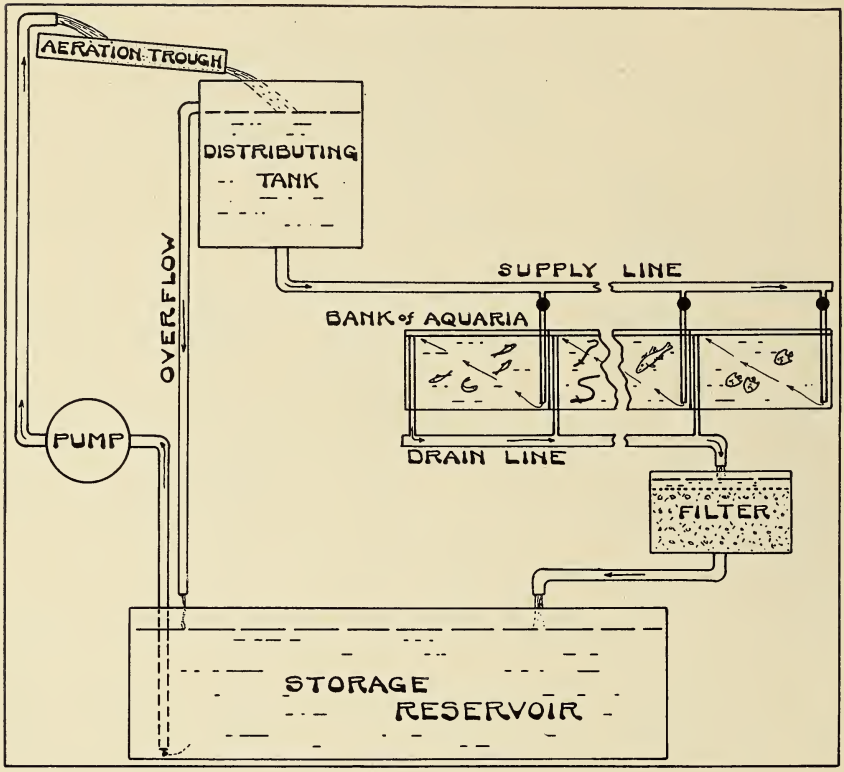

Fig. 332. Diagram of closed salt water system in the New York Aquarium. A heating coil is operated in the "distributing tank" when necessary. The aeration trough as shown is inadequate.

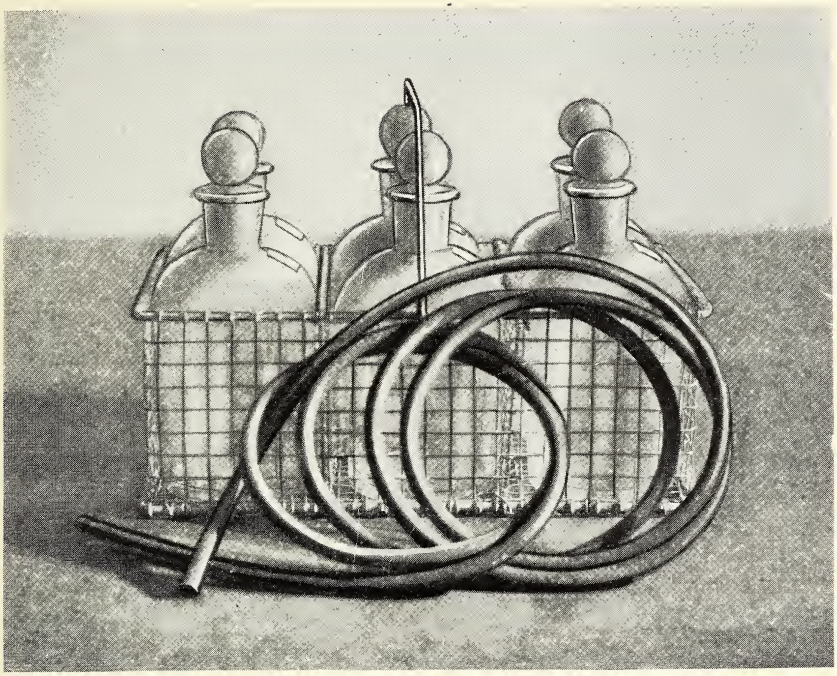

Fig. 333. Equipment used for collecting water samples for analysis.

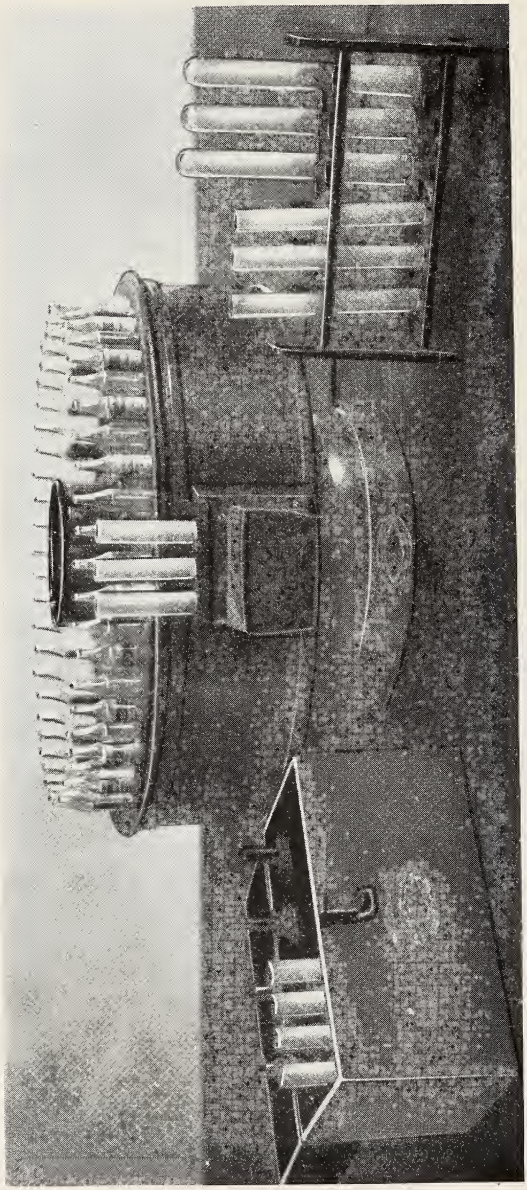

Fig. 334. Apparatus for estimating hydrogen ion concentration (pH value).

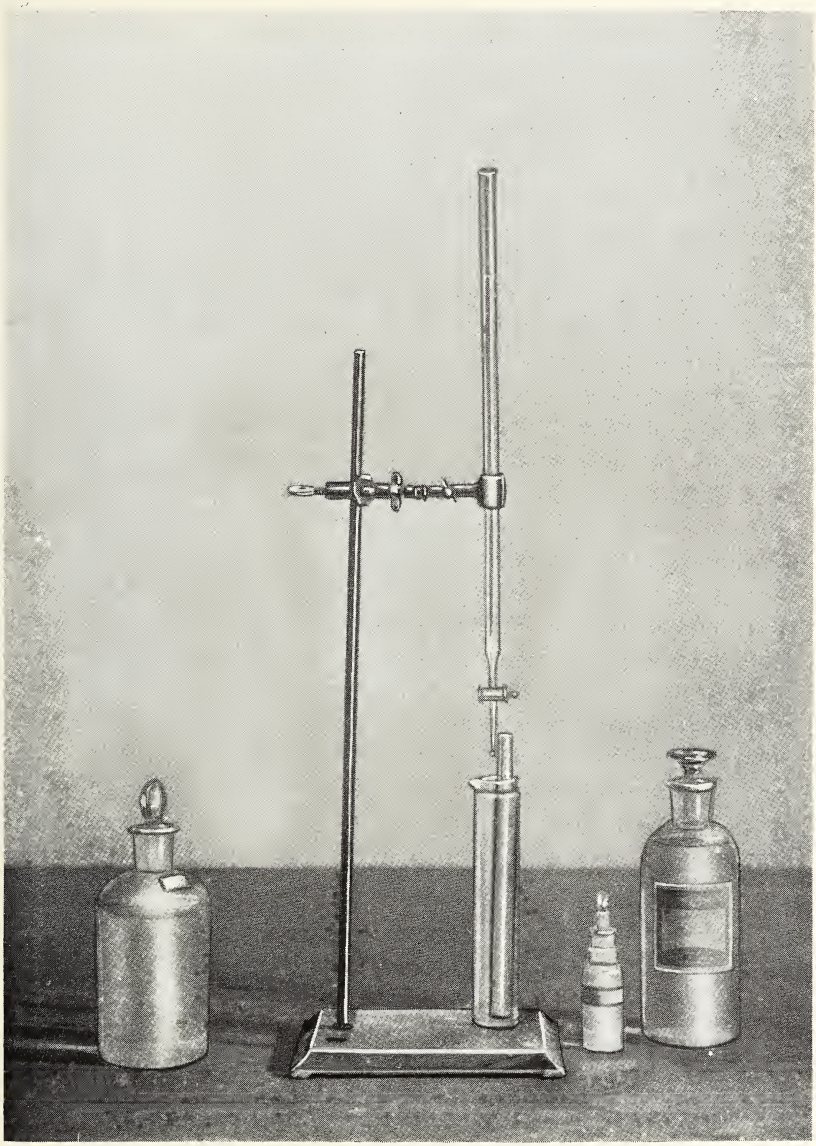

Fig. 335. Titration apparatus for estimating free carbon dioxide.

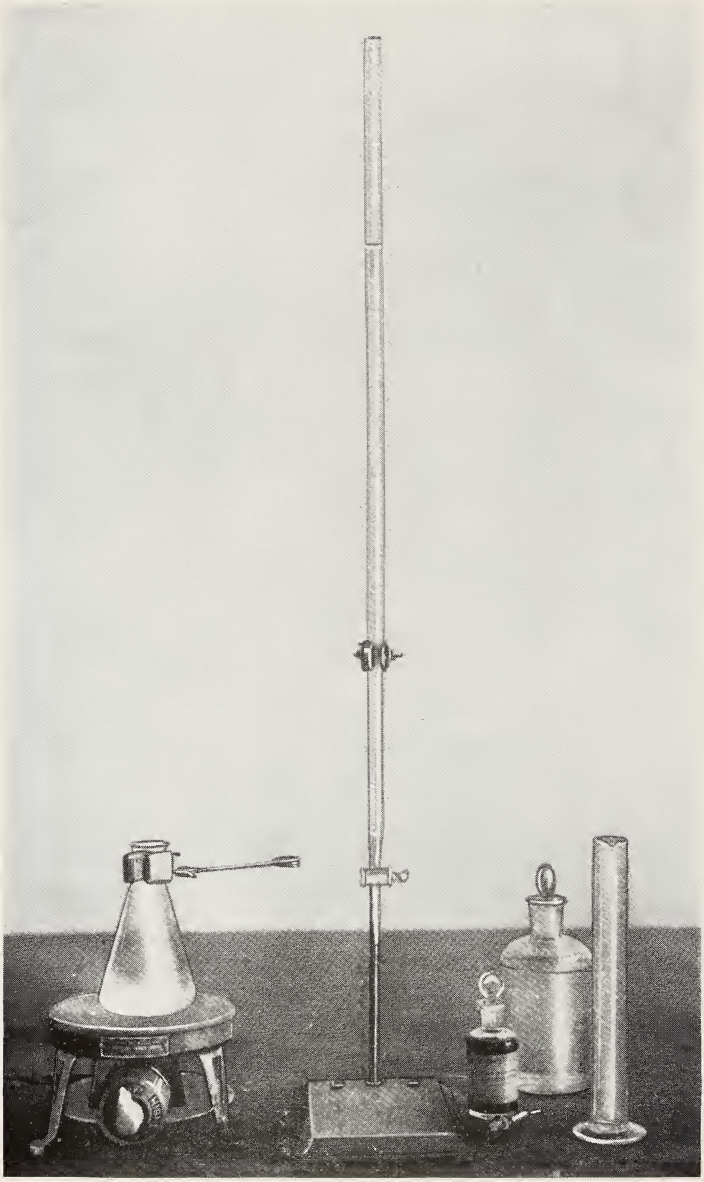

Fig. 336. Titration apparatus for estimating bound carbon dioxide.

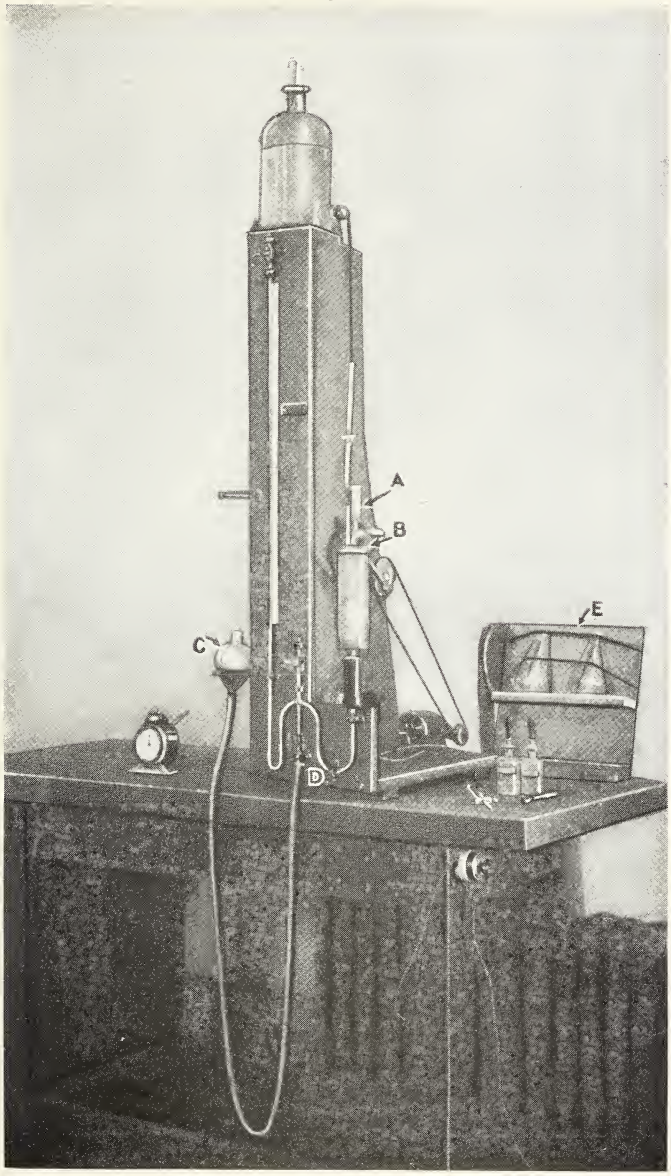

Fig. 337. Van Slyke constant volume manometric apparatus with shaker for liberating free carbon dioxide. A, Graduated cup. B, Two-way cock. C, Mercury Reservoir. D, Stop cock. E, Shaking rack.

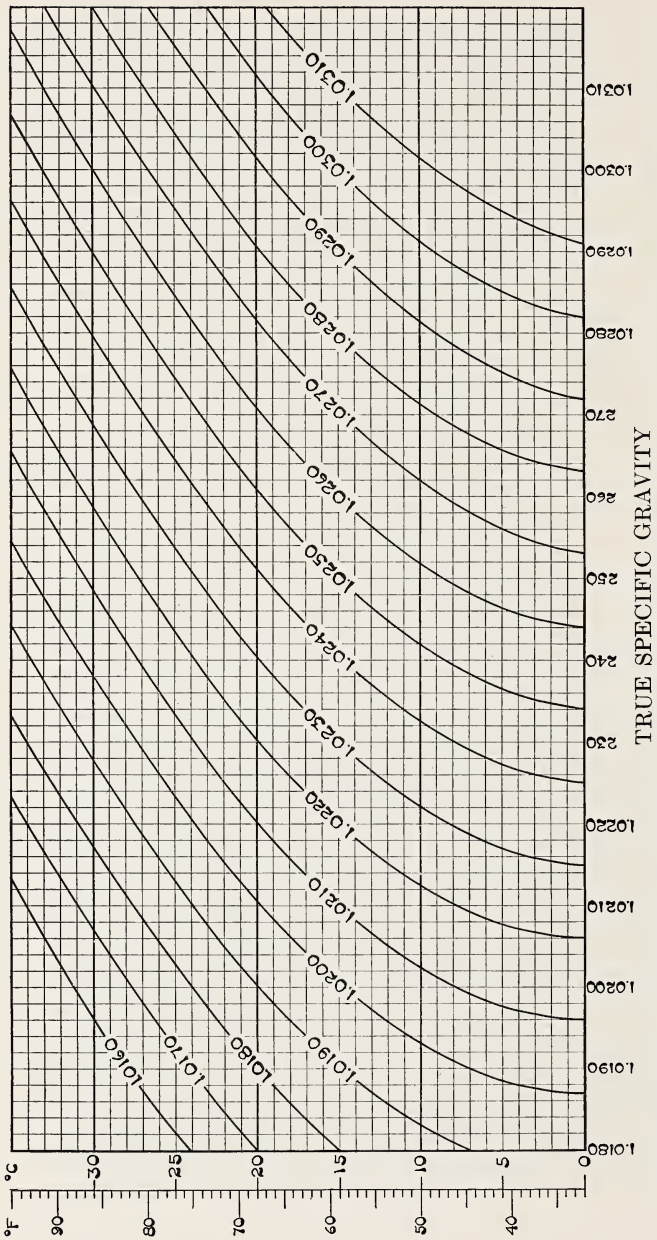

Fig. 338. Chart of temperature corrections for hydrometers. Intersection of horizontal temperature lines and curved apparent specific gravity lines mark true specific gravity reading on vertical lines. Example: Apparent Sp.G 1.0250, Temp. 30° C. (or 86° F.). True Sp.G then = 1.0290. Interpolations may be made to nearest tenth in last place. This chart is plotted for hydrometers standardized to read at 15° C. If a hydrometer standardized to read at 60° F. is used, proceed as above and deduct 0.0001 from the result. Thus in the above example if a 60° F. hydrometer were employed the True Sp.G would be 1.0289. This chart will give results accurate enough for all ordinary aquarium purposes. If greater accuracy is desired other methods, as discussed in the text, are recommended.

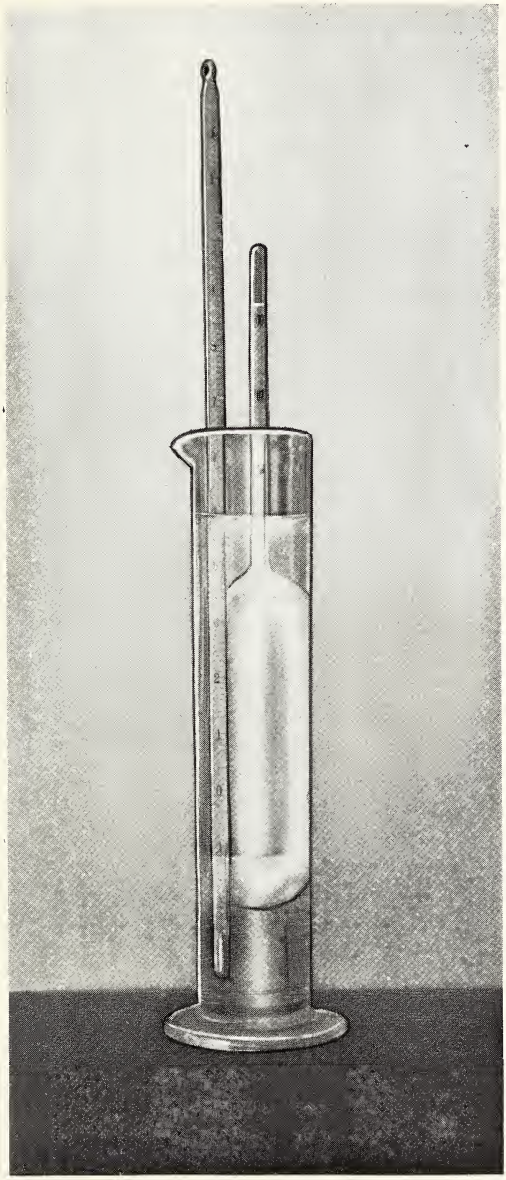

Fig. 339. Hydrometer for determining density of sea water.

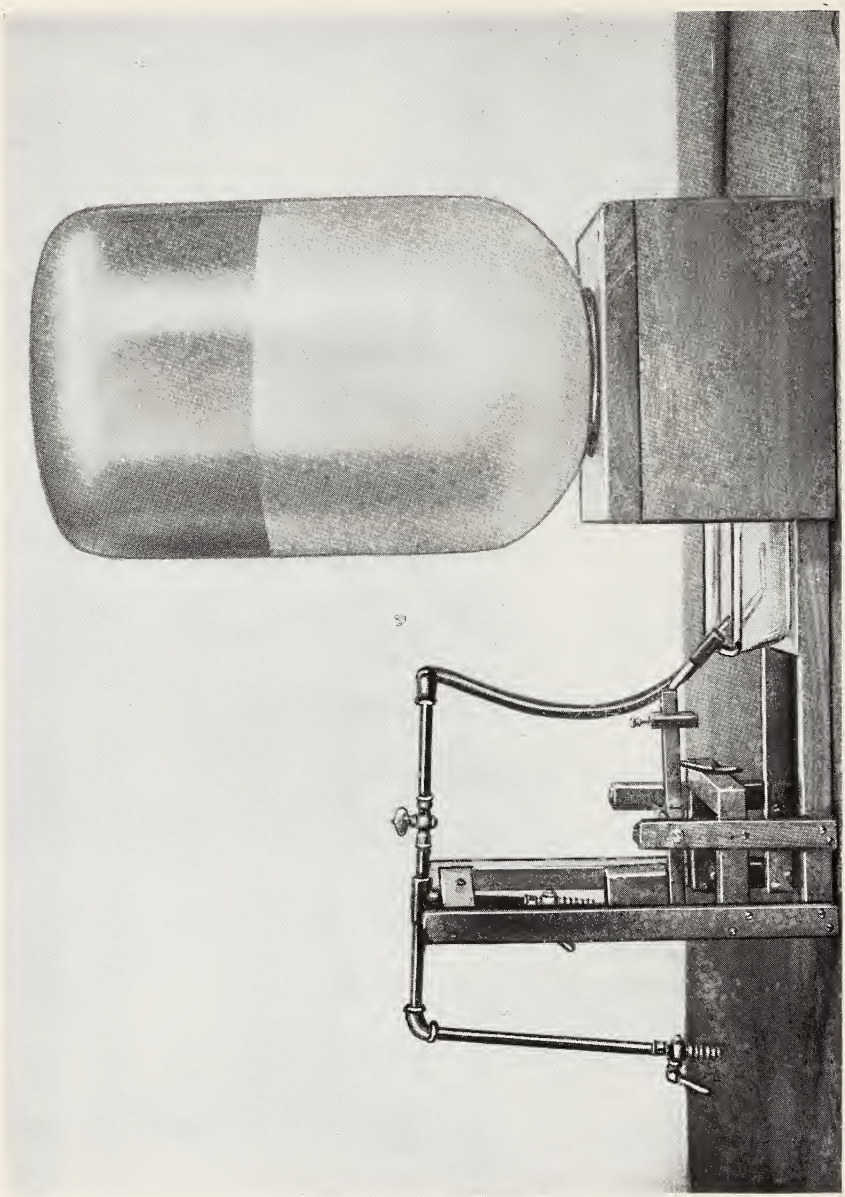

Fig. 340. Chemical supply apparatus (side view).

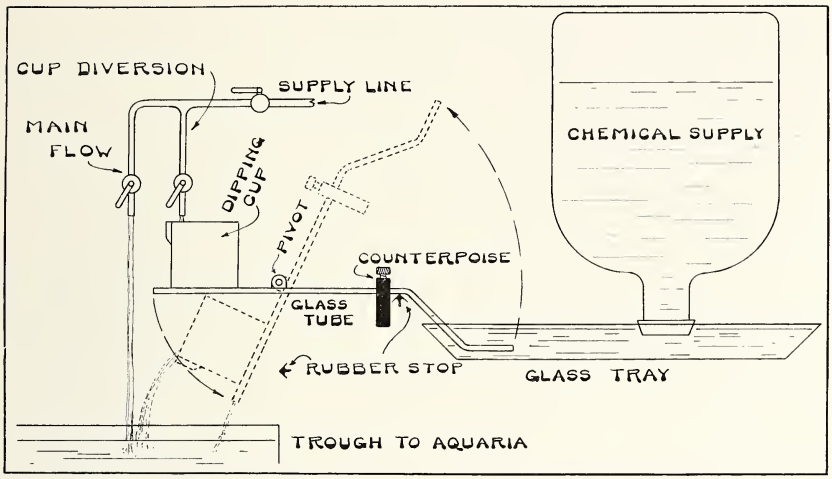

Fig. 341. Diagram of operation of chemical supply apparatus.

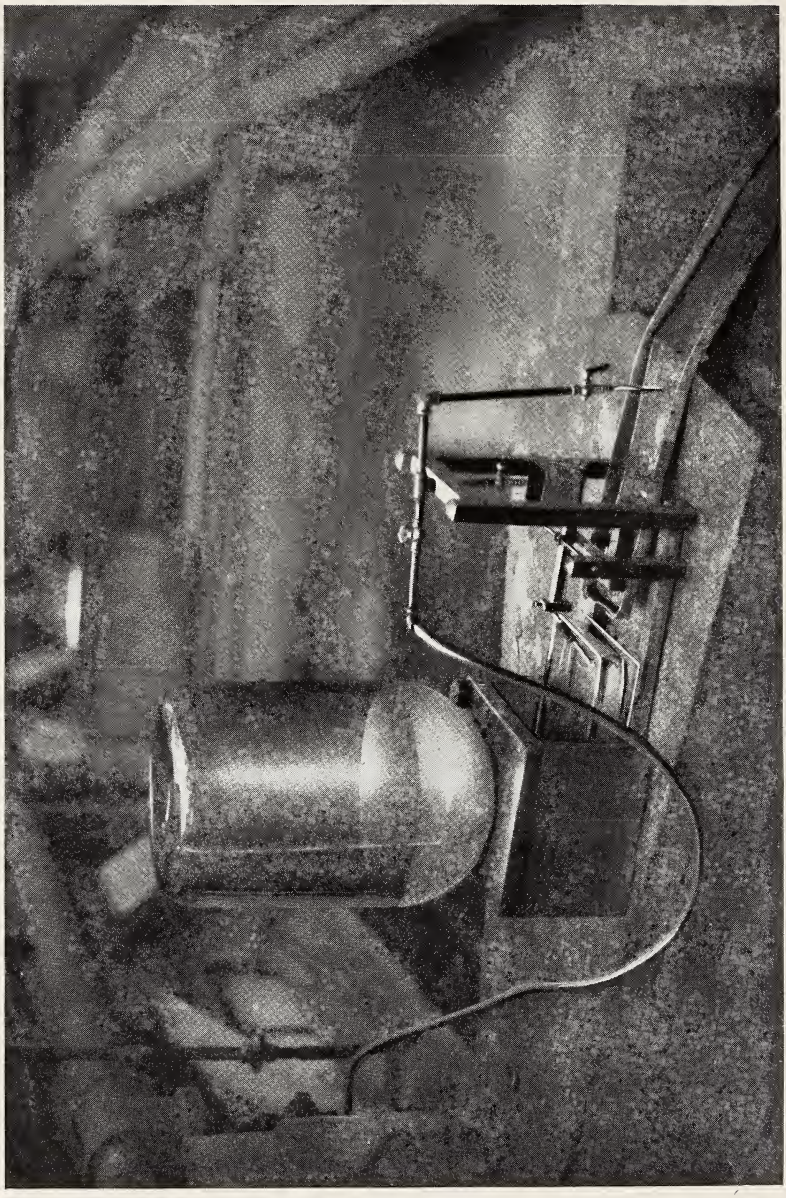

Fig. 342. Chemical supply apparatus in operation. (From Breder 1930).

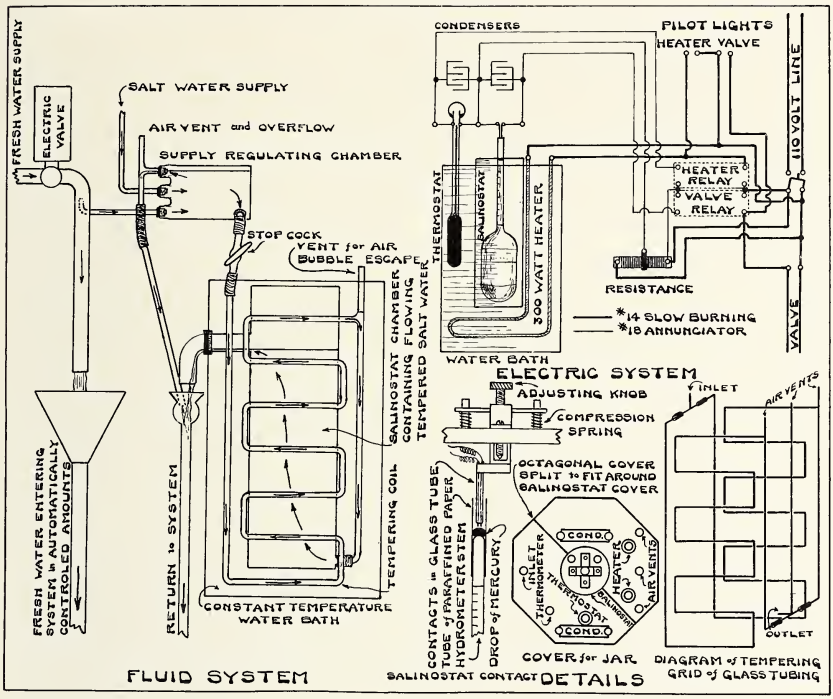

Fig. 343. Diagram and details of salinostat.

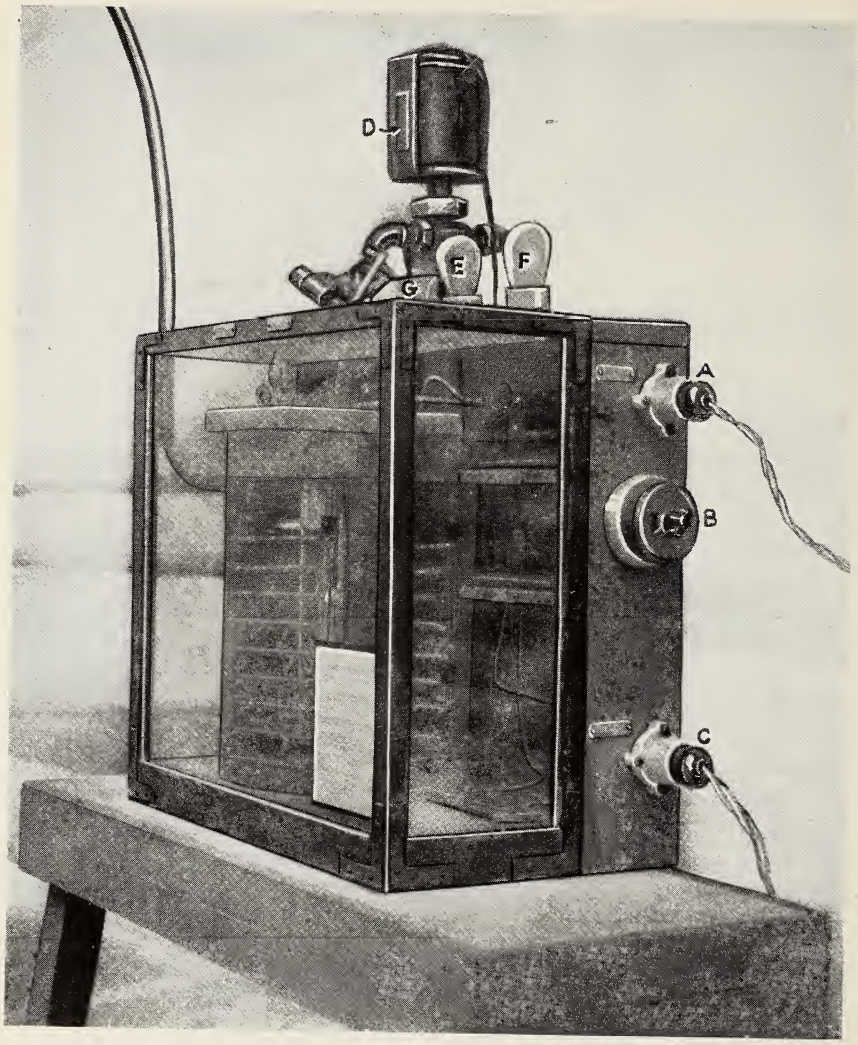

Fig. 344. Salinostat. A—110 volt line; B—Control Switch; C—Solenoid line; D—Solenoid valve; E—Heater pilot (yellow); F—Valve pilot (blue); G—Supply regulating chamber.

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VOLUME IX. NUMBER 12

THE FUR SEAL OF THE CALIFORNIA ISLANDS

WITH NEW DESCRIPTIVE AND HISTORICAL MATTER

By Charles Haskins Townsend

Director of the New York Aquarium

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THE FUR SEAL OF THE CALIFORNIA ISLANDS

WITH NEW DESCRIPTIVE AND HISTORICAL MATTER

By Charles Haskins Townsend

Fig. 345. California fur seal, *Arctocephalus townsendi*, Merriam. Painted by Carl Rungius from a specimen recently living in the Zoological Garden, San Diego, California, and now in the American Museum of Natural History.

Zoologica, Vol. IX, No. 12.

THE FUR SEAL OF THE CALIFORNIA ISLANDS

WITH NEW DESCRIPTIVE AND HISTORICAL MATTER

By Charles Haskins Townsend

Director of the New York Aquarium

(Figs. 345–356 incl.)

The re-appearance in 1928 of this long-missing species of the genus *Arctocephalus* is a matter of interest chiefly to naturalists. The fishery interests of our west coast have long since forgotten its former commercial importance.

It was once abundant from southern Lower California northward to the latitude of San Francisco. It was apparently the principal object of a sealing industry during the early part of the nineteenth century, which included also the taking of the northern elephant seal for its valuable oil.

The history of the sealing operations that so rapidly reduced its numbers is unfortunately fragmentary. Although taken in large numbers, it has not yet been shown that the value of the fur seal skins sold, exceeded that of the oil of the elephant seals taken in the same region during the same period. We only know that the capture of both species was conducted so persistently that their commercial importance amounted to but little after the middle of the century.

Exact information relative to fur sealing in this region earlier than the year 1806 has not yet been brought to light. In Mariner's history of the Tonga Islands, published in London in 1827, there is

a record showing that fur seals were being taken at the San Benita Islands in 1806. The *Port au Prince,* whaler and privateer, sailing from Gravesend, England, reached Ceros Island off Lower California on August 1, 1806. It was determined between the captain and the whaling master "that the *Port au Prince* should proceed for the Island of Ceros, to make up for her ill-success in her whaling cruise, by laying in a cargo of elephant oil and seal skins."—"She left Ceros on the 23rd August and on the 25th came to anchor at the Benita Islands, where she remained until the 15th of September, having salted and laid in 8,338 seal-skins." Another early record relates to the ship "*Dromio* of Boston, which in 1807, at "Shelvock Island," alleged to be southwest of Cape San Lucas, in latitude 21°, in a fortnight killed 3000 fur seals." The position of this island is unknown. It may have been Socorro Island where Morrell in 1825 observed "fur seals," but was without doubt an island of the Lower California region.

It is certain that the islands of Lower California were well known to whalers and sealers prior to the visit of the *Port au Prince* and had been exploited for both fur and elephant seals. "Many whalers, sealers and otter hunters between 1800 and 1825 frequented the west coast of Lower California."—"In some years there are reported to have been not less than thirty different whaling and sealing camps below San Diego, aggregating some 2000 men and as seals, and the affiliated families, are in the greatest abundance, cargoes are often prepared with great rapidity."[1]

The researches of Dr. E. C. Starks, respecting the identity of the fur seal formerly abundant at the Farallon Islands, have shown that the many thousands of seals taken there belonged to the genus *Arctocephalus* and could not have been the northern fur seal *Callotaria.*[2]

The records found by Dr. Starks account for the killing of 73,402 fur seals at the Farallons between 1810 and 1812. The taking of fur seals at these islands was continued from 1812 to 1824 by Russians who secured 1200 to 1500 skins annually for five or six years. "After 1818 the seals diminished rapidly until only 200 or 300 per year could be caught." From 1824 to 1833 sealing was carried

[1] J. Ross Browne, Lower California. 1859.

[2] Records of the Capture of Fur Seals on Land in California, Edwin C. Starks, Calif. Fish and Game. Vol. 8, No. 3, pp. 155–160. July, 1922.

on there, over 1,000 being taken the first year, the catch diminishing until only 54 were secured the last year. From this time until toward the close of the century, a few fur seals were taken from time to time on the Santa Barbara Islands.

The present writer's interest in the fur seal of this region did not begin until 1892, when he was sent by the Department of State to Guadalupe Island, Lower California, to identify the species of fur seal reported to exist there.[3] Only seven fur seals were seen—none of them on land and none were secured. The identity of the species was established, however, by Dr. C. Hart Merriam, who studied the four weather-worn skulls we found there and who described the species as *Arctocephalus townsendi*.[4]

Returning from Guadalupe Island, to San Diego, I interviewed certain persons who had formerly been engaged in sealing at Guadalupe and other islands of Lower California. The result of the inquiry was considerable information on the seal hunting which had brought this species so close to extermination. It appears from the records then secured that between 1876 and 1892 not less than 5,575 fur seals were taken at Guadalupe and San Benita islands.

Through the kindness of Mr. A. W. Anthony of San Diego, who was with me at Guadalupe in 1892, I have recently received extracts from a logbook kept by Captain George W. Chase, recording his voyages in search of fur seals to islands off Lower California. From 1878 to 1880 Captain Chase took 217 fur seals at Guadalupe Island. Of these 114 were sold at San Diego for $1,600. Another lot of 73 sold for $1,300. Interesting notes in Chase's log refer to eight other sealing vessels met with repeatedly during his cruises to Guadalupe, San Benita, Cerros, San Geronimo, San Roque and Asuncion islands. He makes no mention of catches made by these vessels, but frequently complains of their interference with his hunting and of the scarcity of fur seals.

The following records relative to fur sealing in Lower California waters, copied from San Diego newspapers of the years 1879 to 1881. have been received through the kindness of Mrs. Belle J. Benchley of the San Diego Zoological Society:

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[3] Notes on the Fur Seals of Guadalupe, the Galapagos and Lobos Islands. C. H. Townsend Rept. Fur Seal Ind. 1896–7. Pt. 3. pp. 265–70.

[4] A New Fur-Seal or Sea Bear. C. Hart Merriam. Proc. Biol. Soc. Wash. Vol. XI. pp. 175–178.

1879. Schooner *Ellen.* Joe Burges, master, arrived September 27 "with 150 skins."

1879. Sloop *Annie Herring.* J. M. Niles, master; arrived November 16, with "a catch for which $950. has been offered."

1880. Schooner *John Stillson.* Joe Peterson, master, arrived January 13, "seal skins."

1880. Sloop *Annie Herring.* J. M. Niles, master, arrived January 24 with a "hundred or more fur seal skins."

1880. Sloop *Isabelle.* W. J. England, master, arrived June 9 with "a cargo of seal skins and oil." A portion of the catch was sold for $1600.

1880. Schooner *John Stillson.* Joe Peterson, master, arrived July 6 "with some two hundred fur seal skins and several fine sea otters."

1880. Schooner *Ellen.* Joe Burges, master, arrived July 27 "with a catch of four hundred seal skins."

1880. Schooner *Anastasia.* Cashman, master, arrived August 14 from Guadalupe Island, "with a cargo of seal skins."

1881. Sloop *Brisk.* Jones, master, arrived March 22, "laden with seal skins."

1881. Schooner *Liberty.* Arrived April 20, "with a lot of fur seal skins."

1881. Sloop *Isabella.* W. J. England, master, arrived July 6 from Guadalupe Island with "fur seal skins and sea elephant oil."

1881. Sloop *Brisk.* Jones, master, arrived July 10, "with a cargo of seal skins."

There are in connection with the above records, those of five other sealing vessels reported as arriving but no mention is made of catch. All are of interest as showing that the hunting of fur seals in Lower California waters was practiced during the period covered by the records.

The total number of seal skins taken by these twelve vessels is unknown. Four of them, *Ellen, Herring* and *Stillson* as shown above, reported catches to the number of 850. If the other eight voyages yielded skins at the same rate, we might assume a total of 2550 seal skins for the above mentioned vessels.

There appears to be no information relative to the existence of this seal subsequent to the year 1894 and it was supposed to be extinct. It was a matter of decided interest to naturalists when the San Diego Zoological Garden received two adult males on April 25, 1928.[5] They were captured at Guadalupe Island by Capt. Wm. O. Clover, and I had the opportunity of examining them shortly after

[5] The Guadalupe Fur Seal. Harry W. Wegeforth. San Diego Zoonooz. May–June, 1928. pp. 4–9.

they were brought to San Diego. Previous acquaintance with fur seals of the genus *Arctocephalus* in the Straits of Magellan, enabled me to confirm at once the identification of those from Guadalupe Island. Both were full grown, each having developed the grizzled mane of the adult fur seal. Both animals had the flattened head and sharply-pointed nose that so readily distinguishes *Arctocephalus* from the northern genus *Callotaria.*

Many photographs of the two seals were made by direction of Dr. H. M. Wegeforth, president of the San Diego Zoological Society, to whom I am indebted for those reproduced here, and also for the skin and skeleton of one of the seals which died in 1929.[6]

The species described by Merriam having been based on weather-worn and imperfect skulls, may now be described more fully from a perfect skull and skin—the first available for the purpose.

Fortunately the carcase of this seal had been carefully measured by Dr. R. A. Whiting, pathologist of the San Diego Zoological Society. Its weight at death was 221 pounds. These measurements, as compared with those of a freshly-killed, seven-year-old, Pribilof male, weighing 319 pounds, indicate that it was of rather smaller size. During its decline it lost greatly in weight, and it may have been somewhat younger than the Pribilof animal.

The skull has been compared with other adult skulls of *Arctocephalus* collected by me in the Straits of Magellan and at the Galapagos Islands in 1888. The characters pointed out by Merriam in the examination of the weatherworn type skull, hold good in the fresh and perfect specimen—especially in the narrow palate, flattened bullae and broad zygomatic root of maxilla.

Measurements of Perfect Skull of Male

Arctocephalus townsendi, Merriam:[7]

Greatest basal length, 248 mm.
Same in skull from Straits of Magellan, 258 mm.
Same in skull from Galapagos Islands, 265 mm.
Basal length (gnathion to basion), 233 mm.
Basilar length of Hensel (basion to incisors), 223 mm.
Palatine length (gnathion to postpalatal notch), 120 mm.

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[6] Skin and skeleton now in Am. Museum of Natural History, New York.
[7] Measurements by C. H. Townsend and H. E. Anthony.

Postpalatal length (postpalatal notch to basion), 113 mm.
Zygomatic breadth, 135 mm.
Lateral series of teeth (canine to last molar inclusive), 88 mm.
Same in skull from Straits of Magellan, 77 mm.
Same in skull from Galapagos Islands, 84 mm.
Distance between canines, 20.5 mm.
Distance between 3rd pair of molariform teeth, 23 mm.
Same in skull from Straits of Magellan, 31 mm.
Same in skull from Galapagos Islands, 30 mm.
Breadth (anteroposterior) of zygomatic root of maxilla between inferior lip of antorbital foramen and orbit, 18 mm.
Same in skull from Straits of Magellan, 15 mm.
Same in skull from Galapagos Islands, 16.5 mm.
Least interorbital breadth (anterior to supraorbital processes), 24 mm.
Least interorbital breadth (posterior to supraorbital processes), 21 mm.
Breadth across supraorbital processes, 47 mm.
Greatest length of nasals (nasals lost in type specimen), 38 mm.
Same in skull from Straits of Magellan, 46 mm.
Anterior breadth of nasals, 27 mm.
Same in skull from Straits of Magellan, 25 mm.
Breadth of rostrum (in plane of 2nd molar), 46 mm.
Mastoid breadth, 119 mm.
Breadth of brain case at fronto-parietal suture, 81 mm.
Greatest length of ramus, 172 mm.
Length of mandibular tooth row from incisors, 82 mm.
Same in skull from Straits of Magellan, 75 mm.

The skull from the Galapagos Islands (*Arctocephalus philippii*), has a very high sagittal crest—25 mm. at greatest height.

The crest is absent in skulls from Guadalupe Island (*A. townsendi*) and Straits of Magellan (*A. australis*).

Measurements of the Carcase (Male, weight 221 pounds)[8]

Dorsal length, tip of nose to tip of tail, 71½ inches.
Ventral length, tip of lower lip to tail, 64 inches.
Girth of head around eyes, 14 inches.
Girth at neck immediately behind ears, 25½ inches.
Girth at shoulders, 45 inches.
Girth at axillae within lateral flippers, 47 inches.
Girth at tip of lateral flippers, 39 inches.
Girth, at base of tail, just anterior to rear flippers, 20½ inches.
Length lateral flippers, axilla to flipper tip, 20½ inches.
Girth of lateral flipper at shoulder, 12½ inches.
Length rear flippers, base of tail to flipper tip 16 inches.

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[8] Measurements by Dr. R. A. Whiting, Pathologist, Zool. Soc. of San Diego.

ADDITIONAL MEASUREMENTS (From the Half-dried Skin)[9]

Length of tail, including hairs on tip, 63 mm.
Length of bare surface of fore flipper—anterior border, 305 mm.
Length of bare surface of fore flipper—posterior border, 292 mm.
Breadth of fore flipper at 4th claw, 146 mm.
Length of exposed scratching claws—hind flipper, 32 mm.

Color. Body with buff underfur, which on top of head and back has a length of 1 cm.

Hair of body dusky black, grayish on head and shoulders. Gray of head extending forward to between eyes and to below ears. Color of belly not so dark as back. Length of hair on head and back 3.5 cm. Skin of nose dusky black. Short hair of face rufous, extending around eyes. Short hair at base of fore limb rufous. Bristles about twenty, ivory white, longest 7.9 cm. Length of ear 3.2 cm.

While the general appearance of the living animal is not unlike that of the adult male seal of the Pribilofs, it is instantly distinguishable by the more flattened head and the longer and more sharply pointed snout. This is characteristic of other species of *Arctocephalus* and is apparent in the accompanying photograph of a female fur seal from the Cape of Good Hope (*Arctocephalus capensis*) now living in the New York Zoological Park. The photographs of the northern fur seal (*Callotaria ursina*) are presented for comparison.

Little is known of the habits of the California fur seal. Like the equatorial species (*Arctocephalus philippi*) of the Galapagos Islands, it had the habit of occupying caves along the shore line. Sealers killed many in such places, often using lanterns to locate the animals.

It appears that the young were born in June and July. The limited numbers of fur seals recently ascertained to frequent the shores of Guadalupe Island, are apparently moving to some extent about the former range of the species. Recent reports by fishermen, of fur seals seen in the vicinity of the Santa Barbara Islands *in summer,* must relate to the California fur seal and not the Alaskan species which resorts to Bering Sea in summer.

It is unfortunate that the convention providing for the preservation of the northern fur seal, does not protect the California species south of the thirtieth parallel of north latitude and thus include Guadalupe Island some fifty miles farther south. Its preser-

[9] Measurements by C. H. Townsend.

vation there must depend chiefly upon the effectiveness of the regulations established by the government of Mexico.

The remnant of this species still in existence was roughly estimated at about sixty animals when discovered in 1928. It represents a resource worth preservation.

The immensely valuable fur seal herd of the Pribilof Islands, as a result of long-continued pelagic sealing, became reduced to less than 125,000 animals by the year 1911. It has, under the protection afforded by the North Pacific Sealing Convention of that year, already increased to more than a million seals and the killing of surplus males for commercial purposes has been resumed.

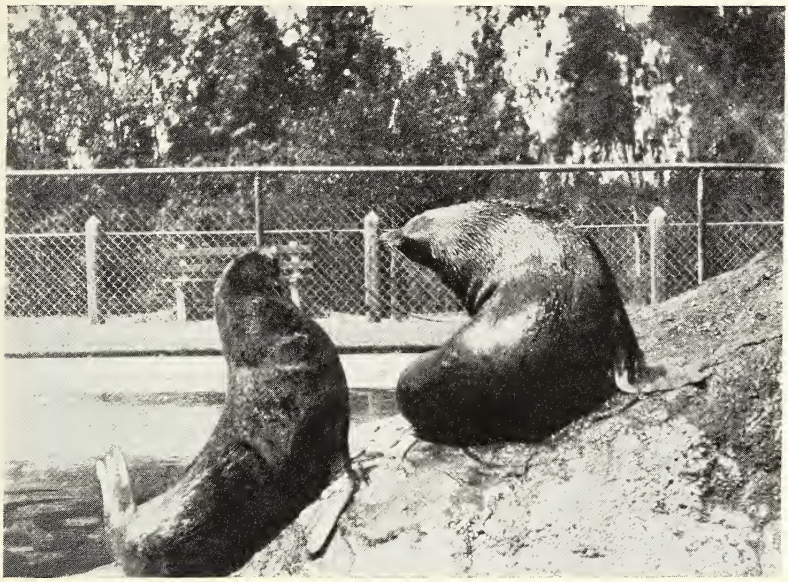

Fig. 346. *Upper.* California fur seal. *Arctocephalus townsendi,* Merriam. Adult males. Zoological Garden, San Diego, California. The first known specimens in captivity. Fig. 347. *Lower.* California fur seal, *Arctocephalus townsendi,* Merriam. Adult male. Zoological Garden, San Diego, California

Fig. 348. *Upper.* California fur seal, *Arctocephalus townsendi*, Merriam. Adult male. Zoological Garden, San Diego, California. Fig. 349. *Lower.* California fur seal, *Arctocephalus townsendi*, Merriam. Adult male.

Fig. 350. *Upper.* Shore of Guadalupe Island, where two fur seals were captured in April, 1928. Fig. 351. *Lower.* Cape fur seal, *Arctocephalus capensis.* Female. Cape of Good Hope. From a specimen living in the New York Zoological Park.

Fig. 352. *Upper.* Northern fur seal, *Callotaria ursina.* Adult male. Pribilof Islands, Bering Sea. Fig. 352. *Lower.* Northern fur seal, *Callotaria ursina.* Adult male. Pribilof Islands, Bering Sea.

Fig. 354. *Arctocephalus townsendi*, Merriam. Guadalupe Island, Lower California. 1928. Adult male. Photograph from the American Museum of Natural History.

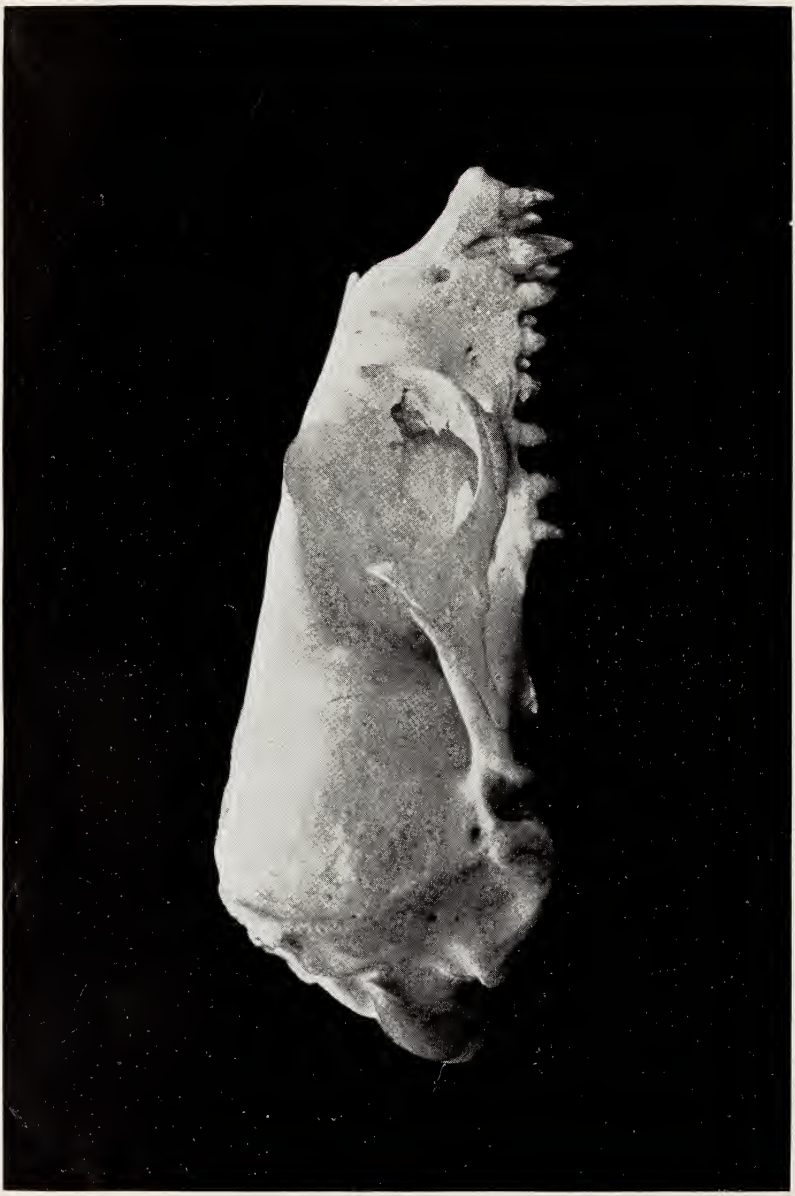

Fig. 355. *Arctocephalus townsendi*, Merriam. Guadalupe Island, Lower California. 1928. Adult male. Photograph from the American Museum of Natural History.

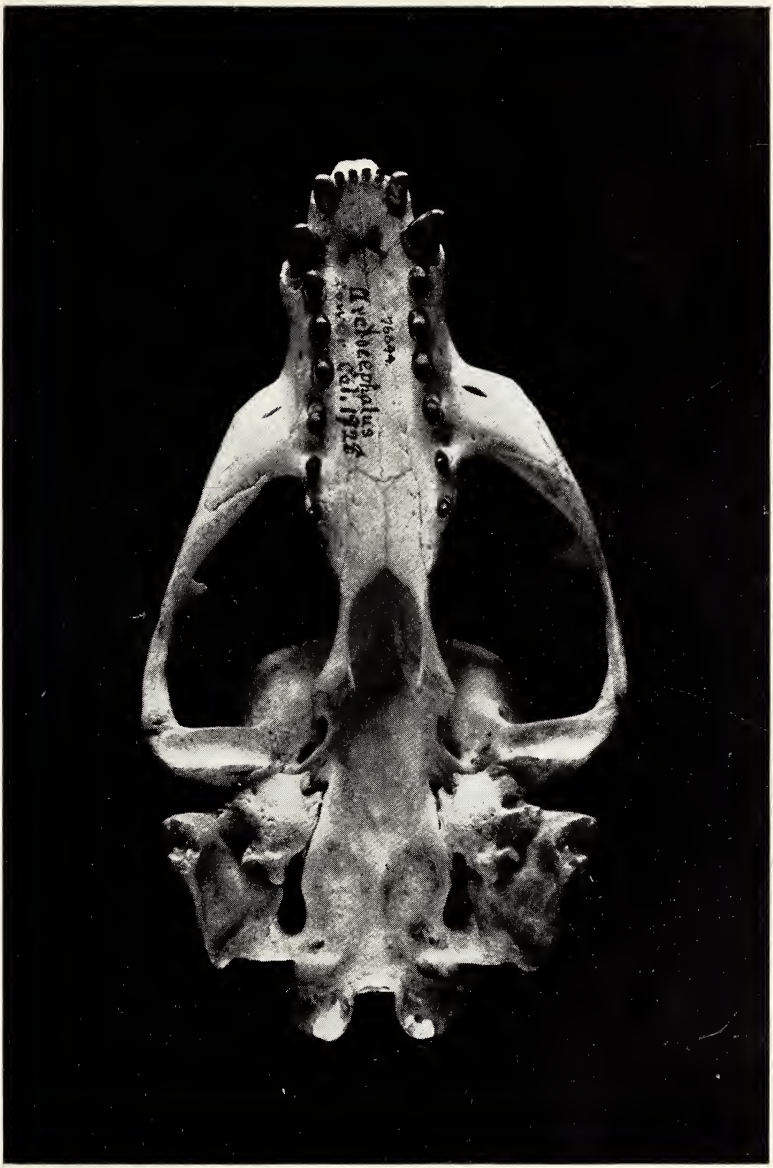

Fig. 356. *Arctocephalus townsendi*, Merriam. Guadalupe Island, Lower California. 1928. Adult male. Photogrpah from the American Museum of Natural History.
Zoologica, Vol. IX, No. 12

New York Zoological Society

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VOLUME IX. NUMBER 13

GROWTH AND AGE IN THE GIANT TORTOISE OF THE GALAPAGOS

By Charles Haskins Townsend
Director of the New York Aquarium

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GROWTH AND AGE IN THE GIANT TORTOISE OF THE GALAPAGOS

By Charles Haskins Townsend

Director of the New York Aquarium

(Figs. 357–369 incl.)

The tortoises brought from the Galapagos Islands in 1928 under the auspices of the New York Zoological Society, were located in small colonies at several points near the southern boundary of the United States, and also in the Bermuda and Hawaiian Islands. All are of the same species, *Testudo vicina.*

The object in view was their propagation under various climatic conditions supposed to be favorable. Tortoises from the Galapagos, mostly specimens of large size, had long been kept in zoological gardens in Europe and in our northern states, where being housed for many months in winter and otherwise confined, they had never bred.

During a period of more than three centuries, tortoises were taken from the Galapagos Islands in great numbers to be used as food on vessels cruising in that part of the Pacific Ocean. By the end of the nineteenth century they had disappeared from most of the smaller islands of the group and from the coastal regions of the larger islands. It was known that the introduction of dogs, pigs, cats and rats by settlers on the Galapagos, had caused the destruction of eggs and newly-hatched young of the tortoises so that there was little or no increase. The settlers have been eating them for a hundred years and continue to do so.

Learning that tortoises were probably obtainable in the mountains of Albemarle the largest of the islands, the writer was authorized to secure if possible, specimens for propagation elsewhere. The number secured being much greater than was expected, they were distributed more widely than was originally intended, with the result that some localities proved to be less favorable for this tropical animal than others.

It was therefore found desirable to transfer many of the tortoises located in the southwestern states to southern Florida, where housing in winter seems to be unnecessary. Although occasional frosts occur at three of the four stations in southern Florida, one colony is located at Lignum Vitae among the islands farther south, entirely beyond any record of frost. The colonies in Bermuda and Hawaii are well placed. The tortoises composing them have made rapid growth and have suffered no losses in numbers. The Bermuda colony of ten young tortoises having a total weight of sixty-six pounds in 1928, now (1930) weighs 175 pounds. The colony of six larger tortoises at Honolulu weighing 159 pounds in 1929, has at present (1930) a total weight of 378 pounds.[1]

The growth made by tortoises located in the southern states has been as follows:

Place	*Number of tortoises*	*Average lbs. 1928*	*Total lbs. 1928*	*Total lbs. 1930*	*Increase (%)*
Brighton, Fla.	5	7	35	135	286
Opa-Locka, Fla.	5	8	42	127	202
Biscayne Is., Fla.	18	18	334	602	80
Lignum Vitae Is., Fla.	8	31	248	519	109
New Orleans, La.	7	14	100	286	186
Houston, Texas	14	13	192	709	269
San Antonio, Texas	8	14	111	316	185
Superior, Ariz.	3	23	71	118	66
San Diego, Calif.	19	25	479	1041	117

An examination of the above table shows an uneven rate of growth, which requires explanation. The conditions contributing to the results attained are traceable chiefly to climate and method of treatment. The tortoises located in the southern states outside of Florida, were with one exception kept on grassy ranges in zoological gardens, where in addition to grazing they had a variety of garden vegetables.

At Superior, Arizona, the tortoises had the range of a cactus grove in the Southwestern Arboretum and subsisted chiefly on the abundant prickly pears, very little other food being provided.

Coming from an equatorial island, and lacking the protection of either fur or feathers, it was soon discovered that these cold blooded animals required protection in winter at all of these places.

[1] On March 31, 1931, the weight of the Honolulu colony had increased to 434 pounds.

Although at first provided with accessible shelters the tortoises did not always seek them at night, with the result that there were early losses at some localities before complete winter housing was arranged for. Portions of these colonies have been removed to the milder climate of southern Florida. While protection in winter has proven a safeguard for those left at the original stations, this practice may not be favorable to reproduction. It is apparent that the best conditions for growth and increase in numbers cannot be expected within the limits of the United States, except in southern Florida.

At Lignum Vitae Island in latitude 25°, well below the frost line, the tortoises have subsisted entirely on the numerous kinds of grasses found there. The moderate growth so attained is assumed to be normal. It has been stimulated among those located in zoological gardens where regular feeding of vegetables in addition to grazing was practiced.

Reports on the colony of tortoises presented to the Zoological Society of Sydney, Australia, have not yet been received.

The most important record of growth within our borders is that of a Galapagos tortoise kept at Riverside in one of the interior valleys of southern California. This tortoise (Fig. 357) weighing twenty-nine pounds in 1899, reached a weight of 350 pounds in seven years, or nearly twelve times the earlier weight. Its later growth was slower as it gained only sixty-five pounds during the next seven years. This animal was kept summer and winter in a yard sixty feet square and provided with a small shed which it habitually sought for shelter. There was no opportunity for grazing but it must have been well fed. Because of the presence of a cow, the trampled yard became muddy in winter. The tortoise died in 1914 (Fig. 357). Mr. Edmund Heller, to whom it belonged, says that if it had been kept on dry ground it would probably be alive today. It attained large size while young but unfavorable conditions account in part for the limited growth made during the latter part of its life. Large tortoises grow slowly; the young rapidly.

Climatic conditions at Riverside are apparently more favorable than at San Diego, located on the coast in the same State and frequently exposed to chilly sea winds and at times to frosty weather. Post-mortem examinations show that the losses here were from enteritis, the well-fed tortoises failing to seek shelter after the day's grazing, were too cold at night for digestion to proceed.

A Galapagos tortoise (*T. vicina*) a male weighing 140 pounds was received at the New York Zoological Park in 1904. During the next twenty-five years its growth was slow, the present weight being but 305 pounds. (Fig. 358). Its condition is similar to that of other Galapagos tortoises confined within doors during more than half of the year. Its plates are worn smooth, due apparently to the habit the tortoises have of crawling over each other in moving about the pen. Its rings cannot now be counted. It has never had a mate. The growth of several very young tortoises (*T. vicina*) still retained at the New York Zoological Park, has been negligible as compared with those located in the South. Although most comfortably housed in winter, they have not had the advantage of grazing in summer which we now know is conducive to rapid growth. This defect in treatment will doubtless be corrected with the return of summer.

The following shows the character of the records being kept at each locality where tortoises have been placed:

No.	LENGTH Straight	LENGTH Curved	WIDTH Straight	WIDTH Curved	Height	wt. lbs. June 18 1928	wt. lbs. Mar. 8 1929	wt. lbs. July 11 1930
90	13⅛	17½	11	17¼	7¼	13¾	21	44
91	12½	15¾	9½	14⅝	5⅞	10	15	39
92	11⅛	14½	8½	13¼	5¼	7	12	35
93	12	15¾	9¼	14¾	6	8	13½	45
94	11¾	14⅝	8⅞	14	5⅝	7⅞	16	39
95	12¼	15½	9½	15	6	10	15	40
96	13¼	17¾	10¾	17¼	6¾	12	23½	61
98	10¾	13½	8½	13	5⅛	7¾	17	47
99	12½	15¾	9⅝	15¼	6⅛	10	15	46
100	11⅝	15	9⅛	14½	5¾	9	14	47
101	12	15	6½	14¾	5⅞	8	13	32
102	11½	13⅝	8¾	13¼	5	8	16	28
103	12⅛	15¾	10	15½	6½	10¼	19	40
104	24	29¾	18⅛	29¾	12¼	71	98	166
						192⅝	308	709

This colony is in the Zoological Garden at Houston, Texas. Weighed and measured in the New York Zoological Park before shipment in 1928.

It will be seen that the hope of propagating the giant tortoise is based on conditions involving captivity and control. It would be

difficult at the present time to liberate tortoises anywhere with expectation of safety for the young. The amazing numbers and great size attained on the Galapagos Islands was the natural result of absence of enemies of the young. Such a condition no longer obtains on those islands where introduced predatory animals now abound.

When the half-grown tortoises now ranging widely on Lignum Vitae Island attain breeding size, they will require the same protection as those located elsewhere under control and will probably be removed. Otherwise, the newly-hatched young would be decimated by the raccoons and other predators abounding there. It is doubtful if more than a very small proportion of the newly-hatched young of any of our native tortoises escape the smaller carnivorous mammals and birds of prey. The larger snakes may also destroy them. The natives say that the Galapagos hawk feeds to some extent on baby tortoises.

The breeding age of the giant tortoise is unknown. Our largest specimens in the South do not weigh more than one hundred pounds. Observations are being made. When mating occurs and the digging of nests is seen, the nests will be closely protected with wire and the tender young removed to safe quarters.

Age.—The age of the giant tortoise while comparatively young seems to be traceable in the striations of the horny plates of its carapace. We have one Galapagos tortoise, No. 190, the age of which is known within a year or two. It was taken to Guayaquil, Ecuador, when "small enough to be clasped in one hand." After "ten years" in that city, it was presented in 1930 to the writer who at once took it to his country home near New York for observation.[2] Its weight on July 1, was eighty pounds. Established on a grassy range and fed a variety of garden vegetables, its weight increased to ninety-one pounds by September 1, when it was taken to the Zoological Park for the winter. This tortoise, like those in northern Zoological gardens, was entirely black when placed on grass. Within a month, thin white lines of growth appeared around the margins of its plates, as shown in figure 359. By the end of another month the white margins had broadened into very conspicuous bands, as though the plates had been heavily outlined with chalk. This of course was not done. The tortoise then had the appearance shown

[2] Presented by Captain Murphy, Commanding *S. S. Buenaventura* of the Panama R. R. Steamship Line.

in figures 360, 361 and 362, the white bands being most pronounced between the costal and marginal plates. This tortoise may be regarded as an example of stimulated growth.

On March 18, 1931, we received a Galapagos tortoise (No. 191, Fig. 363) the age of which is also known.[3] Taken to Guayaquil when very small it was kept there for "fifteen years." Its weight upon arrival at New York was only eight pounds and its length (curved) of carapace fourteen inches. The very distinct growth rings on its plates number fifteen, corresponding with its reported age. This specimen, three years older than No. 190, but only a tenth of its weight, may have lived under conditions not favorable to growth. With the return of warm weather, it will have treatment similar to that under which tortoise No. 190 so rapidly attained weight.

Measurements of many tortoises show that growth in height is more rapid than growth in length. Assuming that the small smooth area in the center of each plate represents the first year's growth, it is not difficult to count with a lens on most of the plates of tortoise No. 190, eleven rings which seem to represent annual growth, not including the white ring acquired rapidly in 1930. Such counting of rings appears to confirm the statement of the original owner of the tortoise as to its age—now about twelve years. The rings are more readily discernible on the animal itself than in the photographs. In larger and older tortoises the striations tend to flatten out.

An examination of photographs of other tortoises of the same species reveals similar markings. Being of nearly the same size, and having the same number of rings, we assume that they are of about the same age. The large tortoise, No. 104 (Fig. 364) weighed seventy-one pounds when brought from the Galapagos in 1928. Its weight is less than that of No. 190 and it is slightly smaller.

The rings on its plates are fewer in number. Its age may be ten years. The younger tortoises around it have still fewer rings—six to eight. This colony is in Houston, Texas. An eighty-four-pound tortoise (*Testudo porteri*) was brought from Indefatigable Island, Galapagos, in 1930 by Mr. Vincent Astor. This is No. 187 (Fig. 365). Having about the same number of plate rings as No. 190 (*T. vicina*), its age should be about twelve years. The large tortoise referred to above (Fig. 357) weighing twenty-nine pounds when

[3] Presented by Mr. Wm. H. C. Castles, Purser of *S. S. Buenaventura* of the Panama R. R. Steamship Line.

captured, lived fourteen years in captivity. The rings on its plates seem to be about twenty in number, indicating approximately its age. The counting of such rings, except on very young tortoises, is about as difficult as counting them on the scales of salmon.

The smallest tortoise secured in 1928 (Fig. 366) and now in the New York Zoological Park had, when captured, a length of three and three-eighth inches (carapace) and a weight of three and three-fourth ounces. It then had two distinct rings in its plates. Its present length is four and one-half inches and its weight twelve ounces. It has now four rings which seem to indicate its age (Fig. 367).

It is not unlikely that the striations of the horny plates have already been considered as indicative of age in Galapagos tortoises, but we have not searched for literature on the subject. Coker has stated that "the markings of the horny scutes of the carapace and plastron compute with approximate certainty the ages of some terrapins of various sizes."[4] He presents reproductions of photographs that well support the statement.

The common supposition that large Galapagos tortoises must be of great age is unwarranted. Under natural conditions and especially under *favorable* climatic conditions in captivity, they reach a large size in a few years, when the rate of growth becomes slow. There are records of both Galapagos and Aldabra giant tortoises that lived under observation in tropical climates more than 150 years, when their lives ended upon removal to cold climates. The real length of life is unknown. Certain museum specimens known to have exceeded 500 pounds at death, were doubtless very old.

Note on Habits:—While being kept in a grassy yard, tortoise number 190 afforded an opportunity for observations on its habits. About an hour before sunset it headed into some nook or corner where the carapace could be pressed against something solid. The sod was then slowly scratched away until the animal rested with its plastron flat on the raw soil. This practice doubtless safe enough on the well-drained volcanic earth of the Galapagos and possibly there inducive to warmth, could not be allowed on damp ground in the North. Each evening the tortoise was pulled out of its newly made form and driven to a dry shed in the corner of its yard, where

[4] Cultivation of the Diamond-back Terrapin. R. E. Coker. North Carolina Geol. Surv. Bull. 14, 1906.

it burrowed under some straw. This procedure continued for about two weeks, when the tortoise habituated to the procedure or realizing that there was comfort in the shed, sought its warmth voluntarily. There were but few lapses into its inherited habit of scratching out a form in which to pass the night (Figs. 368–369).

While the giant tortoise pays little attention to ordinary sights and sounds, its sight and hearing cannot be defective. A noise made at the gate when vegetables were brought served to attract it to the spot. It could see a red tomato perhaps at a greater distance than any other vegetable thrown in its direction. It liked grazing on the open lawn. When not too far back in the high-walled yard, it could see the way out when the gate was opened quietly and lost little time in escaping.

Acknowledgments

The Zoological Society is indebted to the following named persons coöperating in the attempt to rear the giant tortoise in captivity: Dr. Harry M. Wegeforth, President Zoological Society, San Diego, California; Dr. F. J. Crider, Director Boyce Thompson Southwestern Arboretum, Superior, Arizona; Mr. A. H. Hanson, Superintendent of Parks, San Antonio, Texas; Mr. C. L. Brock, Superintendent of Parks, Houston, Texas; Mr. Marion Weis, President Zoological Society, New Orleans, Louisiana; Mr. James H. Bright, Hialeah, Florida, for facilities afforded in the small zoological gardens at Brighton and Opa-Locka; Mr. Hugh M. Matheson of Coconut Grove, Florida, for similar assistance at his properties on Biscayne and Lignum Vitae islands; Mr. L. L. Mowbray, The Flatts, Bermuda; The Commissioner of Parks, Honolulu, T. H. and the Secretary of the Zoological Garden, Sydney, Australia.

The following members of the Board of Managers of the New York Zoological Society contributed the fund of $6,000 which made possible the writer's search for tortoises: Robert S. Brewster, Bayard Dominick, Anson W. Hard, Anthony R. Kuser,* Irving K. Taylor and Henry D. Whiton.* Hon. Henry O'Malley, U. S. Commissioner of Fisheries authorized the use of the U. S. S. *Albatross II* for the voyage to the Galapagos in 1928.

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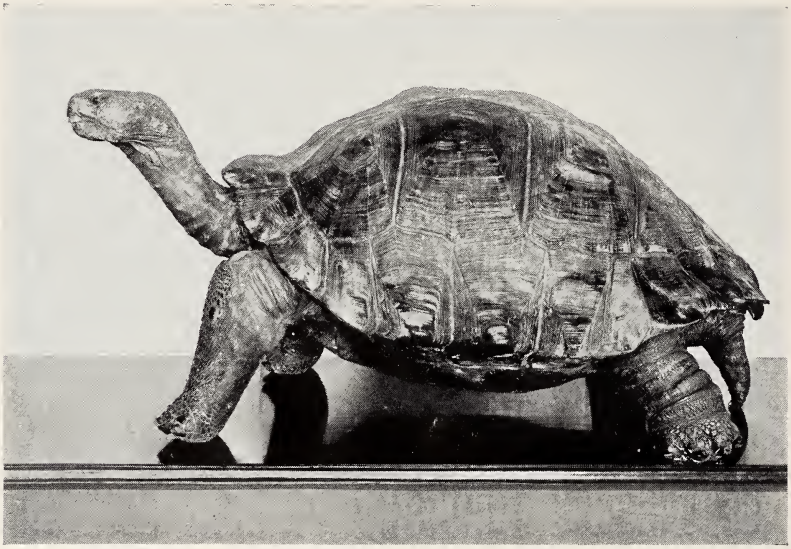
* Deceased.

GROWTH AND AGE IN THE GIANT TORTOISE OF THE GALAPAGOS

Series of Figures



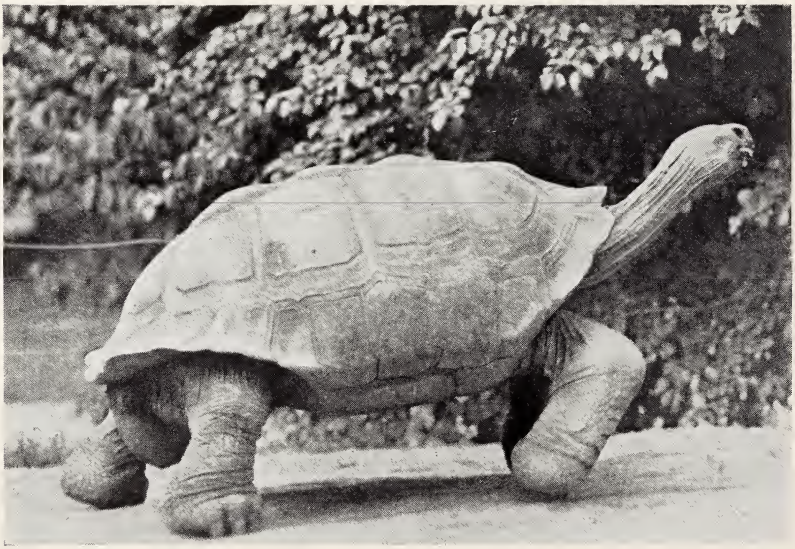
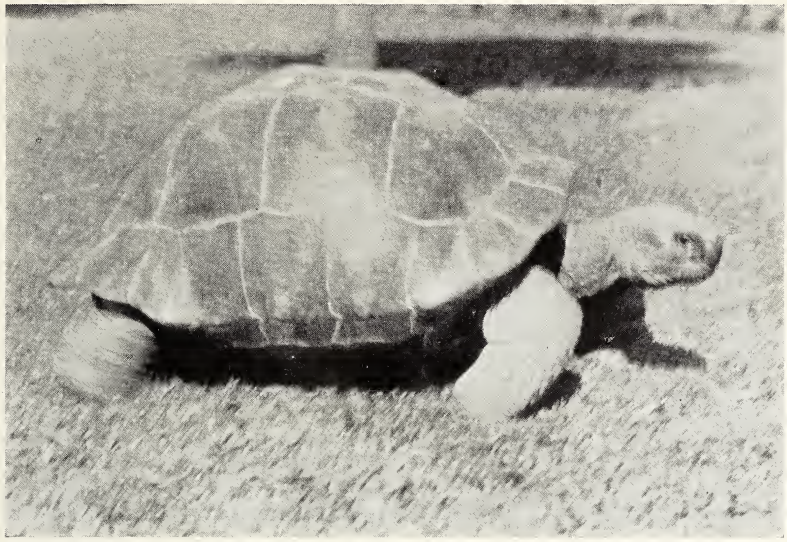


Fig. 357. *Upper: Testudo vicina,* Albemarle Island, Galapagos. Increased in weight over 300 pounds in seven years. Fig. 358. *Lower: Testudo vicina,* Albemarle Island, Galapagos. Increased in weight from 140 pounds in 1904, to 305 pounds in 1930. Kept in the New York Zoological Park.



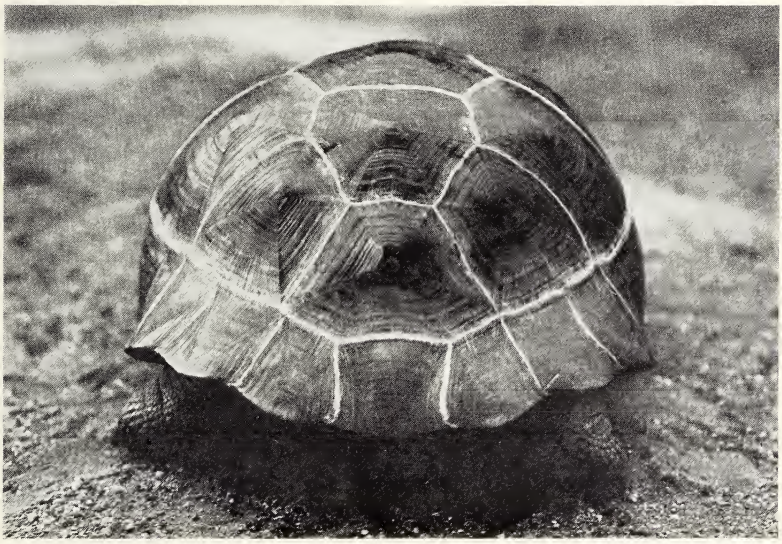


Fig. 359. *Upper:* Tortoise No. 190. Weight increased from 81 pounds to 91 pounds in two months. White margins of plates beginning to show at the end of first month. Fig. 360. *Lower:* Tortoise No. 190 after two months on a grassy range. Rings of growth on plates correspond with known age—12 years.

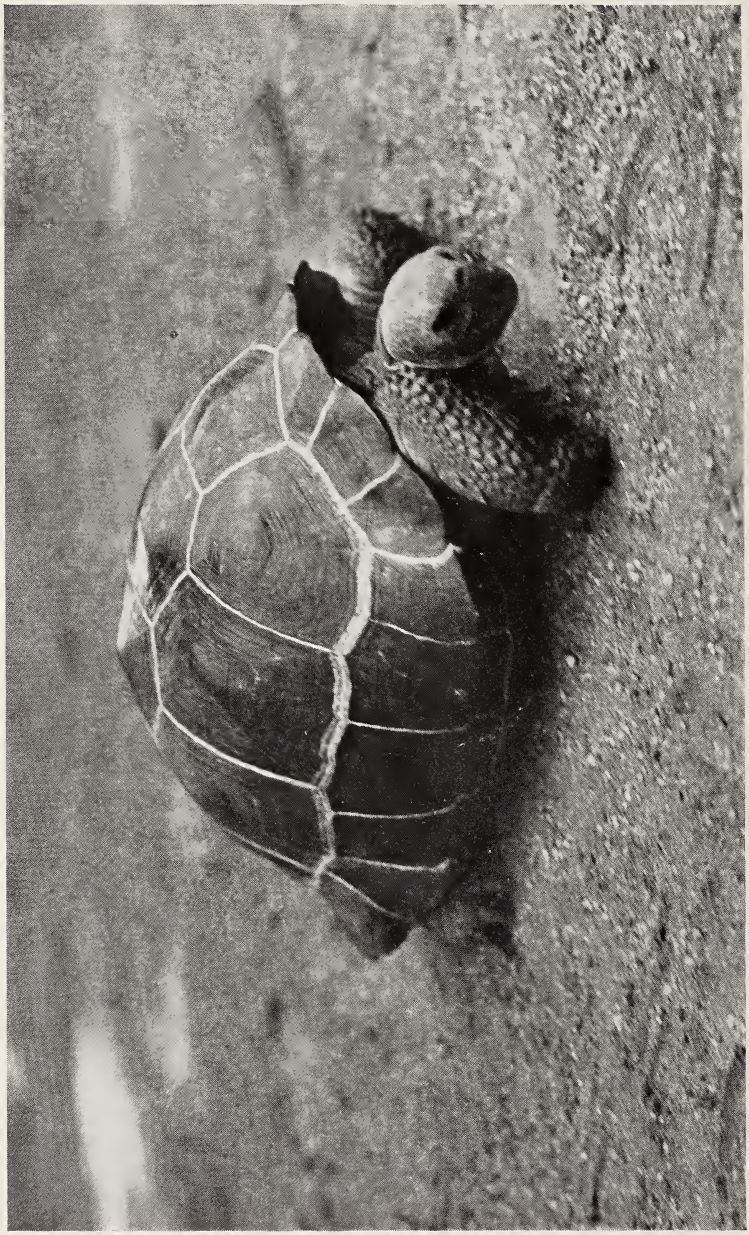
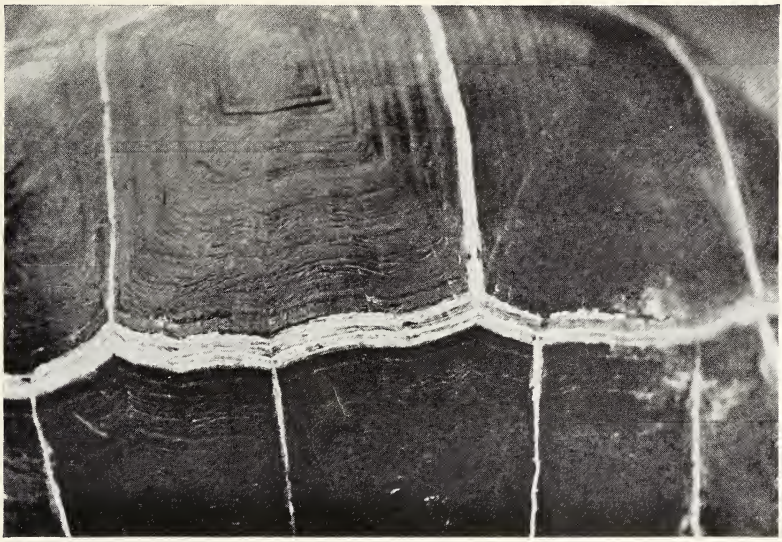


Fig. 361. Another view of Tortoise No. 190 after two months on a grassy range.



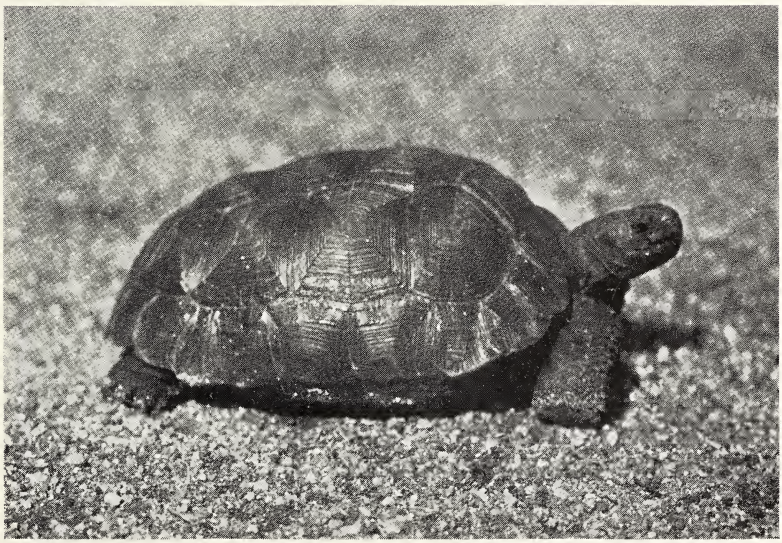
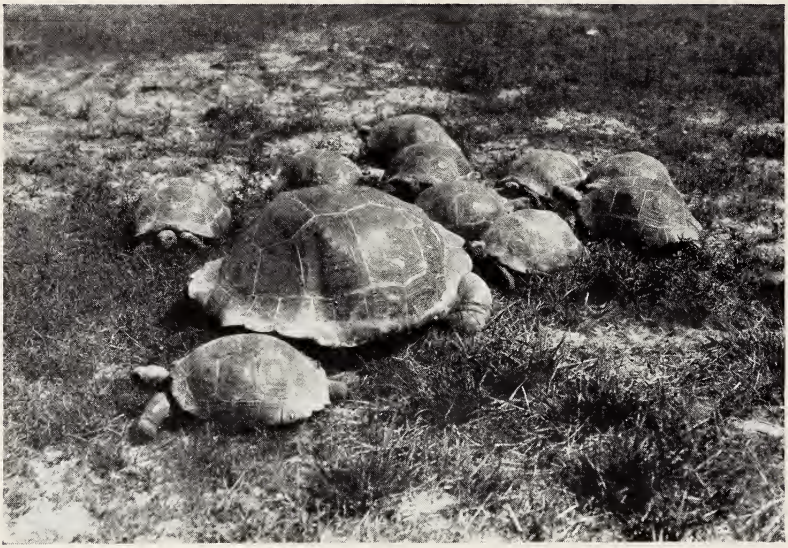


Fig. 362. *Upper:* Tortoise No. 190 after two months on a grassy range. White skin-growth between costal and marginal plates, one-quarter inch wide. Fig. 363. *Lower:* Galapagos tortoise, species not known. Raised in Guayaquil Ecuador, reported to be 15 years old.



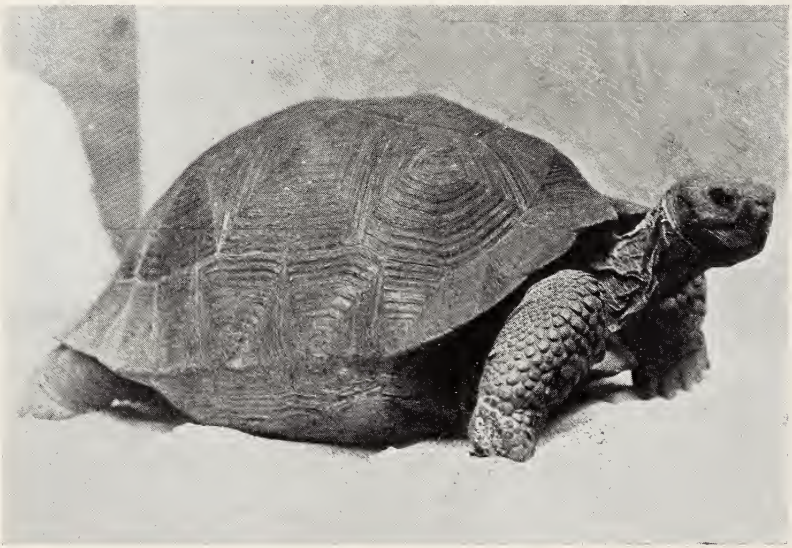


Fig. 364. *Upper:* Tortoise No. 104 (largest). Weight 71 pounds. About 10 years old. Rings on plates, 10. Fig. 365. *Lower:* Tortoise No. 187, *Testudo porteri*, Indefatigable Island, Galapagos. Same size as No. 190, with same number of rings. Should be the same age, 12 years.

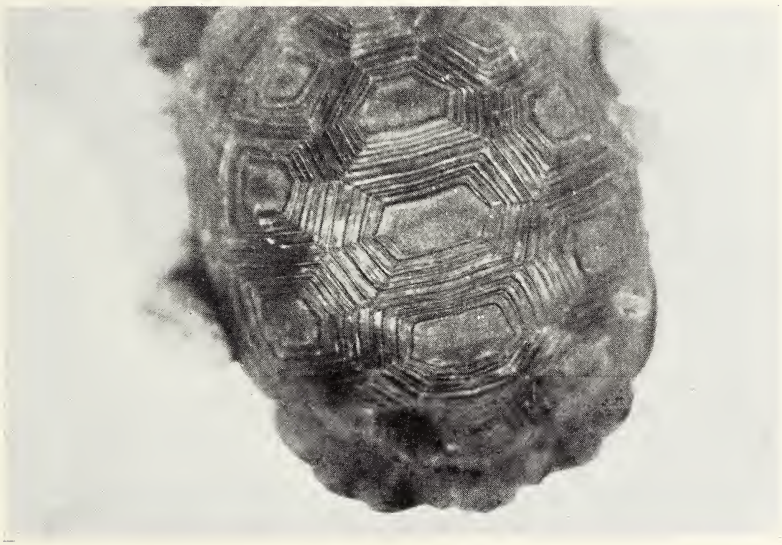


Fig. 366. *Upper: Testudo vicina*, with 2 growth rings on plates. Fig. 367. *Lower: Testudo vicina* (same as Fig. 366), but two years older, with 4 rings of growth on plates.

Fig. 368. *Upper:* Resting place of Tortoise No. 190 at night. Shows where the sod is scratched away. Fig. 369. *Lower:* Another night resting place, also shows where the tortoise scratched the sod away.

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VOLUME IX. NUMBER 14

A VOYAGE ON THE SEALER EMELINE

AND

THE JOURNAL

FROM WASHINGTON FOSDICK'S MANUSCRIPT PRESERVED IN THE MUSEUM OF THE OLD DARTMOUTH HISTORICAL SOCIETY AT NEW BEDFORD

Edited by

ARTHUR C. WATSON

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OUTLINE

(Figs. 369-382 incl.)

INTRODUCTION

A century ago, when the New England mariners lorded-it over the oceans, the seal rookeries of the high southern latitudes had become the particular province of the Connecticut and Long Island ports. "O, they are under-water fellows!" was said of crews from New London, Stonington, Mystic and Sag Harbor. Adventurers were never lacking to tempt the bleak Antarctic wastes, and neither were men of means to place their stakes on the dangerous enterprise. Among the vessels which took part in

this movement was the small sealing schooner *Emeline,* belonging to the fleet of Charles Mallory of Mystic.

The *Emeline's* 1843-44 voyage, under Capt. William Eldridge, embraces two high-rank adventures: the first, which was performed as scheduled, in the sea elephant hunt at the Crozettes; the second, which came unexpectedly, in the guano boom on the southwestern coast of Africa. Situations arose which drew out the pluck, the doggedness, and the impertinence in the Yankee character. Thousands of voyages like the *Emeline's,* taken as a composite picture, show a true splendor in the age.

The journal herein appearing was written by the steward of the *Emeline,* Washington Fosdick, a man with an education far superior to that of the average sealman or whaleman. What Fosdick's earlier life was like and why he chose the sea as a refuge are mysteries; for nearly thirty years he roamed the oceans in Connecticut sealers and New Bedford whalers, always in a steward's berth. His captains trusted him with important duties; he was relied upon as an expert navigator and he was always respected as an amateur physician.

The Antarctic Fisheries

The Antarctic seal fishery has always been considered a subsidiary of whaling. The two fisheries were closely allied in customs and traditions, and vessels sailing to the Far South often made what were called "mixed voyages." Moreover, it was due to the explorations of the pre-Revolutionary whalemen that the seal rookeries were discovered and that the oil and skins obtained from the amphibious mammals were brought to the attention of the New England and New York merchants. Under the general name of sealing, it is customary to include the hunt for the sea elephant as well as the fur-seal and hair-seal operations.

Sealing did not begin in earnest until after the close of the Revolutionary War, when a large number of vessels were fitted out to secure cargoes of fur-seal skins to carry to the Canton market. A period of indiscriminate slaughter began, due to the rapacity and jealousy of rival sealers. Even breeding females

and young cubs were killed without thought of the preservation of the species. The animals were slain by the millions on the Falklands, at South Georgia, off the southwestern coast of Africa, at Terra del Fuego, at Masafuera and Juan Fernandez, and at other minor places. Extermination came quickly in some spots, resulting in a zealous search for new rookeries. Certain sealing masters, more ambitious and more daring than their fellows, became explorers in the finest sense of the title.

In 1819 the apparently inexhaustible rookeries of the South Shetlands were opened, and the sealmen rejoiced over the prospect offered. Yet during the next two years the herds diminished with alarming rapidity. In an effort to find new grounds, Captain Nathaniel B. Palmer of Stonington left a fleet of thirty vessels at the South Shetlands and in his sloop *Hero* of only forty tons pushed further South. One day, when the fog lifted, he found himself in the company of two Russian warships on a discovery expedition. The Russians believed they had discovered new land, and the presence of the little Connecticut craft dismayed them. Out of respect for the Yankee, however, they offered to name the land for him, and a bleak spot in the Antarctic region still bears the name of Palmer's Land.

This episode indicates the bold but unassuming spirit characteristic of the fishery. The scenes of the principal sealing activities were on inhospitable coasts where the elements combined in hostility and practically defied the approach of mankind. Though the sealing season fell in the southern summer, yet the snowstorms continued, and gales blew with terrific force and treachery. Safe harbors were almost unknown; the black, rocky coasts, the strange currents, and the hidden reefs were constant perils. There were no charts, of course, in the early days of sealing, and, as the vessels were fitted out at a minimum expense, the nautical instruments were apt to be faulty.

When the fishery crystallized, the sealing masters ceased carrying their skins to China, but instead made voyages of a more regular character back and forth between their home ports and the South. Connecticut towns such as New London, Stonington and Mystic soon had almost exclusive control of the fur-seal fishery and continued to draw wealth from it until the late

1830's, when the increasing scarcity of the animals, accompanied by a falling-off in market prices, led the ship-owners to seek a variation in their enterprise.

This variation was a simple matter; it consisted in changing the cargoes from fur-seal skins to sea elephant oil. The Antarctic scene remained practically the same. There had been more or less demand for elephant oil during the fur-seal popularity, but the market did not encourage any concentration on elephant until nearly 1840—at exactly the most propitious time for the Connecticut ports.

Numbers of sea elephant were found in most of the places where the fur-seal resorted, but the more important elephant rookeries visited during the first years of the boom were at the Prince Edward group and the Crozettes. Later, these islands were virtually abandoned for the more abundant rookeries on Kerguelen Land (sometimes called Desolation Island) and Heard's Island. The sea elephant voyages brought excellent returns until the early 1870's. Before the decline definitely established itself, there was the same shortage of sea elephant as there had been, some forty years earlier, of fur-seals.

Time replenished the rookeries to some extent. In the 1870's New London experienced a renewed interest in fur-seal skins, and several vessels made satisfactory voyages in that fishery. Also, the Antarctic sea elephant fishery had a slight revival in New Bedford within the present century. Captain Benjamin D. Cleveland of that Massachusetts port made several voyages to the southern islands, principally to Kerguelen Land and South Georgia, between the years 1901 and 1917. His last voyage, made in the bark *Charles W. Morgan,* brought home a cargo worth $30,000. That was the end of Yankee sealing. Captain Cleveland considered himself too old for another season in the Antarctic, and the entire whaling industry had by that time all but completely vanished.[1]

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[1]The most complete survey of the Antarctic seal fisheries is that prepared by A. Howard Clark for the *Report of the U. S. Commission of Fish and Fisheries,* Government Printing Office, 1887.

The Crozettes

The first sealing operations at the Crozettes were in 1805 when Captain Henry Fanning visited the group in the ship *Catherine* of New York. The islands had been originally discovered by the navigator (the name was Crozet) whose name they bear, but, as he had merely observed the islands, without going ashore, the crew of the *Catherine* were presumably the first human beings ever to land.

The "re-discovery" of the Crozettes—for that was what Captain Fanning's visit really amounted to—was attended with much secrecy. The voyage was inspired by the little known records of Captain Crozet; his sailing directions, meager as they were, enabled the *Catherine* to find the islands. The abundance of fur-seals in the untouched rookeries gave promise of many rich voyages in the future, and Captain Fanning expected to preserve his discovery, at least for a season or two, from the general knowledge of the sealing fleet.

In accordance with instructions received before sailing from New York, Captain Fanning returned from the Crozettes to Prince Edward Island, at that time one of the important rendezvous of the sealers. Here he buried in a spot that had been previously designated the records necessary for sailing to the Crozettes, so that another vessel under the same ownership, due to arrive in the Antarctic the following season, would be able to profit by the discovery.

Captain Fanning then went back to the Crozettes, obtained a cargo of skins, and sailed with them for China. He experienced only one hitch in his plans and expectations, and that was the arrival of two other sealing vessels at the Crozettes, one from Boston and one from Hudson. But, as the masters of these vessels, too, were interested in keeping silent about the new rookeries, and as they were also headed for China, Captain Fanning's hopes for a continuation of the secret were not absolutely thwarted.

Rival sealing masters at Prince Edward Island, suspecting that Captain Fanning had discovered a new sealing ground, made every effort to ferret out the truth. They removed the

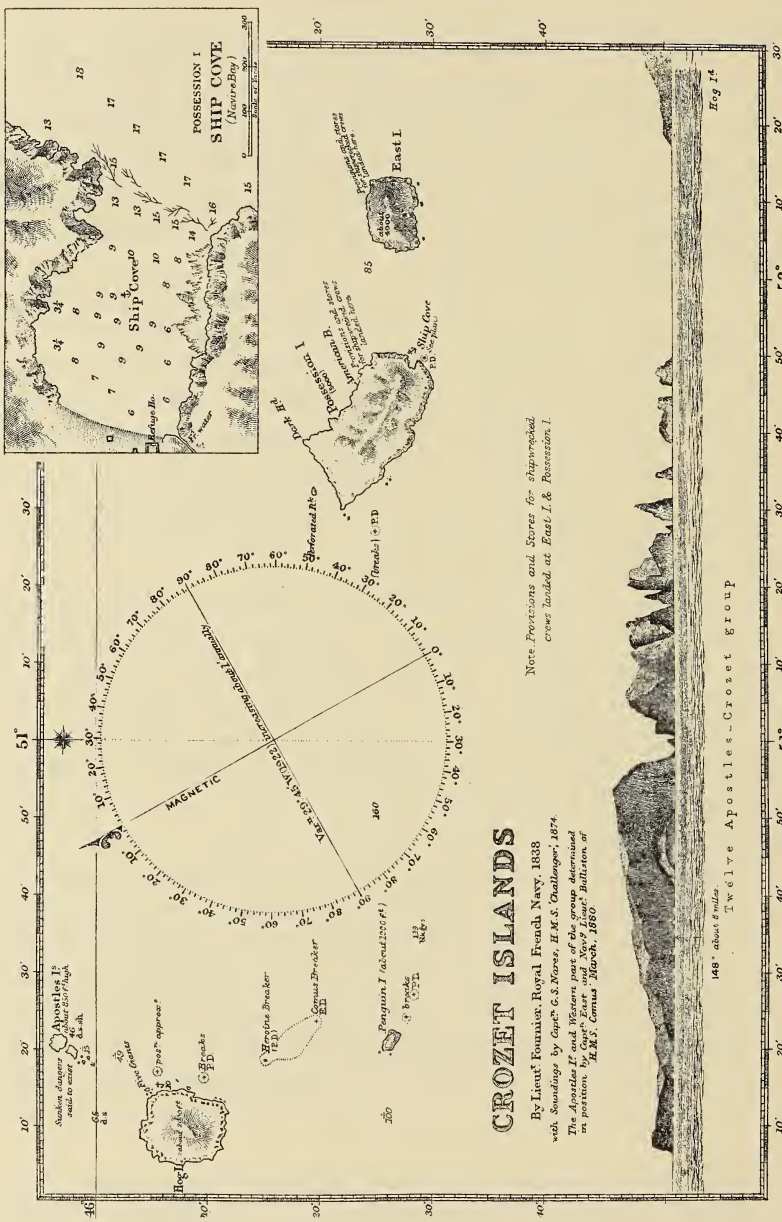

Fig. 369. The Crozet Islands 1400 miles south of Madagascar, Lat. S. 46 to 47, and the Twelve Apostles lying west of the Crozettes, by Lieutenant Fournier, Royal French Navy, 1838, with soundings by Cap't G. S. Nares, H. M. S. *Challenger*

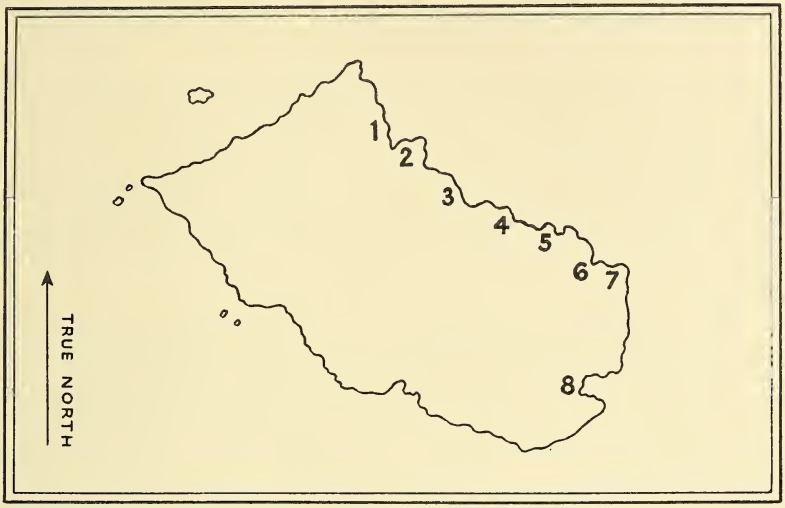

Fig. 370. Sketch map of Possession Island (Crozettes) showing the bays on the lee side. 1. Northwest Bay. 2. Hebe Bay. 3. Windy Bay. 4. American Bay. 5. Little American Bay. 6. Shallop Bay. 7. Boat Bay (?) 8. Ship Bay. Based on the account in Washington Fosdick's journal.*

cairn which Captain Fanning had erected near his buried papers, and they dug in various places. However, they were unsuccessful, and the records remained safely hidden until the vessel for which they were intended arrived according to schedule. When this vessel reached the Crozettes, a cargo of seal-skins was already waiting, for Captain Fanning, in following his instructions, had left a part of his crew to prepare this sort of welcome.

Of course the secret could not be kept very long, and soon the Crozettes became one of the more important centers of the fur-seal fishery and later of the sea elephant fishery. When the *Emeline* arrived there for the season of 1843-1844, the islands had long been worked as the common property of the sealmen.

*The best bay . . . . . is called Ship Bay, being the most southerly bay on the lee side . . . . The next bay to the northward is a small bay called Boat Bay, and a short distance from it another called Shallop Bay. The next bay is called Little American Bay; the next bay is called Little American Bay; the next American Bay, ... The next, Windy Bay, a very large bay. Beyond this, and around a very high bluff, is another bay called Hebe Bay, which is the most northerly bay worked, although there is another about a mile beyond called Northwest Bay, usually filled with elephants, which might be worked in westerly weather, but it is an ugly-looking hole.

"This group of islands so called," writes Washington Fosdick of the Crozettes,[2] "are five in number and are: Pig Island, Lat. 46. 15 S. and 50.00 E.; the Seven Apostles, Lat. 46.09 S. and Long. 49. 59 E.; Penguin Island, Lat. 46.30 S. and Long. 50. 14 E.; Possession Island, Lat. 46. 28 S. and Long. 51. 46 E.; and East Island, Lat. 46. 28 S. and Long. 52.00 E. (southwest point). There is also another laid down on some charts as Seal Island. No such island exists and is mistaken for the largest one of the Apostles.

"These islands are nothing but a pile of barren, dreary and desolate rocks where vegetation ceases—the haunt only of the wild sea-fowl and the resort of the harmless, careless, stupid sea elephant, in pursuit of which they are annually visited by several vessels from the United States. In all the bays which line these islands the elephant are found in great numbers from October to February, and from 2000 to 2500 barrels of oil have been taken by one vessel in one season. There is, however, a vast difference in the islands as to the number of elephants hauling upon the beaches, the facility with which they can be worked, and the safety to a vessel in mooring.

"All these islands have been worked at various times by a party of Englishmen from the Cape of Good Hope under the orders of an individual from that place, who has amassed a large fortune. In most of the bays, try-pots are found as well as works, and in some instances all the necessary apparatus for trying-out, together with huts for the use of those who should visit the bays for the purpose of elephanting—thus affording facilities for trying-out on shore or rafting off your oil to your ship, or trying-out on board, or in both places, as circumstances might warrant.

"Pig Island is the most noted of these islands, and an abundance of elephant are annually found here. The anchorage is an open roadstead, there being no good bay on this island to anchor in. There is also a very rapid current setting to the eastward, which makes the beaches on this island more difficult to work

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[2]This general description of the Crozettes is taken from material written down by Fosdick on some extra leaves of his journal and also from an article written by him for the New Bedford *Mercury*.

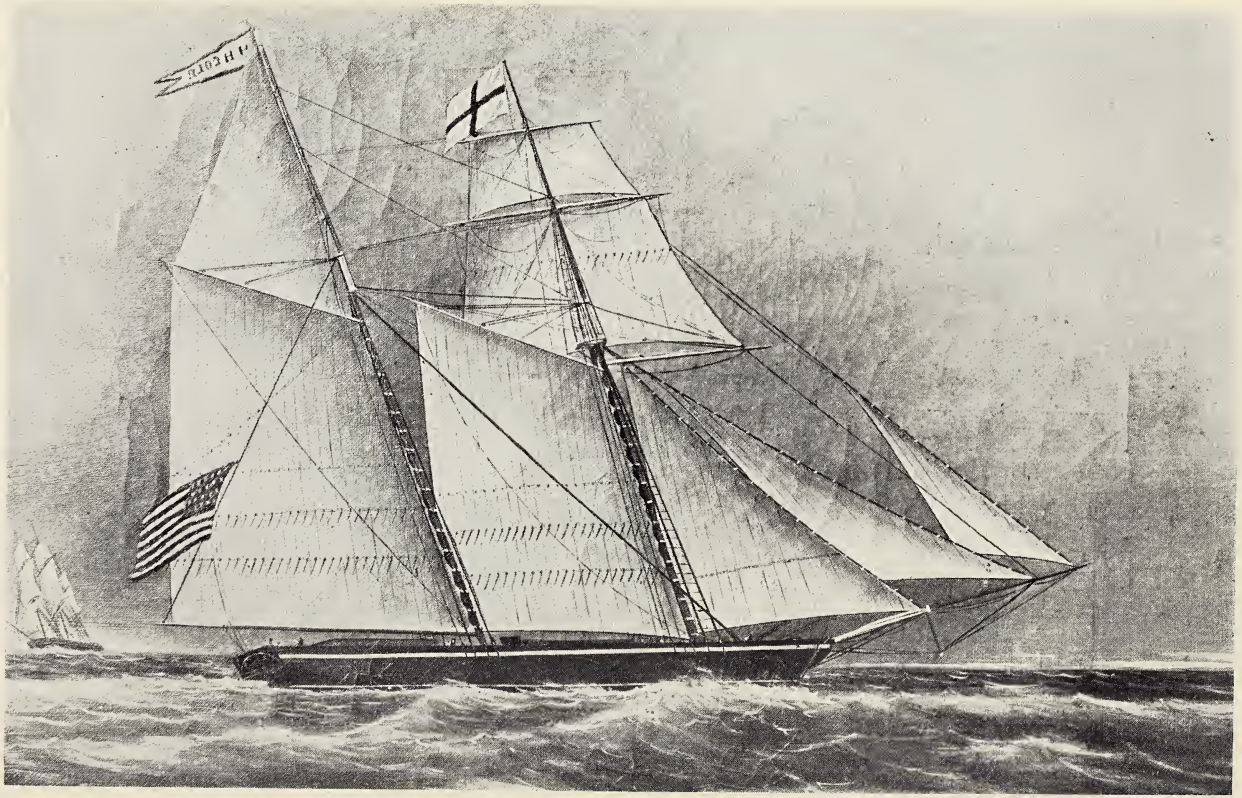

Fig. 371. Foretopsail Schooner *H. H. Cole* of the period of the *Emeline*. From a painting by Clement Drew, by courtesy of Lawrence W. Jenkins of the Peabody Museum, Salem, Mass.

than on those islands more to the eastward, and there is always a much heavier surf. Independent of the vessels going there, there is also a shore party of forty Englishmen from the Cape now residing there.[3] The consequence is that the elephant, having been disturbed so much on this island, have been abandoning the island for the last two or three years and hauling on the islands more to leeward, where the anchorage is safer and the bays more easily worked. Possession and East Islands, therefore, have been improving for the last few years in a ten-fold ratio.

"In proof of this the writer need only add that he has been on two voyages to Possession in pursuit of elephant. On the first voyage, all the bays were worked on the lee side except Northwest and Southwest, which latter may be called on the weather side, and nearly all of the elephant killed that we could find, but few escaping, even to pups. The next year we visited the same island again and found that those very bays were alive with elephant, more than five times the number than was there the voyage before. There is, therefore, no question but that these elephant came from Pig Island, and although this island (Possession) was supposed to have been worked out, it is evidently growing better and will continue to annually improve as long as Pig Island is worked in the manner it is, even if it (Possession) should be worked every season by one or more vessels.

"There are also good whaling grounds in the vicinity of the islands. We passed through shoals of right whales in the same latitude and longitude two summers (southern latitude) in succession, when bound to the Crozettes elephanting, and in neither instance did we fall in with a whaling ship. Prince Edward and Marion Islands also abound with elephants, on both of which are huts and try-works, and also a rookery for the fur-seals."

Fosdick's two sea elephant voyages were both on the *Emeline*. In the season of 1842-1843, he visited both the Prince Edward group (which includes Marion Island) and the Crozettes; in the following season, when he wrote the journal that

[3]The schooner *Franklin* of New London, which left the Crozettes Jan. 1, 1844, later "gave a favorable report of Mr. Jearey's fisheries (English) at the Crozettes and stated that a full cargo of oil was waiting the arrival of the *Ghiha*."

appears in this volume, he visited the Crozettes only. That he was unmindful of the great elephant rookeries existing on Kerguelen Land and Heard's Island, which were destined to be the most renowned in the fishery, is understandable. The rush of the sealers to Kerguelen Land did not begin in earnest till the season of 1844-1845, and Heard's Island was not discovered till 1853.

The slaughter of the sea elephant at the Crozettes was no less indiscriminate than at other islands, and not many years after the *Emeline's* visits the sealers practically abandoned the group. About the close of the year 1864, Washington Fosdick had an opportunity to observe the change that twenty years had made in the rookeries. He was then on the whaler *Java,* bound to the North Pacific, but, as the vessel was passing fairly close to the Crozettes on her passage, Fosdick prevailed upon his captain to pay a visit to the sea elephant. The *Java* anchored in Ship Bay, where the *Emeline* spent the season of 1843-1844.

"Near the beach," writes one of Fosdick's ship-mates, "we found the ruins of an old shanty that had some time sheltered the elephant hunters of years before. A rusty, broken try-pot was half buried in the sand, scraps of hoop iron, pieces of rotting oak staves, weather-beaten clubs that had once been used in the slaughter of the innocents, and an iron blubber fork were among the evidence of a former occupancy of the island.

"Ruins of an old stone try-works were still in existence, and could have been easily repaired, the original structure having been most substantially built.

"On a narrow beach, beyond a projecting point of ledge, we came upon seven elephants, that seemed as much surprised as we. One old fellow, a veteran, judging by the grayness around his jowls, uttered a snort as we came in sight and drawing himself clumsily over the rough shingle, closely followed by his family, tumbled into the sea, where they remained, swimming about in the surf, apparently little alarmed at the strange beings who were paying them a visit. As each animal would furnish no more than a barrel of oil, the few we saw were not worth capture could we have accomplished it.

"A beautiful spring of crystal water, pure and cold, welled

from the ground in bubbling freshness just beyond the old shanty, from which we filled our kegs, then we bade adieu to nothing and went on board."[4]

Left undisturbed for a period of years, the rookeries generally replenished themselves. Thus in December, 1874, at the time when the sea elephant fishery was taking its last gasp, the *Monongahela* paid a brief visit to the Crozettes and found the elephant "very numerous."

Among the Sea Elephants

The sea elephant or elephant seal is the largest of the marine mammals that periodically resort to land. Its most striking feature is a proboscis (present only in the male, however), a characteristic which serves to distinguish the sea elephant from other varieties of seal and which is responsible for the name given to the animal. The males are much larger than the females and average about fourteen to sixteen feet in length. Charles M. Scammon in his *Marine Mammals* speaks of seeing a sea elephant twenty-two feet long.

A sea elephant on land is among the most sluggish and defenceless of creatures, and, in spite of its huge size, yields easily to human attack. The Yankee sealmen found little difficulty in the hunt, if the slaughter which took place deserves to be called a hunt. A group of men, armed with clubs and lances, and planning their onset so that the elephant could not escape to the water, would advance slowly against a herd. The shouts of the men would throw the elephant into a panic, and once the herd was broken up it was a simple matter to dispatch the individuals. Occasionally a bull elephant would stand his ground and attempt to bite his attacker, but such a gesture would never be dangerous to any one with an ordinary amount of agility.

The real labors began with stripping the blubber from the dead elephant. When removed, the blubber was cut up into "horse-pieces" about a foot and a half square, and handling these pieces sorely taxed the strength of the sealmen, especially if the elephant carcasses were at a considerable distance from the

[4]*From Forecastle to Cabin,* by J. F. Beane; New York, 1905.

beach. Generally eight or ten "horse-pieces" were strung along a pole to be carried on the shoulders of two men. This method of transportation was called "backing"; as might well be supposed, it was heartily despised by the men. Even without the discomforts of a load, walking was no easy matter across the rocks and the tussock bogs. Whenever possible, the blubber was floated down a brook to the beach.

Trying-out the blubber, in the case of the *Emeline,* was done entirely at the try-works on shore; on other voyages, at least some of the blubber was carried on shipboard for boiling. A shore try-works was in the center of an elaborate out-door factory. Large pits were at hand for washing the blubber as it arrived covered with blood and sand; platforms provided places where the blubber could be "minced" or sliced for the boiling operation; and cooling vats and empty casks were near to receive the oil.

When a sufficient number of casks were filled with oil and coopered, they were towed out to the vessel for stowing down. Technically this towing operation was called "rafting", and occasionally as many as twenty casks were bent to the same towline. The word "rafting" was also applied to the transportation of blubber from the distant beaches to the try-works; in this case it was simply a matter of towing several floating bunches of "horse-pieces" attached at intervals to a line.

The oil yield of the sea elephant varied considerably, owing to the fact that the animals were killed irrespective of age or physical condition. A small elephant might yield less than half a barrel of oil; larger ones would give perhaps six or seven barrels. According to one ship-master, elephants have been killed giving as much as ten barrels, but such must have been extremely rare. Hundreds of the animals had to be killed for even a moderately sized cargo, and in the flourishing days of the fishery, when the rookeries were abundantly crowded, there was a great waste of blubber and consequently a great waste of animal life.

The sea elephant season, the period when the herds resorted in their biggest numbers to the land, was from December through February, and the vessels engaged in the fishery gen-

erally limited their visits to those months. Occasionally a shore party remained at an island during the long period between seasons in order to secure the straggling elephant that might come ashore and to prepare a cargo for the next visit of their vessel. In spite of the discomforts of an Antarctic winter and in spite of the utter lonesomeness of the sea elephants' haunts, men were always found, when wanted, for such dismal work.

Living quarters on shore had practically none of the comforts which would be considered necessities today. Sometimes the huts were made of lumber carried South for the purpose, but quite as often they were mere frameworks of spars, braced against the rocks, and covered with sailcloth or elephant skins. When a vessel was staying out a season at an elephant island, most everything movable on desk, including the galley, was taken ashore for the convenience of the shore workers.

The Emeline

The square topsail schooner *Emeline* was of only ninety-two tons burthen, but she would not have been singled out as a particularly small craft from the vessels engaged in the fur-seal and sea elephant fisheries. Small schooners which could be handled easily had a decided advantage over larger vessels in "working the bays" of the treacherous Antarctic islands. In recognition of this fact, agents would frequently send out "tenders" to do the in-shore work for the more capacious ships and barks. The *Emeline,* however, made her voyages independently.

Speed and swank are generally associated with the square topsail schooner, famous for its use by the slavers and smugglers of an early date. In the first part of the nineteenth century it was developed into the Baltimore clipper, one of the raciest vessels afloat. The *Emeline,* like other schooners used in the Antarctic, had to don an extra sturdy rig to withstand the great winds of the South, and her short, stout spars were not compatible with the best traditions of the square topsail schooner. Nevertheless, she was a speedy vessel, as many passages in Fosdick's journal clearly indicate.

The square topsail schooner had two masts. The main carried a fore-and-aft mainsail and a gaff topsail; the fore, a fore-and-aft foresail with two square sails aloft (topsail and topgallantsail). But the *Emeline* carried another square sail on the foremast, bent to the fore yard as a course, and set when sailing before the wind or with a free wind. She departed from the general custom, too, in the use of a fore topgallantmast. Usually the topsail and topgallant yards of a square topsail schooner were slung from the same spar, and the addition of the topgallant mast on the *Emeline* indicates her special preparedness for the Antarctic fisheries. The *Emeline's* head sails included a jib and flying jib, together with a bonnet which could be laced to the foot of the jib in light winds.

The *Emeline,* like other sealing vessels, was equipped for whaling in case opportunity offered on her passages to and from the South. On each side hung a boat with all the necessary whaling-gear, and her try-works were in readiness for blubber. Lowering over the stern was a "gig" for light harbor use, and she also had on board a large six-oared "blubber boat" for the work at the Crozettes.

Nothing has been found of the *Emeline's* history outside of two voyages in the sea elephant fishery, the second of which provided the subject of Fosdick's journal here presented. On the earlier voyage she sailed from New London on July 27, 1842, with Silas Latham as master, and stopped first at the Prince Edward group. Here she met the schooner *Franklin* of New London[5] and together they worked the beaches under a partnership agreement. Later the two vessels went to the Crozettes to complete their cargo. On the *Emeline's* homeward passage in the late spring of 1843, she was seen at St. Helena by the ship *Delta* of Greenport and at that time hailed 450 barrels of sea elephant oil.

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[5]The schooner *Franklin* of New London, 119 tons, sailed on August 13, 1842 and did not return until April 8, 1844. Her owners were Perkins and Smith. After parting company with the *Emeline* at the Crozettes, she sailed to Rio, where her cargo of 450 barrels of elephant oil was sold. The money was invested in coffee which was sent home by freight. The *Franklin* then cruised off the coast of Africa and finally returned to the Crozettes for the 1843-1844 season. The master of the *Franklin* was Captain Gurdon L. Allyn whose memoirs are preserved in *The Old Sailor's Story,* Norwich, Conn., 1879.

The West African Guano Boom

Had the voyage of the *Emeline* been made according to schedule, she would have returned directly home with her sea elephant oil cargo from the Crozettes. But when a misadventure forced her into Cape Town, she found herself drawn into that frenzied guano boom which formed one of the wildest and most evanescent chapters in maritime history. Let us first survey the scene of the guano operations.

The early mariners of the whale and seal fisheries found the coast of southwest Africa, from Walfisch Bay to the Orange River, a dreary line of sand-hills, monotonous and without vegetation. Just one break appeared, between Spencer and Hottentot Bays, where a range of precipices rose 600 feet high. But even these were barren, and gave, they say, a stronger feeling of desolation than did the lowland sands. At various intervals along the coast were the bird islands, small masses of rock on which the excrement of birds had been piling up for centuries till it had attained remarkable heights; here, in season, came the seals, covering the rocky shores and reefs. Chief among these islands were Hollams Bird Island, just south of the Tropic; Mercury, at the entrance to Spencer Bay; Ichaboe, a little further south; then a few islets in Angra Pequena; and finally Possession, opposite Elizabeth Bay.

Very little rain was known to fall on this section of the coast. The sun shone hot out of a cloudless sky, though a thick haze was apt to cling to the horizon, preventing a distant view of the land. At night the dews were heavy and the air chilly; during the greater part of the year, the fogs came in thick and uncomfortable. The winds were treacherous; shipmasters enjoying a moderate breeze outside would suddenly find themselves in the center of a gale in-shore. The northerly winds that prevailed from May to August, though not so severe as the southerly winds of the remainder of the year, would often start the rollers sweeping along the coast and make every roadstead of doubtful security. These roadsteads were between the islands and the main; on the seaward side of the islands the surf beat wildly against the rocks and pounded into chasms with fury.

The inhospitality of this forlorn and fearsome coast was increased by the absence of fresh water; the few bands of Hottentots who came to the shore from the interior brought water with them in ostrich shells. These occasional groups of Hottentots were the only natives ever seen, for neither the islands nor the sand-hills of the mainland were inhabited. The Hottentots were a degraded, wretched people, but their nature was kind, simple and inoffensive. A New London sealing master writes of them:

"On the fifth of April (1830), natives or Hottentots came twelve days' journey from the interior to the harbor of Angra where we were, with cattle and sheep to barter for powder and ball for hunting purposes. We bought five neat cattle and two sheep, paying two junk bottles of powder each for the former and one bottle apiece for the latter.

"The whole coast of this region is a sandy desert, and the natives who wander to and along shore, coming several days' journey from the interior, are the most miserable specimens of humanity I have ever seen. They like tobacco and will barter anything they possess to procure it. They are nearly or quite naked, oil themselves from head to foot, and eat birds' eggs, offal, or anything they can procure to sustain their miserable existence.

"They offer in trade ostrich egg-shells from which they have extracted the inside through a hole in one end, and also feathers of the largest known bird; but the feathers, like themselves, are in a dirty, greasy and unpresentable condition."

The abundance of whales along the coast and the large numbers of seals that came to the islands enticed many Yankee vessels there at an early date. The whaling grounds off Guinea were opened about 1763, and thence, in the following years, the more enterprising captains worked their way southward. Alexander Starbuck says that in the year 1773 fourteen vessels were reported arriving home from the African coast. And when American whaling revived after the gloom of the Revolution, a large proportion of the vessels visited these waters, particularly from the parallel of 16 degrees South up to the Cape of Good Hope. "Woolwich" (Walfisch) Bay appears often in

Fig. 372. Antarctic elephant seal (*Mirounga leonina*) From a photograph made in Hagenbeck's Tierpark, Stellingen, Germany. Courtesy Carl and Lorenz Hagenbeck.

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the late eighteenth century records. For more than a half century after the Revolution the desolate coast of southwest Africa was yearly visited by American vessels.

Captain Gurdon L. Allyn made many sealing voyages to the coast during the 1830's and has left a record of them in his memoirs. His last sealing operations on the coast were in the schooner *Betsey* of New London in company with the brig *Tampico* of Mystic, and when these two vessels returned home after the season of 1835-1836, they found that the hitherto favorable market for seal-skins had declined and would no longer permit the sealers to make satisfactory profits. Southwestern Africa seemed destined to sink into oblivion, but the emergence of guano as a new commodity in the world markets was soon to give the coast a greater prominence than it ever enjoyed during the prosperity of the seal fishery.

The connecting link between the old and the new order has a touch of the dramatic. Captain Allyn, in command of the schooner *Franklin* of New London, was on his way to the Crozettes in the month of August, 1843; his interests were now centered on the Antarctic sea elephants. Being already in the South Atlantic and having more than enough time to reach the Crozettes before the opening of the season, he decided to pay a passing visit to the Island of Ichaboe, once the concentration-point of his African sealing operations. He might find some sea elephant in the familiar haunts.

Landing upon Ichaboe, Captain Allyn was astonished at finding "planks, wheel-barrows, pickaxes, and bags of guano, apparently left without ceremony." The sight seemed more like a hallucination than a reality. None but the sealmen had ever stepped on this island before. And, since Captain Allyn had never heard of the fertilizing qualities in guano, he couldn't understand why any one should come to this forlorn region and disturb the deep beds of bird excrement. He was not to learn the explanation of the strange sight until he revisited Ichaboe the following spring.

Guano was the first commercial fertilizer ever used in any large quantity. It is not what can be strictly called bird manure, but a new substance formed by decomposition under extremely

dry climatic conditions. Of course one great essential for the formation of a guano bed is a vast multitude of certain birds perennially nesting and raising another multitude within a comparatively small area. And, as the guano-producing birds are fish-eaters, a more basic essential is a proportionate abundance of small fish within range.

The most famous deposits of guano are off the coast of Peru on the Chinchas and Lobos Islands, to which the cold Humboldt current has brought much of the wild life of the South Temperate type which otherwise would not have been found so close to the Equator. Many birds of both the Peruvian and the West African guano islands are of southern, even Antarctic, origins.

The chief guano producing birds, according to Dr. Robert Cushman Murphy[6], are "three or more species of the single order known as the Steganopodes, the group which includes the cormorants, the pelicans, and the gannets or boobies." While penguins are generally found on guano islands, their nesting habits are such that they have a minor part in the production of guano. Both the cormorants and the gannets are extensively represented on the islands of southwest Africa; the cormorants by the duikers, and the gannets by the malagash. Most of the islands differ from one another in their bird-life, but Ichaboe is especially distinctive since the malagash are, with the exception of the jackass penguins, in exclusive control.

The nest of the malagash is simply a small shallow depression which soon develops a rim of excrement, and the entire surface of Ichaboe was found pitted with these nests, placed so closely one against the other that the whole appeared like the cross-section of a vast honeycomb. The malagash congregate for their nesting season in October and remain till April. The other important African guano-producer, the duiker, has its nesting season from December to June.

The visit of the *Emeline* to the guano islands took place in the off-season for the birds, and consequently there is no description in Fosdick's journal of the remarkable bird-life. Other mariners have left accounts, however, all in similar vein to that of Captain Gurdon L. Allyn:

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[6]R. C. Murphy: *Bird Islands of Peru.*

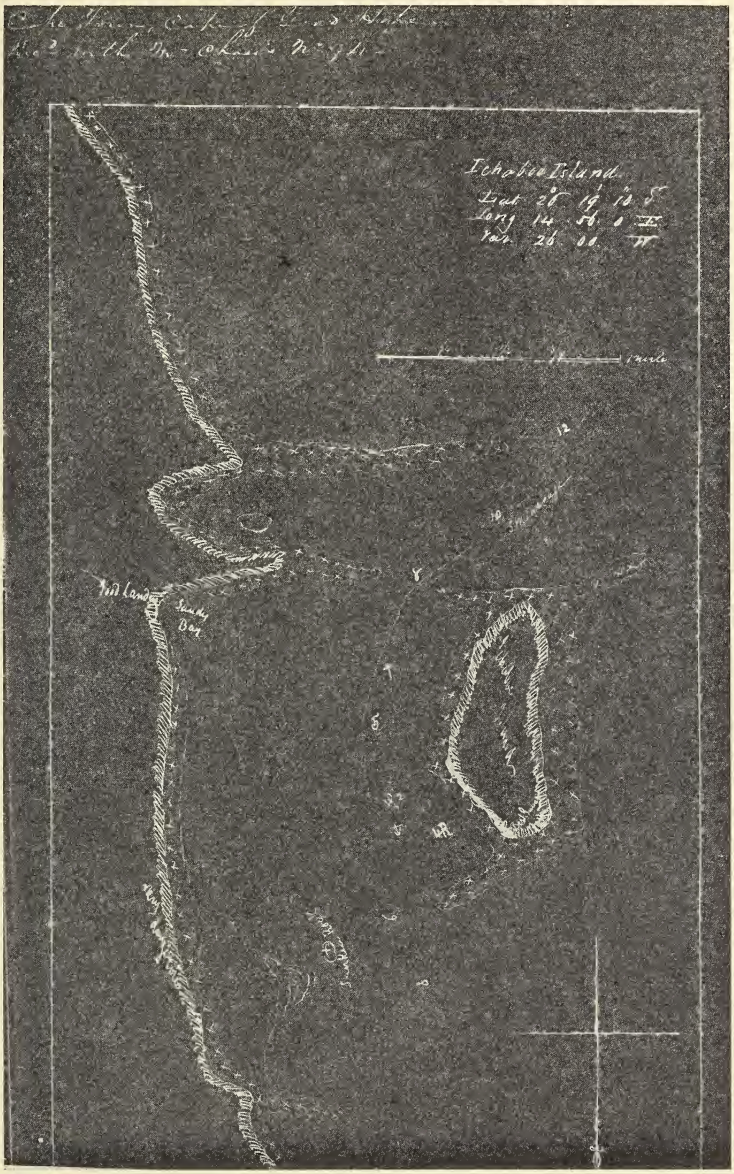

Fig. 373. Sketch chart of Ichaboe Island sent to the U. S. State Department by Isaac Chase, Consul at Cape Town, with his dispatch of July 30, 1844. It will be noted that the chart is drawn upside down. By courtesy of the State Department.

"We arrived on the barren coast of Africa, in the latitude of 26 degrees South, on January 14, 1830. At that place is a small island, a mile or more from the coast, on the inside of which is a fair anchorage. This island, called Ichaboe, is the rendezvous of millions of sea-birds, which there lay their eggs and hatch their young, and we obtained at this time and afterwards quantities of eggs, many of which are excellent for food. The birds were so thick as to prevent our travelling on shore without first beating passage-way with our seal-clubs, and yet we endeavored not to hurt them, although they regarded us as intruders, and attacked us with ferocity, scratching and biting with such effect as to draw blood through the legs of our pantaloons. We were plentifully supplied with eggs during the fifteen months we were on this coast, our men eating gulls' [gannets'] and penguins' eggs without much distinction, although the former are much superior."

The Island of Ichaboe, center of the great guano activity during the boom period of 1844, was the first island of the coast from which the substance was taken. It is situated about 1400 yards from the nearest point of the mainland and is about 600 yards long by 200 yards wide in greatest dimension. Estimates made of its height before the removal of the guano vary considerably, but it seems certain that at some points of the island the deposit was at least sixty feet deep, tapering down a little at eaeh extremity, and the whole resting on a granitic foundation about thirty feet above sea level. The guano was a solid, compact mass, rendering necessary the use of the pickaxe, and it was loosely covered over with comparatively fresh excrement and the bodies of dead birds. The first ship-master who visited Ichaboe for the specific purpose of procuring guano estimated the entire deposit to consist of between 700,000 and 800,000 tons.

The first digging at Ichaboe was done perpendicularly; that is, pickaxe crews, working from stagings, cut the deposit back evenly from top to bottom, preserving an escarpment which gradually receded from the eastern shore. Because of this method of digging, objects buried deep in the guano were uncovered at a time when their distance from the topmost layer of

the beds could be visualized. The preservative qualities of the guano amazed the diggers.

A seaman present during the height of the Ichaboe boom period told afterwards of the excitement caused by the digging-out of a coffin with a body fairly intact inside. An inscription on the lid was believed to indicate that the body was of a Dutchman who had died in 1689, possibly on a very early sealing or whaling voyage. If the interpretation was correct, the guano had risen twelve or thirteen feet in 155 years, as the body was found eighteen feet below the then existing surface. It was hoped to take the remains back to Europe, but the coffin and its contents crumbled after a brief exposure to the air.

In the *Whalemen's Shipping List,* March 18, 1845, is found the following curious item:

"A letter from Wm. Carroll, Esq., U. S. Consul at St. Helena, dated Jan. 24th, received at the office of the Whalemen's Shipping List, mentions that two dead bodies were recently found buried in the guano at Possession Island, coast of Africa, with the following inscriptions upon a board at their heads, viz:

" 'Charles Church, of the ship Atlantic of Nantucket, U. S., died Dec. 31, 1791, aged 21 years.'

" 'Daniel Smith, of Newburyport, U. S., died on board schooner Betsy, Dec. 30, 1832, aged 32 years.'

"The bodies were taken up and reburied. They were in a remarkable state of preservation, and looked as fresh as if they had not been interred more than a fortnight."

Such were the strange deposits to which the whalemen and sealmen had given only a passing attention. Yet knowledge of the fertilizing value of guano had existed in remote antiquity. The Incas of Peru, long before the Spanish conquest, had used the guano of their coastal islands to spread over the soil of the mainland plains. The name of this manure, too, comes down to us from the Peruvian aborigines.

The Spanish conquerors, if they paid any attention at all to the fertilizing activities of the Incas, saw no reason why similar methods should be tried on European soils. In fact, Europeans had never thought about scientific fertilization. The first suggestion to the Old World that soils could be enriched arti-

ficially came through the *Royal Commentaries of the Incas*, written by Garcilasso de la Vego, a man born in Peru of a Spanish father and Inca mother. The book was published in Lisbon, Portugal in 1609; it contained descriptions of various native customs and practices, and fully explained the successful use of guano.

The Inca's suggestion about manures met no response, although about two centuries later, it may have had some influence upon the German scientist Alexander von Humboldt when he was shaping the plans for his travels. Humboldt had many interests to take up his mind during his long sojourn in South America, but at Callao in 1802 he made an exhaustive study of the effects of guano. In 1804 he brought home with him the first specimens of guano ever to arrive in Europe, but no general interest was aroused.

It was not until the 1830's that Europeans began really to think about manures. Great Britain was in the van. In 1835, Messrs. Myers and Company, merchants of Liverpool, imported the first consignment of Peruvian guano to England. Practically no attention was paid to it except by a few chemists. In 1840 twenty casks of the guano were brought to England for testing purposes, and the experiments made with it on wheat and turnip crops were so enormously successful that a lively interest was at last aroused. Land-owners began to ask questions and merchants began to compute future profits. In 1841, seven vessels were employed to bring guano to England from the Chincha Islands; altogether they brought 1733 tons.

But it must not be supposed that the new substance immediately gained widespread recognition and favor. Even as late as July, 1844, the London *Times* printed a despatch from Berwick, announcing the arrival of the *Leo* with a cargo of guano from the Chincha Islands of Peru, and stating that this was "the first knowledge of these islands in England." And among those agriculturists whose attention was attracted to guano were many who were skeptical of its real merits. In observing the luxuriant crops produced by guano fertilization they feared some strong chemical effect was exhausting the soil. The complete conversion

of England to the merits of guano was more or less coincident with the West African boom.

Peruvian importations, however, increased during 1841 and 1842, but a decrease came in 1843, apparently due to the action of the Peruvian government in letting out to a single party the rights of removing guano. We find British merchants complaining bitterly of the monopoly. But the new situation encouraged the efforts of those who had already been trying to locate other sources of guano: the outcome was the "discovery" of Ichaboe.

A Britisher named Andrew L. Livingston, while reading the memoirs of the American sea captain, Benjamin Morrell, Jr., conceived the idea of exploiting Ichaboe. Morrell had visited the island in the sealing schooner *Antarctic* of New York in 1828. His description in the memoirs made only a casual mention of the thick layer of excrement—only a single sentence, in fact—but that was enough. Livingston went to John Rae, an enterprising merchant who had become interested in the commercial possibilities of guano, and immediately Rae's son organized a company which secretly sent out from Liverpool, in the fall of 1842, a fleet of at least three vessels to find Morrell's island.

One of these vessels met with a mishap and had to abandon the voyage. Another, arriving on the coast with her water supply diminished and finding no possibility of replenishment, returned without making a thorough search. Finally, the brig *Ann* was the only vessel of Rae's fleet remaining in southern parts, and even her master, Captain Parr, was ready to admit failure and sail back. He went to Cape Town to take on supplies for the homeward passage, and there, through a stroke of sheer luck, met an American whaling captain who was acquainted with Ichaboe and who was willing to provide the necessary sailing directions. Thereupon Captain Farr promptly found the island and began to load the *Ann* with guano. Before he had completed his cargo, a gale forced him to put to sea and he returned directly to England, arriving at Bristol in July, 1843. The evidence of the *Ann's* visit was what had startled Captain Allyn of the *Franklin* when he arrived at Ichaboe in August.

Captain Parr's reports about Ichaboe aroused great excitement among a select group of merchants. He was prevailed upon

to accompany a large fleet that was assembled by certain Liverpool and Glasgow firms and that sailed the following autumn. Again secrecy attended the departure, and the ships sailed under sealed orders, clearing for distant ports they were not intended to reach. The first vessel of this fleet to return was the *Levenside;* she arrived at Liverpool February 20, 1844, with 400 tons of guano. Other vessels soon followed. The great flood of African guano into Great Britain had commenced.

The secret had begun to trickle out before the return of the *Levenside,* and the first part of the year 1844 found Ichaboe a much talked-of island. The fertilizer idea was now sweeping England and Scotland, and the markets were feverishly demanding cargoes. Cape Town was in a turmoil, and British merchants there were chartering every vessel they could find for the guano traffic. Tremendous profits loomed; Ichaboe was the new El Dorado. Captain Allyn of the *Franklin,* on his return from the Crozettes in February, found eighty British vessels at the island. He stopped only long enough to get the news and then sailed immediately homeward, hoping to convince his agents in New London of the possibilities in guano.

During the early part of the boom the stage was being set for the turbulence to follow. There was no controlling power, but a system of tenure developed which the privileged parties were strong enough to maintain. The early-comers at Ichaboe staked out claims, like conquerors landing on a new continent, and against those who arrived later they jealously guarded their rights. Each claim was called a "pit," and the boundary lines were parallel, extending back from the eastern shore.

Each pit was furnished with a raft or wharf which extended far out over the rocks. Along the wharves the guano was transported in wheel-barrows or in bags carried on the back. The use of the wharves was more of a necessity than a convenience, for to load the boats close in shore would have been a hazardous or at best a very slow undertaking. The sea was never quiet along the rocks, and frequently a shore landing was a sheer impossibility.

The expense of building the stagings and wharves gave each claim-holder an excuse for monopolizing his pit. But the system

Fig. 374. Colony of Cape gannets (*Sula capensis*) on Ichaboe Island. From Reichenow, 1908. Deutsch Sudpolar, Exped. 1901-1903, Vol. IX, plate XLIX. Courtesy of Robert Cushman Murphy, American Museum of Natural History.

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created opportunities for extortion. Most claims were held by merchant companies rather than by individuals, and vessels belonging to the privileged firms found pits awaiting them on their arrival. At the same time other ships would be forced to wait weeks for a chance to load and then only after accepting the price demanded by the claim-holders.

The *Emeline's* visit to Ichaboe was made in the early part of the boom. During the following summer and autumn there were frequently three hundred ships jammed at one time into the roadstead. The island was the scene of the grossest disorders, and warships were sent from Cape Town to stop the rioting. The guano diggers worked with feverish haste, and by the end of 1844 the island was cleaned to its bare rock. By the late spring of the following year the other deposits of the coast had been completely removed, and the entire region abandoned once more to the birds and the seals.

American interest in the boom had been slight. The bark *Bruce* of Fairhaven, on her return from whaling grounds in the Indian Ocean, stopped at Cape Town shortly after the *Emeline's* departure. Following Consul Chase's advice, she took on ten tons of guano at Ichaboe. She arrived home September 13, 1844, her guano being the first importation of the substance at the port of New Bedford. In July Consul Chase sent a despatch to the State Department, recommending that American vessels take part in the boom. He also sent a sketch chart of the roadstead at Ichaboe which appears as an illustration in this volume.

Meanwhile, the news which Captain Allyn of the *Franklin* had carried back to New London appealed to the business instincts of his agents, Perkins and Smith, and on September 10th he was back again at Ichaboe, this time in command of the ship *Brookline,* for the express purpose of obtaining a cargo of guano. The committee which was trying to run the affairs of Ichaboe had just issued an order that "as the island was occupied by British subjects, no foreign vessels should be allowed to load guano until all the English vessels were loaded." The order amounted to an absolute exclusion, for the guano deposits were disappearing fast. Inasmuch as the British had made no official claim to the island, the order was not legally proper, and

Captain Allyn protested to the American consul at Cape Town. In due course of time, the colonial authorities had the restriction removed, and not only the *Brookline* but six other American vessels and two French vessels were the beneficiaries of Captain Allyn's protest.

The six American vessels at Ichaboe with the *Brookline* were the ship *Shakespeare* of New York, the ship *Florida* of New Bedford, the barks *Commerce* and *Samos* of Boston, the brig *Messenger* of Duxbury and the brig *Thomas Winslow* of Westport. Toward the end of February, 1845, the ship *Gulnare* of New Bedford obtained a cargo of 400 tons of guano from one of the deposits on the coast; on her homeward passage she put into the Demarara River in distress and was thereupon condemned, though at least a part of her cargo was later freighted to Baltimore. As late as May of the same year the bark *Gentleman* of New Suffolk, returning from a sea elephant season at the Crozettes, stopped at Possession Island and took on board some "sweepings." Possibly a few other American vessels, besides those which have been mentioned, participated in the African guano boom, but it is doubtful if the records could reveal any more.[7]

With the passage of the years the guano beds were slowly rebuilt, though they never attained the great heights observed during the boom. The islands of the coast were annexed to the British crown in 1861, and today their deposits are controlled and managed by the government of the Union of South Africa. Only a limited amount is removed annually, and the "guano season" takes place between April and September when the birds are away from the islands. On some of the islands are small permanent settlements which depend upon vessels from the Cape for their water and provisions. The men of these settlements go sealing during the off-season, and when the time comes for the removal of the guano they are assisted by groups of laborers sent from Cape Town. The Union government sells the guano at advertised intervals; the demand exceeds the supply, and exportation is prohibited.

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[7]A brief article on the West African Guano Boom, written by the editor of the present volume, appeared in the *Geographical Review* for October, 1930.

The composition of African guano varies. In *Soil Fertilization,* a Cape Town publication written by Dr. I. de V. Malherbe, it is described as roughly containing "about ten per cent nitrogen, ten per cent phosphoric oxide and two per cent potash. In addition to being a nitrogenous fertilizer it therefore contains a fairly large percentage of phosphate and a little potash. For South African soils it is not a well-balanced fertilizer and it is essential always to supplement it with phosphate, usually superphosphate, and in many cases with potash, too.

"The nitrogen exists in many forms. Thus we normally find a little nitrate, a fair amount of ammonium compounds and a large amount of various organic forms of nitrogen, some relatively quick-acting, others slower-acting. The nitrogen has therefore a quick as well as a lasting effect on the crop, and this is why Government Guano is such an ideal nitrogenous fertilizer and stands in high repute with farmers. When sown with fertilizer drills, it is necessary to sift it through a one-eighth inch mesh sieve to remove the feathers, stones, etc. Otherwise it is broadcasted over the ploughed land."

About 1879 there was a flicker of American interest in the African guano islands. A group of New Bedford men, recalling the boom of 1844, asked themselves if the deposits had not been sufficiently rebuilt to warrant a commercial expedition to the coast. They sent the *Delia Chase,* a little schooner of 64 tons, to investigate. Captain Edward M. Ellis of Fairhaven, then a boy of fourteen, sailed with the party, and has the following recollections:

"We arrived at Hollams Bird Island. We found many relics of the guano parties, but it looked as though very many years had passed since the last time they had been there. We saw a large derrick for lowering the bags of guano down the cliff, and bags filled with guano were lying about, placed in tiers along the edge of the bluff. A house was on the island fitted up with living quarters and bunks. Near the house were barrels of what seemed to be seal oil and a quantity of picks and other such implements. The roof of the house was partly caved in from the weight of the guano, which in some places was a couple of feet thick. The guano was similarly built up above the sill of the house. We

drilled into the island for four or five feet and found the guano at least that thick."

But the trip of the *Delia Chase* was futile, in spite of the new supplies of guano discovered, for the British authorities, then in full control, would not give permission for the removal of any guano.

The Journal

From Washington Fosdick's manuscript, preserved in the museum of the Old Dartmouth Historical Society at New Bedford

Part I. Outward Bound

[*Abstract*]

The *Emeline* sailed from Mystic July 24, 1843. Four weeks later she raised the Azores, where nearly every whaler and sealer was accustomed to stop on the outward passage. Food supplies were cheap at these islands, and the natives, always dependable men in the fisheries, were more than willing to sail under the American flag. The *Emeline,* like many another Yankee vessel of her ilk, had sailed from home without full provisioning and without a complete crew-list, intending to remedy both deficiencies at the Azores. The Island of Flores filled her needs. A bountiful supply of potatoes, onions, pumpkins and poultry were added to the ship's stores, five young Portuguese signed the articles, and the voyage southward was begun.

The *Emeline* made a slow and sluggish passage; she seemed doomed to light breezes and to days upon days of calm. Barnacles gathered on the schooner's bottom which twice had to be cleaned off with scrub-brooms. Many an idle hour in the Equatorial region was spent fishing for albicore and tunis and darting at porpoises. "The vessel totally becalmed," writes Washington Fosdick, "with a hot sun pouring down upon her decks—almost warm enough to suffocate one. Nothing to be seen from mast head but sky and ocean. Nothing has transpired worthy of record unless it be the almost unsupportable heat." Manuel, a

Portuguese, while fishing sleepily from the flying jibboom, dropped off into the water; he was easily rescued, coming on deck thoroughly frightened, as though roused from a dream.

During these languid days the officers and men on the *Emeline* were greatly worried: they feared they would be late for the elephant season at the Crozettes—a season none too long in any event—and other crews would have the pick of the rookeries before them. Meanwhile Fosdick fussed and fumed over longitudes; the chronometer was erratic, and corrections obtained from two passing vessels did not serve to remedy matters. He failed completely to pick up the Martin Vas Rocks whence he hoped to take a new departure. He tried innumerable sets of lunars, worked laboriously over "double altitudes" and observations of Jupiter. But it was of no avail.

The *Emeline* did not reach the latitude of the Cape of Good Hope until after the middle of November. On the nineteenth of that month she ran into a gale that nearly spelled her doom. For four days it lasted; the sea piled up in every direction, "appearing as though the whole chain of the Allegany Mountains had broke loose from the continent and were taking a trip across the Atlantic." Several sails were split; a heavy sea demolished the galley. Life-lines were rigged on the quarter-deck for the safety of the watch.

But this one gale was but the prelude to the familiar perils of the Antarctic region. The *Emeline* doubled the Cape only to encounter the most severe weather in this region of icebergs, high winds and cold. On the sixth of December, a day of dense fog, the *Emeline* arrived in the vicinity of the Crozettes and Fosdick writes in his journal: "Our situation is now critical as, according to our chronometer, we are among the islands. Blowing fresh directly on a lee shore with a very heavy sea running. It becomes an object of vital importance to obtain an offing, if possible, before night sets in."

Fosdick's next entry, that of the seventh, shows clearly the great danger lying in the combination of incorrect charts, faulty navigating instruments and dense fogs: "At half past ten was astounded by the cry of 'Breakers close on board, a little on our lee beam!' There appeared to be either one or two sunken rocks

or a small reef, over which the sea was breaking. Took in mainsail and put the vessel about immediately, having had a very narrow escape, the sea running very high. We would have been on them in five minutes, had they not been fortunately discovered at the instant."

A reception of this kind was not unusual to vessels arriving at the Crozettes. The fogs encountered at those islands were particularly dreaded. On March 5, 1843, they were the cause of a collision between the ship *Stonington* of New London and the ship *Lancaster* of New Bedford. The *Stonington's* cutwater was wrenched on one side and her martingale and head rigging were carried away; the *Lancaster* stove in her rail and lost some of her fore rigging.

After a few days more of difficult navigating, the *Emeline* dropped her anchor in Ship Bay, Possession Island, her headquarters for the elephant season.

Part II. The Crozettes.

Sunday, Dec. 10*th,* 1843. . . . Shortly after coming to anchor, we went on shore and saw about 600 elephant, a goodly number, and in good order. Even the shanty put up on our last voyage for temporary use by the shore party was occupied by some fifteen of them, whilst seven fine portly elephant were on the front stoop, enjoying themselves with a view of the harbour, we presume.

Returned on board, had supper, and prepared for a comfortable snooze for the first time in nearly five months, without the dread or fear of being dumped out on the floor without any previous notice. The captain ordered that he should be called at 2 A. M. to warp the vessel farther in the bay if the weather would permit. It was his intention to begin forthwith and drive business for fear some other vessel might drop in and share the cream. Our prospects at present are not only cheering, but flattering far beyond our most sanguine expectations—the elephant being twice as numerous and in better order than on our last voyage, and we being alone in our glory this time. At 7 the anchor watch was set for the night. . . .

At 5 A. M. had breakfast. Strong breezes and rain squalls from N. W. Impossible to shift our anchorage at present on account of the wind. Immediately after breakfast the captain proceeded with a boat's crew and a shore party to the beach, taking a bag of bread, some pork, cooking utensils, etc. Another boat followed in the course of an hour with some more articles. . . .

At 9, from the looks of the carcasses on the beach, the ball on shore has already opened in good earnest. At 11 A. M., a boat's crew came alongside from shore, supposing that we had set a signal for them. We had hoisted up the trysail a little to dry it, and they mistook it for a signal. They were, however, in good season to attack a large plum-duff. They informed us that there were about 1000 elephant on the beach, nearly sufficient to fill the vessel, that it was the captain's intention to kill them all, that he should not quit the beach until he had done so, and that he wanted all hands on shore to help skin them. He intended to try-out on shore if we could not try out all the blubber on board. There was a try-pot on shore already set.

After dinner, the boat put off, taking both the dogs and the hog. . . .

Monday, Dec. 11th. . . . Had an early breakfast. Sent a boat on shore with the fore and topsail yards. The boat returned, bringing the captain and all the shore party except two or three who were to guard the blubber from the attacks of the stinkers, myriads of which were flying about watching an opportunity to pounce upon it. Each bird would eat five times his weight in blubber. The party had killed yesterday 200 elephant and skinned about 150 of them, not one-quarter of the number on the beach.

Everything being in readiness to start the windlass, an anchor was carried out to windward about 50 fathoms. We intended, after we hove up the large anchor, to warp the vessel. In not succeeding in that to our satisfaction, we made sail on her. At half past 10, came to anchor a quarter of a mile nearer the shore and in a much better position for rafting blubber. . . .

The shore party then proceeded to the beach. . . . The large blubber boat was hoisted out.

After dinner, commenced breaking out the hold. Sent on shore three boat-loads of barrels, breakers, shooks, heading, hoops, provisions, etc., also a raft of empty casks. At 6 P. M., when it commenced raining as hard as it could pour, we cleared up decks and secured everything on deck and in the hold in anticipation of an easterly wind. Then went below to lay back on elephant's tongue and fried fish.

Tuesday, Dec. 12*th.* Begins with a gale of wind from N. W. with rain, the woolies coming off from the land with the utmost fury, causing every timber to shake and quiver, and taking the water right up bodily like a dense column of spray. No communication whatever this forenoon with the shore.

About 2 P. M., the wind dies away suddenly. Manned a boat and sent it on shore to assist the party there in skinning the remainder of the 200 elephant killed the day before yesterday. The blubber was put in a large pit dug for the purpose. It is supposed to be sufficient to make 100 barrels of oil, and there are 700 or 800 live elephant now on this beach. . . . The boat returned at 7. . . .

Wednesday, Dec. 13*th.* . . . Had breakfast at 4, but found it impossible to get a boat on shore until the wind lulled a little. We wished to tow another raft of casks on shore before we could clear away a blubber-room. Could see the shore party busy at work on shore. At 8 it lulls a little. Watched for a favourable opportunity and sent a boat's crew on shore. . . .

At 7, the boat's crew returned, and informed us that they had killed and skinned 70 elephant today. They had also got the try-pot in readiness and another empty pot for a cooler. They had dug another large pit close to the try-works into which they had introduced water for the purpose of washing the blubber before putting it in the pots, as it is completely covered with sand. Tomorrow they intend hauling up, by means of tackles, another large pot buried in the sand, and using it for a mincing-tub. They will also take on shore a spare set of try-works gear

Fig. 375. Illustrations from the margins of the *Emeline* journal. Courtesy, New Bedford Whaling Museum.

and commence trying-out the day after, if the wind does not blow too hard. We will also be ready to receive blubber on board and start our works as soon as they do theirs. From present appearances there is a good prospect of our filling up in this bay alone, without working any of the six bays to the northward of us, all of which are easily worked and no doubt filled with elephant. . . .

Thursday, Dec. 14*th.* . . . Got out a bag of bread, a couple of double blocks, a tub of line, try-works gear, etc. At 7 o'clock the boat started, it being as moderate then as it was likely to be during the forenoon, and succeeded in reaching the shore.

We have already three invalids on the sick list—the mate with a very painful finger, having every appearance of a bone felon, Frank, a Portuguese, with one of his fingers nearly cut off with a skinning-knife, and Fayal, another Portuguese, laid up with swollen feet. One man named James has just got off the sick list and returned to duty. So our troubles are already commencing. Add to which the windy state of the weather, completely preventing us from doing anything on board. However, we have hopes, relying on the shore party, and we cast many an anxious glance toward the shore where the try-pot is located, in the fond hope of seeing the smoke curling up from it gracefully toward the heavens—in other words, of seeing them torch up and knowing that the pure white oil is beginning to flow. . . .

At 1 P. M., we noticed a smoke at the try-works. Presume they were burning the pot out. . . . At 5, the boat came alongside and the crew, having taken supper, returned again, taking with them a cask of heading, their works on shore being all complete and ready for trying-out. They had already tried-out a couple of barrels of oil to start with in the morning. A large pit full of blubber is at a short distance from the works, and there is another close by it. The men have cut another channel for a brook and directed it into this pit. Close to it is a large wooden platform to receive the blubber after it is washed and leaned, previous to mincing. The whole is the result of a great deal of labour, and is all in complete order. Ere tomorrow's sun

sets, if the weather be anything like passable, they expect to try out at least 40 barrels.

The boat returned again at 8 P. M. and brought another addition to the sick list in the shape of Joe from St. Helena, complaining of severe pains in his loins.

Friday, Dec. 15*th.* Begins with moderate breezes. Took breakfast at half past three and proceeded on shore with a raft of casks, the sick all being able to go with us excepting the mate, whose finger was worse, constantly suffering the most excruciating pain. At an early hour the works on shore were started and a party went up among the elephant and killed 20, sufficient to make 20 barrels of oil, and backed the blubber down near the works, a distance of nearly a quarter of a mile. The remainder of the day, employed in backing the blubber from the pit to the works and in trying-out. At 6, returned on board, having tried out 30 barrels. . . .

Saturday, Dec. 16*th.* . . . Took an early start for shore, and, having hauled up the boat, proceeded to kill some stinkers to obtain their skins to wipe hands, casks, the handles of the tools, etc., hundreds of the birds being around the carcasses of the elephants. Having called the dogs to our aid and arming ourselves with clubs, we marched upon the birds in solid column of attack. The stinkers, aware of our approach, endeavoured to seek safety in flight, but they were so completely gorged they were unable to fly. They then commenced vomiting up the contents of their stomachs in order to lighten themselves, but it was all in vain. We rushed upon them in double-quick time and, having dispatched some twenty or thirty of them, backed our loads and returned to camp.

During the remainder of the day, busily employed in backing blubber from the different heaps to the brook, there washing it and rafting it, then towing it to the vicinity of the works, a distance of a quarter of a mile, and then backing it to the pond alongside of the works. The pot seething and teeming with oil, the arches belching forth dense columns of smoke, and the party

at work there covered with dirt, oil and smoke, their cheerful countenances exhibiting a lustre which would put to blush Day and Martin's celebrated polish. At first sight, the wondering spectator would suppose he had been touched by some magic wand and transported instantaneously into the bowels of Africa, were it not for the snow-capped mountains which tower loftily above him, high in the heavens.

Would that the owners could now see the condition and appearance of the group now on this island! Little do they know of the excessive toil, trouble and fatigue, and the privations undergone in obtaining elephant oil; and, I suppose, as little do they care, so long as the vessel returns in safety well-laden.

Throughout the day, a continual succession of severe snow squalls. Some idea of the force of the squalls can be gathered from the fact that one of them blowed the boat over bottom-up with all her oars in, with as much ease as though she had been made of paper. At 8 P. M., returned on board to supper, nearly exhausted with a hard day's work. Tried out today 42 barrels.

The barometer now is totally useless, the mercury remaining stationary, too low to mention, almost entirely out of sight. We have seized her up for neglect of duty, lashing her fast to the standard.

Sunday, Dec. 17*th.* Begins with very strong woolies from W. N. W. At 5 A. M., having a lull, the boat proceeded on shore. The party then proceeded to kill elephant, dispatching a sufficient number of them to make about 70 barrels of oil. A visit was made yesterday to two small bays close by—Boat and Shallop Bays—and 300 elephant were found there. . . .

Monday, Dec. 18*th.* . . . At an early hour, the boat proceeded on shore with a raft of casks and returned again to assist in heaving up some of the chain, a northeaster coming on. We entertained strong fears of the vessel's swinging on the rocks. The boat then returned on shore, towing some spars and carrying a load of provisions. The party on shore, having commenced trying-out, were compelled to cool down, the rain coming

down in torrents. At half past 9 A. M., the boat returned and all further work was suspended until better weather.

At 12, took both boats in on deck, the gale increasing and the sea beginning to roll in very heavily, the vessel tailing-in within 50 yards of the rocks, where the sea was breaking half mast-head high. Riding out a gale of a wind at a single anchor was anything but pleasant. At 1 P. M., hauls to W. and blew a most furious hurricane, far exceeding anything we had ever witnessed about these islands, either last voyage or this. The water was taken up bodily like an immense snow-drift. The direction of the wind was, however, of great relief to us, tailing us directly out to sea and removing our anxiety about our near neighbours, the rocks. We therefore paid out the balance of our chain and let her wallow to it.

Toward sunset, the weather moderating and the squalls growing lighter. Hove in some chain, fearful that the wind might shift during the night and tail her in upon the rocks, either on one side or the other. The captain has fully determined to shift our anchorage farther out at the first favourable opportunity, when we would ride at the full scope of the chain without fear of bringing up on either side of the bay or being compelled to watch the weather and pay out or heave in at every change of wind.

Tuesday, Dec. 19*th*. . . . Put the hold in readiness to receive blubber. . . . The shore party killed and skinned about 40 elephant during the day, having now a large quantity of blubber on hand. . . .

Wednesday, Dec. 20*th*. Begins with almost a dead calm; occasionally a few slight puffs from the N. E. Considering this a good opportunity to shift our anchorage, we manned a boat and sent it on shore to inform the captain we were in readiness to heave up. Shortly afterwards the boat belonging to the shore party put off, manned by them, bringing the captain. An anchor was then carried out ahead about 150 fathoms. The large anchor was then hove up, and we commenced warping the vessel. Just at this juncture the wind unfortunately sprung

up from the westward and we were compelled to come to anchor in a position not much better, as a southwester or southeaster would now tail us in close to a point of rocks on the opposite side of the bay.

The woolies now set in from the shore with tremendous fury, preventing the return of the boat. At ½ past 10 A. M., the wind moderating a little and the weather clear, and the captain being anxious to get on shore and commence trying-out, he manned a boat with a crew of the most sturdy oarsmen in the vessel, leaving most of his shore party on board. After a severe struggle they succeeded in landing, and the smoke soon after ascending up from the arches announced to us they had started the works. . . .

Thursday, Dec. 21*st*. . . . The moon changes this day at 8.40 A.M. During the decrease of the last moon we have experienced a continual succession of the most severe westerly gales, varying from N. N. W. to W., having but one easterly wind of about 12 hours' duration since the full of the moon. Manned a boat and sent it on shore. Just as the boat arrived near the shore a most tremendous snow squall set in, the wind blowing most furiously from the westward. The boat, however, arrived in safety. . . .

In perusing a civil almanac for this year, I noticed that a total eclipse of the sun would take place this day at about 1 A. M. in the United States and, as it was to be at midnight, very little was said about it. But midnight at home being 8.20 A. M. here, we intended to watch for the eclipse and see whether it would be visible in the Southern Hemisphere. But we saw nothing of it, so we presume it was not visible south of the Equator. We were in hopes it would be visible here that we might have found the true longitude of the island and corrected our chronometer. Today we had a good meridian observation and found the exact latitude to be 46. 28 South.

At ½ past 3 P. M. the boat returned, bringing off those belonging on board and informing us that the quantity of oil now tried-out on shore exceeds one hundred barrels. . . .

Friday, Dec. 22nd. . . . At ¼ past 4, the boat started and soon arrived at the beach. . . .

The mate still continues laid up with a severe finger, which is a serious drawback to us, as had he been able to come on deck we would have had considerable oil tried out on board, independent of the oil on shore. His finger, however, is mending slowly and we are in hopes that in a week or so he will be enabled to superintend the works and drive a good stroke of business on board in the way of trying-out. . . .

At 7 o'clock P. M., the boat returned and informed us that the try-works were out of order, a portion of them having caved in the night previous.

Saturday, Dec. 23rd. . . . The boat's crew departed for the shore at an early hour, taking their dinner with them, a portion of them expecting to kill and skin throughout the day. The shore party commenced firing up very early in the morning and, the weather being so fine, we confidently look for a good day's work. . . .

At ½ past 4, the wind hauls to N. E. and a light drizzling rain begins to set in, with every appearance of another northeaster in store for us. We, however, lay in a better position for the wind in that direction than when we had the last easterly blow.

At 5, the boat came alongside and reported having killed and skinned elephant enough to make about 30 barrels of oil. They also informed us that the quantity of oil now tried-out was 20 casks, averaging about 8 barrels each. After part of the day, the wind veering from N. to E. and light, not strong enough to counteract the current running in an opposite direction, which causes the vessel to head to all points of the compass, sometimes head to the wind, sometimes tail to it.

Sunday, Dec. 24th. . . . Took an early start and sent the boat on shore with the galley. . . . At 2 P. M. saw a party come down to the hut and, not having seen any one on the beach all the morning, presume they had been skinning again. This

has been a most beautiful day for trying-out and had they been supplied with blubber at the works they might have driven a famous stroke of business. . . .

At 5 P. M., the boat came alongside, the whole party having been occupied during the day in getting blubber down to the mouth of the brook, then backing it to the pond at the works. According to their calculations, they have blubber now on hand sufficient to make 100 barrels more of oil. A lot of elephant not yet killed. Tomorrow, should the weather prove favourable, we expect to commence rafting off oil, and we have no doubt this bay will yield us over three hundred barrels of oil.

Monday, Dec. 25th. Begins with strong woolies, with hail and rain from N. W. to N. N. W. . . . At ½ past 4 P. M., the wind lulling a little, the boat put off, taking a bag of bread for the shore party, and in a few minutes arrived at the beach.

We had almost forgotten that today is Christmas Day, the season of festivity and rejoicing at home, and we can almost fancy that we can hear the halls resounding with the enlivening notes of the violin and the merry step of the fascinating dance. And then the smoking punch, and the tables groaning under the weight of poultry, pies and all the delicacies of the season, and—but stop! the bark of that infernal elephant has destroyed the illusion and recalled our wandering senses back to our anchorage in the cold, stormy, cheerless and desolate Crozettes.

But no matter. 'Tis true we cannot at present revel among the strong, exhilarating mixtures and quaff the luxurious wines of the season, being at present, all hands of us, "tee-totallers". But we can look forward to St. Helena and a full ship, and in sweet anticipation lay back on a bottle of Cunningham's Best, and that is almost as good as though we had it.

And listen to me now, ye epicures, who ransack ocean, earth and air to satisfy your pampered and vitiated appetites. We live—nay, we feast here in this remote and dismal corner of the globe on luxuries of the savoury flavour of which you can form no conception, the richest and the most delicious morsels of food that ever found their way into the human stomach, such as elephant's tongues, flippers, hearts, livers and

tripe. So we are not so bad off during the holidays but that we might be much worse.[8]

Have not seen any of the shore party today on the beach. Expect they are off killing again, as the weather has been too windy today to raft off oil. At 5 o'clock, the boat returned and informed us that a visit had been paid to American Bay where they saw at least 1000 elephants.

The albatross begin to lay, some eggs having already been collected, far exceeding in flavour hen's eggs and five times their size. Tonight for our Christmas supper, independent of all varieties of elephant, we had a sea pie made of young albatross, a delicious meal surpassing in flavour any wild fowl that can be named, as tender as can be, and larger than any goose.

The albatross raise but one young bird and that one never leaves the vicinity of the nest for the space of one year, during which period the old birds constantly feed him. At the expiration of that time the female lays again and, her attention being called to the raising of another family, the young bird, sorely pinched by hunger, spreads his ample pinions to the breeze and puts to sea to obtain his own subsistence, the albatross never touching anything on land. Some idea can be therefore formed of the superior flavour of a young albatross, just before he quits the nest. We have also fish in abundance. Whenever we wish a mess of fresh fish we have only to bait the hooks, throw the lines over the vessel's side, and then transfer the fish to the frying-pan. . . .

Tuesday, Dec. 26th. . . . Had breakfast at ½ past 3 A. M. and started for the shore. Throughout the day the weather was moderate and we intended to raft off oil. We commenced early, both boats towing, the shore party manning one of them. We succeeded in bringing off three rafts of five casks each. These were run down in the ground tier, making at least 100 barrels of oil stowed down. We also sent two rafts of empty casks on shore, and had decks all cleared up by 6 A. M. This

[8]The bark *Napoleon* of New Bedford, passing by the Crozettes on her way to the Indian Ocean in January, 1865, sent three boats ashore on the 12th. The boats' crews, according to the log-book, "caught some fish and penguins and sea fowl, killed some sea elephants and brought on some of their liver to eat."

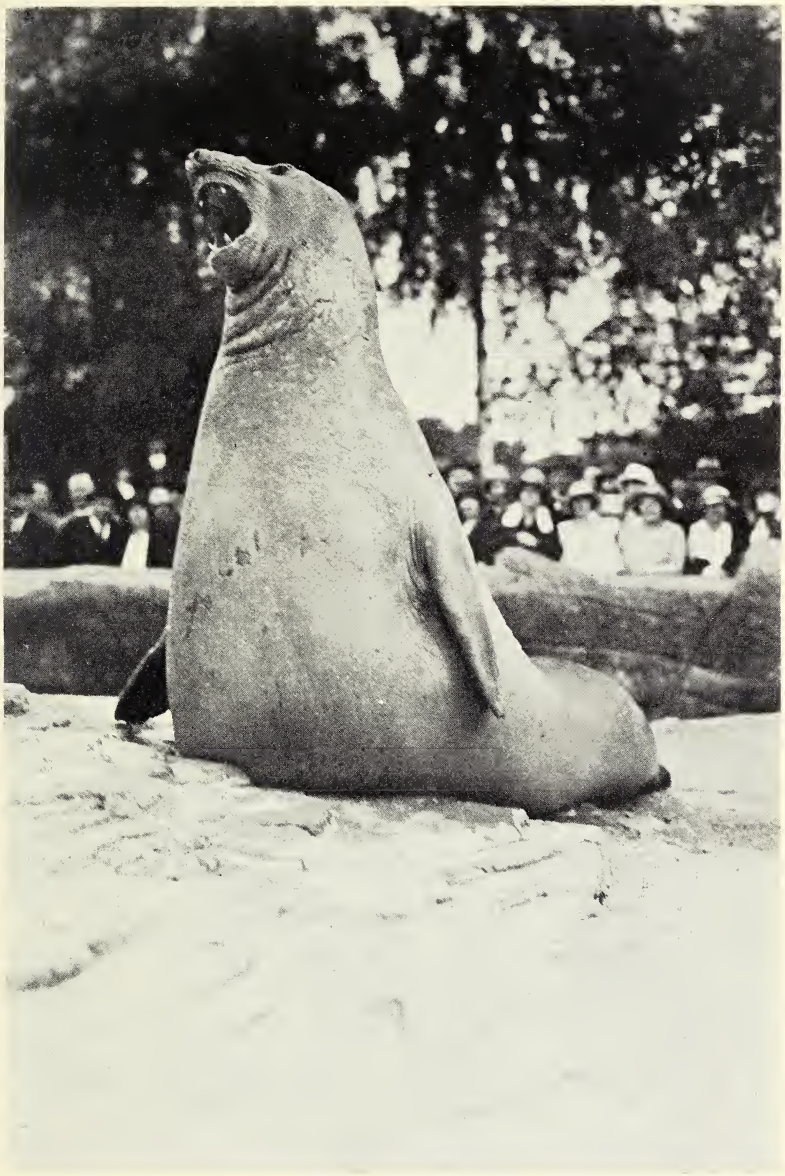

Fig. 376. Antarctic elephant seal (*Mirounga leonina*). From a photograph made in Hagenbeck's Tierpark, Stellingen, Germany. Courtesy Carl and Lorenz Hagenbeck.

Fig. 377. Illustrations from the margins of the *Emeline* journal. Courtesy, New Bedford Whaling Museum.

is the way we keep the holidays. There are also about 35 barrels of oil in casks still on the beach, and blubber at the works to make upwards of one hundred barrels more of oil in this one bay. . . .

Wednesday, Dec. 27th. . . . At 2 A. M. observed the fire on shore at works. Expect the shore party must have started them at midnight. . . . At 4, the rain sets in with the wind out at N. E. From 4 to 10, blows pretty fresh from the N. E. All hands turned in to bottle up a little extra sleep to draw upon in better weather, as this turning out at 2 and 3 in the morning makes a long day of it, particularly in summer, as is the case now with us in this hemisphere. The sun rises at present at 4.14 A. M. and sets at 7.48. Rather an odd summer though, by the by, with snow squalls every day. . . .

Thursday, Dec. 28th. . . . Towards daybreak the woolies constantly increasing in fury. Had breakfast at 4 o'clock and watched for a favourable opportunity to start for the beach. The works in full operation on the shore. At 5, we started, and after a most severe struggle succeeded in landing.

We have missed the buoy to our anchor since yesterday noon. Suppose it must have chafed off against the rocks on the bottom or else the kelp has tailed across the line and drawn the buoy under; most probably the former, as we have had a shift of wind from N. E. to N. W. since the buoy was first missed, which would have tailed the kelp in another direction and cleared the line. Therefore we conclude the buoy has taken a trip to sea.

In an hour afterwards it began to blow harder than ever and set in to rain. At 2 o'clock P. M. the boat returned, the party on shore having cooled down on account of the rain, having now eleven casks full of oil.

At 3, light puffs of wind from S. E. At 4 P. M., the wind hauls out of the westward greatly to our satisfaction and relief, as had a southeaster come on we would have tailed in almost on the rocks. This wind blows very rarely about these islands during the summer, and we did not experience one all

last voyage whilst here. When the southeasters do come it is generally butt-end first, blowing most furiously and heaving in an awful sea. . . .

Friday, Dec. 29th. . . . At 5, sent the boat on shore with a bag of bread and some molasses, as the shore party were without either, and also with a request for the captain to bring his troops off whilst it was a calm and assist us in shifting our anchorage. It was also our intention to bend another buoy to the anchor in case the old was not under the kelp.

The captain's party may be strictly called Joe Bower's Gang, as they consist of the five Portuguese obtained at Flores, not one of whom can yet speak the English language intelligibly, a St. Helena native, and one American. These compose the captain's body-guard. With this heterogeneous party, however, the captain contrives to "push along—keep moving" and drives a considerable business in the oil line, trying-out by day or night as the weather will permit.

In about half an hour all hands came on board and we commenced preparations forthwith to moor the vessel. By ½ past 9 her moorings were all complete, having two anchors lashed together with a long scope of chain toward the beach on the starboard bow and our large anchor out on the larboard bow. The weather being so remarkably pleasant, we commenced rafting, and rafted off two rafts of five casks each, which we stowed down. . . . Caught a sting rae.

At 8 P. M., we were taken all aback by seeing a bark standing on the wind, beating up toward us. Believe her to be the *Bolton* of Stonington.[9]
We will know by tomorrow morning. Should she prove to be the *Bolton,* it will alter our plans materially. . . .

Saturday, Dec. 30th. . . . No vessel in sight this morning. Presume she is to the windward of the island, as when last seen last night she was standing to the westward. At 8, sent the boat's crew on shore and, as they all went back from the beach

[9]The bark *Bolton,* 220 tons, was a Stonington vessel under the flag of Charles P. Williams. She sailed under Captain Nash July 30, 1843, and returned May 24, 1844, with a catch of 1400 barrels of elephant oil.

out of sight from the vessel, we supposed they had started to kill the remainder of the elephant. . . .

At 2 P. M., the boat's crew returned from the shore to dinner. They informed us that when they told the captain about the bark trying to beat in last night he was taken all aback immediately. Upon recovering from his surprise, he summoned all his troop forthwith, ordering them to hold themselves ready to tramp at a minute's warning, then telling the boat's crew to kill the remainder of the elephant on that beach and carry the blubber to the try-works, and, should the weather prove favourable, to begin and work Boat and Shallop Bays, boating the blubber to the works, and, if they were not able to boat, to try out.

The shore party then shouldered their baggage and provisions and in 20 minutes' time they were on the full march for American Bay, the captain leading, spear in hand, to take possession of the beach and the 1000 elephant laying there. Ere the sun sets, he will no doubt have commenced the slaughter and thus secure the possession of the beach, thereby preventing the *Bolton* from bolting us out of a voyage, as, if that was she we saw last night, she will be in that bay tonight or tomorrow morning at furthest. There is a good house there for the accommodation of a shore party and also try-works all complete.

In the afternoon went on shore to obtain some albatross eggs. Whilst on the mountains discovered the same bark coming down between the islands. At ½ past 8, she came to anchor about two cables' length outside of us. In half an hour afterwards her captain came on board of us and she proved to be the Bark *White Oak* of New London, Captain Nory. He stated that he had left Pig Island about 10 days previous, and that Captain Barnham was there with 1300 barrels of oil. The *Bolton* was also there with 200 barrels. Capt. Allyn of the *Franklin* had left for home the day before, all full, hailing about 600 barrels. The *White Oak* had in 400 barrels. Captain Nory also stated that Captain Gibbons had left Pig Island about six weeks since for Possession to wood and water. The wreck, however, the only wood on the island, remained untouched, just as we left it last season, so that he could not have been here. Captain

Nory stated that his object in coming in was to endeavour to bargain for this vessel to take him to Desolation. About ½ past 10 P. M. he returned on board his own vessel.[10]

Sunday, Dec. 31st. . . . Had breakfast at 3 A. M. A lovely morning. Manned a boat and started to the beach after lances and clubs previous to going to Shallop Bay. The other vessel immediately lowered three boats and pulled up toward Boat Bay. This looks strongly like going after blubber, although Captain Nory said last night that he did not intend to interfere with us, but that in the morning he would take one of his boats and go up to American Bay to see our captain and obtain some information with regard to Desolation.[11] We will soon see, however, whether he has been "playing 'possum" or not.

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[10]The *White Oak* of New London, 220 tons, Captain Nory, sailed July 13, 1843, and returned Feb. 17, 1845, with a catch of 1900 barrels of oil and 13,000 pounds of whalebone. Joseph Lawrence was her agent.

The *Franklin* is referred to in a footnote of the Introduction.

Captain Barnum was the master of the ship *United States* of Stonington, 244 tons. She sailed June 19, 1843, and returned May 30, 1844, with 1800 barrels elephant oil and 110 barrels sperm oil. J. F. Trumbull was her agent.

The Captain Gibbons referred to in the text is presumably Captain Gibson of the bark *Cervantes* of New London, 232 tons, which was in the Antarctic at the time. She sailed June 23, 1843 and on June 29, 1844 was lost on the coast of Australia. Benjamin Brown was her agent.

The wreck referred to is that of the ship *Atlas* of Mystic, 261 tons. She sailed on her last voyage in 1837. Her tender, the *Colossus*, was also lost at the Crozettes at the same time. The Brazilian brig *Flamineuse,* formerly the *Athenian* of New York, was lost at the Crozettes in 1841, but Fosdick does not refer to this later wreck.

[11]This reference to Desolation Island (or Kerguelen Land) indicates the dawning interest in this prolific resort of the sea elephant. Prior to this time only a few ship-captains knew about the value of its rookeries and perhaps preferred to keep their knowledge as secret as possible.

American vessels were first attracted to Desolation by the abundance of right whales in neighboring waters. There is a record of the ship *Phocion* of New Bedford and the ship *Houqua* of New Bedford anchoring in Christmas Harbor toward the close of 1836, intending to make that bay their headquarters for whaling operations; they soon left, finding the anchorage too foul. However, in the summer of 1838-1839 the ship *Arab* of Fairhaven and the ship *Elizabeth* of New York spent considerable time at the island, and not only did some successful whaling from their anchorage, but also obtained a few elephant on shore.

Probably no American vessel went to Desolation for the express purpose of securing a cargo of elephant oil prior to 1837, though English sealers visited there earlier. The ship *Columbia* of New London, during the season of 1838-1839, obtained 3700 barrels of elephant oil at Desolation, one of the largest cargoes on record. She made other voyages to Desolation, sailing with the sloop *Shaw Perkins* as tender, and in 1844, after a twenty-one months voyage, she is reported arriving at New London with the magnificent cargo of 3200 barrels of elephant oil, 1000 barrels of right whale oil and 7000 pounds of whalebone.

Today took two sets of altitudes and made the longitude 53.02 and 53.04 E. by chronometer. It was nearly 11 A. M., however, when they were taken, although the horizon was good. The chronometer therefore is going it now on the high pressure principle, being 5 m. 08 s. slow of all her corrections, according to these altitudes.

At ½ past 2 P. M., our boat hove in sight with a load of blubber and took it to the works. In half an hour the Mosquito fleet hove in sight with a raft of blubber which they carried to the *White Oak.* At 4 P. M., our boat returned bringing some wood and albatross eggs. The mate went on board the *White Oak,* and Captain Nory informed him that he had got his blubber in Windy Bay, that there was any quantity of elephant there, that he would bring his ship in and moor her, and that he would not interfere with our bays but work the bays above American Bay. He had also been to American Bay where our party are at work and stated that he had seen enough elephant there to fill us and 150 barrels to spare, so that there is every prospect of business going on harmoniously instead of a "pull-Dick, pull-Devil" system between our two rival vessels.

We have only thirteen barrels of beef and two casks of bread left besides the one opened a few days since; consequently we are short. The other vessel has an abundance of provisions but her captain is in want of two men, and is willing to let us have provisions provided we will spare him a man or two. To this our captain will not consent until we are a full ship; so that is "diamond cut diamond". We will, however, bet two to one that our old man outgenerals the other captain at last, keeping the men until we are a full ship and then getting the provisions.

January 1*st,* 1844. . . . Manned a boat and sent it to assist Captain Nory in mooring. They immediately commenced heaving up and towed the vessel a quarter of a mile inside of us, where they moored her. At 4 the boat returned and started for Shallop Bay. A boat's crew from the bark is killing elephant in this bay. At ½ past 8 our boat returned, having left a load of blubber at the works.

Tuesday, Jan. 2nd. . . . At 4 manned the boat and started to the works to try out. At 8, four men came down from American Bay after provisions; they had an order from the captain to man both boats and come up after a raft of blubber, if possible—if not, to send one boat with the provisions. They also reported having seen the three boats belonging to the other vessel in Little American Bay, killing elephant in direct violation of their own agreement.

The wind now shifted to N. E. and looked threatening. Manned the 6-oared boat and sent it with her crew and three of the shore party up to American Bay. One of the shore party, St. Helena Joe, fell overboard just as she was ready to go; consequently we kept him on board. Also sent two bags of bread, etc.

We miss our barometer now greatly in our calculations upon the weather.

We are now fearful that the prospects of our voyage are blighted by the arrival of the *White Oak* and by her interference in the bays where we have commenced killing. We will do our utmost, however, at this island, not relishing the island opposite where we will be compelled to go in the event of not filling up here. . . .

Wednesday, Jan. 3rd. . . . No signs of our boat yet this morning; we are in hopes that the Captain has detained her and has kept all hands to skin. That would be the best policy under existing circumstances—to skin away as though life depended upon it until they have about 300 barrels, then for all hands to come down and get the schooner under weigh, leaving one or two Portuguese to stand guard over the blubber until her arrival, and then to raft the blubber off, which would easily be accomplished in one day. On the schooner's return to Ship Bay, part of this blubber could be sent on shore for trying-out and the remainder tried-out on board. In this way we would save a great deal of time in the way of boating, and would be enabled to keep pace, if not obtain the whip row over the other vessel; at any rate, to use a common phrase, we must begin to work roots and logarithms.

At 9 o'clock the mate and two others, all there were in the vessel, went on shore to look to the blubber in the pits. Found that the recent rain had broken through them and let the water out. Repaired them and put things in order about the buildings and works. Then returned to the ship.

At 3 P. M. saw the captain crossing the mountain toward the beach. Lowered a boat and went after him. He reported that Captain Nory's men had killed all the elephant in Little American Bay. They had also killed fifty elephant in Shallop Bay and left them there without skinning them in order to secure them. This conduct is unmanly and outrageous. Our men, however, went up to Windy Bay and killed a large number of elephant; the boat's crew is to remain there until sufficient are skinned to fill us, which will be by the day after tomorrow. So we will be even with Capt. Nory. He eventually will be the loser, as so much going on among the elephant will drive half of them off. Had Captain Nory acted according to agreement, we would not have disturbed that bay, in which there are 1500 elephant; we would have left them all for him.

At 5 P. M., the Captain took the two men belonging to his party and went on shore to prepare for trying-out in the morning. . . .

Thursday, Jan. 4th. . . . At 8 A. M., the mate started for the beach, taking with him the only two men that were on board, leaving the schooner to take care of herself, intending to assist the captain in trying-out. During the day tried-out about 25 barrels. The other vessel's boats were bringing a large raft on board of her and then starting to Windy Bay to encamp. Think they will be somewhat surprised when they find our men, who must have skinned at least 500 elephant there. Expect them down tomorrow, as we shall have blubber enough to fill the vessel. We will then get the schooner under weigh and go up after it. This has been a lovely day, extraordinary weather for these latitudes. At 8 P. M. returned on board again.

Friday, Jan. 5th. Begins with strong breezes from W. S. W. No chance this morning of going to the shore. The shore party

have not yet commenced firing up. About ½ past 8 A. M., saw some men crossing the mountain. Knew them to be our men from American Bay. In an hour afterward the shore boat put off with the captain and ten men, and, although the wind was blowing fresh from the westward, we immediately commenced heaving up the anchor, slipping the two lashed together. In a very short time we had the anchor on the bow and made sail for American Bay. At 12 M. came to anchor there.

After dinner the captain with all his party went on shore to raft off blubber to us, the mate and three men remaining on board to receive it. During the afternoon the boat brought up two rafts, 14 fathom longer than the moral law, the first having 284 large bunches of blubber and the second, 333 bunches. Each raft will make at least 75 barrels of oil. It was 9 P. M. when we had the last of the blubber on board. Should the weather prove favourable in the morning, we will take the blubber out of Windy Bay, about 100 barrels more, and then start for Ship Bay, land our blubber and drive the works all we know. This is the way we do business these days.

Saturday, Jan. 6th. Begins with calm weather. At an early hour sent the boat on shore for the shore party which soon returned. All the party had breakfast and manned both boats to start for Windy Bay, leaving only the mate and one man on board, a Portuguese with a sore finger.

One of the boats started with a raft, leaving the other boat and the rest of the crew to raft the large raft. In about an hour we arrived at the vessel with our raft of 50 barrels and then returned to assist in towing the other. This raft was a poser, being 30 fathoms long and containing upwards of 110 barrels of oil.

This was the hardest work of the voyage. The tide turned and for half an hour we pulled and tugged without gaining one inch. We next undertook to kedge it with two shot of line. The first time we run the kedge we lost it. Rendered desperate by this mishap, we buckled to it again, pulling, tugging, sweating and swearing, which appeared materially to assist us, for the tide turned in our favour, and by 20 minutes past 12 we had the

Fig. 378. (*Upper*) Bull sea elephant and harem, South Georgia Island. Photograph by J. Innes Wilson.

Fig. 379. (*Lower*) Bull sea elephants, South Georgia Island. Photograph by Robert Cushman Murphy, American Museum of Natural History.

Fig. 380. Bull sea elephant (*Mirounga leonina*) swimming through kelp beds, Bay of Isles, South Georgia, January 1913. Photograph by Robert Cushman Murphy.

raft alongside. Without waiting for dinner, we whipped the blubber in board, completely filling the vessel.

Next we commenced heaving up and got underweigh. The wind light and baffling, which soon died away. We then lowered all three boats and towed, leaving only the captain on board. After considerable difficulty we arrived at our anchorage in Ship Bay. About 8 P. M., took supper and commenced rafting off blubber from the schooner.

Sunday, Jan. 7th. Commences with fine weather and calm. During the day took most of the blubber out of the vessel. At 7 P. M., the boat's crew went on shore to keep the works going all night, watch and watch with the shore party.

Monday, Jan. 8th. Took the remainder of the blubber on shore. The intention is to drive business now to the utmost.

At 4 P. M. a strange boat came alongside. It proved to be Captain Nash of the *Bolton,* direct from Pig Island with 400 bbls. elephant oil, who reported Captain Barnum at Pig Island with 1400. He said that the elephant were very scarce there and thought he should go to East Island. He also reported there were plenty of whales outside, and that he had chased them yesterday and today, but could not get on them, as the weather was so calm. He remained on board but a short time, as his vessel was nearly out of sight to the southward of the island.

At 7, the boat's crew came on board for supper, having tried out nine casks since last night. At ½ past 7, they went on shore again to relieve the shore party at the works and returned again at 1 A. M. to take their watch below.

Tuesday, Jan. 9th. In the afternoon took a boat-load of casks on shore. About 5 P. M. the boat's crew came off and stated that they had been backing blubber from the raft to the pit and that some of them had helped the cooper in heading over and driving the oil.

Wednesday, Jan. 10th. At 4 A. M., the boat's crew went on shore to assist in trying-out, as the works were already in full operation.

Thursday, Jan. 11*th.* Saw the shore party engaged in trying-out. After dinner, saw a signal from the shore. Sent a boat. She soon came off with orders for us to start immediately for American Bay. We took a bag of bread and started, a boat from the *White Oak* following. This was a severe pull, most of the way against wind and tide. We arrived there, however, in about two hours, both boats landing at the hut at the same time, each ignorant of the destination of the other.

Our object was to kill the elephant we had left some days back in the tussock about half a mile from the beach. We soon discovered that our rivals had found out the elephant and had the same object in view. We had then no alternative but to mate, which was done. We next proceeded to drag our boats high and dry on the beach and take our blankets, provisions, etc., up to the hut. We then proceeded to the elephant and killed the whole of them, about 100 in number, and commenced skinning.

Toward sunset we returned to the hut to cook supper and encamp for the night. The hut was in a wretched condition, ankle-deep in mud and filth. It was about eighteen feet square. One end of it was composed of the side of a rock; the other three sides were filled with cracks and crevices through which you could thrust a clever-sized dog. Against the rock in one corner we rigged a kind of fireplace and kindled a fire with blubber, and removed about one-quarter of the roof to make a vent-hole for the smoke.

We next overhauled our stock of provisions and found that we each had a bag of bread, but neither beef, pork nor molasses. We also had in our bag some tea and a little dry salt. The pot was filled with water and hung on an iron hoop for a trammel, extending from the rafters to the fireplace. As our stock of cooking utensils was then limited to the pot, we held a consultation of war, when it was unanimously resolved to boil some albatross eggs first in the pot, and then make tea. We also started another fire in the opposite corner of the rock, and a third in the centre of the room in an old copper which had formerly belonged to some ship's cooking-stove.

In about an hour supper was ready, and, sitting or standing around the fires as circumstances would admit, we presented a

picture which would defy the pencil of a Hogarth—our faces besmeared with oil, sand, sweat and smoke, our clothes besmeared with blood, wet and dirt, our sheaths and leaning-knives strapped around our waists. We looked for all the world like a parcel of banditti who had just saved their necks from the halter by a precipitous retreat without stopping to pick their way. However, we contrived to demolish our suppers and our next object was to stow ourselves away for the night as comfortably as we could, which, by the bye, was a pretty serious task.

In the centre of the building the captain had on a former occasion lashed two small spars horizontally about six feet from the floor and thrown loosely over them three or four boards which, by way of distinction, he had christened a chamber. Into this establishment, by dint of perseverance and some considerable exertion, three of the party succeeded in crawling—consisting of the chief mate of the *White Oak,* our second mate, and a boatsteerer belonging to our vessel—and from its rickety motion it appeared strongly inclined to deposit its load before morning.

There were eleven of us still to be disposed of, two of whom took the boat's sails and, rolling themselves up in them, bunked on the floor. On one side of the building was a platform which had been used for sleeping, about the size and shape of a tailor's shopboard. On this we others spread our blankets and laid down in the following order: one tier of three fore-and-aft, then a second tier of three athwartships, then a third tier, also of three, stowed fore-and-aft. However, we lay very comfortably until some one found it necessary to turn, when all hands were compelled to surge at once, as we were stowed so close. We took care, however, to be in readiness, and the individual who wished to turn over would call out: "All hands stand by for stays!" We were also occasionally waked in the night by a gentle tug at the corner of our blankets, occasioned by some unlucky wight who, being half-frozen, was on a foraging expedition, wanting to appropriate to his own use the blankets of the sleepers. And thus ended the first night of camp duty.

Friday, Jan. 12*th.* Begins with fog and rain from the Northward Turned out and made preparations for breakfast. In scouraging

around we found an old frying-pan without a handle and with a hole in the bottom. Scoured it out with a piece of blubber and fried some eggs. Also had some bread and coffee. The wind now out N. E. and raining hard. At noon clears up and wind hauls to S. W. Started out and went to skinning again. At 5 P. M. it commenced raining again. Quit work and went to camp. Had supper and turned in again.

Saturday, Jan. 13*th.* Went out and skinned the remainder of the elephant and divided the blubber equally. Then went back to camp. In about two hours Mr. Patrick came up with another boat's crew from the schooner. Both of our boats then went to Little American Bay, took the remainder of our blubber from that bay, and returned with it to the works in Ship Bay.

Sunday, Jan. 14*th.* Took breakfast at 2 A. M. and started to the northward, taking with us a bag of bread. After pulling up to Boat Bay point, we found the boat stopped suddenly in the kelp, and we could not budge her ahead one inch. Upon examination, we found that her stern was split open. Backed her out of the kelp and into Shallop Bay, where we beached her. One of the men then returned to Ship Bay, and the rest of us, shouldering our dunnage and provisions, tramped it over the mountains to American Bay where, after refreshing ourselves, we started over an infernal mountain which appeared to me to have no end. We surmounted it after a great deal of labour, and began to descend on the opposite side, our object being to find a passage by which we could gain a beach under the cliffs where we hoped to find elephant.

We succeeded in gaining the beach by means of a very steep descent, and found there 32 elephant, which we killed. We had scarcely commenced skinning before it began to rain. However, we persisted in our work rather than leave it and return again, and finished them, although it poured down in torrents. After disposing of our blubber in a place of safety, and covering it over to secure it from the birds, we commenced our return back to camp in American Bay. We rested once or twice in our ascent up that accursed mountain, now rendered slippery by the drench-

ing rain. I shall call it Mount Misery, for richly does it deserve the title. And most religiously do I believe that if a church were located there and a congregation resided at the foot of the mountain, all those who visited it for the purpose of worship would certainly merit a title in the calendar of the saints.

After gaining the top, we stopped to blow a little, and then descended into the valley to our camp, completely drenched. Fires were immediately kindled to dry our dripping garments, and active preparations set on foot to cook supper. After supper we retired to rest, with but one blanket for two of us, six of us present mustering but three blankets. "To rest," did I say? God forgive me for saying so. I should have said, "To freeze to death." And to make the matter worse, just after we had turned in, the fire caught our clothing, and bid fair to send us back over the mountains to Ship Bay naked. We saved our clothing, some of it in a woeful state, and made out to weather through the night.

Monday, Jan. 15*th.* Begins with a rain storm and heavy gusts of wind from N.E. After we had taken breakfast, and whilst we were around the fire drying ourselves, Mr. Patrick and another individual arrived, having footed it from Ship Bay. Two of our party joined them, as Mr. Patrick wished to try the beach where we left off at Windy Bay point, where a high bluff prevented our going any further to the northward. If they could find a passage down on the other side by crossing another mountain, they would no doubt find elephant. The remainder of us, four in number, backed our dunnage and footed it down to Ship Bay, a distance of five or six miles, crossing four or five lofty mountains on our route. As soon as we arrived, we took a boat and proceeded to the vessel to assist in hoisting in a small raft of oil which was then alongside.

Tuesday, Jan. 16*th.* Begins with moderate weather. At 2 A. M., went on shore and found the Captain quite unwell with a severe pain in the back, scarcely able to move. Went on board after his bedding and medicine. We then went on board with a raft of oil, five casks, which were hoisted in. The boat's crew then returned

to the works, leaving the Mate with his party to stow down. Two of the men started up to Shallop Bay, and others of us left in a boat for American Bay after our share of the blubber we had skinned in partnership with the men from the *White Oak.*

Whilst we were rafting in American Bay, Mr. Patrick and his party came down to us and reported having found a passage on the upper side of the reef and having killed 40 elephant. They put their dunnage in our boat, assisted us off with our blubber, and started down on foot. We had a most tremendous pull of it. At sunset, having come to the point in sight of the vessel, when we had wind and tide both ahead of us, we were compelled to make fast to the kelp and load our boat nearly as deep as she could swim. When the other boat made her appearance with Mr. Patrick and his party, they having come down to Ship Bay before us, they took the balance of the blubber, and both boats soon reached the try-works. All hands then turned to and backed it up to the pit. Then we came on board, hoisted up our boat, had supper, and turned in as soon as possible to make up for lost time.

Wednesday, Jan. 17*th.* After breakfast manned the boat and went on shore, intending, if the weather would permit, to man both boats and pull around on the south side of the island. About 10 the boat came off, the wind blowing fresh from the northward, the weather clouding up and looking threatening. The boat's crew whilst on shore had headed up all the casks that wanted coopering, and, after they were finished, had rolled them down to the beach to a good place for rafting.

Thursday, Jan. 18*th.* Commences with a strong gale of wind from N.W. No communication whatever this day with the shore. . . .

Friday, Jan. 19*th.* At 7 started for the shore. Found the captain still unable to do anything. All his party except the cook had gone to the southward to kill some elephant. On our way back to the schooner we stopped on board the *White Oak* where we remained to dinner. Captain Nory informed us that he had

taken about 350 barrels oil since he had come in, and thought that he would put to sea in a few days after whale.

At 5 P. M. returned on board the schooner. Whilst at supper the mate of the *White Oak* came alongside for the doctor, meaning myself (as I had given some little prescriptions for some of their men). He stated that one of his men had been taken very suddenly and was almost dead. Sprang in the boat with him and went on board the *White Oak*. Found the man in great agony with a cramp in his stomach, occasioned by eating elephant's liver several days old before it was cooked. Soon relieved him. Also dressed a man's leg which had been severely bitten by an elephant. Remained on board during the night.

Saturday, Jan. 20th. At 5 A. M. a boat from the *White Oak* put me on board the schooner. The sick man much better. Our boat had started some time before to the northward. At 6, Mr. Patrick came off and I jumped in his boat to complete his crew, when we started to the southward to Dead Man's Cove. When we arrived, after a severe pull, we loaded our boat as deep as she could swim. As we rounded the point at Ship Bay, we found the other boat at the beach unloading. Unloaded our blubber and started the works.

At noon went on board after flour to make some doughnuts for all hands, the captain having promised a blow-out when we obtained 300 barrels of oil. . . . The captain gave orders to man the windlass early in the morning and heave in on the large chain; he would come off with his party and assist in mooring the vessel again. She had dragged the small anchors so that she lay directly over the large anchor.

Sunday, Jan. 21st. Began heaving in the large chain, having run out a line off shore with a boat's anchor. Obtained a kedge and hawser from the *White Oak* and run it out to the Northward. Then hove up the large anchor which came up clear, and hauled up the boat anchor and run a line to the *White Oak*. At 2 P. M., succeeded in mooring the schooner after eight hours' severe labour. . . . Saw a large right whale today in the harbour within a hundred yards of us, going leisurely along.

Monday, Jan. 22nd. Both boats took an early start and went to the Southward and returned with the remainder of the blubber from Dead Man's Cove. The boats then started to the Northward and returned with all our blubber in that direction, having two solid boat loads. At 2 P. M. they came alongside with five casks of oil. . . .

This afternoon the Captain transferred two men on board the *White Oak,* as it was their wish, and we were likely to be short of provisions. Their names were Robert Howard and John Flewdown. They went on board with their dunnage and the *White Oak* then proceeded to sea. . . .

Tuesday, Jan. 23rd. Too much sea to raft oil. The shore party was employed in breaking up the remains of the *Atlas* for fire wood. Mr. Patrick had gone on a tramp after elephant. . . .

Wednesday, Jan. 24th. Took breakfast at ½ past 3 and started for the shore. . . . Put slings on a raft of casks to have them in readiness when the weather should moderate. Also assisted the cooper in heading up the casks to fleet the hoops.

About 9 A. M. saw a ship coming down before the wind under double-reefed fore and main topsails and jib. She had a green boot-top with painted ports. When abreast of the schooner she hoisted her signal at the mizzen peak. Her signal was a red ball or star in a white ground with blue border; at the end of the fly, one blue stripe and another of red. Supposed it to be Mr. Mallory's private signal and that the ship was the *Aeronaut* of Mystic[12]. The schooner answered her by setting her ensign. The ship then passed on and afterwards braced up on the wind.

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[12]The ship *Aeronaut* of Mystic, 265 tons, Capt. West, sailed Sept. 6, 1843, and returned June 23, 1845. She was owned by Charles Mallory. The *Aeronaut* was on a strictly whaling voyage.

The waters around the Crozettes were frequently visited by whalers on their passage to the Indian Ocean. The ship *Arab* of Fairhaven on her way to the Indian Ocean in the early part of 1843 cruised about the Crozettes from the middle of January to the middle of April. Her log-book mentions speaking the following vessels during that time: the *Popmunnett* of Sippican, the *Herald* of Fairhaven, the *Romulus,* the *Superior* and the *France* of Sag Harbor, the *Tenedos,* the *John and Elizabeth,* the *Stonington, Halcyon* and the *Neptune* of New London, the *Fenelon,* the *Milwood,* the *Roscoe,* the *Majestic,* the *Dragon* and the *Cicero* of New Bedford, and the *Aeronaut* of Mystic.

Fig. 381. A New Bedford sealer, from the brig *Daisy* preparing to lance a bull sea elephant lying in the tussock grass. Bay of Isles, South Georgia, February 1913. Photograph by Robert Cushman Murphy.

At 10 came on board from shore. Blowing very fresh from the northward and raining hard. Had dinner; then turned in like good Christians, each man severely engaged in bunk duty. Mr. Patrick informed us that he had found about 300 elephant about a mile above Dead Man's Cove.

Thursday, Jan. 25th. Went on shore and brought off a raft of five casks of oil. Having stowed down the oil, took dinner and went on shore after another raft of five casks, which we brought off and stowed down. . . .

Friday, Jan. 26th. Rafted off eleven casks from shore and stowed them down. The shore party tried out five casks.

Saturday, Jan. 27th. Begins with calm weather. Took an early start for Mr. Patrick's elephant with both boats. Had a severe pull of it, the sea running half-mast high. We found the bay, if so it may be called, a slight indentation on the high rocky shore, an infernal hole, the sea breaking all over it, with rocks half a mile from shore. Found it would be worse than madness to think of landing. Took a good look at it; then, with a willing mind, bid it a farewell, and, we trust and hope, an eternal one. The wind now came out directly in our teeth and continued so until we returned to the vessel, giving us the most severe pull we have experienced this voyage.

After dinner went on shore, when Mr. Patrick and three more started for American Bay by land to ascertain if any elephant had hauled in the bays, as we wanted about two or three loads to fill us completely. At 5 P. M. returned on board. . . .

Sunday, Jan. 28th. Started to the beach and took off a raft of five casks of oil. At 3 P. M., went on shore again and found Mr. Patrick and his party had returned. They stated that they had been up as far as Windy Bay and had looked in all the intermediate bays without seeing any elephant. Concluded to send two boats early in the morning to Northwest Bay, a place we had never yet been to. . . .

Monday, Jan. 29th. Had breakfast at ½ past 3 A. M. Took some provisions, and both boats started to the northward, the

mate in our boat, and Mr. Patrick in the shore boat. About 9 o'clock came in Northwest Bay, a most dismal-looking hole on the weather side of the island. The sea running very high, combing and breaking most fearfully. We saw plenty of elephant. We laid upon our oars, waiting for the other boat to come up, and reconnoitred the bay, and the more we saw of it the worse we liked it.

The other boat soon came up, when the mate asked Mr. Patrick if he wanted elephant bad enough to land there for them, not dreaming that he would answer in the affirmative. Mr. Patrick, however, replied that a boat could land easy enough by waiting for a smoothing. The mate then said: "If you think so, go ahead then. I will remain here and you can take my raft-line and bend it on to yours. If you succeed in landing, I can haul your boat off by the line and my men will get in her and try to land, leaving our boat anchored."

He took the line and started. Smoothing or no smoothing, a dollar was at stake, and to obtain it Mr. Patrick would peril life, limb and property. He had not advanced fifty yards before a huge roller came tumbling in behind him; it would certainly have engulfed him and proved a watery grave for a part if not the whole of his crew, had not the mate snubbed the line and prevented the advance of the boat. Having changed the position of the boats to a more favourable place, Mr. Patrick started again. This time he succeeded in coming very near the beach, when over went boat, men and gear—some out of the boat and some under it, one man apparently somewhat hurt, and all of them drenched to the skin. The boat was stoven to pieces and left there with all her gear, a total loss.

Our situation was such that we could render them no assistance, and, having satisfied ourselves that they could climb up the mountain, we made signals for them to go up and come down to the next bay, for which we started. The wind was very fresh directly ahead with a heavy sea, and it was very doubtful for a long time whether we could get out of it, but by dint of perseverance and excessive labour we reached Hebe Bay, where we landed and beached our boat.

Here we found three large bulls, a couple of cows, and three small pups, which we killed. One of the bulls, rolling in the water, floated off and we lost him. We dispatched one man back to Northwest Bay to see if Mr. Patrick and his party had come up the mountain, the remainder of us bunching up our blubber, kindling a fire, and putting a cave in order in case we had to encamp there for the night.

In about two or three hours the man returned and said the others were not there. We then rafted our blubber, launched our boat, and, pulling through a heavy sea (the wind having been N.E. all day), we reached Ship Bay about dusk where we saw the other boat's crew. . . . We had a pull this day which beggars description. . . .

Tuesday, Jan. 30th. Went on shore and returned with a cask of water. After dinner went on shore again and brought off a raft of spars. The captain intends, if the weather will permit, to get everything off the beach tomorrow, on the morning following to start for East Island and obtain a couple of loads of blubber, which is all we want, and then to start for home.

Wednesday, Jan. 31st. Went on shore and brought off a raft of five casks, which we stowed down. Also brought off two loads of wood. Went on shore and brought off the remainder of the oil, three casks and a sixty. After all our oil is stowed down we shall still want fifty barrels more of oil to fill us. This is hard, considering the opportunity we have had of filling up.

Thursday, Feb. 1st. Begins with strong breezes from N.E. and rain. Stowed down the balance of oil left on deck last night, about twelve barrels, and arranged the empty casks in readiness for more oil in case we should be fortunate enough to obtain any at East Island. . . . No chance of communicating with the shore this day. Nothing to do this afternoon but bottle up sleep to draw upon when occasion may require.

Friday, Feb. 2nd. A heavy sea tumbling in around the south point. It is entirely too rugged to boat any articles from the

beach. Took the blubber boat in on deck and secured everything for another wallowing match. . . .

Saturday, Feb. 3rd. A heavy sea, rolling the vessel bulwarks-to. This is the third day since we have had any communication with the shore. About ½ past 8 A. M. the captain came off and paid us a short visit. He said that it looked mighty pokerish off here yesterday and when he saw the schooner tailing-in toward shore, a heavy sea rolling and tumbling in, and she was as much as she could wallow to, he would have given fifty dollars to have had her out of it. After remaining about an hour, he returned on shore with some provisions, having firmly resolved to up mud-hook the first opportunity and be out of this, being perfectly satisfied with the scenery exhibited in this bay yesterday.

At 6 P. M. the wind hauls to N. W. and blows with great fury, the sea coming in from N.E. If the old man considered it mighty pokerish yesterday, wonder what he considers it now. As his eye scans the troubled state of the waters in the bay, as he sees the short wall-sided seas combing and breaking in every direction, and as he beholds the little schooner going it in full bloom, four rolls to a minute, and each time bulwarks-under, with the sea making a breach directly over her—methinks as he thus views her from shore he is considering her situation rather more than pokerish.

This state of things could not last long, however, owing to the direction of the wind, and in about an hour the sea began to subside and continued so the remainder of the day.

Sunday, Feb. 4th. Begins with severe woolies from N.W. and occasional rain squalls. It is duff day, which is about the only run of the day of the week kept forward. Last duff day is fresh in the recollections of every one, as by some unaccountable process the duff was converted into the consistency of a cobbler's lap-stone. The boat remains, as the lawyers say, in "status quo"; in our vocabulary, keel-up on deck, which signifies bad weather. No chance of going on shore today, to all appearances, the wind roaring most dismally directly off shore.

Monday, Feb. 5th. At 5 A. M. almost calm. All hands busily engaged in boating off water, the remnant of our oil, provisions, wood, sails, and all our old dunnage, which was completed by ½ past 11 A. M., when the captain came on board in the last boat and immediately ordered the windlass manned.

Part III. At Cape Town

[*Abstract*]

No sooner had the *Emeline* left Ship Bay than a bad leak was discovered. The captain decided to abandon his intended visit to East Island and to sail directly to Cape Town. The leak grew steadily worse; the ship's carpenter labored two or three days trying to make repairs, but finally gave up the job in despair. Both pumps were kept in operation almost constantly, and the men on the *Emeline* had grave fears of the schooner's foundering. But on the seventh of March the vessel arrived safely at Cape Town.

At this time Cape Town was buzzing with excitement over the discovery of guano on the African coast. Isaac Chase, the American consul, strongly urged Captain Eldridge to secure a cargo of the new fertilizer before sailing homeward. The elephant oil could be disposed of favorably at Cape Town, and thus the *Emeline* would be enabled to make a double voyage. Incidentally, the schooner could carry to the guano islands a ballast of water, which could readily be sold to the shipping there at five pounds a ton. The consul further recommended that the *Emeline* dispose of her guano at the West Indies, a logical market for the commodity. His scheme in its entirety appealed strongly to Captain Eldridge, and on the twenty-fourth of March the *Emeline*, with her leak repaired and her oil disposed of, set sail for Angra Pequena.

On board the *Emeline* during this second part of her voyage was Captain John L. Harris, bound home as a passenger. He was the late commander of the schooner *Pacific* of New London which had just been condemned at Cape Town. Captain Harris had arrived in Cape Town from an Indian Ocean whaling cruise on

the twenty-sixth of January with his vessel in apparently sound condition. At that time he received from Consul Chase the same suggestion about guano that was later made to Captain Eldridge, and about the eighth of February was on his way to Angra Pequena. Not many days later, however, he was back again at Cape Town with his vessel in distress. A survey was held, and Captain Harris found himself without a command. The misfortune that befell the *Pacific* permitted the *Emeline* to be the first American vessel to engage in the African guano traffic.

Part IV. The Guano Adventure

Wednesday, March 27th. At 10 A. M. land was discovered on our weather beam and quarter, apparently high land, about fifteen miles distant, bearing S.E. by compass. . . . At 12 M., passed Albatross Rocks, standing in for the Island of Possession.

Lat. by Obs. 27. 03 S.
Long. by Chron. 15. 01 E.

Thursday, March 28th. At 40 minutes P.M., rounded to under the lee of the island and came to anchor.

After dinner the captain went on shore and examined into the state of the island as to our cargo of guano. The result of his examination was that the article was not of the quality we wished, and that it had been taken out in several places, as if others had endeavoured to seek the right kind. Some shovels were found there, and it presented every appearance of having been lately visited for the purpose of procuring guano.

This island presents a most forbidding and repulsive aspect, one at which the mind recoils with horror; it appeared as though it had never been made for the use or benefit of either man or brute, but had sprung into existence through some of Nature's wild freaks, the vomiting of some subterranean fire. It is one dreary waste of parched sand. No tree, shrub or bush meets the eye to enliven the prospect, and, to judge from appearances, but few of the feathered tribe resort to it. Possession is the name of it, and the rightful proprietor, we presume, is the Simoon of Africa, as its dry, arid surface too plainly indicates. Seal, however,

have been taken here in great numbers, to judge from the quantity of bones strewed upon its barren surface; and, although they showed instinct in selecting this void in creation as one of their numerous haunts, yet man, always alive and active in the pursuit of gain, has followed and swept them from the island.

During the night, light airs from the southward. At 4 A.M. commenced heaving up the anchor. At 5 A.M. we were fairly under way, coasting along to Angra Pequena, 20 miles distant. At 12 M. entered the Bay of Angra Pequena—the westerly point, Pedestal Point, being in Lat. 26. 38 S., Long. 15. 02. 30 E. This point and Angra Point (three miles distant, bearing E.N.E.) form a small bay called Ship Bay and may be considered as the entrance to the main bay of Pequena. The bay then runs east, 6 miles from Angra Point, where the mainland bounds it. In this bay are located three islands, called Shark, Penguin and Seal Islands.

(*Civil Account*). At 1 P.M., came to anchor under the lee of Seal Island. In the bay we saw several vessels at anchor. After dinner, we went on shore and visited the island and found it to be a barren rock formed principally of quartz and felspar. In traversing the island we observed several parties, belonging to the vessels at anchorage in the bay, busily engaged in obtaining guano, an article at present in high repute.

This guano is obtained in the chasms and fissures of the rocks, which have been filled partly by the periodical visits of the seal in pupping and shedding seasons, and partly by being the rookeries of the sea fowl. These united have filled these chasms for centuries upon centuries back. Guano, therefore, is but the decomposition of animal matter which the strong smell of ammonia plainly indicates. So powerful is its perfume that we can readily scent it at our anchorage about half a mile from the island. In some places it is found to the depth of thirty feet, and, in digging it up, immense quantities of bone (both seal and fowl) are found intermingled with hair, shells and the refuse of birds. The time it has required to fill these fissures and to undergo the natural routine of decomposition is beyond conjecture and leaves one in a maze of wilderness.

Tomorrow we leave for the Island of Ichaboe, the place of our destination, both to discharge our present cargo and to freight ourselves with guano, when better opportunity will no doubt occur to examine it more closely. . . .

Friday, March 29th. At 8 A. M., light breezes from the southward. In half an hour afterwards, the wind shifts to northward, light and baffling. Therefore we deemed it imprudent to put to sea today.

At 12 Meridian the wind breezes up from the southwest, but, it being too late in the day for thinking of getting under way, a boat's crew went on shore after guano. At 3 P.M. the boat returned with a load consisting of 22 bags, which was left on board, and they started again for the beach. During the afternoon two loads more came on board—in all, 45 bags. . . .

In the evening we had some fine sport fishing, taking in the course of a couple of hours about 150-weight of fish called Cape salmon, an article of excellent flavour. The mate went on board of a brig laying in the harbour and obtained a couple of pick-axes which were much needed by us, the equivalent to be paid for in water tomorrow. At midnight, calm.

Saturday, March 30th. At 6 A.M., light breezes from the southward. The captain ordered the windlass to be manned. In half an hour afterward a boat belonging to the brig came alongside and received their water (two small casks) in payment for the pick-axes.

At 7 A.M. we were fairly under way, bound to Ichaboe. . . . At 12 Meridian rounded to under the lee of the island, passing through a fleet of shipping, thirty-three in number, principally ships and barks, all in pursuit of guano. At 20 minutes past Meridian came to anchor about ¼ of a mile from the island.

The shipping here are all English, our flag being the only American one. The island appears like a human hive, the busy throng hurrying to and fro on stages. The plying of the boats back and forth forms quite an animated scene. As we have not yet visited the island we will reserve a description.

Fig. 382. Cape Town and Table Mountain. From a lithograph by Sarony & Co., New York.

After dinner, partial engagements were made for the use of a stage in loading, at the price of 7 pounds, 10 shillings, to be paid in water and vegetables. During the afternoon, threw overboard the guano obtained at Seal Island as it was a very inferior article. In coasting up this morning we saw a great number of seal, two or three reefs or hammocks being covered with them. Presume that one or two thousand fur seal could be taken here in a very short space of time and without much difficulty.

This afternoon the boat went on shore and a suitable place was selected to begin upon on Monday morning, Mr. Patrick selecting the spot, and from the sample seen the guano is pure and unadulterated. Captain Harris, acting as our super-cargo (a voluntary act of kindness on his part), has obtained for us the use of one of the stages, on which to transport our guano to the boats, from the agent of a company in England, whose special business here is to attend to filling the vessels and to procure supplies of both water and provisions for them. At 9 P.M. the agent came on board but, it being late, the contract was not signed, though permission was given to commence using his stages on Monday morning. . . .

Sunday, March 31*st.* At daylight saw several seal within fifty yards of the vessel. Since we have been here 50 pounds have been offered for the use of the schooner to proceed six degrees to the northward to see if there were any more islands near the main—the cruise would have taken about a week. This morning nearly all the vessels had their colours at half-mast, the steward of one of the vessels having committed suicide yesterday (by poison, as the report is). At 12 the funeral procession in boats reached the shore and the body was interred on the back side of the island. At 2 P.M. sold ½ bag of potatoes for 10/ cash.

The guano here is of the purest kind and of the depth of 50 to 60 feet. On the lee side of the island are some twenty or thirty stages rigged out, made of spars and timbers, along which the guano is carried in bags and thrown in to their respective boats. The island is about a quarter to half a mile in circumference and is one solid hill of guano. It has been originally a large or rather a number of reefs slightly elevated above the

water. Upon the spot birds and seals have resorted and in process of time their deposits have made this large mass. How many centuries it has taken to form we leave to the curious to determine. From the manner in which they are taking it away, in a year's time it will be reduced to its original size, as there are constantly from thirty to fifty ships at the island, all English. We will be the first American vessel that has ever loaded with it from this island. . . .

Monday, April 1st. A boat's crew went on shore to commence clearing away the upper surface of the ground previous to digging out the guano. The mate remained on board with a portion of the crew, removing the vegetables and some of the water from the hold to the deck to have a portion of the hold in readiness to begin receiving our cargo.

So strong is the effluvia of ammonia on this island that when our dog went on shore he came very near going into spasms—running about, rolling in the dirt, and frothing at the mouth, as though labouring under an atttack of hydrophobia.

Tuesday, April 2nd. During the day the captain of a bark laying here, hearing of the enormous price charged by the agent for the use of his stage, kindly offered us the use of his, and also permission to dig beside him in his pit (which is the best on the island), as soon as a brig is loaded whose crew are now at work in his pit. She will be loaded in two days at the outside, when we will step in, and in a few days fill our vessel.

This attempt to take advantage of us (as it was impossible for us to work without a stage, and, even had there been room to build one, we had not spars enough belonging to the vessel to build it), has created quite a sensation among the men on shore, particularly as we were not only the only American in the whole fleet, but the first that has ever arrived here after guano. They therefore in derision named the stage the "7-pound-10." This afternoon the entire stage, scaffolding and all, fell down in one mass of ruins, the greater portion of the plank floating off to sea, amid the cheers and merriment of the men.

Wednesday, April 3rd. At an early hour the crew went on shore accompanied by Captain Harris, intending to assist the brig in loading that we may be enabled to commence the sooner. The mate and second mate have also gone on shore this morning.

During the day a ship and a bark arrived here, and one ship sailed. Several more are nearly ready for sea. It presents the appearance of a thriving commercial seaport, but the eye wanders in vain to seek the quiet, cheerful abode of man. The wide expanse of ocean bounds the prospect on one side and desolation on the other—the cheerless, barren and arid coast of Africa. One little mound of earth appears—the small Island of Ichaboe, the centre of all this attraction, isolated in its position, barren on its surface, but teeming with this new substance, guano, so eagerly sought for by active, industrious men.

Thursday, April 4th. At an early hour three of the crew were left on the island to assist the brig's crew, the boat returning. The mate then took the boat with Mr. Patrick and eight of the crew; and, having supplied themselves with water and provisions, they proceeded to the main about 6 miles distant, where several ship's long-boats were laying upon the beach, abandoned by their owners. Our intention was to procure one of them, repair her if she was worth it, launch her, and tow her to the schooner to use in loading, as a boat of that kind is almost indispensably necessary here, and to obtain one from any of the agents would be only a repetition of the 7-pound-10 system.

This morning a foretopsail schooner left homeward bound; a ship also arrived. In the course of the afternoon another vessel sailed. At 4 P. M., the boat's crew returned. They stated that on their arrival at the beach they saw a wolf leisurely waiting for their arrival, a little out of gunshot. As soon as the boat struck, however, he scampered off as fast as his legs could carry him. Fresh footsteps of lions were seen in the sand. The men also saw another wolf. The boats, the object of their search, were found, and after a great deal of labour in digging them out of the sand, they proved to be worthless. Consequently the boat's crew returned without them.

Friday, April 5th. . . . At daylight a boat went on shore and active operations were commenced in the guano line. Both boats were constantly going. During the forenoon the captain went on shore for the first time since we have lain here, being much better today. After dinner it breezes up quite fresh from the southward, so much that we can only use the large boat. In the course of the day we stowed down 264 bags, the mate having floored off a portion of the hold with bags which were first filled with guano and then sewed up. These were stowed as closely as possible. The guano was then emptied on the bags.

A large bark came in here this afternoon.

In the evening the breeze continued freshening. At 8 P. M. a brig ahead of us began dragging her anchor and at one time strong fears were entertained she would drift foul of us. We paid out chain. Her anchor, however, brought up and held about half a length from us. A double watch was set for the night.

Saturday, April 6th. Begins with very strong breezes from the southward. Throughout the day we were unable to have any communication with the shore. In the forenoon the mate broke out a portion of the fore hatch and put it in readiness to receive cargo. . . .

Sunday, April 7th. Begins with a dead calm. At 3 P. M., light baffling puffs from S. to E. At 7 P. M., finding it a good opportunity to shift our anchorage, hove up the anchor, manned the boats, and towed her in to a convenient distance from the stage we work from.

Since our arrival here there have been flying rumours among the shipping that a valuable mine had been discovered on the main by one of the agents stationed here. This rumour daily gained ground, as boats were occasionally seen stealthily plying their way some five or six miles distant and returning, when they could have had no earthly object in view, unless some secret enterprise of this kind. The mine was also stated to be a gold one.

Actuated by curiosity, our national charactertistic, we intended ferreting out this hidden treasure. The vessel being safe-

ly anchored, the captain kindly offered us a boat to pursue the enterprise. We then put up a sufficient quantity of water and a few eatables, taking care also to provide ourselves with ammunition and an excellent piece to use it (Capt. Harris's), as the coast was known to be infested with lions and wolves. Upon mustering, but four of us were in readiness to go. Consequently we proceeded to the *Caroline*, whose captain had kindly lent us the use of his stage. An ample crew was immediately raised, with the addition of another shooting-iron, when we started in full glee for the gold mine.

After a long pull of some seven or eight miles, we succeeded in effecting a landing, and beached our boat. We found another boat there on the same errand. In a few minutes one of her crew came down nearly exhausted with a back-load of this treasure. We examined it and formed but an indifferent opinion as to its intrinsic value. Still we had a desire to see its source, and accordingly all hands started on the tramp, taking with us our bags, a few bottles of water, and our implements of death.

Our journey was on one dreary plain of parched sand intermingled with shells, having a crust upon the surface similar to a meadow of a frosty morning. All the indentations upon its surface were filled with salt, the deposit of the vapours from the ocean when meeting the hot air reflected from the scorching sand, which condensed it and caused a deposit of its saline matter. So complete was the illusion (the salt having an exact resemblance to ice) that were it not for the scorching rays of old Father Sol, we would have supposed that we had been touched by some magic wand and transported into the dead of winter. In our journey across this waste of sand we met two men of the crew backing down their fortunes or somebody else's and almost famishing of thirst. We supplied them with water and passed on, closely following their tracks. After a tramp of about four miles we came upon the mine.

The display of bags, some filled so full that no one man in the harbour could have backed one a quarter of the way to the boat, the pickaxes, the delicate mining shovels—all looked as though the others meant it in downright earnest. It has every appearance of a copper mine, although it may be still more val-

uable; we each bagged our specimens and returned again to the boat. Among the specimens which I selected I have taken some from the different strata of rock from its apex until the vein is struck. Should the substance prove of any value the mine is inexhaustible, as the same can be found one mile distant. An assayer of metals can speedily put this subject to rest—I have my doubts as to its value.

In returning we saw numerous fresh tracks of wolves, but did not see any of the animals; presume they were among the hammocks, near where the tracks were, at the entrance to the plain. After refreshing ourselves we launched our boat and returned. . . .

During the day two vessels more sailed with full cargo. . . .

Monday, April 8th. Had an early breakfast and before daylight the shore party were landed and busily occupied in filling their bags, backing them to the boat, and loading the vessel. All hands determined to take advantage of a fine day, and drive the work to the utmost of their power. We received three boat-loads on board before a single boat belonging to the fleet landed, and throughout the day it was one continued scene of bustle and activity—every man entering into the spirit of it and doing his utmost to perform an extraordinary day's work. The shore party shouldering their bags, depositing them in the boat and returning, constantly on the full jump as tight as they could spring to it; the boat's crew pulling the loaded boat to the vessel, and, as soon as the warp was thrown on board, stepping out of her into an empty boat, and returning forthwith; the mate's party on board, six in number, hoisting in, stowing down, and leveling off in the hold, and, whenever we could gain five or ten minutes on the boats, filling up some bags and sewing them for flooring off the fore hatch—in this manner we received in the course of the day 19 boat-loads, bringing in the aggregate 710 bags, the bags averaging about 100 pounds each, and making us now about 41 tons on board.

At sunset all hands came off to supper. The boats were hoisted up and the watch set for the night, as all felt like enjoying a little repose after such a tremendous day's work. . . .

Tuesday, April 9th. . . . At an early hour the boat went on shore with part of the crew; the remainder of the crew remaining on board to assist the mate in breaking out water, provisions and everything remaining between decks. This was accomplished by 11 A.M. We were compelled to start some of our casks and use them for dunnage.

We received two loads before dinner. In the course of the day, took in eight loads, consisting of 345 bags. Today two more vessels arrived, one of them a large Indiaman carrying twelve or fourteen guns, with a complement of middies and marines. She also is after guano. . . .

Wednesday, April 10th. During the day took in 375 bags, the balance of our cargo, and, in accordance with the general usage here, gave three hearty cheers when the last boat left. After her arrival alongside to unload, the last bag was suffered to remain until everything was in readiness, when we hoisted it up as far as the tackle would admit amid the cheering of the crew. This was responded to by most of the shipping in the harbour. We gave them Yankee Doodle on the flute, the Star-Spangled Banner unfolding itself at the same time to the breeze, the only one among the fleet.

We have shown them here true Yankee play, and to the credit not only of our flag, but our nationality, not counting too much on dollars and cents. The living on board the English vessels is miserable beyond belief, their bread resembling the sole of a scorched boot. Vegetables are known to the foremast hands only by name. Having a good stock on board, some were given to the crew of the *Caroline*. As the captains here were too poor in cash to purchase, and receiving bills of exchange on London for paltry amounts was not worth meddling with, we started seven casks of water on deck, letting it run through the scuppers, and stove up the casks for dunnage. This opened their eyes a little, and they found the little Yankee as independent as the flag she bore at her mast-head. The consequence was a demand for water and vegetables, and the sovereigns began to tumble in as fast as they could muster them. . . .

Thursday, April 11*th.* In the forenoon I went on shore for the first time and took a thorough view of the island. It is much larger than I had any idea of, and two years will elapse before they can remove all the guano, should they employ all the shipping now afloat. The different portions (or pits, as they style it), some a little further advanced than the others, give the island the appearance of a huge fortress, with all its ramparts and abutments. Each party as they work are leaving the walls perpendicular, and so hard is the substance that they are compelled not only to use the pick-axe but the beetle and wedge. The skins of birds and seal are found protruding through from top to bottom, also the eggs of the sea fowl, some of which, taken out sixty feet from the surface, I have preserved. . . .

Friday, April 12*th.* Begins with light airs from the northward. After breakfast, hove up the anchor and manned both boats and towed the vessel out from among the shipping to a good place to get under way from at the first opportunity.

After anchoring, nine of us, including the mate, started for the gold mine. On our landing we saw two wolves on the beach, but could not get a shot at them. We bagged our specimens and returned, coming across the tracks of a large lion. The wolves had been to our boat during our absence. At 4 returned to the vessel.

Today two vessels arrived here. We purchased two hundred-weight of bread at the price of three pounds, sixteen shillings, for which we gave three bags of potatoes at 16/ and two bags of onions at 14/ per bag. We have also made Capt. Harris of the ship *Caroline* a present of some vegetables for his kindness toward us. . . .

Saturday, April 13*th.* Begins with light airs from the northward and a very heavy fog. At sunrise the mists begin to disperse, and there is every prospect of soon getting under way. At ½ past 8 A.M., light airs from the southward. Immediately commenced heaving up and by ½ past 9 A.M. we were under full sail—homeward bound via the West Indies. . . . A

bark called the *Black Prince* sailed this morning in company with us.

Since we have been here, we have been extremely fortunate, more so than any vessel in the whole fleet. Vessels which arrived before us are still remaining there without having received a single bag of guano on board; they have been compelled to put on board some other vessel some 1000 or 1500 bags to obtain the privilege of working in a pit, besides paying a heavy bonus of 30 to 45 pounds sterling for the use of a stage, and that, too, to their own countrymen. The fact is that this island, together with the stages, have been under the control of a set of agents, men devoid of either principle or common honesty, fleecing their own countrymen without hesitation or scruple. Upon our arrival here, a solitary stranger, the only one unfolding the Stars and Stripes, the same game was commenced upon us, but in catching the Yankee they caught a Tartar. We have struck the death blow to extortion and agents on this spot, and we leave the island with the bright escutcheon of our national flag untarnished, unsullied.

A strong remonstrance has been forwarded to the Cape, directed to the heaviest firm there of which the consul is a silent partner, and no doubt energetic measures will be pursued forthwith to protect the interests of our flag and set an example to John Bull which they will profit by. Fortune, although a fickle goddess, has this time favoured us, and the order has proved to us of incalculable benefit. Capt. Harris, our passenger, a member of that fraternity whose basis is charity to all mankind, has been indefatigable in his exertions to aid and assist us in forwarding the interests of the voyage.

After our arrival here and undergoing the 7-pound-10 system, we found a friend in another Capt. Harris, of the British ship *Caroline,* united by the same bond which binds brethren, the boundless ocean's roll between the places of their nativity. The consequence was the offer of his pit and stage gratuitously, which was accepted, and we were filled in a brief period. His courtesy and civility required a corresponding feeling on our part, which was manifested by a present of vegetables and water.

Part V. The Homeward Passage

[*Abstract*]

The passage of the *Emeline* from the African coast to the West Indies was uneventful but disagreeable. "God send us a speedy as well as a profitable deliverance from this cargo!" writes Fosdick. "The smell from the guano is most intolerable, like inhaling the steam from a tea-kettle, scalding the throat, stomach and lungs; in fact, debilitating the whole system. The foremost hands have rigged a windsail to ventilate the forecastle, and the captain is now most actively engaged in making one for the cabin to try what virtue there is in it, as the guano proves a sore annoyance to him."

At the West Indies the *Emeline's* first stop was at Barbadoes. Guano was selling there at twenty-five dollars a ton, but the authorities would not allow the entry of any brought in an American bottom. At St. Thomas, however, the *Emeline* had better luck, for the captain was able to make arrangements there for the disposal of his cargo at St. Cruz. Whether these arrangements went through as planned is not known, as a page of Fosdick's journal is missing at this point.

The *Emeline* reached her home port June 23, 1844.

Acknowledgments

To Mr. Zephaniah W. Pease, president of the Old Dartmouth Historical Society at New Bedford, Massachusetts, and to Mr. Frank Wood, curator of the society's Whaling Museum, acknowledgment is due for their willingness to allow the *Emeline* journal to appear in this form. The manuscript is one of the finest in a large collection of whaling log-books and journals gathered by the late Mr. Andrew Snow, Jr., of New Bedford, and bequeathed by him to the society.

For many courtesies incidental to the preparation of the introductory material the editor is indebted to the following: Dr. Charles H. Townsend of the New York Aquarium; Mr. George H. Tripp, librarian of the New Bedford Public

Library and former president of the Old Dartmouth Historical Society; Mr. Andrew Keogh of the Yale University Library; Dr. Robert Cushman Murphy[12] of the American Museum of Natural History; Mr. Lawrence W. Jenkins of the Peabody Museum at Salem; Mr. Frederic P. Fish of Boston; Mr. J. C. Comstock of the Customs House at New London; Mr. Arthur E. Duffy of the Customs House at New Bedford; Mr. Tyler Dennett of the Department of State; Mr. C. C. Concannon of the Department of Commerce; Mrs. Benjamin D. Cleveland of New Bedford; and Captain Edward M. Ellis of Fairhaven.

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[12]Notes on the Sea Elephant. Bull. Amer. Mus. Nat. Hist., Vol. XXXIII, Art. II, pp. 63-79, pl. 1-VII, New York, Feb. 20.

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GROWTH OF DIAMOND-BACK TERRAPINS

SIZE ATTAINED, SEX RATIO AND LONGEVITY

By Samuel F. Hildebrand

U. S. Bureau of Fisheries

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SIZE ATTAINED, SEX RATIO AND LONGEVITY

By Samuel F. Hildebrand
U. S. Bureau of Fisheries[1]

(Figs. 383–384)

Introduction

The studies and experiments upon which this paper is based were carried on at the U. S. Fisheries Biological Station, Beaufort, N. C., and some of them were undertaken as early as 1909. Although the present writer did not participate in the work prior to 1914,[2] the data from the beginning of the experiments are at his disposal and are drawn upon freely. This report, therefore, is based on experiments conducted from 1909 to 1931 when the writer's connection with the work terminated.

The animals used as a broodstock in the experiments mostly were caught locally and may be referred to as Carolina terrapins for convenience. Two subspecies, namely, *Malaclemmys centrata centrata* and *M. centrata concentrata*, however, are involved, as explained by the present author (1929, p. 27).

Growth

Various experiments pertaining to the care and winter feeding in a nursery house were conducted and are reported upon by the writer at some length in another paper (1929, pp. 44 to 54).

It is sufficient to say here that in general a year's growth is gained by feeding the young during their first winter. Incidentally, mortality too apparently was greatly reduced. Older terrapins, that is, animals in their second and third years, did not respond to winter feeding as favorably as the recently hatched ones. While no harmful effects from the prevention of hibernation were noticed, the increase in size was so small that winter feeding of the older

[1] Published by permission of the U. S. Commissioner of Fisheries.

[2] The terrapin cultural experiments at Beaufort were under the general supervision of W. P. Hay, of the Washington, D. C., Public Schools from 1909 to 1915.

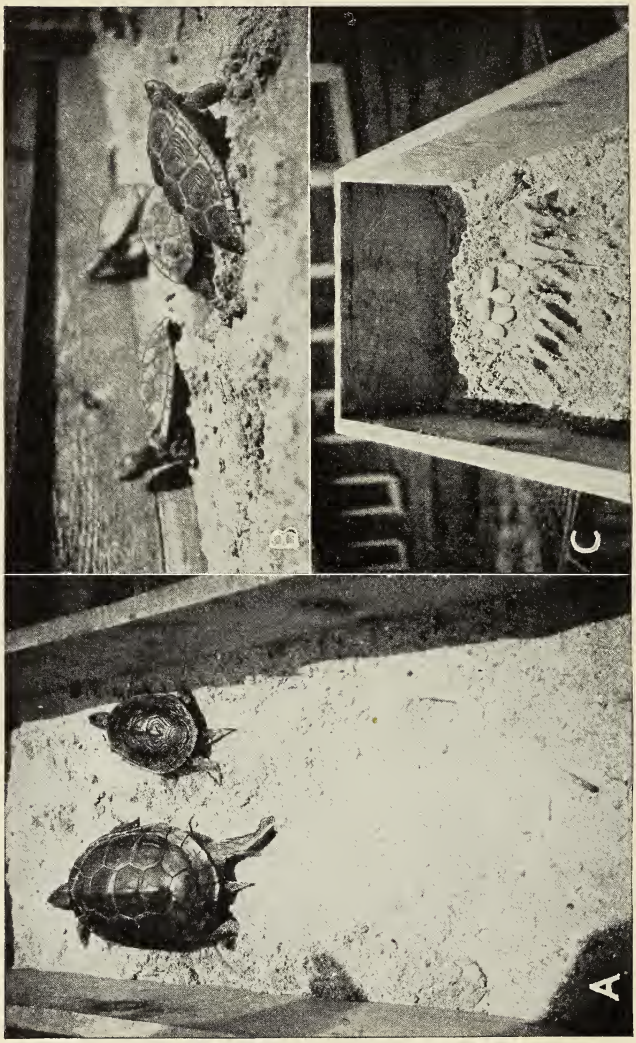

Fig. 383 A. Diamond-back terrapin (*Malaclemmy centrata*): *left*, adult female; *right*, adult male. The males are much smaller than the females and are correspondingly less valuable. Fortunately, from a commercial standpoint, the males have been greatly in the minority among terrapins grown in captivity. B. Female in foreground on nest. To make the nest, a jug-shaped hole five or six inches deep is dug with the hind feet in the moist sand in which the eggs are deposited and then covered with the sand previously removed. C. Diamond-back terrapin eggs. The eggs are elongate and have a very tough, leathery case.

animals obviously is not feasible from an economic viewpoint. Nearly all the terrapins grown to maturity in captivity, therefore, either were allowed to hibernate each winter or were fed only during their first winter. It is principally with the growth and development of the animals after an age of about one year is attained that this report concerns itself. The general treatment and conditions provided were about the same for all lots considered and the feed consisted of chopped fish, occasionally mixed with blue crabs.

The active annual feeding and growing period of terrapins is comparatively short. At Beaufort the animals sometimes become active in March, if the season happens to bring warm days. However, they seldom are continuously active and feed regularly before about the first of May. Egg laying commences very soon after the terrapins become active in the spring, and it continues for several weeks. The earliest date on which laying has been observed is May 6, and the latest one is July 31. Some females lay only once during the season, others lay two and three times, a few lay four times and rarely five times. The usual number of eggs laid at one time is eight, and the average incubation period is close to 90 days. By the first to about the middle of October the terrapins again become inactive and cease feeding. The animals are so sensitive to temperature that even during cool days in mid-summer their capacity for food consumption is markedly reduced. It perhaps is superfluous to say that growth stops as soon as feeding ceases.

While the annual growing period lasts only about five or six months (at Beaufort), the life growing period is a long one, and it varies greatly among individuals as well as among different lots and broods. A few animals have attained a length of five and one-half to six inches (on the median line of the plastron) in six years. Other individuals have required more than twice that length of time to attain such a size.

The older broods, that is, the lots hatched in 1910, 1911 and 1912, grew comparatively fast until the age of eight or nine years was reached. Thereafter, the rate of growth was so slow that the present writer (1929, p. 57) was led to make the statement that it probably would not be profitable in commercial terrapin culture to retain the animals after an age of eight to ten years was attained. However, some of the younger broods have grown more slowly during the first eight or nine years of life and accordingly needed a

greater length of time to reach a marketable size.[3] Two lots of the 1916 brood, the slowest growing of any terrapins raised in captivity, apparently were gaining growth more rapidly during their twelfth year than during their eighth and ninth years. It is to be noted, also, that even at the age of twelve years only thirty-nine of the seventy-four females (52.7 per cent.) in one lot and forty of seventy-four (54.0 per cent.) in the other one were 125 millimeters (5 inches) or more in length. Therefore, many of the animals were still definitely below a marketable size at the age of twelve years.

The other younger broods on hand grew somewhat more rapidly than the 1916 brood. Yet it is evident from the accompanying tables that it would have been decidedly advantageous from a commercial standpoint to retain most, if not all, of the animals until an age of ten or even twelve years was attained.

The tables offered herewith are based upon lots of the broods of 1916, 1919, 1920, and 1922. For the rate of growth of the older broods, that is, those of 1910 to 1915 inclusive, the reader is referred to an earlier paper by the writer (1929, pp. 59 to 61, tables 22 to 27, figs. 1 to 6). One series of measurements made in the fall of 1928, in addition to the ones in the earlier paper, is available. The average size of the three oldest broods, namely the broods of 1910 (last previous measurements made in 1925), 1911 and 1912 (last previous measurements of each made in 1927), consisting of six lots had increased at most only two to three mm. in average length. The animals of the 1913 and 1914 broods (those of the 1915 brood having been discarded), being younger, had gained considerable growth, the sixty-eight females of the 1913 brood having increased in average length from 128.5 mm., when measured previously in 1925, to 135.2 mm., but the five males in this lot had not grown. The brood of 1914, consisting of seventy-eight females and three males, had increased in average length (sexes combined) from 121.3 mm. in 1925 to 131.0 mm. in 1928. When the last measurements were made (in 1928), and the animals of the 1913 brood were fifteen years old, six of the females were still under 125 mm. (5 inches) in length, and fourteen of the seventy-eight females in the 1914 brood, fourteen years old, were under that length.

[3] Terrapins less than six inches long on the median line of the plastron do not command a fancy price and those less than five inches in length have little value on the market. Accordingly the males, which seldom exceed a length of four and one-half inches, are almost worthless.

With the view of determining whether the stock was improving or deteriorating under domestication as early as the second generation, equal lots of the broods of 1916, 1919, 1920, and 1922 of the offspring of wild animals confined for breeding purposes and of the offspring of terrapins grown in captivity were retained for comparison. These lots of each brood either were placed in separate pens and treated identically or placed in the same pen, each lot bearing a distinctive mark. In the tables which accompany this paper

TABLE 1

RATE OF GROWTH OF THE WILD AND DOMESTIC STOCK OF THE 1916 BROOD

When Measured.	Wild Stock.					Domestic Stock.				
	Number.	Smallest mm.	Largest mm.	Females 125 mm. and over in length.	Average mm.	Number.	Smallest mm.	Largest mm.	Females 125 mm. and over in length.	Average mm.
Oct. 4, 1918....	120	47	104	..	70.6	81	47	83	..	63.2
Oct. 9, 1919....	99	*45	116	..	74.4	96	*45	85	..	65.3
Oct. 8, 1920....	99	42	123	..	75.5	95	47	92	..	66.8
Sept. 24, 1921....	99	56	133	1	82.6	88	53	103	..	73.7
Sept. 13, 1922....	†103	69	136	4	91.4	†92	69	120	..	85.2
Oct. 5, 1923....	100	74	138	4	97.2	91	71	135	2	93.0
Sept. 12, 1924....	100	77	139	6	101.9	†95	73	130	2	95.5
Oct. 20, 1925....	93	78	140	7	103.3	95	74	132	5	98.0
Oct. 1, 1927:										
Males.....	18	81	102	33	89.3	22	78	101	33	90.7
Females.....	82	92	141		119.4	76	83	141		116.4
Nov. 6, 1928:										
Males.....	18	78	99	39	96.5	23	83	104	40	96.3
Females.....	74	97	142		123.9	74	107	142		124.8

* The apparent decrease in size no doubt is due to the failure to find all the animals when the previous measurements were made.

† An increase in the number of terrapins shows that all the animals were not found when the previous census was taken.

the offspring of the wild breeders is designated "wild stock" and the offspring of the animals grown in captivity as "domestic stock."

A study of the data given in the various tables shows that comparatively great fluctuations in the rate of growth, as already stated, may be expected. The two lots of animals of the brood of 1916 (Table 1), for example, grew more slowly than any others

grown in captivity. A comparison of Tables 1 and 2 shows that the average length of these animals (both wild and domestic stock) was less at twelve years of age than that of the animals composing the two lots of the 1919 brood at nine years of age. This difference in rate of growth occurred, notwithstanding that virtually identical food and treatment was supplied.

The data set forth (Tables 1 to 4) show, furthermore, that sometimes the domestic stock grew slightly faster than the wild

TABLE 2

RATE OF GROWTH OF THE OFFSPRING OF THE WILD AND DOMESTIC STOCK OF THE 1919 BROOD

When Measured.	Offspring of Wild Stock.					Offspring of Domestic Stock.				
	Number.	Smallest mm.	Largest mm.	Females 125 mm. and over in length.	Average mm.	Number.	Smallest mm.	Largest mm.	Females 125 mm. and over in length.	Average mm.
May 13, 1920....	100	37	55	..	38.4	100	33	48	..	40.2
Sept. 20, 1921....	*54	36	71	..	51.8	90	41	82	..	62.0
Sept. 19, 1922....	47	49	96	..	70.7	87	46	110	..	77.4
Oct. 10, 1923....	..	..	..	..	..	81	53	117	..	87.6
Oct. 8, 1924....	46	75	114	..	91.3	78	69	123	..	90.2
Oct. 27, 1925....	44	78	123	..	96.0	78	75	132	4	95.2
Oct. 8, 1926....	41	83	135	..	101.0	78	75	139	14	104.7
Sept. 28, 1927:										
Males.....	..	..	..	..	..	22	74	98	26	90.4
Females.....	..	..	..	..	..	52	87	144		119.3
Nov. 2, 1928:										
Males.....	8	89	101	18	92.2	26	86	104	37	92.0
Females.....	38	102	142		127.1	45	109	147		131.5
Oct. 23, 1929:										
Males.....	..	..	..	..	..	24	86	103	43	93.5
Females.....	..	..	..	..	..	46	115	149		135.5

* Many terrapins in this lot were destroyed by rats. This accounts in a large measure for the decrease in number over the preceding year.

stock. Again the reverse was true. The conclusion apparently may be drawn that domestication had not influenced the rate of growth. It is evident, also, that many of the terrapins in the oldest brood (Table 1) both of the wild and domestic stock at the age of twelve years, were still under 125 mm. (5 inches) in length and below a marketable size. These animals had gained a comparatively

TABLE 3

RATE OF GROWTH OF CAROLINA TERRAPINS OF THE 1920 BROOD

When Measured.	Offspring of Wild Stock.					Offspring of Domestic Stock.				
	Number.	Smallest mm.	Largest mm.	Females 125 mm. and over in length.	Average mm.	Number.	Smallest mm.	Largest mm.	Females 125 mm. and over in length.	Average mm.
June 1, 1921....	50	33	45	..	37.5	200	32	47	..	38.5
Sept. 24, 1921....	50	46	83	..	59.6	165	35	57	..	43.8
Sept. 14, 1922....	..	..	..	..	..	163	35	73	..	50.3
Oct. 10, 1923....	39	68	105	..	83.2	144	40	87	..	61.3
Oct. 11, 1924....	*31	76	108	..	91.1	145	45	110	..	63.0
Oct. 22, 1925....	..	..	..	..	..	122	52	111	..	75.7
Oct. 1, 1926....	26	76	130	4	108.0	121	56	126	1	84.7
Sept. 28, 1927:										
Males.....	..	..	..	..	..	23	72	97	2	84.0
Females.....	25	98	138	6	116.9	89	†61	132		98.1
Nov. 16, 1928:										
Males.....	..	..	..	..	..	30	68	96	11	86.4
Females.....	24	99	144	11	122.2	83	82	136		103.5
Oct. 23, 1929:										
Males.....	..	..	..	..	..	20	81	98	39	88 3
Females.....	26	110	149	22	134.3	86	75	141		119.3

* The males were removed from this lot as soon as recognized. Thereafter no measurements are available of them.

† It is quite certain that some of the animals listed as females, later proved to be males, as the sexes generally are not distinguishable until a length of about 80 millimeters is attained.

TABLE 4

RATE OF GROWTH OF THE BROOD OF 1922

When Measured.	Offspring of Wild Stock.				Offspring of Domestic Stock.			
	Number.	Smallest mm.	Largest mm.	Average mm.	Number.	Smallest mm.	Largest nm.	Average mm.
June 3, 1923.....	200	36	51	37.2	200	36	47	37.0
Oct. 24, 1924.....	*142	36	72	47.5	*130	36	70	43.1
Oct. 27, 1925.....	99	41	92	58.0	105	41	84	53.4
Oct. 7, 1926.....	93	44	95	65.2	94	42	91	62.3
Sept. 27, 1927.....	93	51	130	80.6	93	46	106	78.7
Nov. 2, 1928.....	85	56	141	92.7	83	57	117	89.2

* This lot was selected from the one listed under the preceding date.

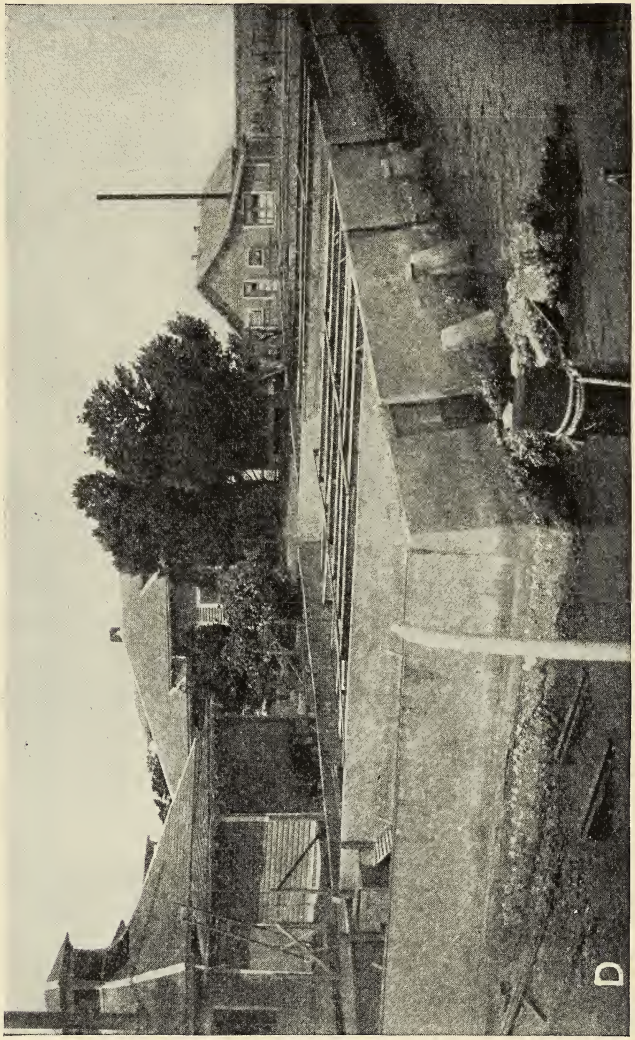

Fig. 384 D. Terrapin pounds at the U. S. Fisheries Biological Station, Beaufort, N. C., at near low tide. Interior of pounds are provided with beds of sand for laying eggs. An average change of about three feet in the water level takes place twice a day, due to tides, which bring a fresh supply of sea water and aid in washing away filth.

large amount of growth during their twelfth year. It is obvious, therefore, that although a few terrapins grown in captivity attained a marketable size in five or six years and were nearly or quite full grown in eight or nine years, the majority required a much longer period of time to attain the same size. Some animals very evidently (Table 1) require twelve to fifteen years or possibly longer to reach full growth. The number of measurements of recaptured terrapins that had been liberated when less than a year old is quite limited. The indications are, however, that the rate of growth in nature may be about equal over a period of years to that of animals in confinement.

Size Attained

Carolina female terrapins in nature occasionally reach a length as great as seven inches and rarely slightly more than seven inches. One female occurred among the original wild brood stock which had a length of nearly seven and one-half inches (185 millimeters). This animal probably approached the maximum size attained by the species. Texas terrapins, of course, grow larger and the females of that species may attain a length of eight inches or slightly more.

Male terrapins do not attain a large size and are of little commercial importance. The largest male included in the wild brood stock was about four and four-fifths inches (120 millimeters) long. This probably is near the maximum size attained by the male Carolina terrapin. Although the male of the Texas terrapin no doubt grows larger occasionally, no record of one exceeding the length of the largest Carolina male is at hand.

While terrapins occasionally reach the large size indicated in the foregoing paragraphs, the average size is very much smaller. A six-inch female and a four-inch male may be regarded as large Carolina terrapins. Although a terrapin must be six inches or more in length to be a "count" and to bring a fancy price on the market, it is quite certain that many females never reach that large a size. Among the original wild brood stock, confined in part in 1909 and in part in 1912, in which all animals were considered adult at that time, seventeen of the seventy-three females (23.3 per cent.) remaining in this lot in 1925 were still less than six inches (150 millimeters) in length. The age of these animals, of course, is not

known. Judging by the information gained during more than a score of years relative to the rate of growth of terrapins in nature and more particularly in confinement, it seems certain that few, if any, of the terrapins of the original brood stock were less than eight years old when procured. If that were true, then the youngest females in this lot would not have been much less than twenty-one years old in 1925. It is highly probable that animals of such an age had attained full growth.

Many of the females of the older broods grown in captivity are still less than six inches in length. In one of the lots of the 1910 brood containing ninety females in 1928, at the age of eighteen years, just seventeen (18.9 per cent.) were six inches (150 millimeters) and more in length. In another lot of the same brood containing eighty-seven females eighteen (20.7 per cent.) were six inches and more in length at the same time. A lot of the 1911 brood consisting of seventy-six females, contained thirty individuals (39.5 per cent.) six inches and more in length in 1928, or at the age of seventeen years. Another lot of the same brood consisting of seventy-five females contained twenty-six individuals (34.6 per cent.) which were six inches and more in length at the same time. Similarly, a lot of the 1912 brood, containing sixty-eight females, included just one individual (1.4 per cent.) over six inches in length in 1928 at the age of sixteen years. Another lot of the same brood, containing fifty-four females, included eleven individuals (20.3 per cent.) six inches and more in length at the same time.

The average size of the several lots mentioned in the preceding paragraph has increased little since an age of eight to ten years was attained, and it is evident that the animals, although some of them are still growing slightly, have just about attained full growth. Therefore, it is rather certain that the majority of the females in the older broods grown in captivity will never reach as great a length as six inches.

Sexual Maturity

During the course of the experiments no eggs have been produced by any lot grown in captivity until at least some of the females were five and one-half inches (137 millimeters) in length. However, smaller females among the older broods have been observed making nests and laying eggs. The smallest one seen, which was caught

after laying eggs, was only four and three-fourths inches in length. Presumably, the male is sexually mature as soon as the external sex characters are fully developed. These characters, consisting of a longer and heavier tail, narrower head and somewhat narrower and proportionately longer carapace, may be quite evident at a length of three and one-fifth inches (80 millimeters) in some individuals, but considerably later (90 millimeters) in others. Males, no doubt, reach sexual maturity equally as early as the females, for at least some of the first eggs produced by every lot of terrapins grown in captivity (exclusive of two of the 1911 brood which contained no males) were fertile and hatched.

It is quite evident from the data that the size of a terrapin is a better criterion relative to sexual maturity than age. The youngest terrapins that have produced eggs were four years old (a lot of the 1911 brood, fed three winters) and the highest age at which eggs were produced for the first time was eight years (brood of 1919, fed one winter). Therefore, a variation in the attainment of sexual maturity of four years in age has taken place. It is true that the lot of the 1911 brood, having been fed three winters, was "forced" somewhat. However, the lot of the 1919 brood, too, was fed one winter. On the other hand, a lot of the 1910 brood that had hibernated each winter laid eggs at the age of six years. Therefore, winter feeding, although it no doubt hastens maturity in some lots, is not wholly responsible for the variation indicated. The most usual age at which eggs were produced for the first time was seven years. Of fifteen different lots, from ten broods, nine lots began laying at seven years of age, three at the age of six years, one at the age of five years, and the other two respectively at four and nine years, as already stated.

It may be concluded from the evidence presented that when Carolina female terrapins reach a length of five and one-half inches (137 millimeters) they are sexually mature, regardless of age. It was shown that one brood when it began to produce eggs was four years younger than another. It has been shown, also, under the section of this paper entitled, "Growth" (p. 551) that great variations in the rate of growth of animals within a single lot and brood has occurred. Therefore, some females, as well as males, no doubt reach sexual maturity four or more years earlier than others, even when identical treatment is provided.

Sex Ratio

The latest full census of all terrapins grown in captivity was taken in 1928. At that time 1,442 Carolina terrapins were large enough to show plainly the external sex characters. This number of animals consisted of 209 males and 1,233 females. The ratio, therefore, was one male to 5.9 females. The extremes of the sex ratio in the Carolina terrapins was met, on the one hand, in the 1911 brood, which consisted of 148 females and no males, and on the other in the brood of 1919, which consisted of fifty-four males and ninety-three females, that is, one male to 1.7 females.

In view of the scarcity of males among the straight Carolina stock it is very interesting to find eighty-six males and fifty-three females, a ratio of 1.66 males to one female, among three lots of hybrid terrapins resulting from cross breeding Carolina and Texas terrapins.

Most of the lots of Carolina terrapins were selected for large size and vigor at eight to ten months of age. However, a few lots were unselected, and the animals of one lot of the brood of 1912 (consisting of ten males and fifty-four females) were selected as runts when about a year old. It is not evident that the selections affected the sex ratio.

No information is available relative to the sex ratio of terrapins caught in nature. In any event, such data would not show the natural ratio for the Carolina terrapins, because of the extensive fishing operations carried on for many years throughout its range. During all this time it has been the practice to return to the water most of the males caught, because they were almost worthless, whereas the females were valuable and were marketed. Such a practice, in a group of such long-lived animals, having a small population, no doubt would affect the sex ratio profoundly.

The sex ratio of young immature terrapins has not been studied. Since the external sex characters are not evident until the animals reach a length of at least three inches, the sex of the young could be determined only through dissections. While such a study would be very interesting, time and proper material have not been available.

It appears to be of interest to note in connection with the discussion of sex ratio that experience proves it unnecessary to main-

tain an even sex ratio for breeding purposes. Comparatively large fluctuations in the rate of fertility of the eggs have prevailed, sometimes within a single lot, without change in the sex ratio and again among various lots containing a variation in sex ratio of one male to 1.7 females to one male to twenty-six females. It may be stated, however, with some degree of certainty that a ratio of one male to five females is ample for a high degree (80 to 90 per cent.) of fertility.

Longevity

It was pointed out in an earlier paper (1929, p. 42) that in age the wild brood stock probably ranged from twenty-five to possibly more than forty years. It cannot be stated yet what the span of life of diamond-back terrapins is. However, the lot of wild breeders have not yet shown any signs of weakening, for in 1930 this lot produced 22.2 eggs per female, a much higher rate of production than any of the several lots grown in captivity. It was higher, also, than the average of 14.5 eggs per female for this lot from 1915 to 1927 inclusive.

The oldest lots grown in captivity (brood of 1910) now on hand are twenty-one years old. These animals all have the appearance of being young, as the growth rings on the carapace are all quite prominent, whereas in several of the wild breeders the carapace is smooth with scarcely an indication of growth rings. The smoothness of the shells is believed to be due to long wearing. Furthermore, to the writer's personal knowledge, some of these animals had smooth shells as much as seventeen years ago. Judging from this and other meager information at hand, the writer now regards the estimate of the highest age of forty years, made in the earlier paper referred to, for the animals which have been in captivity nineteen and twenty-two years as much too low. However, he is not prepared to state how old they are, nor to predict how much longer they will live. The evidence certainly is that these slow-growing and late-maturing animals reach a high age.

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THE FISHES OF BARRO COLORADO

Gatun Lake, Panama

By C. M. Breder, Jr.

New York Aquarium

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THE FISHES OF BARRO COLORADO, GATUN LAKE, PANAMA.

By C. M. Breder, Jr.
New York Aquarium

Various students, visiting at the Barro Colorado Research Station, have made small collections of the fishes inhabiting its waters and shores. Since it is useful to such students, who are not primarily ichthyologists, to have a regional list of these fishes, the following has been prepared together with a key and plate of figures intended to facilitate differentiation of the various species known to occur there.

As Barro Colorado has been transformed from a hilltop to a small island by the rising waters of the artificial Gatun Lake, it may be that ecological readjustments are still in progress. Consequently, a periodic examination of the fish fauna would not be without interest. This interest is enhanced by the fact that here the fauna of the Atlantic and Pacific drainages have an opportunity of mixing, due to the presence of the Panama Canal.

The species here listed have in part been collected by Dr. and Mrs. E. R. Dunn and in part by various other collectors who deposited their material with the Museum of Zoology of the University of Michigan. Dr. C. L. Hubbs kindly made these latter records available. Dunn's material is deposited at the Philadelphia Academy of Natural Sciences. In addition to his granting permission to use the material, I am indebted to Dr. Dunn for checking over the notes and making various suggestions.

The numbers following the records of Dunn give the range of standard lengths in mm. and the number of specimens. The latter are in parenthesis, as are those following other records which refer to number of specimens. Inquiry at the Philadelphia Academy of Sciences, The U. S. National Museum, and the Museum of Comparative Zoölogy, failed to reveal any further material from this locality. A single species was located in the American Museum of Natural History. The localities are the names used by Barro

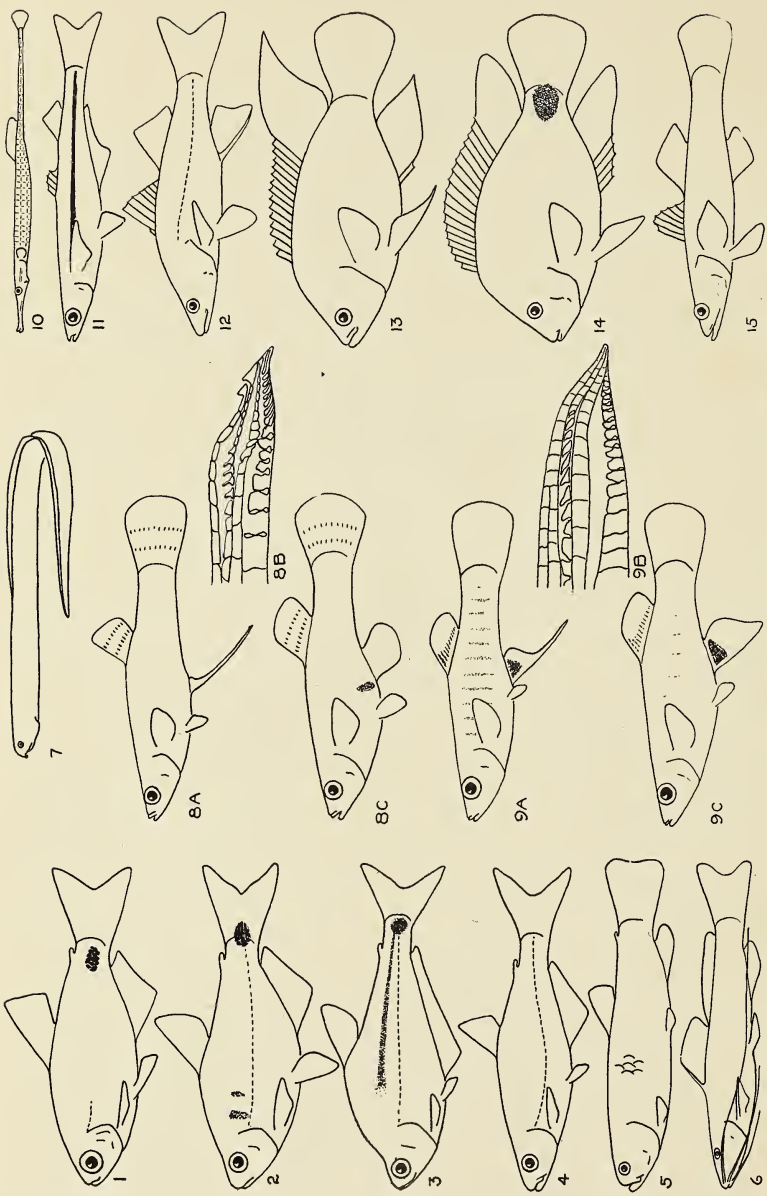

Fig. 385. 1. *Compsura gorgonae*; 2. *Astyanax ruberrimus*; 3. *Roeboides guatemalensis*; 4. *Brycon chagrensis*; 5. *Piabucina panamensis*; 6. *Rhamdia wagneri*; 7. *Synbranchus marmoratus*; 8. *Gambusia affinis speciosa*; A. male; B. enlarged tip of gonopodium; C. female. 9. *Brachyrhaphis episcopi*; A. male; B. enlarged tip of gonopodium; C. female. 10. *Oostethus lineatus*; 11. *Thyrina chagresi*; 12. *Centropomus parallelus*; 13. *Aequidens coeruleopunctata*; 14. *Cichlasoma maculicauda*; 15. *Gobiomorus dormitor*.

Colorado investigators. Numbers following the name of a trail indicate distance in hundred yards from the beginning of the trail.

"Flooded jungle around island" refers to the lake waters forming the shore line. The "House" localities all refer to specimens taken in the lake. "Allee Creek" is just west of the laboratory and "Lutz Creek" just east.

Family CHARACIDAE

Astyanax ruberrimus Eigenmann.
Flooded jungle around island, June 1926, Van Tyne (2). Asbestos House, Sept. 1929, Bangham (1). Laboratory Dock and Bang's House, 1932, Dunn 48–78 (4).

Brycon chagrensis (Kner).
Flooded jungle around island, June 1926, Van Tyne (3). Laboratory Dock, 1932, Dunn 155 (1). This species is frequently used for food on the island, although not especially well thought of in the Canal Zone generally.

Roeboides guatemalensis (Gunther).
Flooded jungle around island, June 1926, Van Tyne (30). Asbestos House, Sept. 1929, Bangham (1). Laboratory Dock, 1932, Dunn 83–89 (3).

Piabucina panamensis Gill.
Pools in dry creek bed, Mar.–Apr. 1926, Gaige (114). Lutz Creek, above several high and steep rock slopes; Armour Trail 9, in center of island; Barbour Lathrop 4; 1932, Dunn 124–157 (3).

Compsura gorgonae (Evermann and Goldsborough).
Asbestos House, Sept. 1929, Bangham (20).

Family SILURIDAE

Rhamdia wagneri (Gunther).
Pools in dry creek bed, Mar.–Apr. 1926 (21). Laboratory Dock, 1932, Dunn 130 (1).

Family SYNBRANCHIDAE

Synbranchus marmoratus Bloch.
Pools in creek bed, Mar.–Apr. 1926, Gaige (4). Flooded jungle around island, June 1926, Van Tyne (1). Allee Creek, above a quite steep and high rock slope, where it was fairly common, 1932, Dunn 376 (1).

Family POECILIIDAE

Gambusia affinis speciosa Girard.
Asbestos House, Sept. 1929, Bangham (7). Dock at Fuertes House and dock at Bang's House, 1932, Dunn 17–26 (6). This species is the *Gambusia nicaraguensis* from Panama of authors. Hubbs and Gordon MS. identifies this fish with the race *speciosa* of *G. affinis*, native to northeastern Mexico and central Texas. Consequently, the present species must be an introduction from early Canal building days for the purpose of mosquito control.

Brachyrhaphis episcopi (Steindachner).
Permanent pools in creek near laboratory, Jan.–Mar. 1924, Allee (3). Pools in dry creek bed, Mar.–Apr. 1926, Gaige (68). Seepage pools on Barbour Trail, Mar. 1926, Gaige (1). Brook on Pearson Trail, Sept. 1929, Bangham (17). Asbestos House, Sept. 1929, Bangham (5). Three of these from some unnamed locality. Allee Creek, 1932, Dunn 15–40 (25). Jan. 1927, Peterson, A.M.N.H. (20).

Family SYNGNATHIDAE

Oostethus lineatus (Kaup).
Inlet near Laboratory Dock, August 1928, Chickering. Recorded in Copeia with remarks on the possible movements of marine fishes through the Canal. Chickering, 1930.

Family ATHERINIDAE

Thyrina chagresi (Meek and Hildebrand).
At Laboratory Dock, 1932, Dunn 43–66 (20). Seen in large numbers at the surface, but only at night.

Family CENTROPOMIDAE

Centropomus parallelus Poey.
Flooded jungle around island, June 1926, Van Tyne (1).

Family CICHLIDAE

Cichlasoma maculicauda Regan.
Flooded jungle around island, June 1926, Van Tyne (62). Unnamed locality. Sept. 1929, Bangham (1). Laboratory Dock and Fuertes House, 1932, Dunn 92–110 (4). Mr. J. O'Reilly reports that a large pair with a brood of young were seen at the laboratory dock in August, 1932. This species is frequently used for food on the island, as elsewhere.

Aequidens coeruleopunctata (Kner and Steindachner).
Pools in dry creek bed, Mar.–Apr. 1926, Gaige (9). Flooded jungle around island, June 1926, Van Tyne (23). Fuertes House and Laboratory Dock, 1932, Dunn 52–70 (2).

Family GOBIIDAE

Gobiomorus dormitor Lacepede
Pools in dry creek bed, Mar.–Apr. 1926, Gaige (10). Flooded jungle around island, June 1926, Van Tyne (8). Fuertes House and Laboratory Dock, 1932, Dunn 69–138 (2).

The collection made by the Dunns shows remarkable agreement with those of others. They missed only three species previously collected on the island and obtained one not previously collected there. When it is considered that this list does not make up more than one half of the fishes known from the Chagres River, the island

fish fauna appears to be rather poor. Others are surely to be expected and it is strange that some have not been taken. The Chagres fishes not so far known from the island are listed below. Those marked with an asterisk would seem to be species that might most likely be expected.

Family CHARACIDAE

Bryconamericus emperador (Eigenmann and Ogle), *Brycon petrosus* Meek and Hildebrand, *Gephyrocharox atricaudata* (Meek and Hildebrand)*, *Creagrutus notropoides* Meek and Hildebrand, *Hyphessobrycon panamensis* Durbin, *Pseudocheirodon affinis* Meek and Hildebrand*, *Hoplias microlepis* (Gunther)*.

Family GYMNOTIDAE

Hypopomus brevirostris (Steindachner)*.

Family POECILIIDAE

Brachyrhaphis cascajalensis (Meek and Hildebrand), *Mollienisia sphenops cuneata* Garman.

Family CYPRINODONTIDAE

Rivulus elegans Steindachner.

Family MUGILIDAE

Agonostomus monticola (Bancroft)*, *A. macracanthus* Regan, *Joturus globiceps* (Gunther).

Family CICHLIDAE

Neetroplus panamensis Meek and Hildebrand, *Geophagus crassilabris* Steindachner.

Family GOBIIDAE

Awaous taiasica (Lichtenstein), *Dormitator maculatus* (Bloch)*, *Leptophilypnus fluviatilis* Meek and Hildebrand, *Microeleotris mindii* Meek and Hildebrand, *Eleotris pisonis* (Gmelin) *Guavina guavina* (Cuvier and Valenciennes), *Sicydium salvini* Grant.

Although it is true that some of the gobies are known only from below Gatun Spillway, they seem to be the most likely to be found above it. Other species from the lower Chagres (Breder, 1925) are mostly marine, although some of them might be expected above the dam.

Most of the fishes in the present list occur in Gatun Lake proper, inhabiting the shores of Barro Colorado. The only species so far recorded from the island streams and pools are *Piabucina, Rhamdia, Synbranchus, Brachyrhaphis, Aequidens* and *Gobiomorus.* As many

of the Chagres fishes, not known from the island, normally inhabit small streams and pools, it may be that the large expanse of Gatun Lake has acted as a barrier to a number of them.

The U. S. Bureau of Fisheries introduced large-mouthed bass, *Micropterus salmoides* (Lacepede), crappie, *Pomoxis annularis* Rafinesque, and sunfish, *Lepomis pallidus* Mitchill into Gatun Lake in 1924. (See Fisheries Service Bulletin 1925 and Breder 1925). The Fisheries Service Bulletin No. 182 reports that a single "13-inch crappie weighing about 1¼ pounds was caught below the spillway from Gatun Lake, and this is taken as evidence that the species have become established in these waters." It also reports "that the bass planted in Stilsons Lake, which is entirely cut off from Gatun Lake, are alive, flourishing, and plentiful. It is evident that Stilsons Lake may constitute a reservoir from which fish may now be planted in other waters of the Canal Zone." It is consequently possible that any of these forms may appear at Barro Colorado. Especial attention is called to this as such records are naturally of considerable interest and no existing catalogue of Panama fishes includes them. This latter fact might cause considerable confusion to visitors not familiar with North American fishes nor expecting centrarchids in Panama, especially as they have a considerable general resemblance to the abundant and diversified native cichlids.

Key to the Fishes of Barro Colorado

A. Dorsal fin single with one or no anterior spines, followed by an adipose or not; never preceded by a series of spines.
B. Dorsal fin followed by an adipose fin; first dorsal support a spine or not.
C. Body covered with normal scales; no long barbels about mouth; adipose fin small, a mere tab; no spine in dorsal fin.
D. Body compressed; dorsal, 10 or 11; anal, 16 to 52; depth of body less than 4.
E. Vertical fins reddish in life; body silvery; teeth in a single series in each jaw, or in 2 series in upper jaw, or with 2 teeth in each jaw projecting directly forward.
F. Teeth in a single series in each jaw; lateral line incomplete, present only on 5 to 13 scales; caudal peduncle with a prominent dark spot.
Compsura gorgonae
FF. Teeth not in a single series in each jaw; lateral line complete.
G. Dorsal profile convex; teeth in upper jaw in 2 series, those in lower jaw in a single series; no forward-pointing teeth; anal fin, 22 to 27; one or two dark spots on shoulder; base of caudal with a dark spot.
Astyanax ruberrimus

GG. Dorsal profile concave; teeth in upper jaw in more than 2 series; 2 conical teeth in each jaw pointing forward; anal fin, 47 to 52; a prominent lateral streak and base of caudal with a dark spot.... *Roeboides guatemalensis*

EE. Vertical fins not reddish; body silvery; teeth of upper jaw in 3 or 4 series; no teeth pointing directly forward; a dark spot at caudal base. *Brycon chagrensis*

DD. Body subcylindrical; dorsal, 8 or 9; anal, 10 or 11; depth of body, 4 to 5.4; fins reddish.... *Piabucina panamensis*

CC. Body naked; 6 long barbels about mouth; adipose fin long and low, longer than head; first dorsal support a strong, stout spine. *Rhamdia wagneri*

BB. No adipose fin; no spine in dorsal.

H. Gill openings united as a single median opening below; body naked; no pectorals or ventrals; dorsal and anal confluent with tail; body eel-like. *Synbranchus marmoratus*

HH. Gill openings separate and lateral; body not naked; pectorals at least present; dorsal and anal not confluent with tail; body elongate or not.

I. Gill openings large, not constricted; body with normal scales; ventrals present; body not elongate; viviparous; males small and with a prominent intromittent organ.

J. Anal fin without a dark spot at its base; dark dots on dorsal caudal fin forming transverse lines; intromittent organ with 2 strong, retrorse hooks at tip; anal fin of female not at all falcate.... *Gambusia affinis speciosa*

JJ. Anal fin with a dark spot at its base; no dark line forming dots on dorsal and caudal; intromittent organ with no retrorse hooks; anal fin of female falcate.... *Brachyrhaphis episcopi*

II. Gill openings small, restricted to upper angle of gill openings; body circled with angulated bony rings; body elongate; oviparous; males carry developing eggs and young in a ventral pouch.... *Oöstethus lineatus*

AA. Dorsal fins 2, the first composed only of sharp spines, or dorsal single with the first several, at least, sharp spines followed by flexible rays.

K. Ventral fins posterior to pectorals, caudal forked and dorsals separate; or ventral fins under pectorals, caudal convex, and dorsal fin single.

L. Ventral fins posterior to pectorals, caudal forked, dorsals separate.

M. First dorsal composed of 3 or 4 weak spines; anal I, 20 to 23; head flat above; body depth, 6.1 to 6.9.... *Thyrina chagresi*

MM. First dorsal composed of 7 or 8 stout spines; anal III, 6; head concave above; body depth, 3.5 to 4.... *Centropomus parallelus*

LL. Ventral fins under pectorals; caudal convex; dorsal fin single, first 14 supports, at least, are spines.

N. Dorsal XIV or XV, 9 to 11; anal III, 7 or 8; no prominent dark spot on peduncle.... *Aequidens coeruleopunctata*

NN. Dorsal XVII or XVIII, 11 or 12; anal VI, 9 or 10; a large dark spot on peduncle.... *Cichlasoma maculicauda*

KK. Ventral fins slightly in advance of pectorals; caudal convex; dorsal fins separate, the first with 6 or 7 spines.... *Gobiomorus dormitor*

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