Our Water Resources and Their Conservation

By

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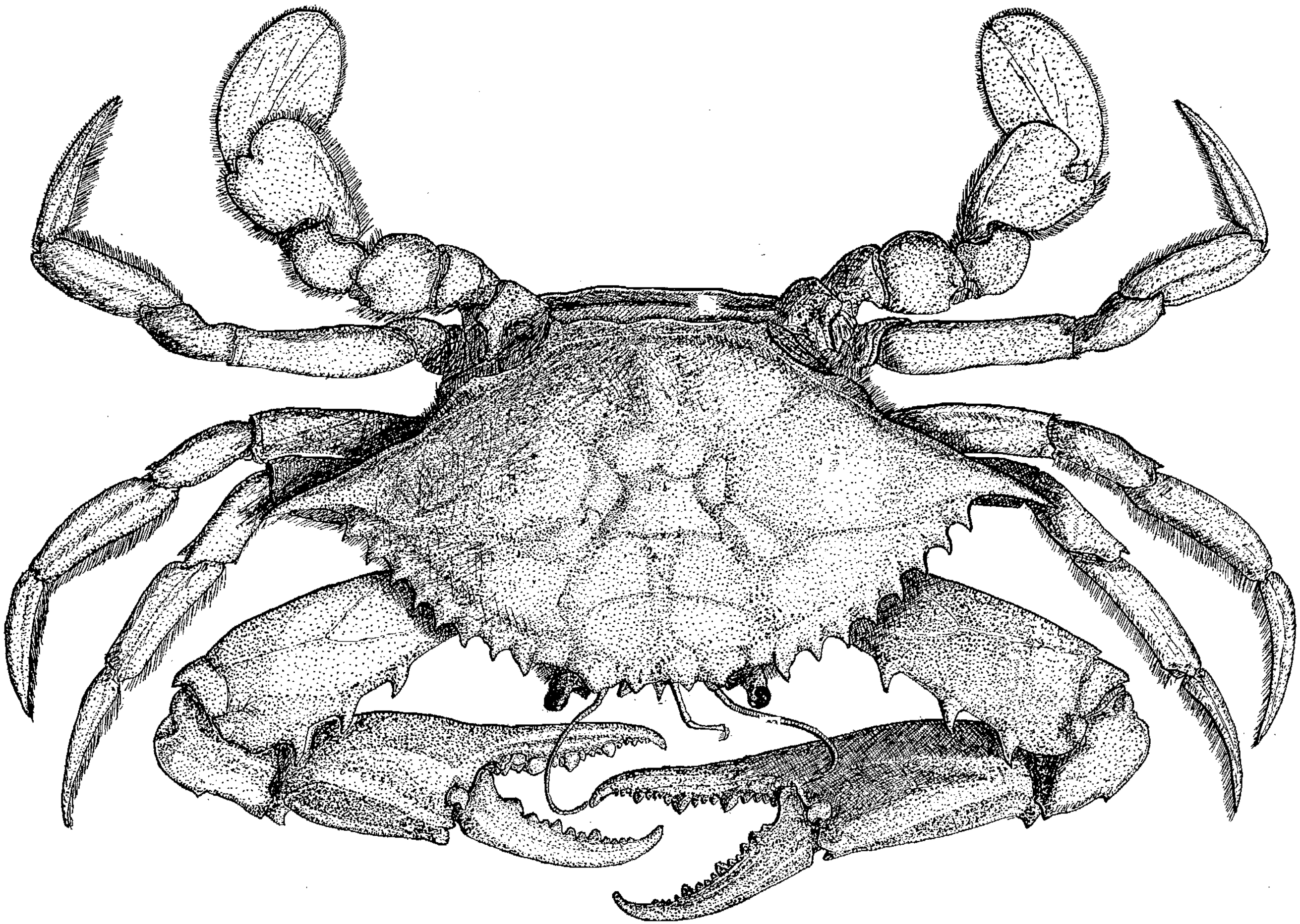

The Blue Crab, *Callinectes sapidus*

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FOREWORD

The Maryland Conservation Department, in an effort to further and to disseminate knowledge concerning our natural resources, is pleased to offer in printed form information about the enormous bounty of the State's waters and the problems that confront husbandry and conservation of valued aquatic forms. Maryland ranks first in the production of certain of the commercial species, while many of the fish types found in the Chesapeake Bay are superior from the sportive viewpoint.

This bulletin is presented by the Director of the Chesapeake Biological Laboratory, an integral part of the Conservation Department, and has back of it the experience and thought derived from his years of study and observation of our aquatic life. It is felt that such a reference work is needed in the State's general libraries and those of schools and colleges so that indirect as well as more direct contributions, through general diffusion of knowledge, may be made to conservation.

The cordial cooperation, through financial, academic, and administrative interest of the Carnegie Institution of Washington, Goucher College, Johns Hopkins University, University of Maryland, Western Maryland College, and Washington College, in the development of the Chesapeake Biological Laboratory, is gratefully acknowledged. It is felt that education holds the key to the solution of conservation problems. The participation of these institutions in the program at Solomons Island is significant.

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Solomons Island, Maryland

The Chesapeake Biological Laboratory

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Our Water Resources and Their Conservation

by

R. V. Truitt

Introduction

"Share the wealth" is not a new philosophy or practice of the men who till the soil, since farmers from time immemorial have contributed to the welfare of the fisheries. Experimental procedure has demonstrated, to cite an instance, that, in the case of the Eastern Shore farmer, who pays $35 for a ton of fertilizer that he uses on an acre of potato ground, twenty per cent of the nutritive value is leached out of the soil during the first year, and that approximately thirty-five per cent is lost by the action of rainfall over a longer period of time.

This dissolved fertilizer—and great amounts of other inorganic matter—finds its way down rills, branches, and creeks to the rivers and bays, and, upon coming to rest there, is none the less available to support vegetable matter even though it is free in the water. Indeed, it is probable that the most luxuriant vegetable growth in all creation is such as that found in the Chesapeake Bay, vegetation of the proper type to maintain large animal populations and, in turn, afford vast harvest to the commercial fisherman.

Someone has said that "Thar is gold in them waves". This is true literally and figuratively, for, in addition to the millions upon millions of dollars harvested yearly through the fisheries, it is generally known that the bays, sounds, and oceans of the world today hold great wealth in dissolved matter, including the king of metals. It is not exaggerating facts to state that over fifty millions of dollars in wealth is harvested each year from the waters embraced by the comparatively small area between New Jersey and North Carolina, inclusive. The sportive value associated with fishing and hunting in this area is incalculable. Yet, the potentialities of the water have been barely more than approached.

Current publications point out much about gold hidden by pirates, and about the persistent efforts to reclaim sunken treasure along the coast. Little is heard about the much more abundant wealth in the waves that, through planned conservation based upon fundamental information, awaits development.

Farmers sow and then they reap. Watermen merely reap. Year in and year out, nature has been kinder to the waterman, for his ups and downs have been less precipitious until late years, when he has suffered greatly from the added problems of pollution and types of competition for which he has not prepared himself. Farmers have seen the advantages of agricultural colleges and have asked for research, extension work, and the like. Not even a course in the technology or the management of our fisheries is offered in a college in the eastern part of America. In the two states that control the fisheries of the Chesapeake Bay, with its exceeding fishery wealth, now more potential than real, just about no effort has been made in the past by the research and educational institutions to preserve aquatic resources. Yet, these assets yield sums that are far in excess of those realized from any one of some six or seven important land crops, each of which is receiving subsidy extending into thousands of dollars to carry a personnel of scientists capable of properly administering to it. Such work and more of it is needed. But if the need is readily recognized for the more tangible and more easily managed land crops, what about the crops that grow on submerged lands and in the free waters? It would seem, upon reflection, that the state institutions east of the Alleghanies are failing to meet a challenge in that they are not more strongly attempting to promote the welfare of the waterman. Certainly they are not taking advantage of a fine opportunity to render a great service.

Today, Japan is considered the paramount fishery country. Leadership for this work in that far removed land comes primarily from trained sources with the backing of university faculties and university curricula. The same situation holds in Europe, while in the United States the educational institutions, whether private or state, have given little or no consideration to the problems that have arisen in the fisheries. Of the several countries leading in the fishing industry, America is the only one without a research vessel to study the many problems involved in production, capture, nutritive values, and the basic biology involved. With Americans, laws have been the remedy for conservation ills, and the result has been that many valuable fish forms literally have been "lawed to death".

The outstanding need today in the fishing industries is that of exact knowledge, research, to supplant superstition and the practices, in the main unchanged since the pioneer, that have played such a marked part in the ever downward trend in production. Decline in economic and social conditions around our tidewater demand such knowledge, while the fertility of the Bay and its demonstrated potentialities justify the demand.

Seafoods are eaten primarily as a treat, simply because they are pleasing to the palate. Experimental tests on the oyster, the crab, and a few others have shown that these forms contain nutritive values far in excess of those found in most foods and, at market prices, at a lower cost per unit value. It is but natural to suspect such high food values if it is realized that, through the ages, rainfall and seepage have been denuding the soil and depositing soluble matter essential to human physiology in the permanent bodies of water. There it remains to be used and reused—matter no longer available to land plants and animals. It may be said in general that water crops are richer in food units and health regulating elements than are land crops.

Years ago it was thought that, if people could obtain plenty of food, the body would function satisfactorily. Later on it was learned that it is possible to starve a man to death, even though he were abundantly fed, say, only starchy substances. Then it was discovered that certain elements, especially calcium, are necessary for bone building, that iron is essential to the functioning of the blood, and that vitamines are essential to certain metabolic processes. About this time analysis disclosed that these elements do not occur in like quantities in all foods and, indeed, that some foods are completely devoid of certain of the essentials. Thus the development of the so-called "balanced diet" not only for human beings but for their domestic creatures. It has been thoroughly established that goiter, a dread disease, is brought about by a deficiency of iodine, especially in those sections of the country where the geologically older soil has been washed comparatively free of this metal. Anaemia, caused by iron and copper deficiency in the blood, is preventable or curable, we are told, unless it be of a pernicious nature, by use of foods in which these elements are readily available. Iodine, iron, and copper, as such, will do the human body little, if any, good; but, if elaborated by plant and animal activity and consumed in this form, they make possible the normal physiological activities of the body. Seafoods are especially rich in all three of these elements.

It has been estimated that there are, today, 35 million Americans who are undernourished, and whose condition of inefficiency and minor health problems in most cases could be relieved if some of the more common water products were added regularly to the diet. When these facts are generally appreciated, it becomes apparent that, potentially, big demands will arise for the products of the sea. This being the case, it behooves the fishery industries, and the three millions of people directly or indirectly dependent upon the fisheries for their livelihood, to anticipate future developments based upon a campaign of education. This is especially true of Maryland's Tidewater, where many thousands of the State's old and sturdy stock make their living from these industries.

The consumption of seafoods in America at present is less than it was fifty years ago. This fact may be illustrated by the accompanying table based upon the oyster.

CONSUMPTION OF OYSTERS IN THE UNITED STATES: BY DECADES, FROM 1880 TO 1938

Year	*Population*	*Year*	*Oyster Production (Pounds)*	*Per Capita Consumption (Pounds)*
1880	50,155,783	1880	155,059,968	3.09
1890	62,947,714	1890	185,448,795	2.95
1900	75,994,575	1900	176,894,085	2.33
1910	91,972,266	1910	173,152,784	1.88
1920	105,710,620	1920	199,131,978	1.13
1930	122,775,046	1930	86,255,610	0.70
1938	130,726,000	1938	66,670,260	0.51

In this same period of time the population of the country has more than doubled. The price of several classes of water products is barely if any higher to the consumer today than it was formerly—an anomalous situation in that more consumers and lower productions have resulted in diminishing prices. However that may be, the facts stand out and challenge thought, research, and business ability. The merits of oranges, nuts, bacon, and many other commodities in the production of food units and health factors are advertised widely so that all may understand the work of the laboratory promoted by alert producers. The nutritive and therapeutic values of our seafoods, extraordinary as they are, have received little attention and, because of this, they are in small demand. This situation has contributed to the increasingly sub-marginal existence of more and more watermen.

Maryland waters are among the richest known to man. Hildebrand and Schroeder (1928) *, in discussing the productivity of the Chesapeake Bay, compared it with Georges Banks, an outstandingly productive Atlantic Ocean fishing area, as follows: *"The Chesapeake Bay and the brackish parts of its tributaries contain about* 20,700 *square miles and produced about eleven tons of fish per square mile in* 1920, *whereas Georges Banks, with an area of about* 700 *square miles, produced about three tons of fish to the square mile".* These rich waters are blessed with many of the choicest water products known to man. Certain Chesapeake forms stand out in quality and flavor when compared with those of the same type taken from more distant points. Blue crabs, diamondback terrapin, striped bass or rock, Susquehanna shad, black bass, trout, Tangier Sound and Sinepuxent oysters, especially, have contributed to the far renowned culinary fame of the State. All of these species have suffered depletion, largly because of overfishing and poor husbanding. Lack of information about them has, in part, contributed to their decline, since policies of conservation have not been founded upon fundamental information. The present trend, however, is in a more constructive direction, and rehabilitation is in the offing. The pages that follow are devoted to a more detailed discussion of several of the more important species of Maryland's water life, both commercial and sportive in nature.

THE BLUE CRAB

The Blue Crab, more commonly termed the "crab" in the Middle Atlantic region, is known to the scientists as *Callinectes sapidus.* It well deserves its place with lobsters and other more choice marine forms used in the diet. The flavor and nutritive values, especially the protein and vitamin content, justify the high esteem in which the crab is held gastronomically, while its rich supply of metals may offer distinct therapeutic values. In life history developments, biological relationships, migrations, economic values, and many other interests, this crustacean is rather unique in our waters.

The crab is a marine creature preferring waters of lesser salt concentrations, thus being more abundant in the bays, sounds, tidal rivers, and shallower indentations of the sea. The fecundity of the animal is great,

*Hildebrand, S. F. and Schroeder, W. C., 1928. Fishes of Chesapeake Bay. Bull. U. S. Bur. Fish., Vol. 43, Part 1.

while the life span is comparatively short. These facts, combined with its modification and adjustment to its environment, have made it possible for the organism to survive against the great odds of persistent and not too cautious fishing operations, as well as the many enemies that prey upon it.

The blue crab fishery has a comparatively short history, dating back no further than sixty-five years, when, with the development of modern transportation methods in the Chesapeake Bay country, the product could be delivered rapidly to the consumer. For many years the Chesapeake Bay supplied the entire market, and not until depletion threatened the supply of crabs, thought by the fishermen to be inexhaustible in this body of water, did the industry spread to other sections. While the species is distributed over a wide coastal range along the Atlantic Ocean and the gulf of Mexico, it was and continues to be found in greatest abundance in the waters of Maryland and Virginia. Being principally a warm weather operation in Maryland, this fishery greatly augments the income of the watermen who, because of the closing of the oyster season and the absence of certain fin-fish runs in summer, otherwise would be without employment.

Life History, Habits and Structure

The blue crab has its start in life near the sea. Recent experimental work at the Chesapeake Biological Laboratory has shown that the egg and early stages of the crab will develop satisfactorily only in waters of high salt content, thus seeming to explain why mature females, after mating, move to the region of the ocean preparatory to spawning. In the Chesapeake Bay, which is nearly two hundred miles in length, and is controlled, in part, by Maryland and, in part, by Virginia, spawning for the most part takes place in Virginia waters on an area described by a thirty-mile radius from the mouth of the bay. Other bodies of water, such as Delaware Bay, Sinepuxent Bay, Chincoteague Bay, and Pamlico Sound, North Carolina, show comparable migrations of gravid female crabs toward saltier waters before spawning. Typically in the Chesapeake, this oceanward movement takes place in late summer and fall, although late maturing females are found over-wintering in the upper reaches of their habitat only to complete the voyage during the following spring.

Eggs are produced in prodigious numbers by the crab. Painstaking estimates have revealed that from 723,500 to 2,173,300 eggs are extruded at a single time. Just how many times a crab may spawn remains speculative although one spawning is considered typical. During the course of the studies upon which this treatise is based, it was possible to secure only one deposition of eggs per crab, although a few adults were carried through a period of nearly a year after spawning before they died. On the other hand, Churchill,* 1919, reports that "A female crab may lay two and probably more batches of eggs during the course of her life." Egg laying takes place at night, and the extrusion of the entire egg mass, or sponge, may

*Churchill, E. P., Jr., 1919. Life History of the Blue Crab. Bull. U. S. Bur. of Fish., Document No. 870.

be accomplished within two hours. Egg production by crabs, in general, is carried on over a long period, from April until October, inclusive, with occasional records from other months and, in one case, even in mid-winter. Optimum water temperatures for egg production in the Chesapeake range around 75° F., a temperature reached toward the end of June. At this time the spawning peak is reached, although considerable egg laying takes place in May, July, and August.

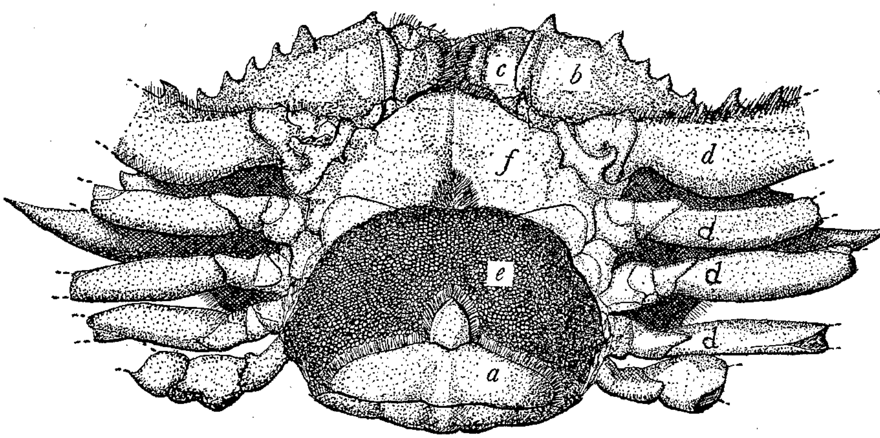


Figure 1. VENTRAL VIEW OF BODY OF CRAB SHOWING EGG MASS OR SPONGE. a. Abdomen; b. *Anterior-lateral carapace; c. Third maxilliped; d. Legs; e. Egg mass or sponge; f. Sternal* plastron.

Upon spawning, crabs fasten their eggs to the many fine hairs borne by modified legs, the pleopods, attached to the underside of the abdomen. These eggs form a large spongy mass (Figure 1) between the lower surface of the crab and the turned-under abdomen, which is known to the industry as the "apron". The modified legs in question, termed "swimmerets", extend from the second, third, fourth, and fifth segments of the turned-under abdomen, and each consists of two branches bearing many hairs. When discharged from the body, the eggs become attached to the hairs of the inner branches, which are finer and longer than the other hairs of this region. During the spawning period these hairs become coated with a semi-transparent secretion, to which the eggs adhere by means of short stalks or tendrils. Thus, the sponge consists of eight tufts of eggs which, being compacted and crowded, seem to form a continuous mass that, typically, is about three inches in width, two inches in length, and one and three-quarters inches in depth. Eggs are fertilized before extrusion. The individual egg, when deposited, is slighlty pearlish or opalescent. The mass color is light orange, becoming darker to nearly black as the eggs develop. This change in the color of the sponge is due mainly to increasing quantities of pigment in the eye region of the developing embryo. At this time, the adult crab is termed variously "sponge crab", "spawn crab", "cushion crab", "berry crab", or "punks". Many of these names are applied in the same community.

Egg-bearing crabs are exceedingly abundant in the lower Chesapeake, especially in the regions of Cape Charles and Cape Henry, and more particularly in the region between the latter point and Hampton Bar, at the entrance of the James River. From these points northward in the Bay, where there is considerable diminution of salt in the water, until the fresh water of the Susquehanna River is reached, fewer and fewer sponge crabs are to be found. In the upper reaches, where the water is brackish, rarely are egg-bearing crabs found, although there are records of such crabs having been taken in fresh water tributaries. Experimental work has shown that crab eggs only rarely hatch in brackish waters and that the young from eggs of crabs deposited in a region north of the Rappahannock River, in Virginia, and the lower Pocomoke Sound, in Maryland, will not develop even should they hatch.

Few sponge crabs are found in Maryland waters of the Chesapeake in comparison with the waters of Virginia, thus substantiating the findings of researches that indicate the necessity of a high salt content if eggs are to develop. Studies made in the Reedville district, in Virginia, below the Potomac River confluence, during late June of three successive years, 1932, 1933, and 1934, showed less than two per cent of the female crabs captured were egg-bearers, while, during the same period, watermen of Hampton, Virginia, were taking crabs near the ocean, about seventy per cent of which bore sponges. Records made during recent years indicate that fully sixty-four per cent of all crabs caught in the Capes section of the lower Bay during the months of June and July were egg-bearing individuals, while similar records at Solomons Island, Maryland, thirty miles above the interstate boundary, show sponge crabs in numbers barely appreciable. Twelve crabbers, making observations in the Patuxent River during the 1936 season, worked a total of twenty-three days and took an average of only forty-three sponge bearers from ninety-five barrels of crabs captured.

Five thousand specially designed tags placed on crabs during the years 1934 and 1935, at many points throughout the Chesapeake, gave abundant proof of the fact that female crabs migrate from the upper reaches of the Bay and its tributaries to the saltier waters near the ocean after mating, which typically takes place in late summer or fall, upon the last molting or shedding of the female crab. The male is far less migratory, and for the most part remains until his death in waters of lower salt concentrations. This accounts for the small number of large male crabs found in the region of the Capes. Records over a period of years show that crabs taken from the territory below the York River and Cape Charles City run only nine and eight-tenths per cent males the year around, while, on the wintering grounds in the immediate vicinity of the Capes, male crabs do not normally constitute five per cent of the total catch. The female crabs go to the lower regions of the bay for the purpose of spawning, the greater number of them reaching their destination late in the fall. Here they remain until the following year, when the water reaches a suitable temperature for spawning. By this time, their numbers are augmented by a post-winter migration of the female crabs that mated late in the previous season, but did not complete the entire trip to the Capes on account of lowered temperature and comparative inactivity. During the period when Virginia waters teem with mated female crabs, male individuals of the same brood or class remain in the headwaters in Maryland, where, in contrast to conditions in the lower Bay, their numbers may reach ninety per cent of the entire supply.

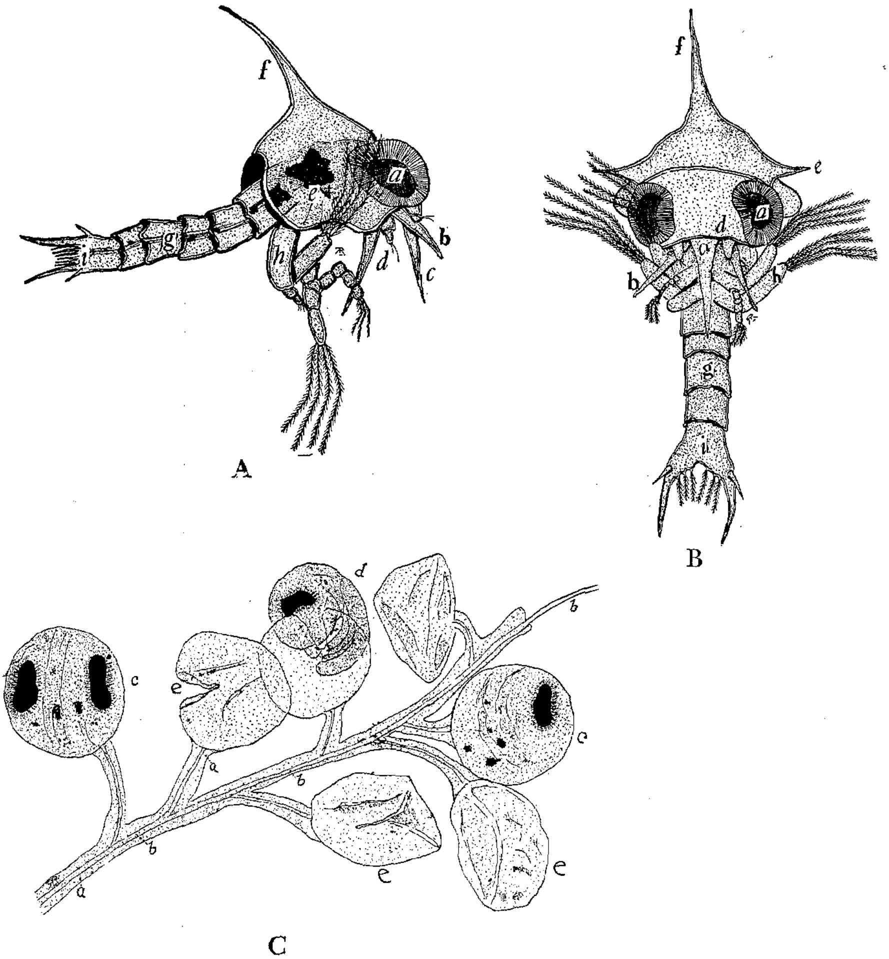


Figure 2. ZOEA OF BLUE CRAB—A. LATERAL VIEW. B. FRONTAL VIEW: a. Compound eye; b. Antenna; c. Rostrum; d. Antennule; e. Lateral spine; f. Dorsal spine; g. Abdomen; h. Maxilliped; i. Telson. C. HAIRY PROCESS BEARING EGGS: a. Sheath; b. Tendril; c. Egg ready to hatch; d. Emerging prezoea; e. Empty capsule.

Growth stages and moulting: When eggs are deposited, they measure approximately one one-hundredth of an inch in diameter. Pigmentation begins shortly after deposition and, after a period of approximately fifteen days, the larval form, known as *Zoea* (Figure 2) is hatched. Under laboratory conditions, it has been impossible to hatch out the eggs when they are detached from the mother crab. However, many attached batches of eggs have been held under observation while they were developing and hatching. During this period the adult crab almost constantly keeps the egg mass in motion to assure aeration and normal development. As the tiny zoea emerges, it is fanned away from the mass and set free in the water to fend for itself. A curious finding in this connection is the fact that, of the many cases observed, in not a single one did the eggs hatch during the daylight hours. To the contrary, the young crabs leave the eggs in the early part of the night, especially about nine o'clock.

There is a persistent story throughout the Chesapeake territory to the effect that the hundreds of thousands of larval crabs released from a "sponge" immediately start to feed upon the mother crab and continue this act until she is devoured. It would seem impossible that such microscopic bits of soft matter could be held responsible for devouring such hard-shelled forms. Observation disproves completely this belief commonly held among crabbers.

The crab, in the early stages, is markedly dissimilar to the adult form, being elongate, thick in the central region, fuzzy in outline, with pointed appendages above and forward on its body. In common with the much better known late stages, the zoea bears an exo-skeleton; that is, hard parts on the outside of its body. As the zoea must increase its dimensions in growth, this skeleton must be discarded and another of larger proportions must be developed to take its place. This process is known as moulting, or shedding, and is passed through for the first time immediately upon the release of the crab from the egg. Present indications are that at least two moultings occur in the zoea, each followed by expansion and growth. After this the larval crab is transformed into its second stage of development, at which time it is know as the *Megalops* (Figure 3).

Zoea are found to be most abundant in the Bay near the ocean, where typically, the adult females spend the winter and spawn during early summer. By means of tow nets made of very fine, sturdy, silk cloth, it has been possible to establish the zone of greatest abundance of the early stages of the crab. This area may be described by radii extending 20 miles up-bay from the two Capes. In this early stage, the crab is a free-floating organism constituting a large part of the plancton, or microscopic life, of the region. In a single towing of one minute's duration and at a rate of speed not in excess of four miles per hour, fully 25,000 zoea have been taken, indicating their abundance in the center of the Bay's most prolific area. Waters in the lower Bay literally teem with these larval stage crabs during early July and for a period of some five or six weeks afterwards. During this same period, towings made off-shore in the Ocean, and in the upper reaches of the Bay and its tributaries, show fewer and fewer larval crabs, according to the distance removed from the mouth of the Bay, with none whatsoever mid-bay, or above, and none off-shore in the sea. These observations indicate the limited distribution of this immature crab, and its concentration in lower Virginia waters.

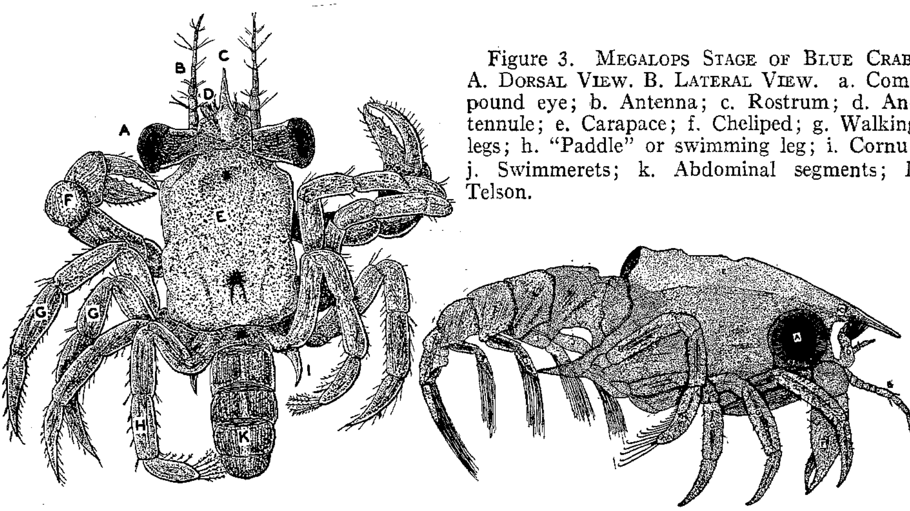


Figure 3. Megalops Stage of Blue Crab. A. Dorsal View. B. Lateral View. a. Compound eye; b. Antenna; c. Rostrum; d. Antennule; e. Carapace; f. Cheliped; g. Walking legs; h. "Paddle" or swimming leg; i. Cornu; j. Swimmerets; k. Abdominal segments; l. Telson.

Zoea propel themselves through the water in jerky fashion and, with their several appendages and spines to support them, they readily remain afloat when they are not in action. They tend to move toward the surface, definitely showing positive phototrophic responses, in contrast to those shown in the second larval stage, when they live on or near the bottom. Being planctonic forms, zoea are consumed as food by many types of organisms, and thus have their numbers greatly diminished before passing through the succeeding stages. The food of the crab in the early stages consists of microorganisms of several types. Experimentally, they will consume oyster eggs, oyster larvae, eggs and larvae of several other molluscan forms, and they voraciously attack other members of their own brood, especially those molting.

Completing the first larval stage, the zoea transforms in shape and appearance to the second or megalops stage, by which time it has grown to to become one-thirtieth to one-twenty-third of an inch in width. After a period of approximately twelve to fifteen days, following the greatest number of first stage larval, the megalops peake of abundance is found. Changing its form from the shrimp proportions of the zoea, the second larval stage of the crab is much broader, has acquired biting claws, pointed terminal leg joints, and other modifications in structure and appearance that render it distinctive from both its earlier and its later stages of development. Larval molluscs and other foods used in the earlier stage are consumed by the megalops, and in addition it may use larger materials that it catches or that may be fed to it. Occasionally, in the breakers along the coast, near inlets to bays productive of crabs, numerous megalops appear during early August. Bathers frequently complain of being bitten by "water fleas", which, upon analysis, prove to be this larval form. "Water fleas" became so annoying at one Maryland seaside resort, Public Landing, during 1925, that bathing practically ceased during early August.

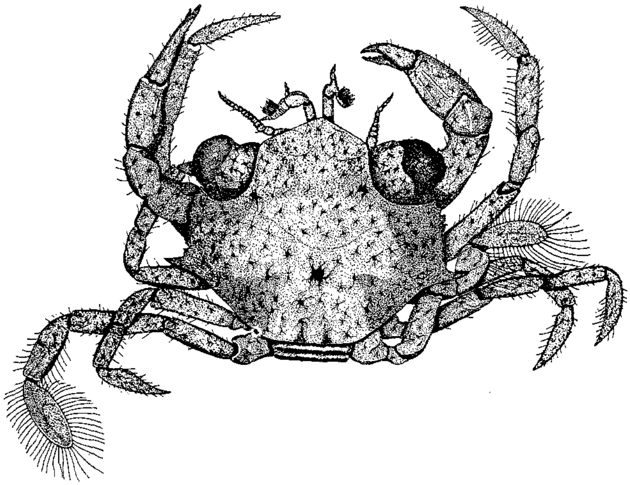


Figure 4. FIRST CRAB OF POST-LARVAL STAGE OF BLUE CRAB.

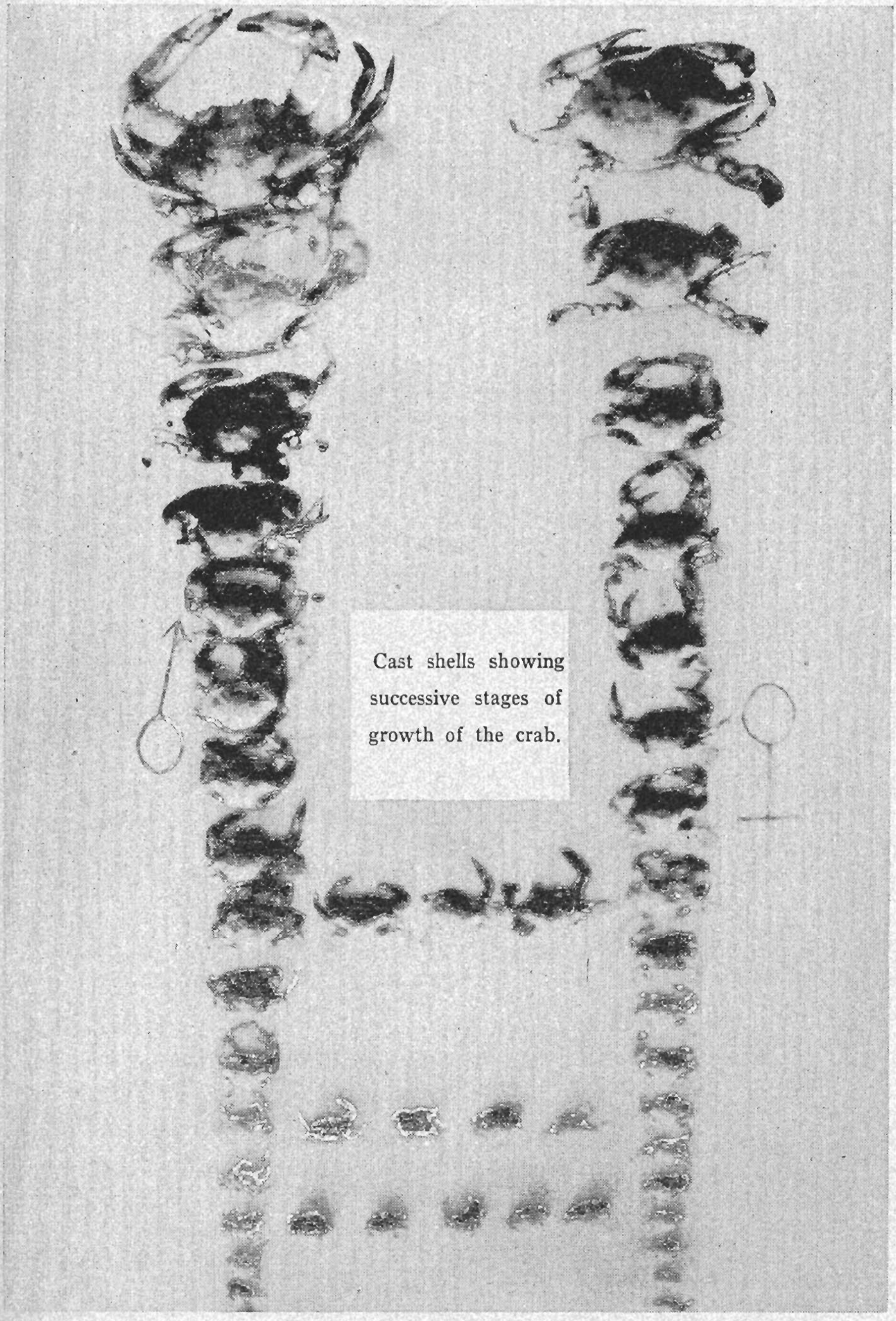
Effort is being made at the present time to determine the number of molts that take place in megalops larvae, the best information available indicating at least two cast skins. Upon changing from the megalops to the adult, commonly termed the "first crab stage" (Figure 4), again great modifications in form and structure occur. Breadth expansion in a single molt may be as much as 190%, while in appearance the animal more nearly approaches the adult crab. Spines are now laterally placed, serrations appear anterio-laterally, the abdomen is folded under the thorax, antennae and antennules assume adult position, and still other changes have taken place.

Beginning with the post-larval, or first crab stage, through growth and moulting repeatedly, the young crab reaches maturity in about fourteen months under Chesapeake Bay conditions. In the laboratory it has been possible to carry the same crabs through from the larval stage to the seventeenth molt, the crabs being alive at the time of preparation of this bulletin. Shedding is speeded up by food abundance and by higher temperatures, while the molting process is stopped, except in rare instances, by lower temperatures. No regular time interval is found between successive moltings. Whereas a larva hatching from an egg may cast off its skin within two hours time, the interval between the last two molts may be six or seven months, if it carries over the winter period.

A crab has its skeleton placed on the outside of its body; thus, to increase in size, this armor-like structure, the shell, must be thrown off, after the old shell has been filled, to accomodate expanding tissues. The number of times a crab casts its skin in becoming mature has not definitely been established. Present work indicates, contrary to the more commonly held opinion, that there are twenty-odd instars, or stages between sheddings. As already set forth, the younger larval crabs shed their exuviae while suspended in the water. From the megalops stage on, they drop to the bottom to shed, for which purpose they seek shelter on grassy bottoms in shallow areas where, in addition to shelter, they find a greater intensity of sunlight and warmer waters to hasten the process.

The first indication of the approach of moulting in the crab is a dark line that develops around the two outer segments of the fins, or posterior pair of legs. Within two or three days this line becomes white. Under natural conditions the white line changes to a light red or pinkish color, and, if the adjacent region is pressed, the tissue within recedes easily, leaving an empty space along the border. This development, along with a certain wrinkled condition that shows up inside of one or two of the claw regions, indicates that the crab is ready to shed, at which time it is known as a "peeler". With experience, these stages of the crab are easily recognizable.

Moulting is a tedious, intricate process, requiring considerable time and effort, with seemingly curious motions and actions on the part of the crab involved. The shell, or carapace, of a crab fits snugly to the hard parts on the lower, or ventral, surface, but is not attached to them. At the posterior margin of the shell a gap appears as the "rank peeler" starts to throw off the old shell. This gap increases in width until it extends around the crab on the undersurface of the shell and reaches the middle anterior region. By virtue of writhing motions within, the gap opens continuously until the two shell regions are far apart—the carapace being forced upward—and the soft posterior part of the crab has begun to protrude through the opening. Twisting, twitching, jerking, writhing motions continue until the body is freed. The greatest difficulty seems to be experienced in withdrawing the legs, especially the claws, with their small joints. For the accommodation of this operation, a triangular piece of shell in the proximal end, dorsally, breaks loose in a very typical fashion. While the crab is releasing itself from the shell, it is known as a "buster" or "rank buster", according to the degree of development. Only during the latter part of the shedding process, the "rank buster" period, is the crab inactive and defenseless. Almost immediately upon shedding, the spines recover their normal form, the legs are adjusted, and the animal is capable of locomotion. Within a few minutes, according to temperature, it becomes quite active and alert, being able to swim and to walk in spite of its extreme softness. Feeding does not start, however, until the second or third day has been reached, by which time the animal has become hard again. As a result of shedding, every hard part or skeletal feature of the crab is discarded, including not only the shell but the mouth parts, the eye covering, the stomach lining, and the gill coverings, all of which have their embryonic origin in the ectodermal layer. Seemingly internal, these features actually are external,



Exuviae of Male and Female Crabs Showing Possible Moulting Stages.

though hidden within the body by the developmental processes. As a result of shedding, there is an increase in the size of older crabs of approximately one-third in all dimensions. After four or five hours, the crab covering becomes somewhat stiff. At fourteen hours or thereabouts, it becomes quite stiff, and with the further lapse of time, say twenty-four hours, tough and then brittle. From this point on the shell hardens by a thickening of the deposits of calcarious matter and chitin, principals in the skeleton structure.

When the shell is hardening, the crab is known as a "paper shell", and as the skeleton continues to thicken and harden, the animal is termed a "buckram", or "green crab". At this time, because of the fact that the body has spread to larger proportions without a corresponding increase in the solid matter present, it is a very poor crab, with watery tissues. Buckrams are of little or no commercial use, even though they meet the legal requirements as to size. With the building up of new tissue the crab becomes heavier and is known to the industry as a fat crab. The time required for this development depends upon the age of the crab and the physical, chemical and biological factors of the surrounding medium. Upon completion of the "fattening" process, the crab moults again, repeating the operation again and again, until maturity is reached after upward of twenty instars.

Food and Movement: Crabs consume a wide variety of foods, both plant and animal. They use considerable dead matter. However, more frequently they avail themselves of such covers as shells, pieces of debris, pilings, and holes, and even cover themselves with sand or light mud to ambush unwary small fish and many other forms available for food. They may go so far as to practice cannibalism. Fish, among the animals, constitute a big item of food for crabs. Roots of *Ruppia* and *Zostera,* two common seaweeds, are favorite vegetables in the diet, though *Ulva,* the sea-lettuce, and the roots of *Spartina,* a salt-march plant, are nibbled freely. Held on floats, crabs devour each other with avidity, smaller individuals attacking larger ones in the soft state, and the older crabs crushing small hard ones. The extent to which this goes on in nature is unknown. Since these animals exercise considerable cunning in being able to hide by digging into the bottom, by running to varied types of cover, and by seeking protection through harmony of color or form, and since it is their habit to seek out highly favorable shedding areas which protect them against their own kind, as well as enemies of many other types, it is probable that cannibalism is reduced to a minimum. It has been found impossible to culture crabs in the same containers; thus in laboratory work larvae as well as older crabs are kept isolated.

Crabs move with facility and ease in the water, being equipped to travel forward, backward, and sidewise. Typically the motion is sidewise, and they may sidle either to the right or to the left. They swim freely in the water and crawl about on the bottom with agility. In an emergency one of them may resort to both swimming and crawling on the bottom, and dart with fish-like speed to a protected area. In a swimming position, the

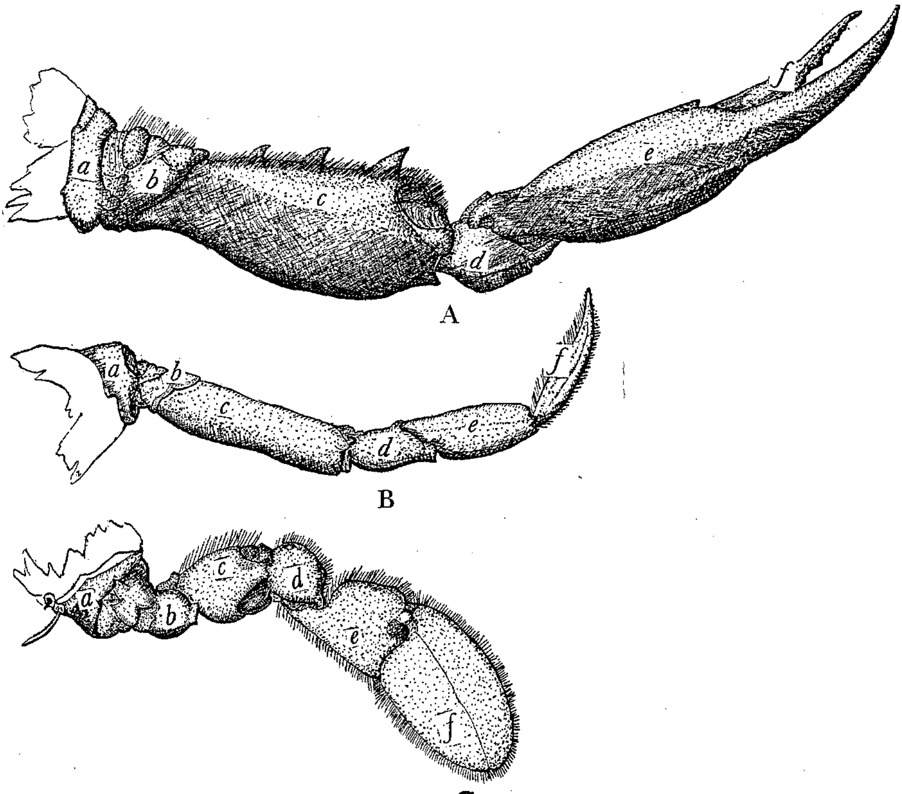


Figure 5. PEREIOPODS OF BLUE CRAB. A. CHELA. B. WALKING LEG. C. FIN OR PADDLE. a. Coxopodite; b. Basischiopodite; c. Meropodite; d. Carpodite; e. Propodite; f. Dactylopodite.

posterior region is slightly higher than the anterior, while the last pair of legs, specialized for swimming purposes (Figure 5) is moved back and forth rhythmically above the edge of the carapace and slightly over the dorsal surface. It has been estimated that this motion, comparable to that of an oar in skulling a boat, may take place at a rate of six hundred and sixty times per minute, with resulting power and speed. While walking, the crab moves slowly, with the tips of the second, third and fourth legs being brought into play, supported somewhat by a slow movement of the swimming legs. Except during the moulting period it is an active creature, shows little fear, and is inclined to be pugnacious. If cornered, the crab immediately lays down the gauge of battle. In fighting, its front pair of legs, especially developed with large, strong claws, is brought into play. One of these claws has a sharp cutting edge while the other has a rounded grinding edge; both are capable of inflicting severe wounds. They are employed in different fashion according to the needs of the crab. When it is moving around seeking food, the claws are usually partially extended, while it is in rest they are folded against the front of the shell. When the crab is swimming, one claw is folded and the other, on the side toward which the crab is moving, is held straight out.

There are marked powers of regeneration of lost appendages among crabs. In the struggle for existence, frequently they lose their legs, which, except in the last growth stage, they are able to replace. Within a week after one of the appendages is lost, a protrusion occurs at the point of the break and continues to grow in bud fashion until a large sack, which gradually takes the form of a new, though non-functional, appendage, is developed. The covering of this new limb is thrown off at the next moulting. If sufficient time has elapsed for the new appendage to reach maturity, the crab now has a new functional limb, smaller in size than a normal leg. It requires at least two full moultings on the part of the crab to restore a regenerated claw to large size. Frequently fully grown crabs are found with claws that have not recovered their normal size. Such recovery will not be made, since no further shedding takes place. Irregular claws of this type are known to the industry as "Jew claws". If a crab is held by a leg, or even one of its claws, almost invariably this member is detached from the body by the actions of the crab itself. There is evidence to indicate that the power to restore a lost appendage is used purposely in the course of escaping from an enemy. Approximately eighteen per cent of the crabs taken in an industrial way show evidence of regeneration and autotomy. To facilitate the sloughing of an appendage there is a region or breaking point on its basal joint known as the "fracture plane". When the appendage is flexed the break definitely occurs along this plane. Special valves located within the blood vessels close following the rupture and prevent hemorrhage. Subsequent to this development the adjacent cells rapidly proliferate to cover over the injured region. If a crab is forced to drop a number of its legs, and as many as eight out of ten have been observed to be lost from a single animal, it still is able to carry on and develop new appendages.

Mating: Mating takes place upon completion of growth, that is, upon the last moulting in the adult female. Males, on the other hand, may copulate during the last three growth stages. When ready to shed for the last time, the virgin female is found by a male, which proceeds to clasp her in a position in which the dorsal side of the female rests against the ventral side of the male. In this position, at which time they are known as "hard doublers", the female is passive and the male literally carries her to a favorable shedding ground to complete the nuptial flight. The male stands by during the period required for the female to moult, and immediately thereafter copulation ensues. During this act the male, a hard crab, holds the female securely to him by means of two pairs of his walking legs. Their ventral surfaces are opposed, in contrast to hard doublers. Mating continues for a varying period ranging from one-half hour up to fourteen hours. Not infrequently the male, carrying the female, will swim away from the shedding ground during this period, at which time the crabs are termed "soft doublers". Incalculable millions of male cells, spermatozoa, are transferred to the receptacles of the female during this

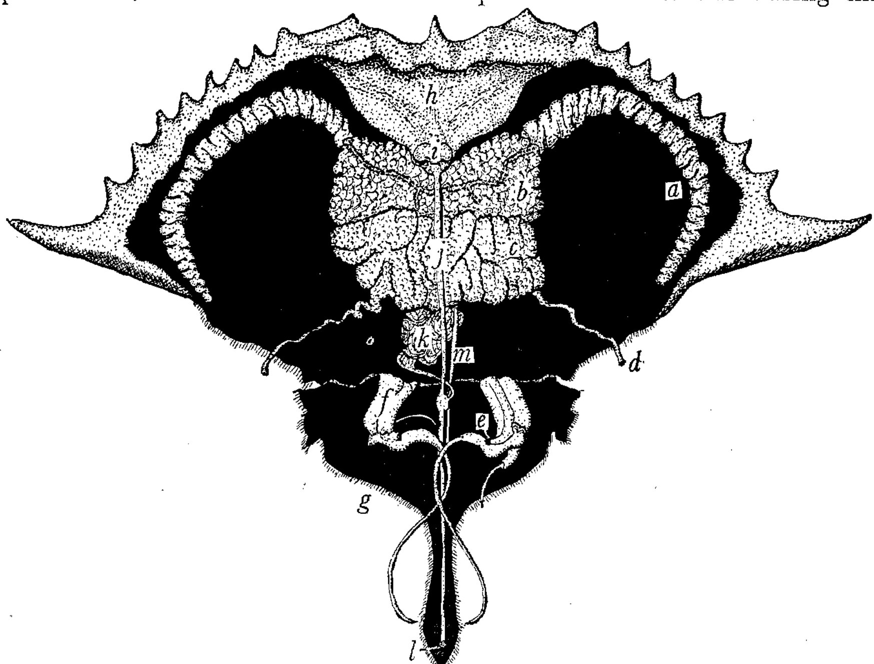
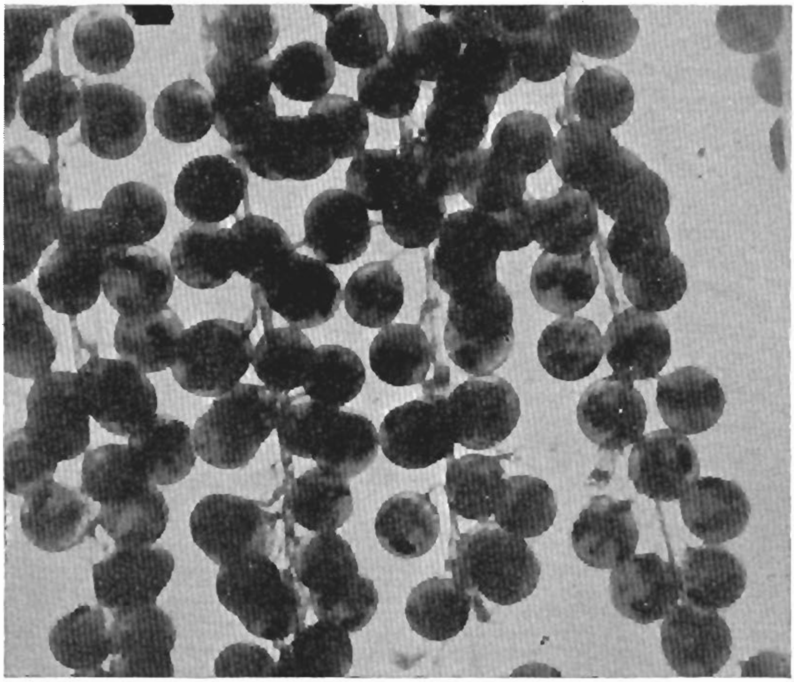


Figure 6. SEMIDIAGRAMMATIC SKETCH, VENTRAL VIEW, OF DIGESTIVE AND REPRODUCTIVE SYSTEM OF MALE CRAB. a. Testis; b. Anterior portion of vas deferens; c. Posterior portion of vas deferens; d. Sperm duct; e. Ejaculatory duct; f. Cirrus; g. Abdomen; h. Stomach; i. Pyloric pouch; j. Intestine; k. Intestinal caecum; l. Annus; m. Abdominal artery.

period. The female mates only once, while it has been established that the male crab will mate several times after reaching sexual maturity. The intromitting organs (Figure 6) consisting of two *cirri,* are inserted through a like number of genital orifices ventrally located on the female. Each of the cirri has attached to it a sperm duct which passes forward, inward and dorsal, to connect with a seminal vesicle and the testes, or organs that produce the germ cells. Upon the completion of mating and the hardening of the female, she starts to move to the lower bay, feeding and taking advantage of favorable tide as she migrates.* The male crab, as already set forth, does not migrate in this fashion. Rather, he remains in the upper half of the bay and its tributaries to pass through the winter.

Life Span: No given period has been established for the length of a crab's life. Typically, a crab hatches from the egg early in July, passes through

*A female crab tagged at West River moved to the lower Pocomoke Sound, a distance of sixty-eight miles, in thirty-four hours, thereby establishing a record.



Attached Eggs of Crab.

the larval stages of development by late August, and starts to move up-Bay during early fall. More generally the region of upper Virginia is reached before the movement is stopped by cold weather in late November or December. The advance wave of this migration may reach Pocomoke and Tangier Sounds, in Maryland, and on occasions it has been observed as far north as the Choptank River and the shores of Tilghman's Island. However, the juvenile crab reaches Maryland waters in greatest abundance after the winter has passed, that is, during April and early May, at which time it measures from one-half inch to one inch in width. By June 1 the crest of the wave of the brood has reached Solomons Island, on the west shore, and Hoopers Island, or above, on the east shore of the Bay. Thereafter they scatter into the rivers and to the headwaters of the Bay, being present in great numbers. The run of these young crabs is heavier on the east side than on the west side of the Bay, probably being associated with slightly higher temperatures and a greater salinity.

Crabs that come from eggs in August apparently are greatly retarded in their growth, both in open waters and under experimental conditions; thus, unlike those hatching earlier, they may not reach maturity in the fall of the second year, but carry over until the following summer. Because of this fact, it is possible to see mating crabs throughout the summer period, though the peake of mating activity takes place in late August. From these observations it follows that crabs may reach maturity in fourteen months, but that some of them require two full years for complete developments. The more typical crab, however, spawns at the time it reaches two years of age and, it is indicated from tagging activities, later on it passes into a senile condition. Many of them struggle against the elements, during the third winter, and pass through to their third year of age. When winters are more severe, and especially during those winters when abnormally violent storms occur, the mortality of these old crabs, now known as "ticky crabs", or "silks", is exceedingly high. Following such conditions, riffs of them are thrown up on the shore in the region of the Capes, thus occasioning fear on the part of watermen that the supply of crabs has been greatly diminished by natural causes. Upon examination, few of these crabs give indication of having been virulent and potentially reproductive. Such crabs, when captured, have an unpleasant odor savoring of iodoform. The meat is of the same flavor, thus rendering it worthless as food. A great many of the female crabs that survive the third winter move out of the Bay into the nearby ocean, at times in great schools, where they later scatter and disappear. These crabs are approaching their third year of age at this time. The male crab more consistently lives to be three years of age. The large, fully-grown male is commonly known as a "Jimmy crab" or "Jimmy Channeler", a type that dominates the catch in the fresher waters during early and middle summer.

External features: The crab is a highly evolved crustacean. Its parts have become modified to such a degree that interpretation of their origin is difficult in certain cases. However, their structural features may be observed if specimens are disarticulated and the general anatomy is carefully dissected. In spite of the great modifications, there is point for point similarity between the crab and the more generalized crustaceans such as the lobster or the crayfish commonly described in text books. A comparison of a crab with a crayfish should be made. Both forms are inexpensive and readily accessible for study. The body of the crab is completely encased in an armor of chiton, impregnated with salts of calcium, characteristic skeletal materials of crustacea. This structure, the exoskeleton, serves to protect and strengthen the soft body parts, while affording attachment points for the muscles.

The body of the crab is segmented although the dorsal and anterior somites of the body are fused together and are, in many cases, so indistinct as to be difficult to determine. This is especially true of the head and thorax. The abdominal part of the body, visible from the under surface of the crab (Figure 7), and spoken of as the apron. plainly shows segmentation. Enclosing the head and thorax regions is the shield-like covering, dorsal in position, the carapace, along the front edges of which are located serrations or spines. The carapace has regions on its marked off by fine lines, or fused sutures, which indicate the segmentation.

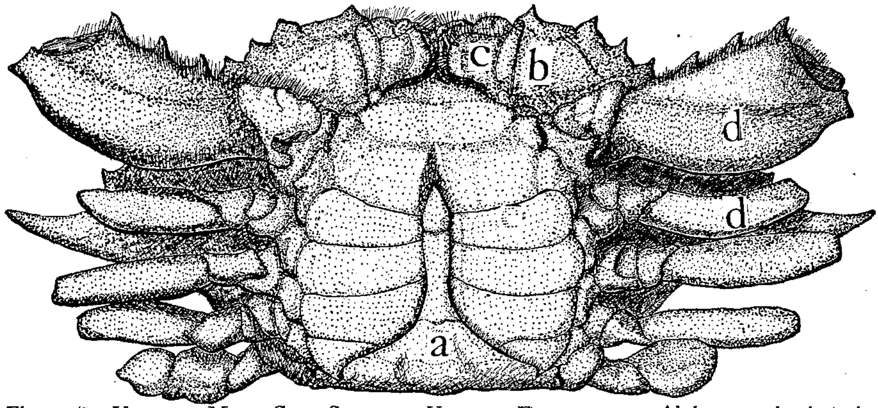


Figure 7. VIEW OF MALE CRAB SHOWING VENTRAL FEATURES. a. Abdomen. b. Anterio-lateral carapace. c. Third maxilliped. d. Pereipods.

Projecting from the front or anterior end of the carapace are the two eyes mounted upon movable stalks (Frontispiece). The bases of these stalks are located inside of a rim of chitin into which the eyes may be withdrawn to protect them from injury. If the tip of an eye is closely examined, it appears darker in color than the stalk proper. Examination with a magnifying glass reveals that this darkened area is composed of tiny six-sided tile-like structures, the facets, which constitute the compound eye. The crab is able to see in all directions without the necessity of moving the position of the eye.

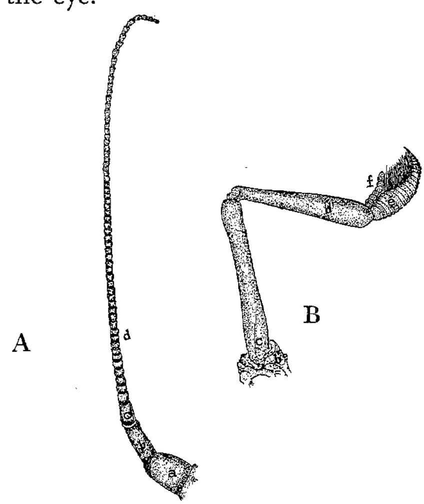


Figure 8. SENSORY APPENDAGES. A. ANTENNA. B. ANTENNULE.

Placed between the pair of eyes are two pairs of sensory appendages, namely the antennae and antennules (Figure 8). The former are finely segmented filamentous organs capable of considerable freedom of motion, while the latter, more anteriorly placed than the antennae, are shorter and thicker, with segments longer and fewer in number. The antennules are so developed as to permit their being folded back in a horizontal position across the frontal region and under the carapace. The function of the antennae is considered to be that of receiving chemical and tactile stimuli, while the antennules function likewise and, in addition, control equilibrium. The centrally located spine between the antennules is an outgrowth from the epistoma or antennary sternum, and is connected to the overhanging edge of the carapace.

The mouth parts of the crab (Figure 9), six pairs in all, are found in the following order, beginning from the outer-most pair: third maxillipeds, second maxillipeds, first maxillipeds, second maxillae, first maxillae and

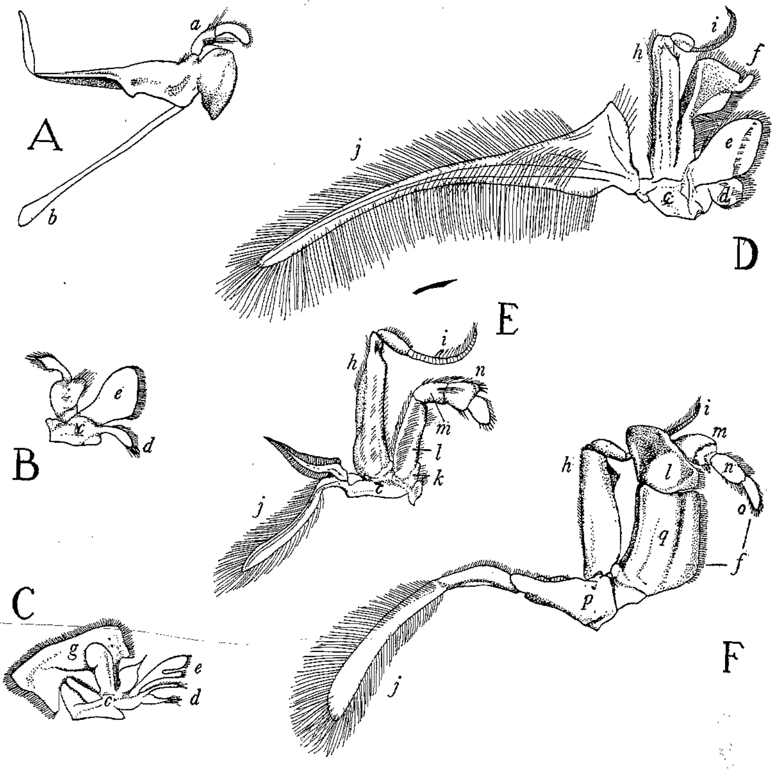


Figure 9. Mouth Parts of Blue Crab. A. Mandible. B. First Maxilla. C. Second Maxilla. D. First Maxilliped. E. Second Maxilliped. F. Third Maxilliped. a. Palp; b. Tendon of posterior adductor muscle of mandible; c. Coxopodite; d. First endite of coxopodite; e. Second endite of coxopodite; f. Endopodite; g. Scaphognathite; h. Exopodite; i. Flagellum; j. Epipodite (flabellum); k. Basischiopodite; l. Meropodite; m. Carpopodite; n. Propodite; o. Dactylopodite; p. Protopodite; q. Ischiopodite.

mandibles. The third maxillipeds, broad segmented structures, cover the buccal or mouth cavity. Lying beneath the third maxillipeds, although actually in front of them, are the second and the first maxillipeds, all of which are modified to assist in holding and perhaps tasting food. The two pairs of maxillae somewhat resembling the maxillipeds in appearance, function primarily in creating currents through the two gill chambers, thus assuring a constant supply of oxygen-bearing water. The sense of taste is located, in part, in the maxillae. The mandibles, toothed knife-like processes, are masticatory in function, serving to cut food into small pieces.

Five pairs of leg appendages, the pereiopods (Figure 5), are found on the thorax of the crab in the following order, starting anteriorly: the chela or claws, the walking legs consisting of the second, third, and fourth pair of appendages, and the swimming legs or paddles, sometimes termed fins. The segments of these appendages are homologous to those in the maxillae and the maxillipeds, though they may appear to be markedly different.

The abdomen of the crab is not nearly as conspicuous as the same structure on the lobster and crayfish. It is folded into a groove under the thorax. In this position it cannot be seen until the crab is turned over. The outline of the abdomen, or apron, varies with the sex (Figure 10), the females possessing a much broader apron than the male. Two abdominal forms are present on the female; the triangular apron of the virgin and the broadly rounded apron of the sexually mature crab. Appendages of the abdomen are known as pleopods, or, more familiarly, as swimmerets (Figure 11). They cannot be seen until the edge of the apron is raised. Five pairs of pleopods are present on the apron. Their form shows considerable variation between the two sexes. On the sexually mature female the pleopods bear numerous long hairy processes to which the eggs are attached. On the virgin female they appear much reduced. The first pair of swimmerets on the male is greatly modified into a pair of long cirri (Figure 6f) that extend to the tip of the apron. In the male the third, fourth and fifth pleopods are not present, while the second pair is short and intimately associated with the cirri.

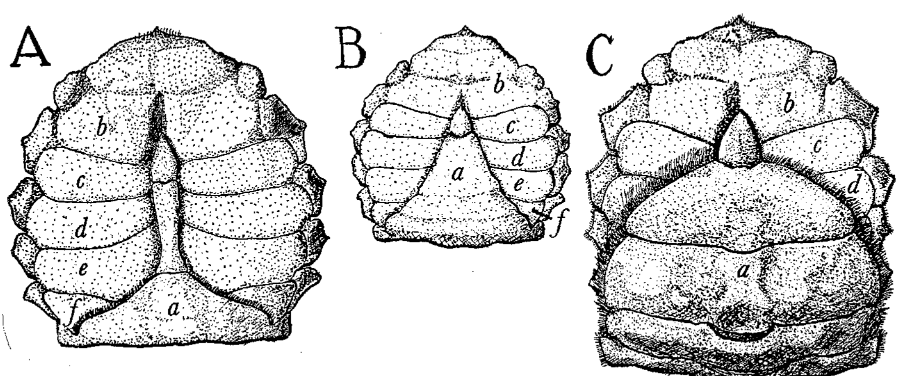


Figure 10. VENTRAL VIEW OF STERNAL PLASTRONS OF CRAB. A. MALE. B. IMMATURE FEMALE. C. MATURE FEMALE. a. Abdomen; b-f. Segments of plastron.

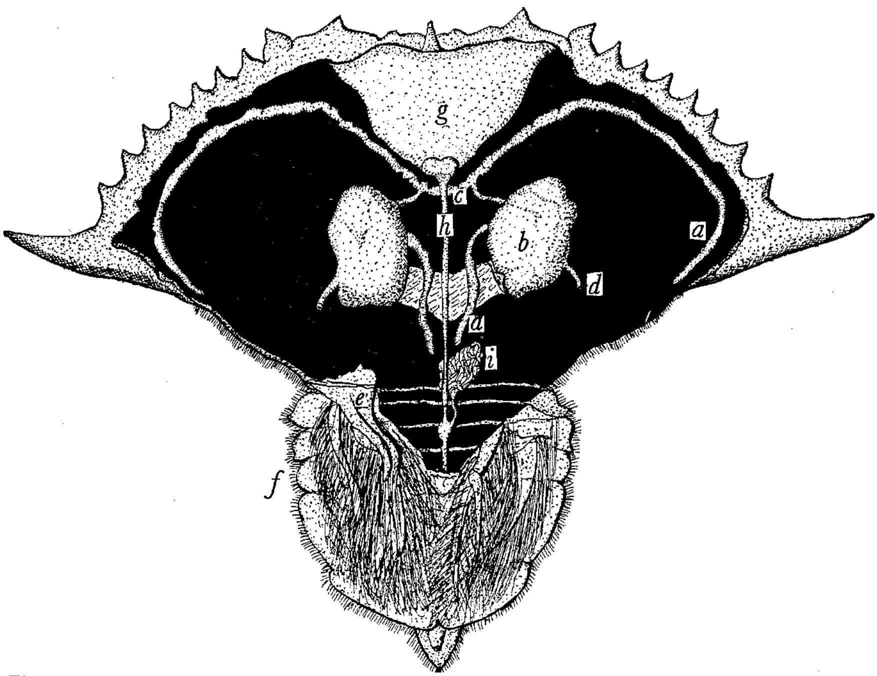


Figure 11. SEMIDIAGRAMMATIC SKETCH, VENTRAL VIEW, SHOWING REPRODUCTIVE AND DIGESTIVE ANATOMY OF FEMALE CRAB. a. Ovary; b. Seminal receptacle; c. Crossbar; d. Oviduct; e. Pleopod; f. Abdomen; g. Stomach; h. Intestine; i. Intestinal caecum.

Segmentation of the crab is visible on the ventral surface, or sternum, where the grooves, that is sutures, delimit certain of the somites. Anterior to these grooves are less well marked off areas which show more complete fusions of segments (Figure 10b). Around the anterior end of the ventral thorasic surface are articulated the several mouth parts previously described. The legs, likewise, are articulated with the ventral surface of the thorax. The paired appendages, that is, the antenae, antenules, eyes, mouth parts, pereiopods, and pleopods, are so developed and arranged that there is one pair to a segment, although the true aspect of this development is greatly obscured by specialization and fusion in the anterior-most region.

Internal anatomy: If the carapace is carefully cut away, piece by piece, the various and well developed internal systems will be exposed, except for the central nervous system. Most conspicuous among these organs *in situ* are those associated with digestion. In addition to the mouth parts, the digestive system consists of the following organs: esophagus, stomach, pyloric caeca, liver, intestine, intestinal caecum, and anus.

Food entering the mouth, located just back of the mandibles, passes through a short, wide esophagus into the ventral portion of the large thin

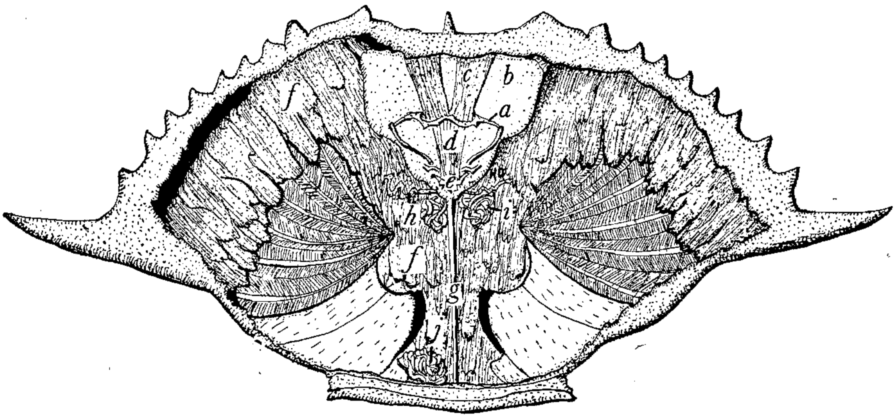


Figure 12. DORSAL VIEW OF CRAB WITH CARAPACE, HEART AND REPRODUCTIVE ORGANS REMOVED. a. Pterocardiac ossicle; b. Cardiac pouch of stomach; c. Anterior gastric muscle; d. Middle gastric muscle; e. Pyloric ossicle; f. Liver; g. Intestine; h. Hepatic duct; i. Pyloric caecum; j. Intestinal caecum.

walled triangular cardiac pouch of the stomach, part of which is anterior to the esophagus (Figure 12). Through the transparent walls of this pouch the bony structure of the food grinding gastric mill is visible. A number of white rods or ossicles are imbedded in the tissue of the stomach to afford rigidity and muscle support. On the ventral side of the cardiac pouch near its posterior end is found an opening which leads to a small thick walled body, the pyloric pouch. Just anterior to this opening calcified inner portions of the ossicles, five in number, form teeth of the gastric mill. These serve to complete the maceration of the food before it enters the pyloric pouch. Ventral to the stomach, overlapping it and extending on each side along the anterior edge of the shell around and beyond the two lateral horns is found the large, pale, brown liver. This organ also extends back from the central part of the body into the first abdominal segment. It is divided into lobes containing many small hepatic tubules which easily separate from one another. These run together from each side forming a hepatic duct. Entering from each side, these ducts carry the secretions from the liver to the pyloric pouch. Also entering this pouch are two slender whitish tubes intricately coiled between the folds of the liver and reproductive organs. These are the pyloric caeca. From the pyloric pouch a straight intestine leads back along the median line, beneath the heart, extending through the abdomen and terminating in the anal opening (Figure 6) on the ventral surface of the tip of the last abdominal somite. Entering the intestine at an enlargement where it passes through the second abdominal somite is a tube extending forward and coiling into a compact ball above the intestine in the posterior portion of the body cavity. This is the intestinal caecum (Figure 6k).

The reproductive organs of the mature female (Figure 11), vary in size according to season. They consist of two ovaries of orange color, when developing eggs, extending around the dorsal margin of the shell from just back of the lateral horns, around the sides of the stomach to the seminal receptacles and beyond them to the posterior region. Slightly back of the stomach and above the intestine the two ovaries are joined by a crossbar. The two seminal receptacles are large somewhat bean-shaped pouches slightly posterior to the center of the body, one on each side. Immediately after mating these bodies are distended and pinkish in color. From their ventral sides a short oviduct runs from each and leads to two external orifices on the sternal plastron. The ovaries when ripe are greatly distended, occupying a large portion of the body cavity. In the male (Figure 6), two slender whitish much folded testes occupy the same position as the ovaries of the female, but do not extend quite so far back along the center line while they run a little farther back beyond the lateral horns. They are connected near the center of the body by a crossbar and open into enlarged folded coils, the vas deferens, one portion of which is on each side. The anterior part of the vas deferens is a pale pink colored gland secreting the fluid which carries the sperms from the testes. The posterior part is more of a pale green color. The seminal fluid containing the sperms is stored in the vas deferens. From the vas deferens, the ejaculatory ducts run through the muscles of the swimming legs in the flancs and out to the exterior through the basal joint of the swimming legs. The ends of these ejaculatory ducts fit into openings in the base of the long hollow first pleopods which have become modified to form copulatory organs. The end of the second pleopod fits into another opening in the first and probably acts as a brace or an aid in forcing the seminal fluid through the copulatory organ.

The crab possesses a simple heart, rectangular in shape, placed just posterior to the center of the body and beneath the dorsal surface. It is covered by a transparent membrane, the pericardium, and between this and the heart aerated blood from the gills enters by sinuses at the corners of the chamber. Four oval ostia acting as valves, two near the anterior edge and two at the posterior edge, admit the blood into the heart from which it is forced through arteries to the various parts of the body. From the central anterior portion of the heart, an opthalmic artery leads forward, terminating just back of and above the rostrum. Two large branches extend from it laterally and supply blood to the eyes and antennae. On each side of and somewhat beneath the opthalmic artery are found hepatic arteries running along the liver and through the muscles of the mouth parts. Just before reaching the anterior margin of the shell each hepatic artery divides into two branches, the more anterior branch extending around the margin of the shell beyond the lateral horns.

Posterior and ventral to the heart there arises the abdominal artery which extends back into the abdomen, anastomosing to supply blood to this entire region of the anatomy. Two branches arise from this vessel between the heart and the abdomen to supply blood to the swimming legs, while branches likewise are given off in the abdominal somites to supply the pleopods. The sternal section receives its blood from still another vessel that arises from the abdominal artery very near the heart. The leg muscles receive their blood from this source. From the various organs venous blood collects in large cavities or sinuses near the ventral surface. Sinuses at the base of the gills communicate with the dorsal veins (afferent branchial veins) of the gills, and after passing by the ventral veins (efferent branchial veins), two large veins on each side converge forwardly to sinuses at the anterior corners of the pericardium and two large veins from near the base of the second and third pereopods enter the pericardium laterally.

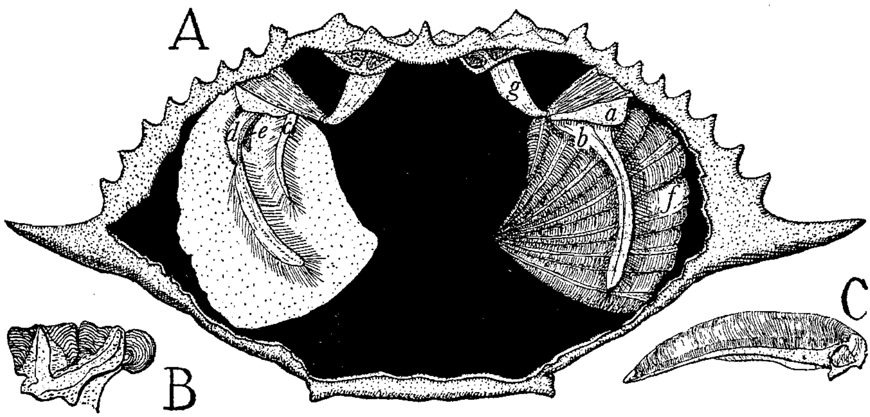


Figure 13. Semidiagrammatic Sketch, Dorsal View, of Respiratory System of Crab with Other Tissues Removed. A. Organs in Position. B. Proximal Ends of Two Gills. C. Single Gill. a. Scaphognathite of second maxilla; b. Flabellum of first maxilliped; c. Flabellum of second maxilliped; d. Flabellum of third maxilliped; e. Opening for water intake; f. Gills; g. Posterior of mandible.

The gills or respiratory organs (Figure 13) of the crab are located in two large branchial chambers placed laterally and dorsally near the horns. The upper wall of a chamber is a membrane, tough, transparent, and chitonous, which extends from the reflected edge of the carapace over the gills to the inner skeleton of the flancs, or bony plates overlying the leg muscles. Water flows into these chambers through slits at the bases of the chelapods, there being one opening to each. After passing over and through the gills, the water is forced to the exterior through an exhalent channel from each chamber. These channels empty above the bases of the second maxillae. Working coordinately, three hairy, fan-like processes, flabella, attached to the first maxilliped, the third maxilliped, and the first maxilla, propel the water from the incurrent canal up through and over the gills and on out the excurrent canal, through which action oxygen is taken up and carbon dioxide is given off.

There are eight gills in each chamber, the first and second being attached to the base of the second maxilliped while the third lies over the base of the third maxilliped. The remaining five gills are located directly over the five legs. Roughly, a single gill is the shape of a long pyramid and consists of many transverse lamellae or pouches to which venous blood is carried from a sinus at the base of the gill by an external dorsal vein. To every lamella is also connected an internal ventral vessel (Figure 13C) by which oxygenated blood leaves the gill. The gills are separated from each other and are free from the walls of the branchial chamber except at the base (Figure 13B).

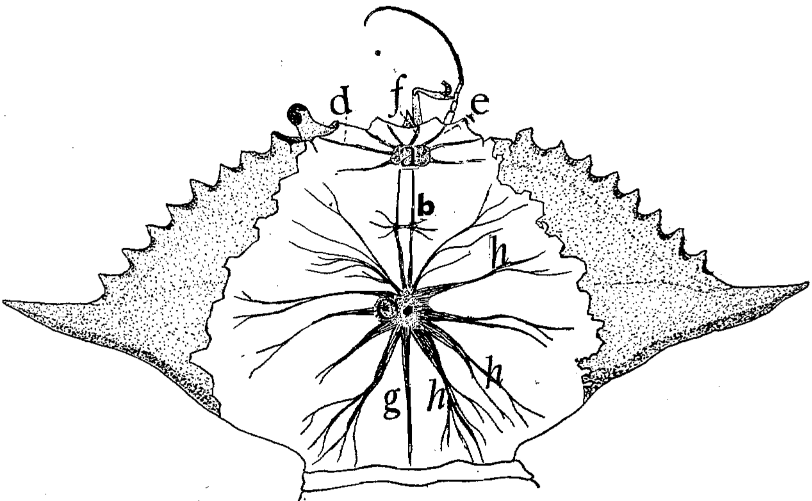


Figure 14. Ventral View of Nervous System of Crab. a. Cerebral ganglia; b. Gastric ganglia; c. Thoracic ganglion; d. Optic nerve; e. Antennary nerve; f. Antennulary nerve; g. Abdominal nerve; h. Nerves to lateral appendages and gills.

The crab possesses a well developed nervous system (Figure 14). Under the frontal lobe of the carapace lies a mass of cerebral ganglia consisting of two oval portions joined together along the median line of the body. From these, nerves branch off to the eyes, antennae, antennules and to the gastric ganglia on the anterior ventral surface of the cardiac pouch. Posteriorly from the cerebral ganglia two esophageal commissures lead beneath the stomach, passing on each side of the pyloric pouch and joined by a transverse commissure. At their points of union with this transverse commissure are small ganglionic enlargements from which nerves extend to the mandibular muscles and to the gastric ganglia. From these two enlargements run a pair of longitudinal commissures leading to the ring shaped mass of the thoracic ganglia near the center of the sternal plastron. From this ring, besides these two commissures, several nerves extend out radially. The central one from the posterior side of the ring runs back into the abdomen while the others extend out to the pereiopods and mouth parts. The complete ramifications of the nervous system have not been worked out.

The auditory organs are located in the large basal joints of the antennules. There is no external opening to them but within each joint there is an irregular, much folded auditory sac containing no solid objects. There are in them, however, many slender auditory hairs, most of which are along a line where the sac joins the wall of the cavity. Enervation of these bodies previously has been described.

The Crab Industry

There are three ways in which crabs are used commercially: as crab meat, as soft crabs, and as fish bait. Crab meat, produced in about equal quantities by Maryland and Virginia, is taken from hard crabs, while soft crabs are obtained largely through holding peeler crabs in float until they shed. Soft crabs are more valuable, individually, than are hard crabs, but the income from this source is less than one-fourth of that derived from hard crabs. The area of greatest peeler crab production is in the general region of Crisfield, Maryland, while hard crabs are common all the way from the mouth of the Bay to its uppermost reaches, including the rivers up as far as they are saline.

Peeler crabs are taken primarily by "scrapes", toothless dredge-like devices that are dragged over the bottoms in those sections favorable to crab shedding. This scraping can be done, legally, only by means of sail boats. For this operation a single-sailed craft, the crab skiff, is used. Crabs typically reach the shedding grounds at night; consequently the crabbers go to their work at daybreak and the pursuit is over by mid-day. Unfortunately, in the past, and to a limited extent at present, certain crabbers have resorted to the use of small, illegal size (less than three inches wide) crabs for chumming purposes. That is, the small crabs captured are kept apart from the lawful ones and at the end of the day they are crushed and thrown overboard on the shedding grounds to attract, as food, moulting crabs of legal size. Curiously enough, the crabber, without being conscious of it, is defeating his own purpose in two ways, since peeler crabs are already fully fed and interested only in shedding, while small crabs are being destroyed—crabs that within a short period of time themselves would be of merchantable size. This waste, more largely practiced in Maryland than in Virginia, is difficult to prevent since there are hundreds of boats employed over a wide territory, while crabs may be dumped overboard alive upon the approach of an officer. An observer from the Chesapeake Biological Laboratory estimated that, during a two-weeks period of scarcity in 1935, certain crabbers used for chum purposes a greater number of crabs than they sold on the market.

The peeler crab is sold to a dealer who places it on a float where it remains until sloughing, or shedding of the shell, takes place. The period of time involved here depends upon how far advancd towards shedding the crab may be when captured. More often this requires two or three days. The shedding process, itself, involves only a matter of forty-five to fifty minutes. As previously indicated, crabs in the actual process of throwing off the shell are isolated in separate floats and, upon completion of the moulting process, they are kept in the water for varying periods, measured in hours rather than days. Crabs are so soft when they extricate themselves from the old skeleton that they collapse and die under shipping conditions. Those to be sent great distances are left in the water for longer periods of time than are those to be consumed locally, in order that the hardening process may start and, in turn, afford some rigidity to the body. Taken from the float in the soft condition, crabs are packed in sea-weed (*Zostera*), under butter paper covered over with ice. This method of packing for shipping purposes assures that the animal will arrive at its destination alive and in a wholesome state for use in the diet. The eastern one-third of the United States consumes 65 per cent of the soft crab output of the Chesapeake, though shipments are made from Crisfield to the West Coast, to Mexico, and to Canada, with an occasional consignment to European hotels.

In the course of shedding operations on floats there is a very high mortality among the crabs, not only because of the intricate process of moulting itself, but because of the all too common practice of using green crabs—those not ready to shed—for peelers. One of the most reliable crab dealers in the Chesapeake offers records to show that 43⅓% of all crabs placed on his floats are lost through death, a condition that should not be countenanced in the industry. Recent Laboratory studies indicate a much higher mortality, which in certain cases ran in excess of 65%. Dealers do not want to purchase crabs that are not ready to shed, but the system of competition is such that not uncommonly they feel that they must purchase a dozen crabs in order to secure the eight or nine peelers included. They are told, frankly, by the crabber that the sale will be made elsewhere unless the deal is consummated forthwith, and that thereafter refusal to sell to the dealers involved will be the practice of the crabber. This, in turn, seems to make the dealers feel that they must purchase non-peeler along with the peeler crabs if they are to supply the market that they have developed. It is these hard crabs that are placed on the floats, along with the more desirable ones, that provoke the high mortality in question. Recent estimates made by the Laboratory indicate that the annual loss from this source is in excess of forty per cent of the total number of animals that find their way to the floats to produce soft crabs. Shedding of crabs is more common in Maryland than in Virginia, thus greater destruction from this cause is going on in the first named state.

Crab meat constitutes the greater volume of the crab industry, and from it is realized the greater income. The source of crab meat is the hard crab, whose muscular parts are picked out after the animal is cooked. Hard crabs are caught on a baited line which, in times of crab scarcity, may be as much as a mile in length. The bait used in the operation is usually either tripe or salted eel, the former being a by-product of the abbatoir. In baiting the line, small pieces of tripe or eel are fastened to the line one-and-a-half to three feet apart. The line is dropped to the bottom of the bay with its ends anchored and marked with buoys. The crabber moves slowly up and down his baited line, running the same over a small roller attached to the side of his craft, usually a motorized boat. In this way the line is lifted slowly from the bottom and the crabs, which cling to the bait, are dipped up as they near the surface of the water. No hard crab less than five inches in width may be captured and sold legally.

The crabs captured are sold to a dealer either by the barrel or the hundred-weight. Later in the afternoon they are placed in large steel vats or cookers and, under steam pressure of approximately sixty-pounds, cooked for 20 minutes or longer in order to prepare them for the picker. All crab meat, which consists of muscle tissue only, is removed by hand. Three grades of crab meat are produced, to wit: lump, flake, and claw, the first named being the most choice. The meat is placed in tin cans, thoroughly chilled, and then packed in ice, ready for shipment. As in the case of soft crabs, the greater part of the crab meat output is used in the eastern part of the United States.

Crab Conservation

A waste of considerable proportions takes place in the hard crab industry in that many of the crabs that go to the cooker have but recently cast their shells and are therefore exceedingly poor, being called at this time "buckrams". When a crab picker comes to this type of crab it, in its entirety, is thrown on the scrap pile to become fertilizer; thus it is a total waste as far as food is concerned. It is estimated that fully 20% of all hard crabs used in Maryland, a far greater loss than that of Virginia, are wasted in this fashion, an unfortunate development in any program involving sound conservation, and a waste, of course, that should be eliminated by the crabber.

It has been established, definitely, that mated female crabs of the Chesapeake go to Virginia waters to spend the winter in the vicinity of the Capes. At this time they are not only concentrated on certain areas but they are phlegmatic and in something of a stupor, brought about by low water temperatures. Congregated in limited areas, these crabs are easily captured by the winter dredging operations practiced in that state. It is these crabs upon which the winter fishery is developed, and the problem presented, in which more than ninety per cent of the entire catch is made up of pregnant crabs, is one confined to Virginia, since winter operations are illegal in Maryland. It has been established, also, that the entire Chesapeake territory receives its crab supply from the egg bearing mother crabs which are found almost exclusively in the lower Bay, females that escape capture and live through to the summer time. It has been the practice in Virginia to use this type of crab when present, and at the peak of the spawning period as many as seventy out of a hundred crabs sold from sections near Hampton Roads have been noted to be egg bearers, each with well on towards two millions of eggs attached to it. Thus every crab of this kind used carried with it to the cooker vast numbers of potential crabs, a loss hardly believable in any type of animal husbandry.

From the foregoing it becomes obvious that crabs have received a minimum of protection and encouragement from those who manage the industry founded upon them, and the spirit has been one of exploitation rather than one of conservation. Few animals, indeed, could withstand such drafts upon them at all seasons of the year while breeding, while carrying the eggs, while moulting, while hibernating, and while in the several stages of growth. That the industry has survived to date is not only marked testimony as to the hardiness of the species, but added evidence of the remarkable richness of the Chesapeake as a fit environment. The already cited adverse conditions affecting the crab industry have been of such a character as actually to threaten its existence. Maryland's crab industry, youngest among its seafood industries, reached a high level of production during the 1900-1901 season. Data presented in Table No. 1 shows that the volume of Maryland's crab production dropped in the early nineteen-twenties to a point that was less than one-half of that of 1904.

TABLE No. 1

CRAB PRODUCTION IN MARYLAND*

Year	*Pounds*	*Value*	*Year*	*Pounds*	*Value*
1901	14,128,375	$288,447	1932	32,939,431	518,804
1904	18,398,147	358,847	1933	30,097,129	570,148
1920	9,062,974	742,944	1934	15,909,700	489,938
1925	9,646,361	576,785	1935	19,821,400	482,057
1929	28,099,678	799,569	1936	15,909,100	512,881
1930	36,938,783	984,171	1937	18,712,400	604,500
1931	33,841,160	701,784			

*Data from official reports of Maryland Conservation Department.

Following legislative correction of certain conservation ills in the industry, during 1926, there was an upturn in production with a jump in yield from 9,646,361 pounds in 1925 to 36,938,783 pounds in 1930. Such figures show definitely the value of the conservation practice instituted.

The all-time high level of production, 1930, was followed by a downward trend in the yield, a condition that is directly traceable to a backward movement in the two states concerned. Maryland authorities passed legislation enabling crabbers to operate over a longer period of time, and especially during the period when mated crabs migrate to the lower-bay wintering grounds, while, in Virginia, there was sanctioned a reversion to the wasteful practice of capturing egg-bearing females. These two practices were the foremost destructive activities responsible for the decline of 1920-1925. This downward trend has continued through the 1937 season, although during 1936-1938 a crab conservation compact between the two states was effected which offers promise providing the crabbers and the dealers in the industry wholesomely cooperate with conservation leaders.

Low levels of crab production in the Chesapeake area have been responsible for two factors that must be considered on a practical basis in connection with the problem of rehabilitation of the industry. Scarcity and higher prices have diverted consumer attention away from crabs as a food, while the same factors have stimulated the importation of crab meat from Japan, in addition to the development of crab resources in other sections of the United States, especially along the Gulf of Mexico. Though the latter region is not as intensively productive as the Chesapeake, the big territory involved has become highly competitive. Thus, with restoration of larger local yields followed by a marked return of crabbers to the industry, under conditions of sluggish markets and greater competition, there will almost inevitably follow a marked decline in prices. History repeating itself, there will rise a cry, as in 1930, about crab abundance and a demand that conservation laws be relaxed which, in simple language, means that Marylanders will want longer seasons of operation and Virginians will want to capture the egg bearers. Destructive practices in times of plenty must not be allowed to supplant practices based upon sound conservation principles. Crab products, constituting a small industry, are rich in food essentials, are consumed over a small territory, and have up to this time had but a minimum of sound business direction. The potential market is great, merely awaiting development. Virtually all of America's supply of canned crab now comes from Japan in spite of the foreign flavor and the tariff gauntlet it must run, although operating for the first time in recent years will be a crab cannery in South Carolina under the direction of a long interested Marylander.

The greatest need in the crab industry is an assured constant supply of crabs. It is difficult to maintain a high level of production in any form of wild life in which there is constant reaping without sowing, as is true of this industry. To save the egg bearing crab in Virginia, and to eliminate the marked destruction that takes place in Maryland, on the shedding grounds, on the floats, and in the steam cooker, would contribute outstandingly to higher and more constant levels of production. However, there still would remain several weak points in the conservation practices that would permit of wide fluctuations in production and in chaotic marketing. Present regulations and practices in this fishery seem not to provide that sufficient brood stock be left in the water to maintain high levels of production. Fishermen take every crab of legal size that it is possible for them to capure, and only limitations of fishing gear and human effort make it possible for any brood stock to escape. In the poultry business, typical of animal husbandry in general, thirty hens are kept if a new brood of 150-200 chickens is desired. Approximately four hundred hens are kept if a flock of 3000-5000 chickens is desired. A similar policy of management is essential to the crab industry and, unlike many of the fisheries, the developments in the life cycle of this crustacean make such a policy not only feasible but workable. The Chesapeake Biological Laboratory, where crab studies have been in progress for six years, urges not only the short seasons of capture, the restrictions as to the use of egg-bearing crabs, and strict law enforcement, but urges that crab sanctuaries be established on sections chosen from the choicest crabbing grounds—areas used for shedding, growing, and hibernating. Such sanctuaries, upon which crabbers would not be allowed to operate, could be expanded or diminished to meet the demands for brood stock and a constant level of production according to subsequent developments in crab production.

THE OYSTER

Just when oysters became objects of economic interest is not known, but records of their being included in the human diet indicate that they were very commonly used and highly prized by the Romans. Pliny the Elder, nearly nineteen hundred years ago, told of their abundance in the Adriatic Sea, while Sallust, after his trip with Caesar to what is now England, said that he could find only one good in the Britons: "they eat oysters". In America, the Aborigines used oysters in great quantities long before the white settlers found them drying this product for purposes of exchange with the interior dwellers. Indeed, in Maryland there are in many places piles of shells, middens, containing thousands of bushels. Found inland as well as in the tidewater regions, these shell mounds which were made by Indians stand today as testimony to the vast quantities of oysters used by the tribes.

The oyster industry is one of the most valuable fisheries of the United States, being second only to the salmon. In Maryland the industry exceeds, by far, other aquatic resources and is paramount in the Chesapeake Bay. In all branches of the industry, state-wide, over ten thousand citizens are employed directly every year, while, indirectly, upward of five thousand others are connected with it. Considering the workers and those depending upon them, the contribution of the oyster industry to the welfare of the citizens of the State is most impressive.

Oyster production in Maryland has, during late years, dwindled to approximately two and a half millions of bushels per annum. The world's yearly output of oysters extends, it has been estimated, up to or above twenty-four millions of bushels, the greater part of which quantity is produced in America. It is indicated that the waters of the United States, alone, are producing approximately thirteen millions of bushels. In monetary terms the industry brings to Maryland, annually, nearly two million dollars. The shells from oysters in Maryland, formerly without commercial use, now add to the industry an annual income of nearly one hundred and twenty-five thousand dollars, and give rise to still another industry, that of chick-grit and lime production. A market for chick-grit is found in Europe as well as in America.

While the oyster industry reaches its greatest proportions in the United States, it is by no means confined to our borders. Oysters are found on practically every coast throughout the world where temperatures range to seventy degrees Fahrenheit and above, though many countries possessing oyster beds have done little or nothing to develop and use them. In the order of importance of the industry, this bivalve is produced in the following foreign countries: France, England, Japan, Holland, India, Ireland, and New South Wales. At least four other European countries, and fifteen elsewhere in the world, produce oysters and consume them, although not in sufficient quantities to be of great economic interest. Thus, while not all of these oysters are of the same species, it is seen that they are widely distributed marine animals upon which industries have been developed; in many places these animals are produced without cultural methods and are simply taken from their habitat in the fashion of gathering wild fruit. This is especially true in America, from Maryland southward along the coast and in the Gulf of Mexico.

From the time of the planting of the colony at St. Mary's City, oysters have been a dependable source of food for people living along Maryland's tidewater. There was, apparently, no industry, as such, in the State until early in the nineteenth century when, with the fuller development of such nearby cities as Philadelphia, Baltimore, and Washington, there sprang up a demand for oysters which resulted in the perfection of devices for their capture, special boats for the operations, and highly skilled men to conduct the work. By 1840 the industry had developed to a point that attracted attention in this country and abroad. However, the peak of production in Maryland's oyster industry was not reached until the decade of 1875-1885, when in a single year more than fifteen million bushels were produced. Because of the ever increasing harvests, watermen had come to feel, by this time, that the oyster resources of the Chesapeake were inexhaustible. Since that period, however, there has been a gradual diminution in the supply, with an occasional, favorable year, until production has reached an alarmingly low level. With the production of less than three million bushels last year, there is thrown down a challenge to the best in science and in practice to effect restoration.

Biology of the Oyster

Contrary to the opinion generally held, the oyster, a sedentary creature, is a highly evolved form, having well developed systems for digestion, circulation, respiration, response to stimuli, and reproduction. The species, *Ostrea virginica* Gmelin, upon which Maryland's industry is founded, is indigenous over a wide range of territory extending from the Gulf of St. Lawrence, in Canada, to the Gulf of Mexico, nearly as far down as Vera Cruz. The most productive areas in its habitat, for the most part in sounds, bays, and lower sections of rivers, range from Connecticut southward to North Carolina, the Chesapeake Bay waters being by far the most productive.

Food and Feeding: Apart from a small amount of plant detritus, oysters use for food microscopic particles of living matter termed plancton. These particles are animals and plants of a low order, largely single-celled, which thrive prodigiously in saline waters, and especially in those of the Chesapeake. Just how very rich this body of water is in such forms can be better understood when it is pointed out that millions of them are at times found in a single quart of water.

The Chesapeake Bay, through its great system of tributaries, is rather ideally situated with reference to watershed, being a drainage basin for the greater part of Pennsylvania, Maryland, Virginia, and Delaware. That is to say, the excess water that falls on some one hundred and thirty-five thousand square miles of rich land finds its way to the Chesapeake, carrying with it, in solution, valuable substances dissolved from the soil to enrich the already fertile ocean water and make possible the luxuriant vegetable and subsequent animal life found therein.

The oyster is highly modified to gather the microorganisms produced in the water. Its respiratory organs (Figure 15g), four fringe-like gills on the ventral and posterior surfaces, are covered with cilia, delicate hair-like processes, which beat somewhat in wave fashion and assist in gathering the food particles. Secretions from these same gills entangle the organisms, which, by means of the cilia, are passed forward to the palps or lips in the immediate region of the mouth. By this time considerable selection has taken place and most of the non-food substances, such as mud particles and fine debris, have been discarded. By creating currents of water over and through the gills the cilia not only assist in securing food for the oyster and transporting it to the mouth, but, at the same time, they maintain a flow of oxygen-laden water for respiratory purposes, as well as remove excretory wastes that are freely discharged through the gills. During the active seasons an average size oyster may pump 15 or 18 gallons of water through its gills each day. Obviously, an organ which pumps water, collects food, transports food, secretes, excretes, and acts as a gill, is complicated. Oyster gills do all these things effectively.

Food enters the mouth (Figure 15) which, contrary to the opinion generally held by watermen, is located near the hinge of the shells, that is anteriorly. From the mouth the food is led to the stomach—a comparatively spacious organ—through a short tube, the esophagus. Digestive juices secreted by the folds of the stomach and by a massive gland—usually very dark in color and known as the liver—which surrounds the stomach discharge into the digestive tract. Aided by the crystalline style, a uniquely constructed amber colored and rather eel-shaped body that, unattached in the system, disappears some minutes after oysters are removed from the water, these juices break down and digest the food, so as to permit its diffusion and distribution throughout the body. Digestion is completed and absorption takes place for the most part in the intestine, a long tube which runs posteriorly and ventrally to a point opposite the heavy muscle (adductor), whence it bends back upon itself passing anteriorly and dorsally around the stomach, by the esophagus, and again posteriorly to an external orifice, the anus, located on the dorsal surface above the posterior edge of the adductor muscle. Non-digestible matter is voided through this opening as in animals of higher types.

Respiration and Circulation: The circulatory system (Figure 15) takes the digested foods from the eneric canal and delivers them to the tissues over the entire animal. This system, while not as completely closed as are those of higher forms, is well developed, having a central pumping body, the heart, divided into two distinct regions—a large sac-like muscular ventricle followed by a somewhat smaller thin-walled, globular chamber, the auricle. The direction of blood flow is regulated by a valve between the ventricle and the auricle. The heart lies in a cavity just in front of the adductor

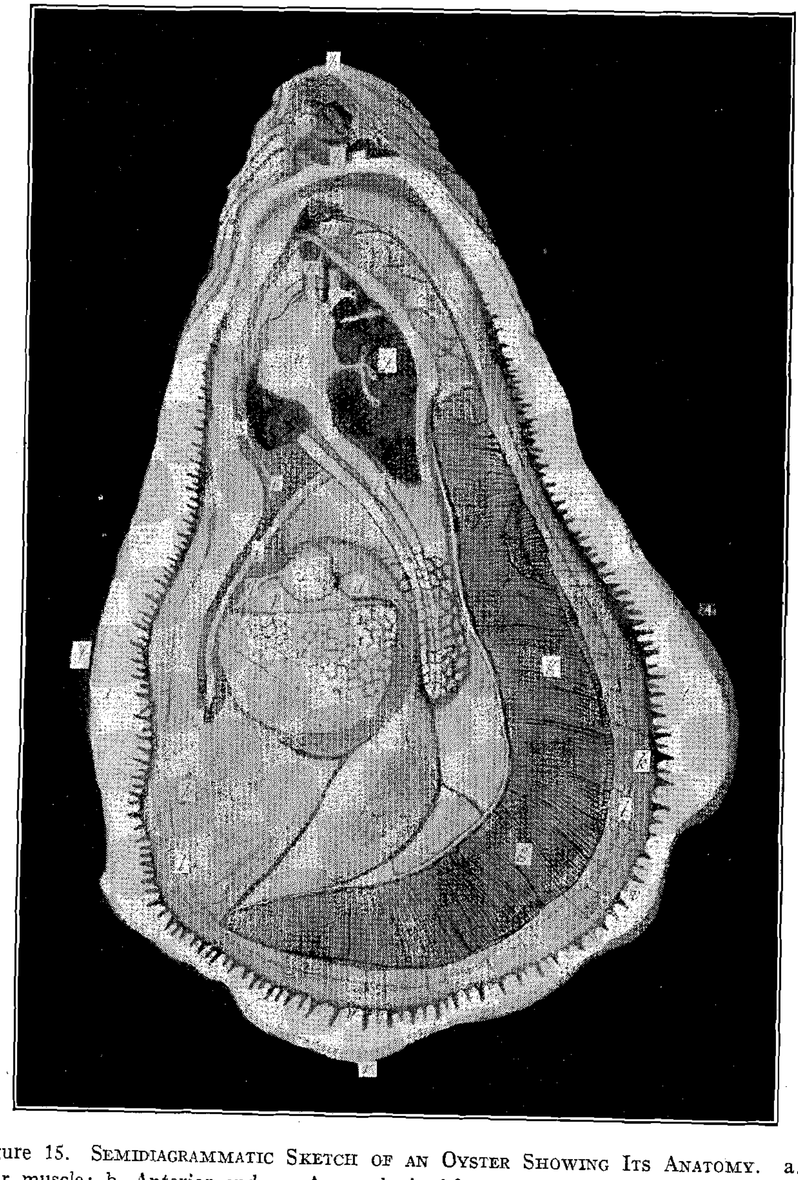


Figure 15. Semidiagrammatic Sketch of an Oyster Showing Its Anatomy. a. Adductor muscle; b. Anterior end; c. Anus; d. Auricle; e. Anterior aorta; f. Dorsal aspect; g. Gills; h. Hinge ligament; i. Intestine; j. Liver; k. Mantle; l. Nerve; m. Mouth; n. Oesophagus; o. Palps; p. Pericardial cavity; q. Posterior aorta; r. Posterior end; s. Reproductive glands; t. Shell; u. Stomach; v. Tentacle; w. Ventricle; x. Ventral aspect.

muscle. This, the pericardial cavity, is covered laterally by a thin membrane through which the strong pulsation of the heart may be seen even after the severe shock of "opening" the oyster. Pulsation may continue, under favorable conditions of humidity and temperature, for hours after the valves have been removed. This pulsation forces the aerated blood, a slightly gray, nearly clear fluid, into the auricle, on into the ventricle, and from thence out through the arteries into the body parts, passing over the digestive tract and gills before returning through the veins to the auricle. The blood passages between the arteries and veins are devoid of walls proper and partake of the nature of sinuses, thus bathing the tissues in the food and oxygen laden plasma which, at the same time, takes up carbon dioxide to be discharged when the blood passes through the gills, thereby effecting complete respiration. As already indicated, great quantities of water are passed through the gills in the gathering of oxygen and the removal of waste matter.

Response to Stimuli: Sense organs are not as highly developed in the oyster as might be expected considering the animal's sensitivity. In the anterior region, near the gullet, there is a centralization of nervous tissue from which nerve fibres run to all parts of the body. These tissues thicken in several regions, forming still smaller "ganglia" whose immediate connectives innervate the organs and the surfaces near them. On the margin of the mantle (Figure 15k), the thick membrane that envelopes the whole oyster, there project outward small tubercles or tentacles (Figure 15v) that are highly sensitive to touch. These bodies, normally extending out over the edges of the shells, receive impulses even of the most delicate nature, as a result of which the shells snap to upon the slightest provocation such as change of water pressure, density, rate of flow, and even change of light intensity. Such response offers a high degree of protection for the soft bodied animal. The tentacles are usually highly pigmented, being darker by far than oyster gray. No eyes are found in adult oysters, though organs of sight are not uncommon in other species of molluscs.

Valves and Their Operation: Most noticeable in the organization of the oyster are the shells which, because of their concavity, offer ample space for the animal. These shells or valves are produced by the mantle, which, as previously indicated, is a heavy glandular membrane surrounding the oyster and which secretes a liquid substance that, upon hardening, becomes shell. Brooks, in his treatise, "The Oyster",* tells of his observations of shell building upon glass inserted within the values, as follows: "At the end of twenty-four hours the glass was found to be covered by a transparent faintly brown film of thin gummy deposit, which exhibited no evidence of structure, and contained no visible particles of lime, although it effervesced when treated with acids, thus showing that it contained particles too small to be visible with a microscope. The gummy film is poured out from the wall of the mantle, and in forty-eight hours it forms a rough, leathery membrane fastening the glass over the inside of the shell. At about this time

*The Oyster, 1905. Brooks, W. K., Johns Hopkins Press.

the invisible particles of lime begin to aggregate and to form little flat crystals, hexagonal in outline and about 1/2500 of an inch long. The crystals grow and unite into little bundles or groups, and new ones appear between the old ones, until at the end of six days the film has completely lost its leathery character and has become stony, from the great amount of lime present in it. In three or four weeks the glass cover is completely built into the shell and can no longer be seen, and its place is only to be traced by its form, which is perfectly preserved upon the inner surface of the shell. When broken out it is found to be coated with a thick plate of white shell, which is beautifully smooth and pearly upon the side nearest the glass. Microscopic examination of this plate shows that it is made up of an immense number of minute crystals, packed and crowded together into a solid mass, without any regular arrangement. These observations show that the new layers are thrown off in the form of a gummy secretion from the mantle, with the lime in solution, and that the particles unite with each other and form crystals while the gum is hardening."

Since lime is deposited in successive films (Figure 16) on the inside of the shells, it would seem that the space occupied by the oyster would eventually be filled to the exclusion of the oyster's body. However, this is not the case, for the mantle, when expanded, overhangs the edges of the concave shells and secretions are deposited thereon. Thus constantly the shells are being opened as their edges grow apace.

The hinge mechanism consists of a ligament (Figure 15h) secreted by the anterior portion of the mantle. As in the case of shell, this is not living tissue in the common sense of the word. Binding the two shells together it, at the same time, acts as a spring to force open the free ends of the shells. Since this ligament is not living substance and acts not only to hinge the shells but to keep their free ends apart as well, it is apparent that the shells of an oyster would remain open indefinitely were not provision made for closing them. By means of the adductor muscle, a prominent and toughened mass of tissue just back of the heart, the shells may be closed tightly and strongly. It is this muscle that must be cut in the operation of oyster shucking. After it is severed, or upon death of the oyster, the shells open forthwith due to the hinge ligament. The adductor muscle is attached to the shells at points where the greatest mechanical advantage is derived and, as the shells are extended in growth, the muscle attachments grow outward to retain the relative mechanical advantage. The outward movement of the muscle is accomplished by an extension of the posterior section followed by absorption of the more anterior part. By breaking either shell lengthwise the progress of the outward migration of the muscle may be noted by the imbedded scar, or pinkish area, caused by the muscle imprint in the earlier stages.

In their native state oysters keep their shells open nearly all the time, though frequently they close them for protection and to wash out foreign matter, excretion, and fecal wastes. It is commonly held by watermen that the oyster opens its shell, feeds, and is active only on flood tide, but observations have established that the shells are opened on both flood and ebb

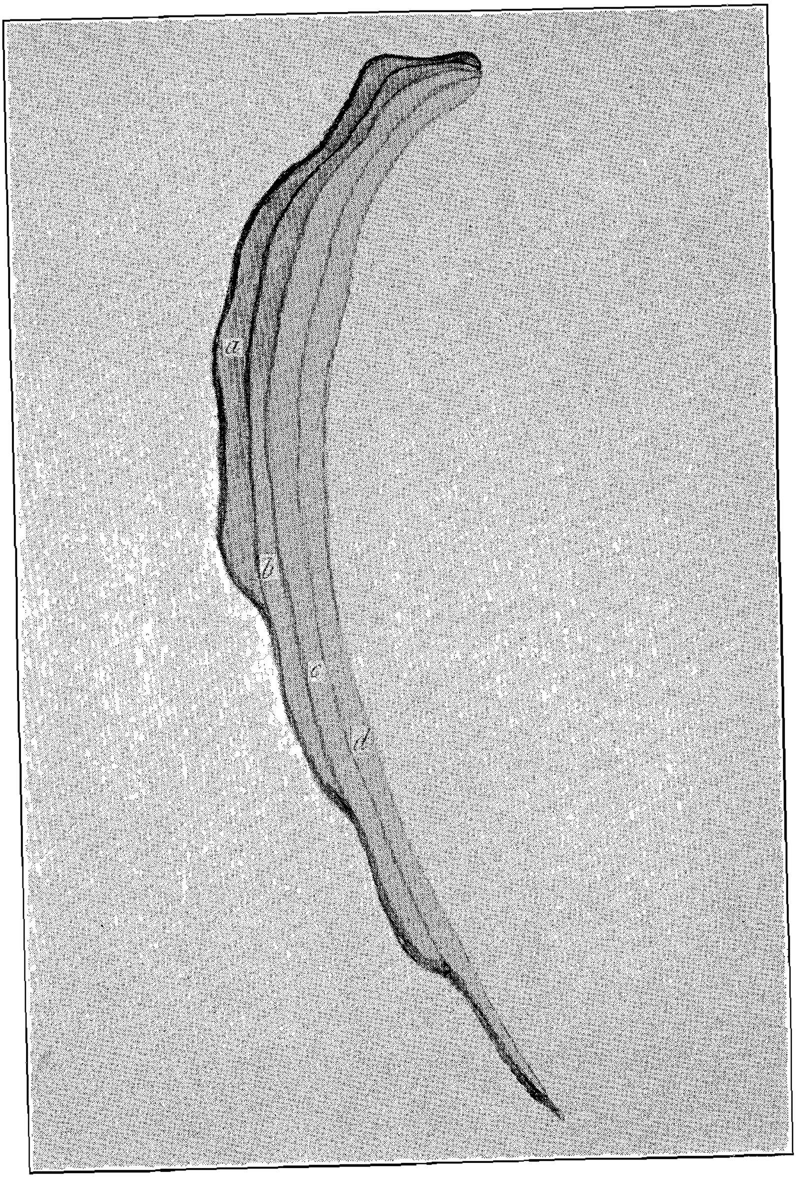


Figure 16. DIAGRAMMATIC SKETCH OF LONGITUDINAL SECTION OF A SHELL FROM A FOUR-YEAR-OLD OYSTER, SHOWING ANNUAL DEPOSITS OF LIME. a. Lime deposit first year; b. Lime deposit second year; c. Lime deposit third year; d. Lime deposit fourth year.

tides, at night as well as during the day, and that they stay open upward of three-fourths of the time. However, the activity of the gills in respiration and feeding varies with the temperature and, as would be expected, lower thermometric readings tend to slow up activity. It has been shown that at a temperature of 5° Centigrade or below oysters cease to feed.*

Out of the water, oysters live for varying periods, depending upon temperature and humidity. They may be kept long periods at very low temperatures, while, conversely, they die within a few hours if the temperatures are extremely high. The animal does not cease its vital activities when removed from the shell, and may remain alive for many hours, the length of time depending upon the physical conditions around it. The clear viscous fluid associated with shucked oysters of commerce is due to congealed blood or to substances secreted and thrown off by the oysters themselves and is not a sign of decay, as many purchasers of the raw commodity believe.

Reproduction: Maryland oysters have their sexes separate, differing thereby from the common European form, *Ostrea edulis*, each of which has two sex systems present in its body. The reproductive system (Figure 15s) whether male or female, is located in the more bulky portion of the animal. Without the aid of the microscope the sex of an oyster can not be told, though, when "ripe", the greater part of a sex system is plainly visible to the unaided eye, due to the distention caused by the vast number of germ cells present or in the course of maturation. In this distended condition the reproductive system has somewhat the appearance of a tree, with the base of its trunk opening to the exterior in the region of the pericardium and its branches anastomosing to the extent of covering nearly the entire lateral surface, there being an organ on each side of the oyster body. Oysters eject their reproductive cells (Figure 17) directly into the open waters where, if the sperms and ova chance to come in contact with each other, fertilization ensues. The ejection of female cells is accompanied, or, possibly, aided by sudden snapping of the valves which forces the water, loaded with cells, from around the body of the oyster and out into the open waters. At short intervals this operation is repeated, each time a small cloud, nearly cream colored, being produced, so abundant are the cells. Male cells are emitted without shell snapping. At the Chesapeake Biological Laboratory it has been estimated that a single female contained 49,000,000 eggs—a very conservative estimate—while, in the male, the germ cells may be present in such prodigious numbers as to baffle ordinary methods of computation, hundreds of millions of them being found. In a five-inch oyster, whose gonads were not extraordinarily distended, some 2,960,000,000 spermatozoa were estimated to be present. Oyster eggs, when taken from the ovary, have somewhat the shape of a kernel of corn, but upon fertilization become round. The male cell is roundish with a tail-like appendage which drives

*Paul S. Galtsoff, 1928. Experimental Study of the Function of the Oyster Gills and Its Bearnig on the Problem of Oyster Culture and Sanitary Control of the Oyster Industry. Document No. 1035, U. S. Bur. Fish.

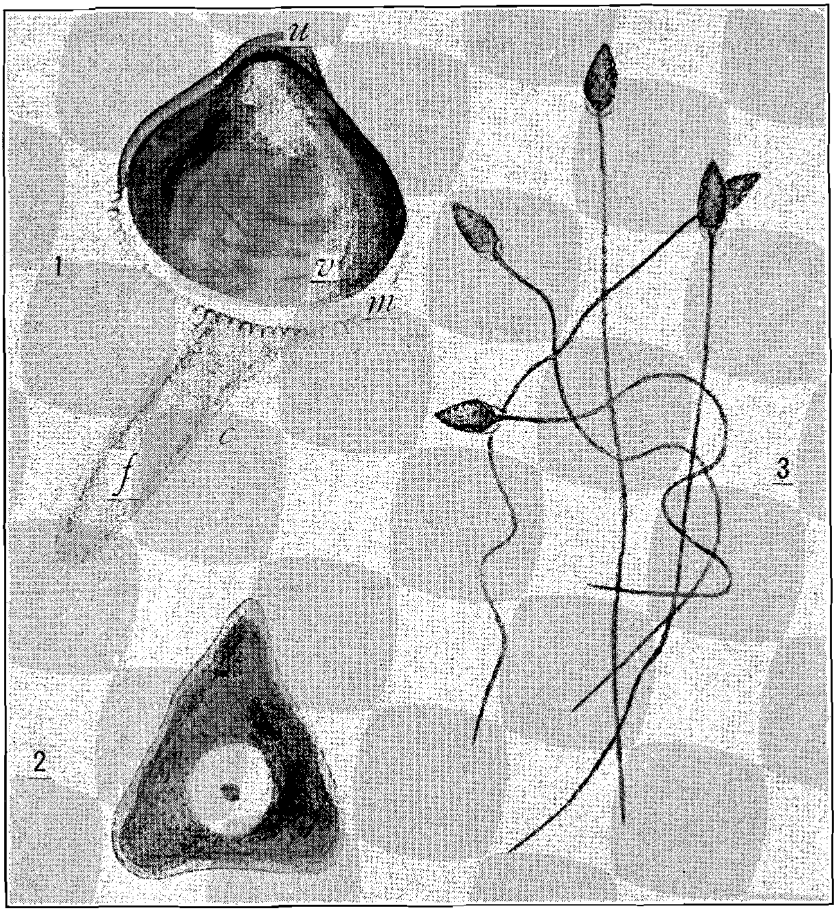


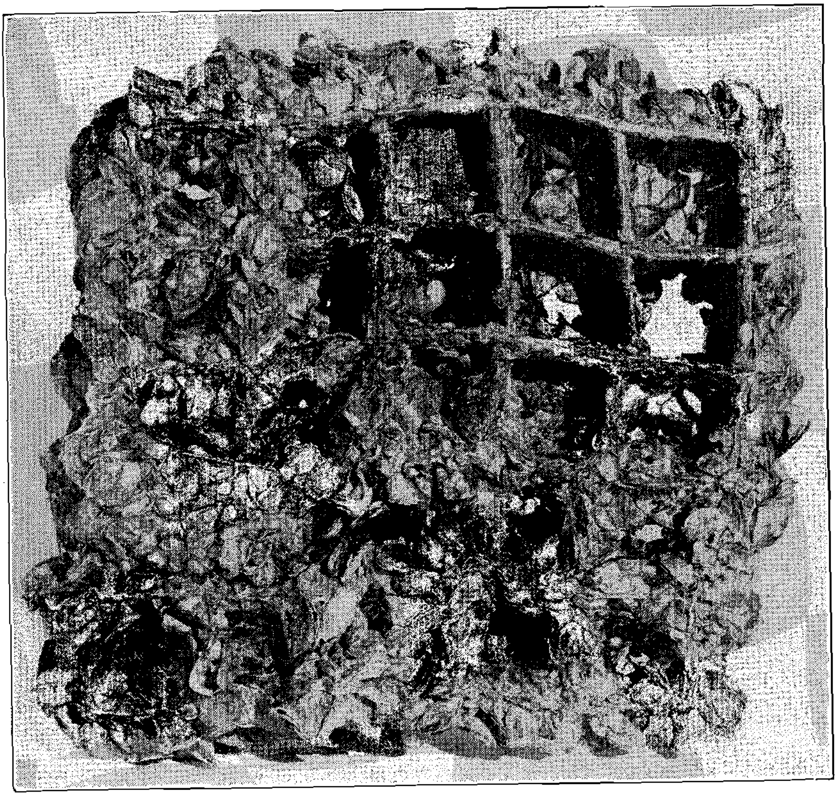
Figure 17. 1. FULLY DEVELOPED OYSTER LARVA, magnified 160x. c. Cilia; f. Foot; m. Mantle; u. Umbo; v. Shell or valve. 2. EGG OF OYSTER, magnified 550x. 3. MALE CELLS OF OYSTER, enlarged 2000x.

it through the water; spermatozoa are mobile, while ova do not have the power of movement. Milt and spawn are interchangeable terms applied to the genital products.

There is a marked correlation between spawning activities of oysters and the temperature of the water. In the Chesapeake region and, for that matter, through the greater part of the habitat of the species, oysters begin to spawn freely when the temperature reaches about 67°-70° F. Optimum spawning takes place at about 76° F., while there is an almost complete cessation of spawning when the temperature of the water reaches 82° F. Oysters with ripe gonads can be excited to spawn if, taken from water ranging from 68° F. to 74° F., the temperature of the water around them is gradually raised to the optimum degree, or slightly above it, and germ cells from the opposite sex are added. Knowledge of facts about spawning contributes to a better understanding of the proper time to plant shells or other cultch in order to secure a maximum catch for seed purposes.

Development: An egg allows but one sperm to penetrate and fuse nuclei with it, though commonly many gather around and try to work their way in, partially gaining entrance in many instances. Rapid changes follow this initiation of development, the egg changing its shape to become almost spherical. Following this by a few minutes, there appears a knob-like protrusion on the surface of the egg, which is followed shortly by the development of another. These protrusions are the pole cells. This early embryo, with its pole cells not far removed from each other, is now rather pear-shaped in outline. Continuing development, the smaller end undergoes rapid cell division with subsequent additions to the number of cells. These small cells eventually nearly cover the larger end of the embryo where the cells, in the meantime, also have divided forming, with the first layer, an embryo of two layers of cells, the inner one of which, some three hours after fertilization, surrounds a cavity with an opening to the exterior. The cavity is known as the coelenteron, while the opening is known as the blastopore. The layers of the gastrula, as the embryo is termed at this stage of development, are known as the ectoderm and endoderm, the former being outside of the latter. At this time a circular tuft of hairs makes its appearance. These hair-like processes beat back and forth producing locomotion in the embryo, which, from this time on, swims freely in the water, though its development is nowise complete.

Following the developmental path of metazoan animals, a third layer of cells appears between the layers of the gastrula, and the embryo then flattens out considerably. On each side of the embryo a small plate appears and, with further secretion by the specialized cells or glands at the bases of the pads, these plates become the valves. While this is taking place the retractive ciliated rim, or velum, becomes more prominent, and a protuberance from the region between the mouth and the anus develops into a foot for locomotor and other purposes. (The presence of the velum gave rise to the term veliger so generally used for molluscs in this state of development.) By rapid development the shells grow to cover the entire embryo. The mouth, lengthening into a digestive tract with its special organs, and the anus have, by this time, made their appearance. From near the base of the velum two ridges have been developed at this time, and from them, through growth, the mantle appears. During mantle formation and the period of shell extension the gill filaments arise as a row of delicate processes which, though simple at first, bend themselves so as to form a V-shape and then a W-shape structure. Spots apparently sensitive to light are present at this stage of development. Some four or five days time is necessary for the embryo to acquire full larval form and development (Figure 17) at which time it appears to be more clam-like than oyster-like in shape and general pro-



Concrete Egg Crate Partition, Side and Bottom Views, Bearing 18,000 Spat Caught Experimentally During 1930 in Tar Bay.

portions. After an additional period of ten to twelve days, the fully developed free swimming larval oyster attaches itself to a clean hard object and thereafter leads a sedentary existence. It is now termed "spat."

During the larval period oysters spend most of their time actively moving about in the water. The chief enemies during this period are the plancton feeding forms, although they are destroyed by marked physical changes in the water. When there is an abundance of oyster brook stock, larvae appear in the water in prodigious numbers. Indeed, not uncommonly upward of twenty thousand of them may be taken in a fifty-gallon sample of water in such a place as Tar Bay. However, during the last few hours of this free swimming period they begin to search for a suitable surface to which they may attach themselves preparatory to settling down for life. This operation is known as spat-fall. When it is realized that the veliger at this time is about one-seventieth of an inch in its greatest dimension, the reason for selecting a smooth and very clean surface is understandable. Debris of any kind readily precludes it or, by rolling under tidal influences, crush the larva easily. Then, too, hard objects available are those above the mud line of the bottom, since such serve the added useful purpose of holding the tiny, now attached creatures up into oxygen and food laden waters.

Setting or Spat-Fall: The activities concerned with attachment of larvae are markedly similar throughout. With the foot protruded a larva scuds across objects, in effect feeling out their surfaces to ascertain their availability for spatting. As previously stated, of necessity the surface must be permanent, clean, hard, and smooth; otherwise so delicate an organism would be subjected to many unconquerable hazards. When a favorable spot is selected the larva forces its adhesive foot out full length, about .22 mm., and temporarily attaches its tip. Around this point as a centre it draws itself toward the attached foot, releases the end of the foot and attaches it elsewhere only to pull the body up to the tip of the foot again. Repeating this performance several times and describing circles of successively smaller radii in the course of the action, it finally comes to rest with the left valve against the object and inclined toward the opening of the valves. From a lobed gland (byssus) at the base of the foot, secretions are produced at this time which, aided by the velum and the foot itself, are distributed in such a way as to cement, upon hardening, the oyster to the surface.* For the whole operation about one quarter of an hour is required. Henceforth, the oyster, in this stage termed spat, remains stationary and depends upon the tides to deliver its food and other necessities of life.

Not all clean hard surfaces attract larval oysters alike. Experimental work with such materials as brick-bats, oyster shells, broken glass, chips of various kinds of wood, coal, slag, pebbles, and other things suspended in wire baskets, side by each, over a bed of oysters at Spencer's Wharf, near

*For further reference in connection with this interesting activity see The Attachment of Oyster Larvae, Biological Bulletin, Vol. XLVI, No. 3, March 1924, New Jersey, Thurlow C. Nelson.

Solomons Island, produced varying results. Using all the materials in a clean state and at a time when fully grown oyster larvae were known to be abundant in the water, shells proved to be more preferable than glass, slag, pebbles, brick-bat, or chips. Slag was second in importance. Glass, brick-bats, pebbles and chips followed in order of efficiency.

Growth and Age: Growth, after the spat-fall, is very rapid, though varying according to environmental conditions such as rate of tide flow, food abundance, the physical and chemical nature of water, abundance of set or extent of crowding, and the like. If isolated and suspended where full tide-play on the spat is possible, growth is phenomenally rapid, as much as one-half to three-quarters of an inch per month. Spat that attached themselves to a boat's bottom in late June were found, in the Choptank River region, to be two and one-quarter inches in length on October fifth. However, under normal conditions at the bottom in that section, spat grow in the same period of time, barely an inch in length. Oysters ranging from spat sizes up to dimensions of an inch and a half, or even to three inches, are known as seed. Such oysters are used for planting purposes, especially on private grounds. Except for certain very limited beds in Maryland, known as seed areas, oysters may not be captured, legally, under three inches in length. The seed areas are open and available to fishermen only during short periods in early spring.

Oysters in Maryland may spawn at one year of age, though at this early period they produce comparatively small numbers of germ cells. In the case of the oyster whose numbers of eggs were estimated, heretofore referred to, the age was five years. Others have been known to spawn at nine years of age though, it is believed, these very old ones spawn less prolifically as time goes on. The length of time an oyster will grow has not been determined, but there is evidence to the effect that growth may continue for ten or eleven years. During the second winter, under normal conditions, most of the juvenile oysters reach legal size for capture, or become of merchantable size, three inches in length. At two years of age Chesapeake oysters are three and a half to four inches in length, while the greatest length recorded by us, for Maryland oysters, is nine and five-eighths inches.

Enemies: In Maryland waters, oysters, once they have attached themselves and started their sedentary existence, have few enemies. In the lower bay—rarely above Hoopers Straits and St. Jerome's Creek—and on the beds of the coastal waters in Worcester county, a species of snails, *Urosalpinx cinereus,* bores in a peculiar rasping fashion through the shells of oysters, paralyzes the adductor muscle, and, feeding on the prey, destroys it. As many as thirty-five thousand bushels of oysters have been destroyed in the State by this pest in one year. However, comparing that loss, which is much more severe in seed stock than in adults, with the output of the Commonwealth, the "screwborer" is a pest of little importance. Its greatest destruction is done in waters of higher salinity; thus in our neighboring states its presence may be felt acutely, especially on beds constantly used in oyster planting and on natural bars.

Star-fishes, *Asterias forbesi,* the bane of the more northerly oyster farmers' existence, do not thrive in Maryland waters. How fortunate local oystermen are because of the distribution of this animal may be realized from the fact that a single oyster producing corporation in Rhode Island, the Narragansett Oyster Company, mopped up and destroyed, at great expense, 1,259,955 pounds* of this pest in a single year, and even then reported considerable damage to its crop. The pest, by exerting a steady, even, though not powerful stress on the shells, at length overcomes the muscle holding the valves of the oyster together and, everting its stomach, surrounds the body and digests it.

A few fin fishes destroy oysters, the black-drum, *Pogonias cromis,* being an outstanding offender. From the stomach of one such Chesapeake fish as many as thirty-one oysters have been taken. However, there are few of these fishes, so that, though schooling drum occasionally are reported as having made marked inroads on small areas, little injury comes in general from that source. Hardheads, toads, burr fish and others are frequently charged with oyster destruction, but investigations of their digestive tract fail to incriminate them. It seems true that fewer natural enemies of the oyster exist in the water of the State than elsewhere in the habitat of the species, thus affording another explanation of the exceeding potentialities of the Chesapeake.

Oyster Production

Oysters, as indicated previously, are marine creatures. They are not uncommonly found in waters where salinity ranges from 1.005 to 1.032 or, in other words, in such waters as those at the head of the Chesapeake, in the Man O' War Shoals and Tolchester Beach Regions, as well as in sea water proper. Some would claim that oysters will not grow in the sea. It is a common experience at Ocean City, Maryland, to find oysters attached to fishing gear placed in the ocean, while investigations made by ourselves have disclosed recent spat, as well as older oysters, in several places along the coast. However, the most heavily producing natural beds in Maryland have been in the Chesapeake proper, though quantitative production cannot be correlated with the salt content of the water, since highly productive beds are found both in the upper and lower extremes of the Bay. Oyster farming is the exclusive practice in the Sinepuxent Bay, along the Maryland coast, and this in spite of the fact that bottoms are less well adapted and physical conditions are poorer than in many big barren areas of the Chesapeake.

Natural Beds or Rocks: "Natural rocks", "natural beds", and "natural bars" are terms applied interchangeably to certain bottom areas—some 215,000 acres in Maryland according to the survey of 1906-12 (Maryland

*From a personal report by the manager of the Narragansett Oyster Company, dated July, 1930.

Shell Fish Commission, 1912)—of varying sizes, upon which oysters utilize currents, solid foundations for attachment, and food-laden waters for purposes of security and rapid growth. Through long periods of time oysters became dispersed from one point to another by currents and tides; and where favorable conditions such as those enumerated above existed this dispersal continued until about all of the areas available were seeded. Once the spat had gained foot-hold they throve, reproduced, and extended their group upward and outward. When the original spat chanced to fall upon areas of projecting rocks, stones, or other hard objects cropping out from the bottom, an oyster colony, termed "reef", "bed", "rock", or "bar", was developed. In the legal sense, natural bars are held to be such areas as were developed under natural conditions only, and which now produce oysters.

A Natural Oyster Bed in the Chesapeake Showing Cultch, Spat and Mature Oysters.

When man first started to tap the oyster resources in the Chesapeake, he found that many of the natural beds had sub-strata of shells several feet thick and one, the Tea Table, near the head of the Bay, where salinity fluctuations are devastating, extended from the bottom up to the level of mean low tide. As indicated, this bed, in common with many others, was built by virtue of the fact that young forms freely attached themselves to adult oysters, and because of their numbers and the fact that they projected still further out into the food and oxygen supplied water, competed with the old ones for the essentials of life and, finally, smothered and starved the old ones to death. In turn, the younger ones were destroyed by such a process, the shells always being left to build substantial strata and to extend the bed laterally, making available cultch for generations to come. It is obvious, then, that rock ledges and bars, in the nautical sense, were not essential to the building of great natural oyster beds. Indeed, the beds developed upon rocks and stones, of which there are few in the Chesapeake, have not been the greatest producers, for the oysterman works upon them as a last resort, since taking oysters from them is difficult and expensive. This is because dredges and tongs do not function well upon them, and there are hazards, because of "hangs" and jams on the bottom, to craft, apparatus, and man.

Abundance of food for oysters, as well as other favorable factors, exists in many places where oysters did not become established and develop natural beds. In fact, food is abundant on many tide swept, muddy bottoms, which, in the main, could not, and cannot now, support young oysters because of smothering ooze, shifting debris, or silt. Where this type of bottom naturally has clay mixed with it to a somewhat thick consistency, beds may be developed by shell planting. On bottoms with a consistency in between these extremes, larger seed oysters may be transplanted and cultured with success. The Sinepuxent, Chincoteague and Isle of Wight bays, comparatively small bodies along the Coast, are successfully oyster farmed on this last named type of bottom. In the Chesapeake, the outstanding beds are found on bottom areas located between the channel proper, with its soft bottom and the sandy sloping shore areas. These beds vary from a few hundred feet to as much as a mile-and-a-quarter in width, and their depth under water ranges from inter-tidal exposure to eighty feet. In the tributaries and in the coastal waters they range up as far as the mean high tide and may be exposed to the air for long periods because of tidal fluctuations.

Depleted and Barren Bottoms: Under natural conditions oysters established bars, extended the bar boundaries according to the environmental fitness, and maintained the bars by virtue of the fact that upon the death of the older oysters their shells became fine bar-building or cultch materials. However, with the development of the oyster industry and the removal of adult oysters in greater and still greater quantities, the brood stock constantly was diminished. While this was taking place, and fewer oysters were left to die of senility and other causes, no longer were shells being added to maintain the cultch supply. More than this! Since young oysters attach themselves so tightly to old shells, it is impossible in many cases to remove all the shell from the oyster before it is marketed. In the early days of the industry there was little desire to remove these shells at all for they helped to fill the measure, or "tub", so commonly used in buying stock. Not only were the oysters being taken, then, in progressively greater numbers, alone a depleting activity, but the natural bars were being destroyed through the removal of shells. After the decade 1875-1885, when the peak of intensified fishing was reached, the effect of diminished brood stock and reduced cultch material began to show up. From that time, discounting exceptional years, until very recently, there has been a constant diminution in the volume of the oyster business, and bed after bed of natural oyster producing bottom has been reduced to a point where either it does not produce at all or, if still producing, its output is but a semblance of the one time high productivity. An illustration of this is found in the formerly highly productive Tangier Sound with its annual output of some 4,000,000 bushels and its present yearly production of less than 100,000 bushels of oysters. In these waters, the vast "Great Rock", once productive of oysters celebrated for their abundance, size, and flavor, now produces only a few hundred bushels of oysters yearly, and hardly justifies the effort required to capture them. The oyster trade name, "Tangier", has been lost to the industry. Such a bar is said to be depleted. Harris' Rock, in the same body of water, once highly productive, has not produced in the past decade enough oysters even to invite inspection by the dredgers who sail by it weekly. The bed was resorted to persistently and worked so intensively that it became entirely unproductive or barren.

A few of the natural bars of the Bay, mostly seed areas, are producing heavily at this time in spite of the great inroads that have been made on them—a testimony to the richness of the waters over them and to their favorable location. However, the products of these beds were not so highly desired as were those from beds made barren elsewhere. That is to say, the better the quality of oysters the more intensively their beds were fished and the sooner they became exhausted.

Oyster Farming: Oyster farming in many ways is similar to agricultural pursuits. It involves, firstly, property rights, leases, in the underwater lands. Secondly, it involves investments in seed and efforts at culture. Thirdly, it requires planning and study, giving opportunity to match wits with the elements and a chance for the individual to reap from his own sowing.

Much of the bottom held under lease in Maryland is used for the purpose of holding oysters for short periods from early season, when oysters are abundant and cheap, until the rigors of winter slow up oystering on the natural bars and the prices increase. This is not farming. Because of the fact that bottoms permitted by law to be leased are, for the most part, not well suited to that purpose, comparatively little farming is done in Maryland. Thousands of acres of potentially productive bottoms are lying fallow, and, because of the fixed policy of management which now rests in the hands of legislative bodies, there is no immediate hope for their development. Good farming practice requires that seed oysters be planted on suitable bottoms at a given quantity per acre, depending upon the size of the seed and the nature of the bottom. Seed running seven or eight hundred to the bushel should require from 500 to 800 bushels to the acre planting, depending upon the time the oysters are to be allowed to remain on the bottom and the size it is desired to produce. Oyster seed may run as high per bushel as 2000 or more. However, larger sizes are preferable for Maryland plantings.

In planting oysters, it is not conducive to growth to use over and over again the same ground, for enemies thrive under such conditions and a general unwholesome condition may arise as a result of the practice. If the bottoms used tend toward softness, often before maturity is reached it is essential that the crop be transplanted to avoid having it destroyed by sinking below the food and oxygen level. From two to three years are required to produce a crop. Seed running 800 to the bushel will, under favorable conditions, yield two bushels for the one planted. Seed stock sells from 15 to 40 cents per bushel, and the bulk of the supply used in private planting at this time comes from other states, this being especially true of the coastal beds. However, efforts are being made to restore the great seed areas once so productive in Maryland. There is sufficient seed producing ground in Maryland to meet all public and private demands for young oysters, if such grounds were only developed. On particularly favorable bottoms, shells may be planted for seed production purposes. Before shell planting is done it is essential to know that sufficient brood stock exists in the general section so that free swimming oysters will be available to assure a catch. Very little shell planting is done on private grounds in Maryland, since such holdings, for reasons set forth, are not well suited for development. If the bottom is soft, shells will sink into it, while, if sandy, small oysters are precluded from the shells because of the shifting grains.

THE OYSTER FISHERY OF MARYLAND

Since oysters are produced on beds over which the depth of water ranges from a few inches down to 80 feet, quite diversified apparatus and methods of capture have been evolved. Among the Indians and the early settlers wooden forks were used, and oysters were gathered from shallower beds only. However, with the coming of depletion along the shore line, it became more and more difficult to obtain a catch; thus apparatus to reach the supply known to be in deeper waters was essential. First there came simple hand rakes, made of wood and afterwards of iron, very similar to the common garden rake, but wider and with longer teeth and a pole for a handle. Following this, there were developed crude tongs, which lead to the modern "oyster tongs" and the dredge.

In water not more than 18 feet deep hand tongs render good service. Beyond that depth dredges are more efficient, although an effective gear known as "patent tongs" is used in several sections in water of intermediate depths. Sharp lines of demarcation are placed around the dredging grounds, and only by use of tongs may oysters be taken elsewhere. Generally speaking, shallower tributaries are set aside for tongs, and the Bay, with the deeper tributaries, is resorted to by dredgers, all boundaries being fixed by law.

Tongs are operated from boats, usually small ones of 30 foot length or less, which are anchored while the oysters are being removed from the bottom. When the anchor is thrown overboard a short length of cable is payed out, and, after the tonger has worked all the way around his craft raking the bottom thoroughly, more cable is released and the boat drifts over a new area, thus avoiding frequent anchor heaving. In dredging, sail boats only are allowed to operate. The craft tack back and forth over the beds dragging the dredges on the bottom. A dredge ordinarily is drawn from the bottom by power, a special deck motor being used. Tonging has the advantage of inexpensive equipment, though it is greatly restricted and is extremely hard work.

Tongs and Tonging: A pair of tongs consists of metal framework and handles. The framework is made of iron, the lower member of which is a bar of some 40 inches in length, bearing teeth on its lower face. Along this bar, and paralleling it, there are five iron rods, forming the head, whose ends terminate in a slightly curved upright from the end of the main or toothed bar, forming with it a concavity. The width of the metal framework is from five to ten inches, as desired. By placing a wooden handle, or stale, at right angles in each of two such metal pieces and riveting or pinning these handles together at the point of maximum efficiency, usually less than one-third the distance from the toothed bar to the end of the stales, scissors-like oyster tongs are produced. The teeth on each bar are set inward. When the stales are closed the metal-work forms a basket-like affair with the teeth crossed below it. As indicated, tongs work scissors-fashion. By alternately drawing them open and closing them, the teeth gathering the hard objects, it requires only four or five "licks" to fill a bushel measure if oysters are abundant. Such abundance on natural bars, however, rarely exists at present. On private beds an expert workman may handily tong from eight to twelve bushels of oysters an hour. A tonger rarely engages himself in such operations for more than five hours, the remainder of the day being spent in "culling off" his load.

Certain localities in Maryland permit the use of patent tongs on natural bars. Except that their stales are sturdier, shorter, and of iron instead of wood, and that the basket feature of the tongs is much larger, patent tongs are made along the same lines as ordinary hand tongs. They are used in waters of depths which commonly employ dredges but in which dredge boats are not allowed to operate. Patent tongs are lowered and raised by windlasses either by hand or by the power of a deck engine, and they cannot be used from a moving craft. In the upper ends of the iron handles there are holes for the ropes, one each, by which the tongs are operated. A chain link on one handle engages the head of its mate while being lowered, and releases it when the tongs come to rest upon the bottom. By pulling up and down on a line connected to the two lines from the ends of the handles, the teeth of the tongs are worked toward each other and finally closed with the oysters raked into the tongs' head. As many as a bushel of oysters may be brought up from the bottom at a time with this type of gear.

Dredges and Dredging: Dredging is the common, general, and most practical method of harvesting oysters wherever the water is deep enough to

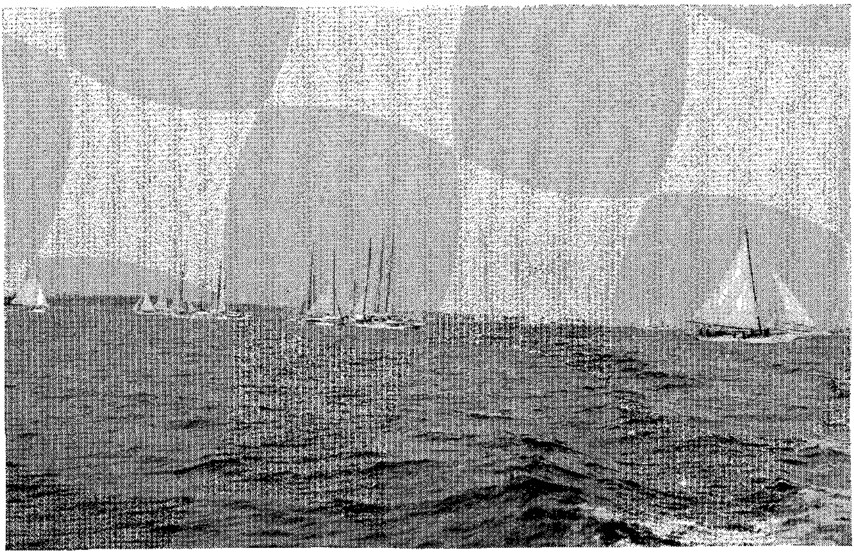
Dredge Containing About Five Bushels of Oysters Being Hauled Aboard.

operate. Since this is the most efficient method of taking oysters from the bottoms, dredging areas in the Chesapeake were the first to become depleted and barren. Very little tonging ground has been made completely barren, though much of it has been resorted to by oystermen since the earliest days of the industry.

A dredge consists of two iron triangular structures, stoutly made and united at their apexes, the lower one of which has an iron blade-like base of heavy construction which carries stubbed teeth. These triangular structures are held apart securely by two curved bars, one on each side of the dredge, running from the apexes of the base angles of the triangles. From the two bases, or cross bars, and the curved part of the dredge the bag is suspended, the bag being one-half of cotton rope and the other half of iron rings and chain points. Meshed rope is used to make the bag more flexible. The triangle bearing the teeth, usually wider and longer than the other one, is the lower part of the dredge. Its cross bar is set at an angle that assures maximum attack for the teeth which it bears. The chain part of the bag is attached to this bar so that metal rather than cotton rope is exposed to the rugged conditions of the bottom. Dredges run in size from so called "hand scrapes" with a capacity of one bushel, to immense sizes with a sixty-inch tooth bar, and in which ten or more bushels of oysters may be taken at one haul. Usually the larger dredges are braced with metal bars and rods in several places so that they will withstand "hangs" and other violent strains while being dragged on the bottom. Often times, and especially with lighter dredges, a "wing" is used to hold the dredge on the bottom. This consists simply of a thin sheet of metal tied in the upper triangle of the framework in such fashion as to cut downward in the water as the dredge moves forward. The "wing" or "devil dive" has been outlawed in Maryland.

Only sail boats are permitted by law to operate dredges on the public beds of Maryland. While power boats are far more effective as dredge boats, they are not permitted since it is recognized that in a period of a few years the remaining productive beds would be stripped bare of oysters and the industry brought to ruin, should the season not be shortened and other limitations effected. Sail craft, depending upon winds, cannot be systematic and exact, and because of their use oysters for breeding purposes are left on the bottoms to some extent. The heavy dredges are operated by windlasses driven by donkey engines on the decks of boats. The type of boat used in dredging varies from the small skip-jack to the coastal trading schooner, though the favorite Chesapeake type has been the bugeye.

In operating a dredge something must be known of the type of bottom (whether hard, soft, rocky, and the like), the depth of the water, and the speed of the boat. Even when these factors are established, experience in company with a veteran dredger helps greatly. Not all expert watermen are good dredgers. Generally speaking, it requires for dredging purposes a line some five or six times as long as the depth of the water on the bed. If too much line is payed out the teeth dig deeply into the bottom and the bag becomes filled with matter other than oysters, and, when hauled aboard, makes far more difficult washing and culling. Conversely, with too little



Skipjacks and Bugeyes Sail Back and Forth Dredging Oysters from the Bottom.

rope payed out the angle of attack for the teeth is such as to cause the dredge to skip from place to place and make only an occasional dig in the bottom. However, by increasing the speed of the boat in the first case and retarding it in the second the efficiency of the dredge may be increased.*

Marketing Oysters

After oysters are taken from public beds they are usually sold to buyers, who transport them to the shucking houses in so-called "buy-boats". Most commonly these boats, now largely driven by motor, are either owned or chartered by dealers or managers of houses where oysters are prepared for the market. Some buyers, however, purchase oysters outright and freight their cargoes to oyster centers such as Baltimore, Cambridge, and Crisfield, where they visit the dealers and attempt to sell at an advantage. Where boats are chartered to buy and run oysters, their masters are paid according to agreement, either by the load or so much per bushel, the distance freighted being a factor. Many oystermen, especially tongers, sell their daily catches directly to seafood dealers when location permits of easy delivery and favorable competition.

Oyster cargoes are unloaded by means of a hoist operating a metallic measure, hand, horse, or engine powered, according to the volume of business. By wheelbarrows, and in some cases by machine driven cars or endless chains, they are transported to spacious bins. From the bins they are delivered in turn to the shucker or, in the case of canning, to the steam oven.

Canned Oysters: Baltimore gave to the world its entire supply of canned oysters for a long period of time after "Cove Oysters", as they were known, were introduced in 1820. Until quite recently the United States continued to supply nearly all of the world output of canned oysters. Since the World War, Japan has made big inroads on this truly American industry, that nation, using more scientific methods of culture, not having experienced such diminution in harvest as have Americans. Canning extended from Baltimore to several Eastern Shore points but, with the decline of the natural supply the business diminished until, at the present time, Maryland does not have a single oyster canning house.† The quality of the Chesapeake oyster and its scarcity made it difficult for the local canneries to compete with similar organizations located in other states where oysters are abundant and are sold at considerably lower prices. More than 7000 workers have lost employment with the failure of this branch of Maryland's oyster industry.

Raw Oysters: The bulk of Maryland's oyster supply finds its way to the market in a shucked or raw state. To remove oysters from their shells

*For further information on dredging see "Some Principles of Oyster Dredging", Agricultural Experiment Station, New Brunswick, N. J., 1929, by J. Richard Nelson.

†See "Baltimore and the Oyster Industry", 1937. Chesapeake Biological Laboratory, Solomons Island, Maryyland. Truitt, R. V., Watkins Press, Baltimore. Also, "The Oyster Packing Industry of Baltimore", 1937. University of Maryland, Nichol, A. N., Weant Press.

there is required considerable skill, whatever the method. From the bin, oysters are placed in stalls assigned to individual shuckers, who proceed to open them. Two methods of shucking are employed. In one method "stabbing", a knife with a thin double edged blade set in an egg-shaped wooden handle is used. By exerting steady pressure along the outer border with short turns of the handle back and forth, the blade enters the oyster and, after cutting the adductor muscle near one shell, forces the shells open to a point where the hinge ligament is broken and the two valves are separated, one bearing the oyster meat. Cutting the muscle near the other shell the meat is freed to be thrown into a measuring cup. The motions of dexterous hands in stabbing oysters are very rapid. Highly expert shuckers employ only five motions to the oyster, and may open upward of twenty gallons per day if big and fat stock is used and strenuous effort is made. Average workers, men and women, shuck about ten or eleven gallons of meat, dry measure being demanded, per day when fair sized oysters are available. The pay usually is thirty cents per gallon.

In the second method of opening raw oysters, the thin outer edges, "bills", of the oysters are knocked off by means of a hammer and block, and the knife is inserted into the opening to cut the muscle. Stabbing is the more general, cleaner and faster method of shucking oysters. When oysters are in a fat condition they yield one gallon of solid meats to the bushel.

Shells accumulate around the shuckers and are conveyed to the shell piles outside of the house by means of wheelbarrows. In the larger houses provision is made by which the shells drop into troughs and are carried to the piles automatically. The shells formerly were a by-product, but today they are a vital part of the industry itself.

The shucked oysters are, in most cases, washed by means of improved machinery and fresh water of known purity. After this, air under pressure is passed through the water in which the oysters are placed to further clean and remove foreign matter, a process that destroys all too much of the flavor and nutritional values. At this point the product is ready to be placed in tin cans. Shuckers grade the oysters as they open them, placing the largest ones, Counts, in one container, the middle sized ones, Selects, in another, and the smallest oysters, Standards, in still another container. The cans used vary in size, the one most commonly used being of one gallon capacity, although more recently the trend has been toward packaging in smaller containers, pints and quarts. No liquor is placed in the cans which, when filled, are securely covered and packed in crushed ice in such a position that all of their surfaces are in contact with it. Usually the smaller cans are iced in barrels for shipment while five gallon cans are placed in separate boxes built for the purpose, though this is a matter of preference on the part of the individual oyster dealer.

Raw oysters are shipped from Maryland to every region of North America, and a few packers of Chesapeake oysters fill orders from Europe. In the long hauls it is necessary to re-ice once or twice while the oysters are in transit. While the flavor of the commodity may not be fully as good upon arrival at far distant points, oysters are delivered in a sanitary and wholesome condition. Properly iced and temperature controlled, this sea-food may be kept for weeks. In a frozen condition preservation for months is possible without deterioration.

Shell Stock: Oysters in the shell are not shipped to a very great extent from the Chesapeake, though the entire supply from the smaller coastal bodies such as the Sinepuxent, Chincoteague, and Isle of Wight bays, until recently, was marketed in the shell. Such stock is used largely for raw bar trade in restaurants and on the half shell in hotels and cafes. Sinepuxent shell stock is marketed as "Chincoteagues", from the name of the near-by island in Virginia. The most celebrated raw-bar oysters of the Chesapeake in Maryland are the "Tangiers", produced in Somerset county. Like the "Chincoteagues", these oysters have a decided tang of the sea and are particularly well-flavored and succulent, comparing favorably with the Lynnhaven oysters of Virginia and the "Bluepoints" of Long Island. Less than 5% of Maryland's oysters are now shipped in the shell, while "Tangiers" have totally disappeared from the menu card.

Oysters to be shipped in the shell are graded into two classes, primes and culls, running to large or small sizes as the market demands. They are packed in barrels made for this purpose which, typically, hold three bushels, though barrels of ten pecks capacity are used in some places. Burlap bags are used in shipping to a limited extent. Oyster barrels are made in the usual way except that they are strongly reinforced. In shipping, the barrel is not headed, but, instead, a cover of burlap is used. No ice is used in the barrel during transportation, though in very long hauls refrigerated cars are employed.

Shells: As previously set forth, shells are transported from the shucker either by wheelbarrow or by endless belts, to the shell pile. This pile or mound may be of immense proportions, having several hundred thousand bushels at the end of the season in big shucking houses. In the early days of the industry the accumulated shells were a problem to the management of the houses since they were of little use except to fill up holes in roads and, to a limited extent, to be burned for lime. However, with the good roads impetus of 1890-1900 period, and the building up of a chick grit demand at the close of that decade, shells began to take on greater value and have risen in price until they are now worth from two to four cents a bushel. Thus the shell pile today is guarded, since in many cases it represents the greater part of the profits from the business. Not infrequently dealers say, "If I can clear my shell pile I will be pleased."

The owners of shell piles in Maryland have two possibilities of sales, to wit: to manufacturers of chick grit or of shell lime, and to the State or private individuals desiring to plant them for oyster purposes. Shells are rarely used now for road building. Details about the use of shells are interesting, but they cannot be given here. Suffice it to say that shell lime for agricultural purposes brings prices ranging from $6 to $8 per ton, and that normally acid soil requires approximately 1200 lbs. to the acre. Chick grit, for the manufacturing of which elaborate machinery and expert supervision are necessary, sells from $12 to $20 per ton. The use of shells in developing oyster beds has been discussed elsewhere. In this connection it should be repeated that shells are the most efficient materials known for the restoration of the natural oyster bars. The Maryland Conservation Department is empowered by law to take, without cost, 10% of the shells produced by the oyster dealers of Maryland. Such shells are used as cultch for oyster bed restoration work.

Rehabilitation of Maryland's Oyster Industry

That the Chesapeake Bay has suffered a great decline in its oyster production is generally conceded by the oystermen and by the public. Equally true is the fact that consumers, as well as the fishermen, are anxious to have the waters produce as heavily and with the quality they did years ago. Scientists have made studies of the physical and biological conditions of the waters and have collected evidence of the fact that this vast body of water is essentially the same today as it was back in the "eighties." Then, Maryland, in its heyday of oyster production, dominated the oyster market by producing more of these bivalves than did all the rest of the world. Why, it is natural to ask, is not the great volume of oyster food available in the Bay converted into oyster meat to feed a growing population in need of, in addition to the rich food matter contained in oysters, the invaluable disease preventing salts carried therewith? When it is realized that four acres of ordinary oyster ground can be made to produce upward of 4000 bushels of oysters in three years (32,000 pounds of fine food) and that a like acreage of first rate farm land sowed to forage crops will, on an average, produce only one steer in the same period of time which will barely dress, bone and rough parts included, 600 pounds, is there not more than a challenge to effect restoration? Unquestionably there is an obligation on the part of the citizenry to restore natural production on the thousands of acres of depleted and barren bottoms. Undoubtedly the obligation goes further than this and directs that naural methods should be assisted and improved upon until unprecedented yields are realized.

Concerning Leasing: The problem of restoration of oyster bars and the rehabilitation of Maryland's industry, now fourth in rank among the states of the Union which it once easily lead, would seem simple since all concerned want restoration effected. However, the problem is not a simple one at all. To the contrary, little progress has been made, primarily, because of the fact that no policy has been evolved upon which those most concerned will agree. Leasing has been and still is the most promising method for the rehabilitation of our oyster industry. Scientifically, it has been shown that oysters can be grown on our barren beds. In our neighboring states, Virginia and New Jersey, especially the latter, leasing has not only maintained oyster production on as high a level as was experienced under natural conditions, but it has effected even greater production. Each of these states, under a leasing system, is now producing oysters in vaster quantities than is Maryland, and this in the face of the fact that fifty odd years ago by far more oysters were produced in Maryland than in both of the states named. Should Maryland have adopted a progressive leasing policy four decades ago, it is felt by those who have made a special study of the problem that, rather than an annual yield of 2,500,000 bushels or even the one time production of 15,000,000 bushels a year, the present yield in millions of bushels would have been in the twenties. Considering the great demands that unceasingly have been made upon the beds, it is remarkable that Maryland's oyster industry has survived at all. The fact that bars are still producing in spite of drains upon them and without man's aid is responsible for the opinion so generally held among oystermen: "Leave the beds alone and they will come back; only God knows about an oyster and can help with production." The thousands of people who have been forced to leave the industry (Table 2) because of depletion have a right to expect the best of leadership in effecting restoration.

TABLE No. II

TONGER, SCRAPER, DREDGER AND OYSTER-PACKER LICENSES ISSUED IN MARYLAND FOR TYPICAL YEARS FROM 1916 TO 1938.*

Year	*Tonger*	*Scraper*	*Dredger*	*Packer*
1916	7,299	730	446	269
1918	3,688	402	222	142
1920	5,439	455	324	271
1922	5,543	460	295	283
1924	5,776	389	299	251
1926	4,808	291	343	219
1928	4,741	270	259	201
1930	4,901	215	204	182
1932	4,777	121	87	167
1933	4,163	113	62	165
1934	4,095	27	166	159
1935	3,132	142	114	165
1936	3,755	80	125	159
1937	4,260	96	104	167

*Data from official reports of Maryland Conservation Department.

An occasional favorable year in which production increases to a point above that of the years immediately preceding, and there have been but few during the past forty-five years, further convinces the oystermen that their attitude toward conservation is sound. However, statistics show that in that same period of time there has been a decline in production of about 12,000,000 bushels, or an average of approximately 250,000 bushels yearly.

Maryland has leasing laws, but their framers so limited the would-be lessees in their choice that they only rarely can acquire grounds well suited to oyster culture, beds like the vast areas once productive but now barren. Consequently, attempts at oyster planting in the main have not been a success, and for the reasons previously mentioned, to wit: bottom textures, currents, and biological conditions present, one or all, are not satisfactory for oyster life. Those who have sponsored the legislative measures which so greatly limit leasing are fearful that someone, possibly by unfair means, will lease grounds which at the time are productive natural bars. This has been attempted on a number of occasions, thus further agitating and antagonizing the oystermen, and setting them more firmly against any form of private development of barren bottoms. At present much of the ground held by the nine hundred lessees, about ten thousand acres in all, is used for "laying down" purposes, that is, to hold oysters until a more favorable market develops. In most cases oysters could not live on these grounds, so unsatisfactory are they, throughout the year. This is not oyster farming. By oyster culture is meant rendering such assistance as to make many oysters grow where one now grows, or at least, to make potentially productive grounds actually produce. The outlook for an immediate, more comprehensive, and effective leasing system and private development of the oyster resources of the State is not encouraging at this time, though the challenge for wholesome thought and constructive action stands before a rising generation who, it is hoped, will not hide from themselves the facts underlying the loss of this rich heritage, but will, on the other hand, study them and find a solution for the vexing problems involved.

Conservation: Conservation means more than preserving or maintaining the *status quo* of the industry founded upon a renewable resource; it means restoration as well. It is estimated at the Chesapeake Biological Laboratory that 25,000,000 bushels of shells, a quantity not available, are needed next year and that yearly thereafter, as repopulation of new bars is effected and new seed areas are established, increasingly heavy shell plantings should be made. Every shell that is taken from the waters of the State is urgently needed right back on the bottoms to check depletion and maintain production. It should be kept in mind that oyster depletion is directly traceable to shell removal and over-fishing.

To restore the oyster industry a stupendous outlay in effort and money is essential. Whether or not this can be done as well by public agencies as by private initiative and investment is a question now being debated. While public sentiment has not developed to a point where the State is empowered to do the whole job of restoration, private capital and business management do await an opportunity to develop this resource to the fullest, needing only legal sanction for the leasing of barren but potentially productive bottoms upon which to plant seed stock and shells to establish profitable beds. Such management would not look with favor upon the use of shells for purposes other than planting, whereas under public control, the shells, because of lack of State funds to purchase them to return to the bars where they inherently belong, or the fact that their return is not made obligatory by law as a conservation measure, are diverted to grit and lime industries.

Encouragement is found today in the fact that the conservation forces of Maryland are giving more and more thought to this vast undeveloped seafood resource, and all indications point to the fact that depletion is, in a measure, being checked by a handicapped Conservation Department, through rendering assistance to the natural factors involved in oyster production. It is to be expected that this accomplishment will lead to the still bigger problems of rehabilitation and that ultimately millions of dollars, derived from either or from both private and public sources, will be added annually to the wealth of the oystering communities, and that decaying villages will recover their one-time prosperity and have the support of the fifteen or twenty thousand added proprietors and workmen needed to handle the extra volume of business. The fear that under such circumstances there would be over-production need be given little thought since today oysters are eaten more as a gastonomic treat than as substantial food.

The American people have not been taught to eat oysters for their great health regulating purposes, such as controlling goiter and in anaemia prevention and cure. Maryland's oyster business does no advertising and still the demand normally is good. Recently, not more than one-half of a pint of oysters has been consumed per person in the United States each year, whereas the animal consumption of fifty-five years ago was ten times as great, and this in spite of the fact that in the intervening period the population increased somewhat more than 100%. This condition represents a business anamoly in that with more consumers, better sanitation, better packaging, better facilities for transportation, and with comprehensive knowledge concerning nutritional and therapeutic values, consumption and demand for oysters are about the lowest in the history of the industry. Surely great potential wealth awaits development in the form of the Chesapeake's oyster resources.

THE FIN FISHES

Fin fishes of nearly all types found along the Atlantic Coast have been vastly depleted, and right now several species of them are being wantonly destroyed by practices in the fishing industry in Maryland and elsewhere. Published data indicate that there are as many as 228 different species of fishes in the Chesapeake Bay and its tributaries.* Some of them inhabit fresh water almost exclusively, being found in the rivers streams and ponds. Typical of these species are largemouth and smallmouth bass, three species of trout, yellow perch, and carp. A very great number of our species of fishes live exclusively in the salt water of the bays, estuaries, and sections of rivers, typical of which are grey trout, croakers, and blue fish. A third group of our fishes are found periodically in fresh and salt water. The shad, herring, rock, white perch, sturgeon, and eel are members of this group.

Practically all of the larger fish forms are edible, although a relatively small number of them is used for human consumption. Those used for food constitute the commercial fishes, there being about thirty-eight species so used in Maryland. Certain of our fishes are taken on baited hooks and afford to the watermen a special industry that is noteworthy. Still other species, without direct commercial or sportive value, are of interest in that,

*Truitt, R. V., Bean, B. A., and Fowler, W. H., 1929. The Fishes of Maryland, Contribution No. 1, Chesapeake Biological Laboratory, State Press, Baltimore.

although small in size, they play a very important role in the economy of our waters. One such form, the Anchovy, with such aliases as "silverside" and "shiner", is the principal food of the commercially important rock and bluefish.

The ways in which different fishes live, feed, move, grow, and breed are very much alike. Consideration will be given here to two or three outstanding Maryland fish types, the shad, the rock, and the croaker, an understanding of which will throw light on fish life in general. It should be pointed out, however, that our food and wealth producing fish forms constitute but three families or groups. Herring, shad, and menhaden are nearly related forms, while croaker, drum, spot, and gray trout or weakfish, are coherent. Rock and white perch comprise the third family, closely allied to which are the black bass and yellow perch.

King among the Chesapeake fishes, in size and value, is the sturgeon, *Acipenser sturio,* one of the most primitive types known to man and a form that is not included in any of the family groups previously cited. Fifty years ago, we are told, over 30,000,000 pounds of this fine fish were taken along the coast, some individuals weighing as much as 500 pounds. While edible, sturgeon sold for little money and, because of the fact that when trapped along with more desirable fish they badly cut the nets, they were destroyed outright "to improve the fish business." In time their eggs became extremely valuable as caviar, and intensive fishing started. This followed deliberate destruction and, with diminished brood stock seeming to be a factor, depletion went on rapidly so that at present the annual output is figured in thousands of pounds.

In the Potomac River region, where this fish was wantonly destroyed in 1885 to "improve the fish business", only one large sturgeon has been taken during the current year, 1938, so far as is known. This fish, containing a full supply of roe, netted a return of $272 to its captor. Virtually no thought, either by conservation authorities or by men in the industry, has been given to the possibility of saving this fine fish, now so very near extermination. To quote a fisherman from Chincoteague, Virginia, "this fish is going because it is the will of God". He might have added that our sturgeon are disappearing without even an attempt being made by man to maintain brood stock and that this fish is apparently consigned to oblivion without benefit of sanctuary or, for that matter, an attempt to learn its habits, to determine its breeding grounds, or to make possible a single avenue of escape and survival.

SHAD

The Shad, *Alosa spidissima,* is probably the best known and most highly prized fish on the Atlantic Coast of the United States. It is taken commercially all the way from the Gulf of St. Lawrence to Florida. For many decades it gave to Maryland its outstanding fishery, and during certain periods of the early history of the shad fishery the species was so abundant that not only was every market demand met, but, during the height of the season, fish were carted away from the upper reaches of the Chesapeake Bay to be used for fertilizer. With limited protection and excessive fishing it was but natural that there should be a decline in the supply.

Commercially, the male shad is known as the "buck shad", and the female as the "roe shad". In certain sections the term "white shad" is applied to distinguish the commonly used fish from certain related forms such as hickory shad, mud shad, and gizzard or winter shad. In size our commercial shad ranges from two to two-and-a-half pounds for the buck, and from three to four pounds for the roe shad. On rare occasions, still larger females may be found, and, in a few instances, as much as eight pounds may be attained by one of the females.

Fish Pounds Trap Tons of Shad and Herring During the Spring Run to the Spawning Grounds.

The greater part of the life history of the shad is spent in the ocean, but for spawning purposes this fish enters bays and sounds, and ascends rivers and streams to reach fresh water to complete its life cycle. The migratory movements of the fish bring them to the rivers in the spring of the year, and in the Chesapeake territory the "run" is noted first either in late February or early March; movement up the bay ceases about the middle of June.

Reproduction: Upon reaching the spawning grounds, which, typically, are located just above the brackish waters of the Bay and its tributaries, deposition of eggs follows. As previously indicated, the sexes of the fish are separate. Fertilization is external to the fish's body and takes place after the roe shad has deposited the eggs, the male being present at the time. It has been estimated that in typical cases a shad produces between 25,000 and 30,000 eggs, although estimates made from the roe of the fish have indicated as many as 150,000 eggs. These eggs, measuring approximately 1/8 inch in diameter, after a matter of a few days, hatch, at which time the young shad is somewhat less than 2/5 of an inch in length. Growth from this time on is comparatively rapid in that by the fall of the year the young fish measures from 3 to 5 inches in length. It is now ready to leave the bay waters and go to the ocean, where it remains for a period of years to complete its growth and development. Biologists have not definitely established the period required for complete maturity, but the best information available indicates that this development requires from three to five years. It is a common assumption among fishery biologists that shad do not spawn under three years of age, and that, more typically, they are four or five years old when spawning takes place.

Food: Food for shad and related types of fishes consists almost entirely of small (planctonic) aquatic organisms, especially the crustaceans. To a very limited extent small fishes are eaten. During the several weeks of early development, young shad are consumed by several predatory fishes, such as the rock and the bluefish, while in some sections it is claimed by fishermen that eels and catfish destroy vast quantities of shad eggs.

Fishery: The methods of shad capture vary, pound nets being used to the extent of 64% of the capture, gill nets 35%, the remaining small quantity being captured by means of haul seines. Approximately 2,000 fish pounds, the heaviest and most destructive gear, were operated in Virginia, while 536 pounds were operated in Maryland, during the season 1934.* The average yearly catch in Maryland during the period 1931-34 was approximately 1,281,000* pounds, having a value of about $140,000. Fishing operations are carried on early in the day, usually at slack tide, and the fish are taken ashore forthwith, to be packed in ice and shipped to the consumer. This fish is sold entirely in the fresh state, there being no canning, salting, or smoking operations in the industry.

The quantity of Chesapeake shad taken in Virginia is some three times as high as the catch in Maryland. More than half of the total shad catch in the United States comes from the Chesapeake territory.

Shad roe is a highly prized delicacy. Roe shad sell for higher prices than do buck shad. This fact militates against the best interests of conservation, since it encourages even more intensive fishing for the female. The necessity of maintenance of the egg producing fish is obvious. During recent years there has been considerable depletion of the shad fishery in the Chesapeake. Maryland alone, during 1890, produced 7,128,000 pounds. while in 1935 the State's total catch of this fish amounted to only 800,000 pounds. In addition to the use of shad eggs as food, there are other factors that have contributed greatly to the decline of this fishery. Industrial

*From official records of the Maryland Conservation Department and the Virginia Commission of Fisheries.

centers and pollution, no doubt, have played their part, while the construction of dams has tended to preclude the breeding fish from some of the choicer spawning grounds. Added to these destructive activities is the extremely intensive operations that are carried on during the entire migration and spawning period.

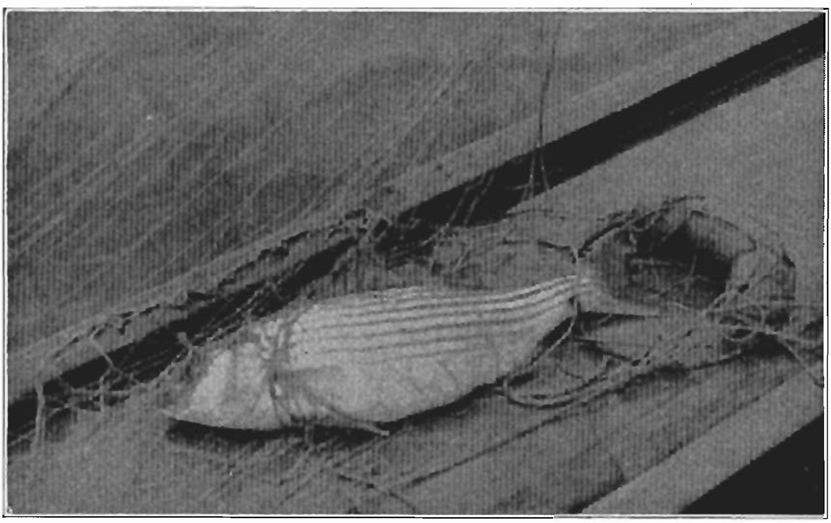
Conservation: Attempts have been made to conserve and rehabilitate Marylands shad population, but such statistics as are available definitely show that there has been, and continues to be, a fluctuating decline in the supply. These attempts have been confined largely to the regulation of the nets, to the season of their capture, and to hatchery work. The fact that there has been a constantly downward trend in production, until the industry at this time is threatened by destruction, is evidence within itself that the pracices in question are not sufficient to accomplish restoration. The efficiency of the hatchery methods is not known, since there is little or no correlation between their output of small fish, the fry, and the catch based upon same. In spite of the fact that the Bay is literally strewn with fishing gears, most of which are set to catch fish all day and all night, throughout the season, thus not giving them access to the breeding grounds, there has not been a single intensive and coordinated attempt on the part of fishery management to have nets lifted from the water intermittently for periods of time sufficient to allow brood stock to escape and perform the function of reproduction. Very little thought has been given to the possibility of shortening the season in order to afford a greater shad escapement. In addition, no effort has been made to curtail or stop outright the present practice of fishing on the breeding areas. It is almost unthinkable that in its attempt to rehabilitate the shad fishery the State finds it difficult to secure shad, even by purchase, from which to strip eggs and sperms for hatchery purposes. The fancy market for roe does not encourage sale of the eggs for conservation purposes. Far-seeing fishermen must recognize the necessity of using the genital products to the extent needed for rehabilitation, and that meeting the market demand will then be more nearly possible.

Rock

The crest of the State of Maryland, adopted during the early days of America, bears a fish after the form of the rock or striped bass, *Roccus lineatus*. This would seem to indicate that in the eighteenth century this interesting fish was prized. From that time to this, it has been one of the most important commercial and sport fishes found in the State.

The striped bass is readily distinguished from the other members of the finny tribes by the presence of six or seven prominent dark stripes that run the full length of its silvery body. It is further distinuished by the presence of strong spines that project from its gill covers and its fins. These spines constitute a strong method of defense, and in handling the fish caution is taken to avoid the painful pricks so well known to the fishermen. From the Chesapeake Bay southward this fish is known primarily as rock, whereas it is known as the striped bass in the more northern waters where it is found. Several local names are applied to the fish, such as the "shiner", weighing about one pound; the "hank" weighing about two pounds; the "pair", from three to five pounds; and the "singles", from six to twelve pounds. Not infrequently very large fish, 15 pounds or more, are termed "cow rock".

The rock seems to be the most typical fish of the Chesapeake Bay, which is the center of its distribution and the point of its greatest abundance. Fully 50% of the entire commercial supply of this fish taken along the Atlantic Coast is produced in the Bay, primarily in Maryland. Its distribution extends from the fresh waters of the rivers down to and throughout the bay area. The size of the fish taken commercially varies



The Rock, Maryland's Foremost Commercial and Sport Fish.

from one-half of a pound to 15 pounds, while the legal limits prohibit the capture of those smaller than 11 inches in length or those larger than 15 pounds by weight. The fish grows to big proportions and may reach upward of 150 pounds. An unofficial record of a specimen taken near Havre de Grace, Maryland, some 40 years ago, gives the weight of rock as 160 pounds.

Reproduction: Sexual maturity in the rock is reached at different ages and sizes. In the male fish the gonads may become functional at two years of age, whereas in the female eggs are not produced until the animal has reached three and a half or four years of age. When the spawning period is reached, the fish enters a river in search of fresh water, which seems to play a part in egg development. The period for spawning in Maryland waters extends from late April to mid June. The fish produce eggs in varying numbers, according to size and age. In the case of the cow rock of twenty pounds weight, as many as 1,500,000 eggs may be produced at a single spawning. It has been estimated by D. H. Wallace, Maryland's fishery biologist, that still larger females may produce as many as 5,000,000 of eggs in a single season.* The number of male cells produced by an individual of the species is even more vast. As in the case of the shad, the sperm cells are released into the open water at the time of spawning, and upon fusion of the male and female cells fertilization takes place. This development is accompanied by great expansion of the eggs, at which time 25,000 of same will fill a quart measure.

In fresh water the developing eggs are carried by the current near the bottom of the stream. The period required for developing of the egg varies somewhat according to the temperature of the water during the breeding period, and is comparatively short, the fish taking form and shape during the second day after fertilization in waters of 67°F. From this time on, the young fish grow to become one inch in length after a period of a month, and reach approximately three inches in length by the time the water has cooled to the low temperatures of December. Growth is arrested during the winter months. However, with the warming of the water toward the end of March, growth again is started and, by June, when one year of age is reached, the young fish measure between four and five inches in length. Two year old fish attain some 10 to 12 inches, while in the fourth year they reach from 18 to 20 inches in length. The length of life of this fish is much greater than that of other common types. A 36 pound rock, taken during 1937, showed from its scale growth rings at least eleven years of age, while in the case of exceedingly large fish it has been estimated that upward of 25 years of age may be reached.

Food: Shrimp and related crustacea constitute the principal food for the young rock, while stomach analysis of the larger and older forms show that the main article of the diet is fish, varied somewhat to include crabs and a few other forms. During the winter months, at which time the fish occupies the lower levels of the deeper waters, the young of the spot and the croaker constitute the chief items of food, while in the summer months anchovy and young menhaden, small and abundant forms in the region, are consumed primarily. The quantity of these small fish consumed is great, since in a 10 pound fish as many as 66 anchovies have been observed at a single time. In the areas where this food is concentrated, the rock gather at times in great schools and pursue the fishes voraciously. This pursuit and the securing of food on the part of the rock is a familiar sight on the Chesapeake Bay, and it can be located readily by observation of the flight of gulls. The small fish, to escape the predator, tend to jump out of the water, only to be consumed by the fast-flying and alert gull which, on the wing, picks them up. When a gull finds such a school of feeding fish, its flight is such as to attract other gulls, and in a short while all of the gulls within

*Personal Communication dated February, 1939.

miles of the point of the school of fish will gather. The practical fisherman and the fishing guide follow the flight of gulls in order to locate fish, frequently placing a man in the so-called "look-out" to accomplish this purpose. The movement of the school is determined in no small part by the presence and distribution of the smaller forms upon which rock feed. The term "breaking" is applied to the habit of rock in pursuing the small fish to the surface. More often the area over which breaking takes place is comparatively small, an acre or so. On rare occasions breaking may occur over a considerable area, and observations were made during 1937 indicating that schooling and breaking may cover as much as two square miles.

Several methods are employed in the commercial capture of the striped bass, the most important gears for which are the pound net, the gill net, and the haul seine. Pound nets are used to trap the fish during the fall months, and to a more limited extent during the summer. Drift nets are used in the winter, at which time the fish have gathered into deeper aeras of the bay and are somewhat slowed up by the low temperature of the water. Early in the spring a small quantity of this fish is taken from the more shallow water areas by means of stake gill nets. A considerable quantity of rock is taken by sportsmen over a period of approximately six months during the summer and fall. This method of fishing has contributed greatly to the development of special and numerous pleasure craft manned by fishing guides, and has greatly augmented the income derived from the Chesapeake Bay.

Fishery: The quantity of rock taken from Maryland waters constitutes upward of two-thirds of the entire catch from the Bay, and, as previously indicated, approximately one half of this fish type taken along the Atlantic Coast is supplied by the Chesapeake Bay. The rock fishery output has fluctuated from time to time, with a general downward trend until 1935, when there was recorded a supply approximately three times as great as that harvested during the 1932-34 period. In Maryland alone, during 1936, 1,864,100 pounds of this fish were taken. This return to a high level of production is directly traceable to a most favorable year, 1934, for breeding and rearing of young. It is essential that a sufficient quantity of the 1934 "year class" be allowed to remain in the water to reach an age in which there will be assurance of a continued supply of brood stock with which to populate the waters. In this connection, one of the outstanding weaknesses in the present conservation policy, and in the practice of the fishermen, is that of permitting the capture of fish that have attained only 11 inches in length. It should be a practice with this and other fishes that they should not be captured until they have grown to a size that will permit a sufficient excapement to maintain a brood stock level that will meet the demands of the environment and maintain maximum population for capture.

There are other members of the rock family found commonly in the Chesapeake Bay, one of which, the white perch, *Morone americana,* is well known. The life history of the white perch is similar to that of the rock, already described. It is a small fish, seldom weighing as much as one pound, which contributes to the annual catch in Maryland of approximately 300,000 pounds. It is caught for the most part during early spring, in the estuaries and the rivers, by means of fyke nets and pound nets. Yellow perch and black bass, somewhat closely related to these fishes, are of considerable commercial and sportive value. These last named are confined almost exclusively to fresh water areas.

Croaker

There are in the Chesapeake Bay several common fishes such as the spot, gray trout, and drum, that belong to the croaker family, the best known members of which, possibly, is the hardhead or croaker, *Micropogon undulatus*. This fish is widely distributed along the Atlantic Coast, occupying a range from Cape Cod to Texas. The area in which it is of the greatest commercial importance extends from New Jersey to North Carolina, the heaviest concentration and the greatest commercial catches being in the Chesapeake region. When this fish is removed from the water, it produces a characteristic and persistent sound from which its name, "croaker", is derived. This sound is produced by an internal organ known as an air-bladder, the vibration of the walls of which produce the croaking sound. In the related spot, drum, and trout, only the male fish is able to croak, while both sexes of the hardhead have functional sound-producing organs.

Croakers do not attain great size, though records of 4 or 5 pounds each are not uncommon. The size that appears in the market ranges more often between one-half and one and one-half pounds each. Croakers are not found in fresh water, though they range from the ocean well up into the brackish waters near the head of the Chesapeake. The spawning season for this fish is in the fall, extending from late August to December. Spawning takes place in ocean water near the coast and not within the Bay. As many as 160,000 eggs have been taken from a single fish eighteen and a half inches in length. These eggs are comparatively small, and upon fertilization they float near the surface. The developing eggs and larval fish drift into the Bay, where in late fall and during the winter the young ones may be found near the bottom in the deeper regions. These young fish attain a size of approximately three and a half inches at one year of age. The food used by the animal consists of shrimps and other small crustacea, small molluscs, worms, and a few other types inhabiting the bottoms. Analysis of the stomach contents of the croaker indicates that it does not consume an appreciable number of fish. After the second winter has passed, the maturing croakers spend the winter season in the ocean, moving in and out of the Bay according to season.

The yearly catch of croakers in Maryland amounts to about 1,500,000 pounds, with a value not in excess of $50,000. They are not considered highly choice for food purposes, especially in the early spring upon their return from the ocean. However, this fish does represent an outstanding asset in that it is more persistently sought by sportsmen than any other form in the Chesapeake Bay, and more readily takes the baited hook. Deep trolling makes possible the capture of some croakers of larger sizes but, for the most part, this fish is caught by still fishing.

Organization of the Fish

At this point we should understand just what a fish is. Not uncommonly whales are seen along the coast of Worcester County, and several of them have become stranded on the beach in late years. Occasionally whales have been sighted in the lower part of the Chesapeake Bay. These leviathans, entirely aquatic, are not fishes as would likely be suspected. Though the common environment has effected changes which give them marked similarities, along with the dolphin and the porpoise, they are mammals—that group of animals characterized, in part, by the presence of hair in some stage of their development and by the production of milk upon which the young are nourished after birth. Not so with fishes.

Fishes, as such, are more or less easily recognized, even the unusual ones. However, a few forms ordinarily adjudged fishes are not true fishes at all, although allied to them in the lower extreme of the vertebrates. The true fishes belong to a Class, Pisces, whose respiratory organs are gills. These gills are covered by a bony flap-like operculum. Usually there is a dermal exo-skeleton of scales or bony plates which furnish a protective covering for the body, while the endoskeleton is of true bone or bone and cartilage. An air bladder is usually present. Perch, minnows, pike, trout and similar forms are true fishes.

Resembling the true fishes in external form and habits are the elasmobranchs, Class Elasmobranchii, or sharks, dog-fish, and skates. This group differs from the above mentioned by a distinct arrangement of skeletal parts, by the absence of membrane-bones, air bladder, and true scales. Representative elasmobranchs of Maryland are the hammerhead shark, (*Sphyrna zygaena*), the saw fish, (*Pristis pectinatus*), and the sting ray, (*Dasyatis sabina*).

A third group of animals known commonly as fishes are the cyclostomes, Class Cyclostomata. These forms have a striking resemblance to eels though differing markedly from them, as well as other fishes, in that the jaws do not develop and there are no lateral appendages. There is only one olfactory pit and the skeleton of notochord persists throughout life. Representative in our waters are the lampreys, *Petromyzon marinus* being especially abundant.

All three of the classes named are abundantly represented in Maryland waters. By far the greatest number of the so-called fishes are true fishes. Differences equally as great as those indicated and others far more in detail are necessary for a clear understanding of classification. Modification and specialization have taken place in a gradual series of perfections from the lowly lamprey to the highly evolved perch group, affecting every system: nervous, circulatory, digestive, excretory, reproductive, and skeletal. While many of our fishes are not difficult to identify, some of them are greatly so, since the characters separating certain closely related forms are hard to distinguish.

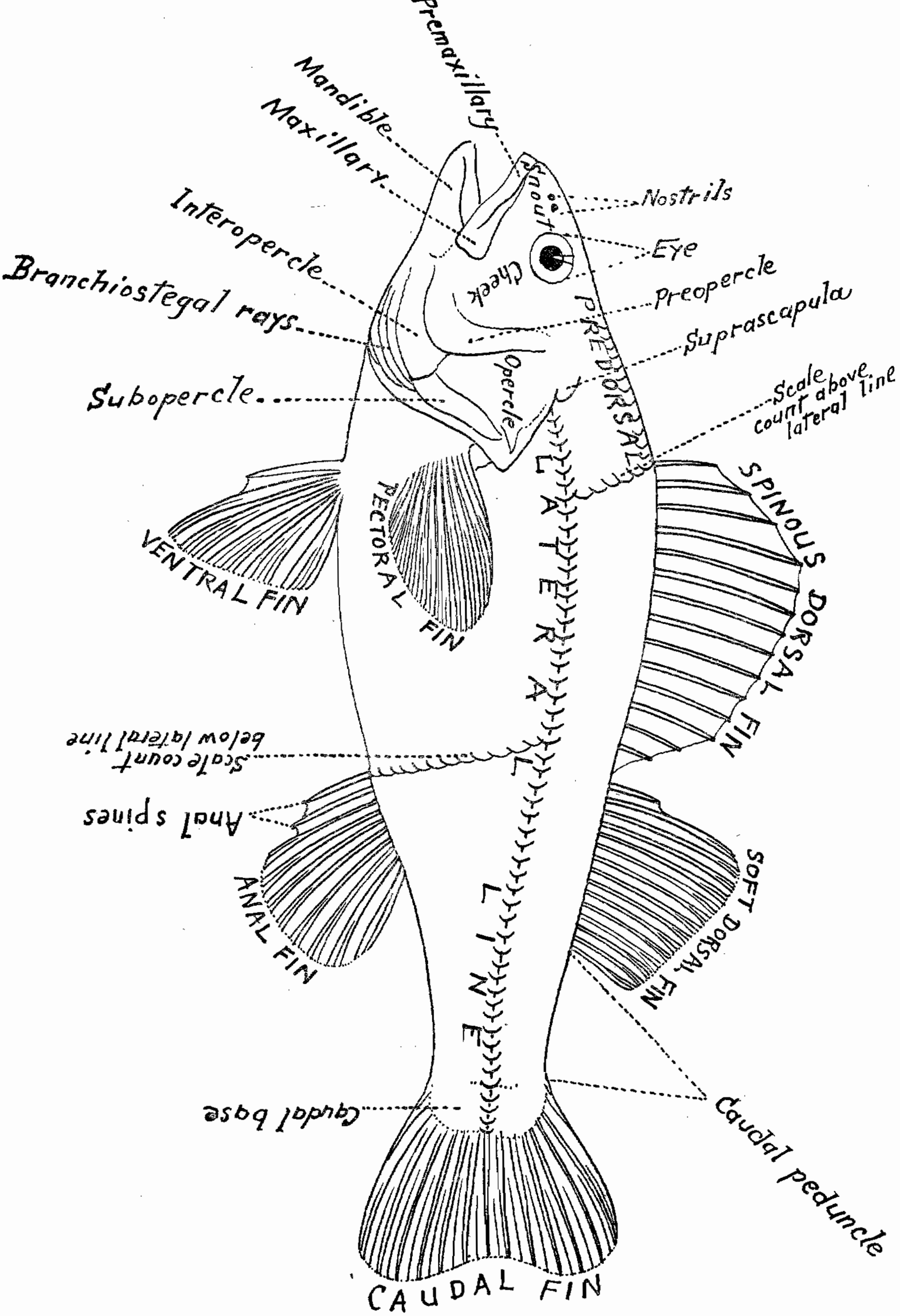


Figure 18. Diagrammatic Sketch of Yellow Perch, *Perca flavescens*, showing external features.

In order that the complexity of the fish organization might be better understood, following are set forth the features, both external and internal, of the yellow perch, *Perca flavescens,* a common fresh water form. This fish, indigenous here and found throughout the northeastern part of the United States, west to the Mississippi, is about ten inches in length when fully grown.

External Anatomy: Fishes represent maximum efficiency in animal streamlining. For the most part their bodies are spindle-shape and with extremely smooth surfaces to offer little resistance as they traverse the dense medium in which they live. While the spindle-shaped body of trout or perch, for instance, is the prevailing form, many variations have crept in as in the case of eels, which are thread or snake-like, and butterfishes, which are greatly compressed. In the flounder, depression has gone on to such an extent as to necessitate the placing of both eyes on one side of the body and the animal swims on its side, the changes taking place largely after hatching. The shape and form of a fish's body is closely related to its habitat, thus we find the eel in and around rocks, weeded areas and in holes; the flat fishes near the bottom or in crevices, and the fusiform members, in which resistance is so greatly reduced, in the open waters, though many exceptions may be noted throughout.

The body is divisible into head, trunk, and tail. It has two dorsal fins, a caudal fin, a single median anal fin, two ventral fins, and two lateral pectoral fins. A mouth with well developed and prominent toothset jaws appears on the forward aspect of the head. Occupying nearly a lateral position, slightly dorsal, on either side of the head is an eye, in front of and slightly below which is a nasal aperature. Back of and below the eyes are the opercula or gill-covers. For these and other features see Figure 18.

Distances from the surface are gauged by lateral lines, one on each side of the body extending forward-backward, usually in the upper half, sensitive to pressure. It is not improbable that these lines function in an auditory capacity and at the same time register disturbances in the water, such as the approach of an enemy. A number of common fishes do not have lateral lines, among them the herring and the marine mullets found in Maryland waters.

Organs common to higher animals are found in fishes and, indeed, a great degree of perfection is noted in them, especially when compared with creatures or classes immediately below. Nostrils are present as previously pointed out, but the part they play in the fish make-up is not clearly understood. Though external openings are present the nasal pits do not extend back to the throat as in higher forms, and no apparent assistance is rendered to respiration. There is some detection of odor in fishes, but this sense is not independently and acutely developed. Likewise the eyes. While well developed cornea, lens, and pupils are present, it is doubtful that vision, although acute within limits, has advanced to a degree corresponding to the high position in the animal kingdom held by fishes. Of particular interest in connection with the eye of fishes is the fact that there is not a fixed point of focus, and a series of eclipses is not necessary for the recording of images. To change focal length the lens is moved nearer or further from the pupil. Fishes do not see objects, even in motion, at great distances.

Drum, catfish, and still others have well developed tactile organs, in the form of barbels protruding, tenacle-like, from the general vicinity of the mouth. These organs are especially sensitive, and are used in "feeling out" strange objects, in search of food, and in explorations.

In fishes taste is seated in the mucous membrane of the mouth and offers a fair sense of discrimination in the selection of food, though it is not particularly well developed. This membrane seems to be sensitive and well out to the edges of the mouth, and not confined to the tongue and mouth cavity.

Probably the most conspicuous external organs of fishes are the fins, which appendages vary in species and are either paired or single, the latter being in a vertical position. The fins are composed of non-scaled membranes supported by cartilaginous or bony rods and rays, through the movement of which locomotion is accomplished. The high speed which most fishes are able to attain bespeaks the efficiency of these modified appendages, the most powerful of which is that on the posterior end, the caudal fin. The pectoral fins are located one on either side of the body and correspond to the fore legs of quadrupeds, while the ventral fins lie posterior and below them, being homologus to the hind legs of a quadruped. The uppermost fin is called the dorsal fin and in some fishes it is divided into two or even three parts which appear to be distinct and not uncommonly are termed "adipose fins". The remaining vertical member is known as the anal fin and, like the dorsal, it may be composed of spines, rays and finlets. Either or all of the paired fins may be absent, the pectorals being much more persistent throughout the fish group. The point of attachment of the paired fins varies in different forms, the ventrals of sharks being located on the abdomen, those of the croaker on the thorax, while, on the common toad fish, they are under the throat. The location of the pectorals, in a way, depends upon the insertion of the ventrals. When the latter occupy a posterior position the former are attached well ventral, but when the ventrals are jugular the pectorals are well up toward the lateral lines. Great variations occur in shape, size, division, position, and other features of the fins of different species, thereby offering characters which serve in a big measure for classification.

Propulsion of a fish, for the most part, is derived from the posterior part of the body and the caudal fin, and is due to a series of alternate contractions of the strong muscles on the sides of the trunk running to the tail extremes. The tail moves to and fro not unlike an oar blade being used in sculling a boat, while the body as a flattened "S" bends from side to side, the fin describing a figure eight (8). The paired fins and remaining verticals contribute but little, if any, to the locomotion of fishes except indirectly through balancing and directing. The muscles controlling them are comparatively poorly developed, though sufficient for their purpose which, in the main, is that of directing travel. The caudal fin, as a rudder, controls largely the directional stability, while the vertical fins might be thought of as the "center-board" of the fish craft, caring for lateral stability; the paired fins correspond to the ailerons of an aeroplane, having the advantage, however, through offering their flat surfaces to the water, of acting as brakes in bringing the body to a standstill.

Internal Anatomy: Fishes breathe by means of gills which represent the greatest departure in adaptation of the animals to an aquatic environment. Lifting the opercula, in true fishes, four pairs of red fringe-like bodies, the gills, are exposed. On either side of the throat just behind the mouth cavity there are four more or less crescent-shaped bones, the gill arches, each of which bears two gill-processes. Being richly supplied with blood the gills offer surfaces for gas exchanges; oxygen, dissolved in water, being taken in and distributed over the body, while the blood is relieved of its carbonic acid charge which passes directly into the water. Breathing in active fishes, as in higher forms, must be carried on constantly, the water passing through the mouth, then on back between the lamella of the gills and out the opercular opening to the exterior. Currents are set up by movements of the jaws, tongue, and opercula, assisted in some cases by the paired fins. Cyclostomes and some elasmobranchs have a breathing pore, the spiracle, through which water is taken in, rather than through the mouth. These have a larger number of gills than the true fishes, and an elaborated system which may consist of a number of small slits laterally placed. Differing greatly in the several species of fishes, entirely wanting in some, are gill-rakers, pointing inward and forward, attached to the gill-supporting bones. These "rakes" are used in the dual role of assisting in food collection and in protecting the tender gills from possible injury through passage of harmful bodies over them. Such plankton feeding fishes as menhaden have gill rakers well developed, while the blue fish, which feeds upon larger forms, has them but poorly developed.

An air-bladder, internally placed, regulates the weight-displacement factor permitting the fish to remain stationary at varying depths without muscular activity. Also, it plays a part in sound production as in the case of the croaker. This organ of equilibrium does not appear in elasmobranchs, cyclostomes, and a few bottom inhabitating true fishes. When present in the last named forms, it is usually very small. Jordan, speaking of a juvenile fish, says "In the very little sunfish, when he is just hatched, the air-bladder has an air-duct, which, however, is soon lost, leaving only a closed sac. From all this it is thought that the air-bladder is the remains of what was once a lung or additional arrangement for breathing. As the gills furnish oxygen enough, the lung of the common fish has fallen into disuse and thrifty nature has used the space for another and very different purpose. This will serve to help us to understand the swim-bladder and the way the fish came to acquire it as a substitute for a lung". The ear, an internal chamber, lies near the brain and has no opening to the exterior. In it are otoliths, or ear stones, which function, apparently, in determining the equilibrium so necessary for an animal which normaly moves with six directions of control. It is highly probable that the ear shares with the lateral line the recording and interpretation of sounds and water disturbances.

In a preceding paragraph it has been pointed out that cyclostomes, elasmobranchs, and true fishes differed markedly in skeletal features, both as to content and arrangement of parts. However, all are vertebrates, that is, animals with jointed backbones (vertebrae) in which the nerve cord lies dorsal to the axis of the column, to the ventral of which is the digestive tract. In most cyclostomes, as the lampreys of Maryland, the notochord skeleton persists as a well-developed structure throughout life. The sharks and other elasmobranchs possess a cartilaginous skeleton with remnants of notochord in the lenticular spaces between the vertebrae. The skull of the latter shows a decided advance in development over the former, having a well developed cranium, two large well formed nasal capsules, and two auditory capsules, as well as a prominent visceral skeleton. It is the third group, Pisces, sometimes classified as an order (Teleostei), which we have referred to as true fishes, because all representatives of that group possess bony skeletons either in part or throughout the sustentative structure.

The exoskeleton of the yellow perch consists of fin-rays and scales, ctenoid rather than placoid* as in the shark group, while certain rays may be hard and spiny, thus offering a strongly protective surface. The endoskeleton, almost entirely bone, consists of distinct parts, the skull, vertebral column, pectoral girdle, ribs, and inter-spinal bones.

The skull of perch, the cranium, though mostly of bone, contains some cartilaginous parts, and houses the brain, the auditory, the olfactory, and the ocular organs. Parts of the skull, the viceral skeleton, are modified into jaws (mandibular arch) which bear teeth, into supports for opercula (hyoid), and into supports for the gills and rakers. The spinal column consists of nearly uniform vertebrae, each of which, typically, is cylindrical and with a neural cavity in it. A spine from each vertebra projects dorsally for muscular attachment and the ribs are strongly bound to the lower extreme of the latter surfaces by strong ligaments. The posterior end of the column terminates in supports for the caudal fin. The ribs are free at the ventral end and form an arched cavity for the coelom in which the digestive and most of the other systems are housed. While the axial skeleton is well advanced in structure, the appendicular skeleton is only poorly developed. There is no pelvic girdle. The ventral fins are attached to a ridged though rather flattened bone which extends forward to the base of the pectoral girdle. The pectoral fin-rays and the radials which connect them to the girdle articulate with the girdle, to which the pelvic muscles are attached.

What has been said here of the skeleton of the yellow perch holds, in a great measure, for all true fishes, though many modifications of parts and decidely different arrangements may be witnessed in different forms. The skeleton, even to the absence of certain appendicular parts, shows a development toward adaptation hardly excelled in the animal kingdom and, no

*Other distinctive types of scales are the ganoid, found on sturgeon and bowfin, and the cycloid, found on herring and shad.

doubt, accounts in a large measure for the efficient life in a medium many times heavier than air.

Of the well developed contractile system little need be said. The muscle cells are greatly elongated, especially in the trunk, and are arranged in zigzag myotomes of varying lengths. By far the strongest muscles are those tapering toward the caudal fin and used in locomotion. Complex muscular arrangements actuate the organs of the head, while apart from those mentioned special muscles move the fins. It is this tissue which is valuable as food.

The brain of true fishes represents a distinct advancement over the other classes, especially the cyclostomes, having as it does the cerebrum, cellebellum, optic lobes and the medulla oblongata well formed and distinctly marked. The sense organs are connected to the brain by cranial nerves, and the spinal cord, encased in the vertebral column, gives off spinal nerves. Thus the fish is highly sensitive throughout, and through coordination of sense organs and acuteness of functions the active, responsive, and alert animal is produced. The senses recognized in fishes are those of taste, in the mouth; sight, through paired eyes; smell, located in two pits anterior to the eyes and without mouth connections; hearing, but slightly developed in the ears, or membranous labyrinths, and most probably shared in by the sensitive lateral line, which is usually present; and response to touch, common over the entire body though the lateral line seems to play a special part in gauging pressure. The ears, with their otoliths, seem to play a big part in the equilibrium of fishes. Indeed, if there be the added sense of balance in animals, as claimed by some, it could well be located, in this group, in the ear.

The digestive tract of fishes varies according to feeding habits. The canal may be short, as in most carnivorous species, or long, as in herbivorous forms. It passes through the body cavity from the mouth to the exterior opening, the anus, located just before the anal fin. Food, in reaching the stomach, passes over a rather ineffective tongue, through the pharynx and a short oesophagus. The stomach, in general, is a rather simple sack-like organ in which food is partially digested before passing on through the pyloric valve into the intestine, which leads to the anal opening. Caeca, or secretive bodies, attached to the digestive apparatus at the lower end of the stomach supply, in part, the juices needed for digestion. A well formed liver, dorsal to and nearly surrounding the stomach proper, empties bile into the forward end of the intestine through a duct leading from the gall-bladder. Other organs of secretion present in fishes are the spleen and the pancreas. Digested foods are taken up largely through the intestinal wall, and waste matter is voided through the vent.

Distribution of the diffused food takes place through a well defined circulatory system which is most closely associated with the respiratory system. An inconspicuous, two chambered heart, lying in the pericardial division of the body cavity, pumps aerated and food laden blood to all parts of the body. Returning, the blood bears off the excreted waste, which is gotten rid of through kidney removal of urea and through the gas-exchange already referred to. The blood plasma contains both red and white corpuscles and, in reaching the most remote and the smallest parts of the body, it travels through a well defined closed system of arteries, capillaries and veins. Circulation is comparatively slow. Osmotic phenomena play, no doubt, the greatest part in the many exchanges of liquids and gases to and from the blood, osmosis being made possible by the complex and variable nature of protoplasm and its fluid contents. The circulatory system of true fishes shows a marked advance over that of cyclostomes and, in most cases, that of elasmobranchs as well.

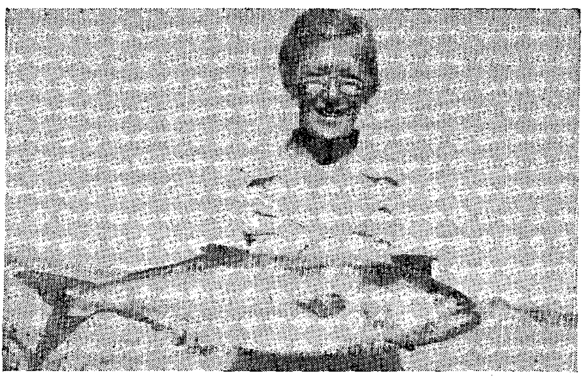
It has been indicated that amino-acid wastes, urea, are voided in the course of circulation through the agency of kidneys. There are two of these organs, greatly elongated bodies, attached to the dorsal wall of the abdominal cavity. From each kidney there runs a small tube, the ureter, which conveys the liquid waste posteriorly to a bladder, where it is stored until expelled from the body through a second opening just in front of the anal fin. Connected to this same opening is the genital or reproductive system, consisting of two testes in the male and two ovaries in the female, the sexes being separate. The reproductive bodies are prominent, extending practically the entire length of the body cavity. In the female yellow perch a short oviduct leads from each of the ovaries to the urinogenital sinus, while a short sperm duct connects each of the testes to the sinus of the male. These ducts may be entirely absent in some female fishes, in which case the germ cells are passed to the exterior through small genital pores between the reproductive bodies and the sinuses. Still other forms pass the eggs into the coelom, or body cavity, where they may be retaind for a period before being extruded. When the period for spawning approaches, the ovaries become vastly distended and fill the greater part of the body cavity, giving the fish a swollen appearance. The reproductive system of lampreys and related members is of a comparatively low order, while the account here given may, in a general way, be taken as applying to all true fishes.

SPORT FISH AND FISHING

The importance of Maryland as a sport fishing area and the favorable reputation it enjoys as such have grown very rapidly during late years. The State is experiencing, at the present time, an increase in the number of individuals attracted by favorable results with hook and line. This increased interest is shown not entirely from the confines of Maryland, but from a wide territory in the general region outside of the State, as well. In the course of recent observations at the Chesapeake Biological Laboratory, it has been estimated that approximately thirty-nine per cent of the entire sport-fishing effort is dependent upon visits made by non-resident sportsmen. In the Eastern Shore territory of the State, fifty odd per cent of those who follow sport fishing are from out-of-State sections.

The unusual topography of Maryland gives to it limited fresh water fish habitats, there being few natural lakes, while the salt water of the Chesapeake Bay penetrates far up many of the rivers that enter it. Certain of the fresh water streams have suffered greatly from mine bilge, a type of pollution that has rendered them useless for fish production. The Youghiogheny River in Garrett County is notable for this type of mine waste destruction. However, considerable fresh water sport fishing does take place in the State, while the Chesapeake Bay affords a vast system, constituting thousands of square miles, well supplied with many forms highly desired by the sport fishermen. The coastal section, too, lures many fishermen.

The relatively great water surface of Maryland, the large number of species of fish, and the abundance of certain of the more choice forms account for the popularity which the State enjoys from the fishing fraternity. According to Truitt, Bean and Fowler,* two hundred and twenty-eight species of fish were recorded as common to Maryland waters while, since the publication of their report, several species have been added to the check list. The most important fresh water forms, from the sportsman's viewpoint, are: small-mouth black bass, *Micropterus dolomieu;* large-mouth black bass, *Micropterus salmoides;* brown trout, *Salmo fario;* rainbow trout, *Salmo shasta;* brook trout, *Salvelinus fontinalis;* yellow perch, *Perca flavescens,* and wall-eyed pike or Susquehanna salmon, *Stizostedion vitreum.* Rock, or striped bass, *Roccus lineatus,* are taken to a limited extent by fresh water anglers though, primarily, this valuable game fish is captured from the estuaries where the water ranges from brackish to marine conditions. Among the more truly salt water forms, in addition to the striped bass, are the very abundant hardhead or croaker, *Micropogon undulatus,* gray trout, known also as weakfish, *Cynoscion regalis,* blue



(Courtesy Chesapeake Bay Fishing Fair Association)

A 15 Pound Bluefish Prize Winner.

fish, sometimes termed taylor, *Pomatomus saltatrix,* spot, *Leiostomus xanthurus,* white perch, *Morone americana,* mademoisselle, *Bairdiella chrysura,* are abundant seasonally in certain favored areas of the Chesapeake Bay. Not all of these species appear in great numbers throughout the season as does the hardhead.

Fresh-Water Forms Highly Prized

Fresh water sport fishes are considered by many to exhibit greater gameness than do the salt water forms of the Chesapeake Bay, a point open to debate. The limited territory of production of fresh water species makes for a greater interest and financial outlay from sportsmen in the salt water section of the State. Several efforts have been made to determine the number of persons who fish in the waters of Maryland. This information is rather accurately known for the fresh water fishermen due to the fact that license for fishing is required by law. No such records are available for the marine fishes, however, since licensing is not required. The popularity of fresh water fishing in Maryland may be realized from figures of the Maryland Conservation Department, based upon licenses issued to resident and non-resident sportsmen. This number was approximately 20,000 during 1938.

Only those streams westward of Baltimore, Howard and Montgomery counties are so located as to afford environments conducive to natural propagation of trout, while certain of these streams in the western part of the State have conditions existing in them which limit their carrying capacity and their value for natural reproduction and growth. Some of the streams, such as the Savage River, are poor in fish food, while several others, such as Western Run, have a fair food supply but suffer from the effects of erosion, following flooding, and temperatures that make reproduction impossible. The greater number of streams in the western part of the State can and do support reproduction, growth, and maturity of trout. However, the fact that these streams are located near centers of population and are fished heavily, and the fact that the water areas are small, make it possible for only a fraction of the annual catch to be derived from natural production.

During the past few years, the Maryland conservation authorities have embraced a policy of rearing trout to legal sizes before releasing them. While it is held that this policy of management does not produce the highest type of gameness, it does afford a much more intense fish population and makes possible the use of many streams not well suited to fish production, which, in turn, afford fishing for a greater number of individuals. There seems to be little doubt but that, as a whole, the policy now in operation is a constructive one.

Bass Abundant. Bass are found in every county in the State, being abundant in the rivers and streams of the Eastern Shore, as well as in the system embraced by the Potomac River. Deep Creek Lake, in the mountains of Garrett County, affords a fair abundance of small-mouth bass and some other types of sport fish. Few places are found in America where bass abound in greater numbers or in larger sizes than in certain Maryland waters. Especially noteworthy in this connection are the small rivers in Dorchester County. While bass are hatched and reared in big numbers at the State Hatchery, natural reproduction among them accounts for the decidedly greater number taken by sportsmen. The center for bass hatching is at Lewistown, Maryland, where there is maintained a thoroughly modern lay-out of ponds, buildings, and equipment. Trout hatching is carried on at the same site, though the main rearing ponds for these fish are located in Garrett County, where water better suited for the purpose is found. These hatcheries and the entire program of fresh water fish conservation, including distribution, is carried on with funds that are derived from anglers' license fees which by law can be used for no other purpose.

The value of the black bass as a sport fish far exceeds its value as a commercial form, with the result that Baltimore, Hagerstown, Annapolis, Frederick, Cumberland, and certain other parts of the State, including several counties, prohibit its capture on a commercial basis. The tendency, country-wide, during the past few years, has been more and more in the direction of curtailing or stopping entirely the capture of bass for commercial purposes. Maryland remains one of the very few states that permit, even in part, the use of several types of gear for mass removal of these game fishes, a situation that should be stopped, since this form is easily capturable while the commercial catches are known to be of far less value than their potential worth in attracting sportsmen.

Shad and Wall-Eyed Pike Sought By Anglers. The Shad, *Alosa sapidissima,* a common plancton feeder, has not been thought of in the past as a sport fish. During the past five years, there has been an increase in the number of people who attempt to take this species. It has been found that this fish will take a "dry fly," hook baited with flannel, and certain metal lures. It strikes hard and it fights in many respects like the small-mouth bass. As many as twenty-four shad have been taken on hook-and-line by one person on a single fishing trip. The choicest area for this type of fishing is in the race-waters below the Conowingo Dam on the lower Susquehanna River. Just below the Dam there is to be found an area richly supplied with wall-eyed pike or Susquehanna salmon. This fish is not a member of the pike family at all, but belongs to the perch family. There are many sportsmen in Maryland who feel that the wall-eyed pike is one of the State's choicest hook-and-line fishes, since it strikes hard and has a steady hard pull that is thrill provoking. The distribution of this fish in the State is limited to the Susquehanna River, a body supplied with a wide variety of fishes though not of great abundance.

Other Fresh Water Types. Pike, *Esox reticulatus* and *E. americanus;* sunfish, *Lepomis auritus, L., gibbosus,* and *L. cyannelus;* cat-fish, *Ameiurus catus, A. natalis, A. nebulosus* and *A. ponderosus,* and many other species of desirable angle fishes are common in the fresh waters of Maryland, all of which have good points, while certain of them have gained partisans in the sporting fraternity who concede nothing to the gameness of other types. Except for sections of a few streams, disturbed by pollution, the fresh water areas in the State are productive of the commonly-thought-of minor sport species. The importance of such forms is great in that more typically the beginner resorts to them to sharpen his wits and to boost his pride in the capture and possession of members of the finny tribe, a thought aptly expressed in, "pity the boy who hasn't had the thrill of taking a sun-fish."

A rare fishing sight or experience is that common in May, in the general region of Baltimore, when hundreds of children, ages ranging from four years up to late 'teens, gather on the streams to catch gudgeons, *Notropis hudsonius.* These fish school in almost unpicturable numbers during the above-mentioned period, and they avidly take the hook, whether it be the small beared minnow hook or a bent pin on the end of sewing cotton. The fish rarely grows to be over five-and-a-half inches long, is good to eat and offers sufficient fight to meet the complete satisfaction of the youthful enthusiast at the other end of the line. Many of these children tire of fishing early, others stop fishing when they have caught a reasonable number of gudgeons, but many of them fish long hours and, wastefully, catch hundreds of the minnows in search of suitable spawning grounds.

Marine Fishes Abundant

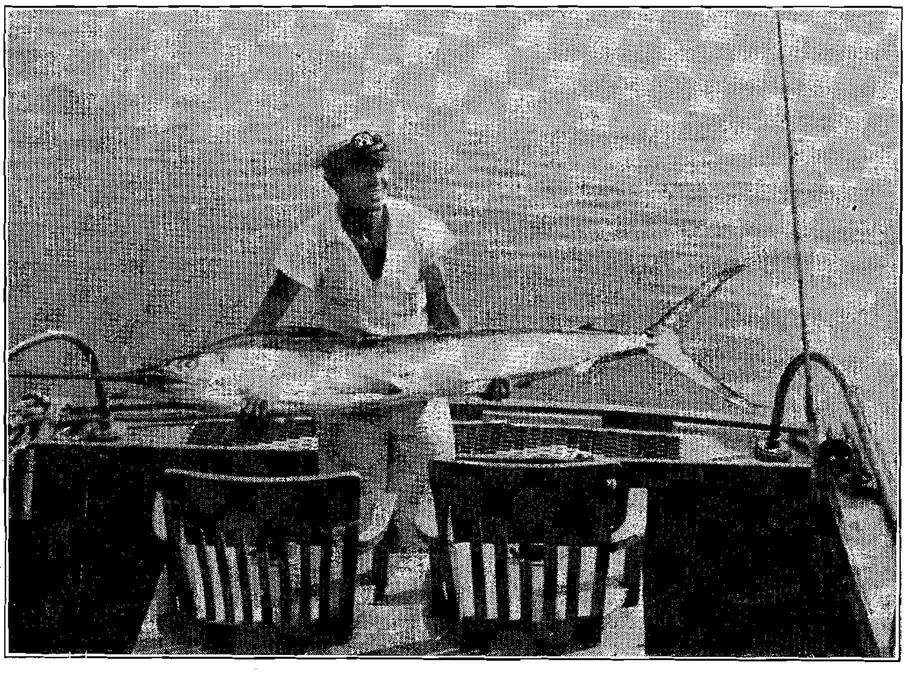
The coastal waters of Maryland abound in species of great interest to sport fishermen, ranging from the small kingfish, or whiting, *Menticirrhus saxatilis,* so common and ready to take a hook cast into the waves breaking on the beach, to one or another of the several big fish, outstanding among which is the marlin or spear-fish, *Tetrapturus albidus.* The bluefish, *P. saltatrix,* trout, *C. regalis* and *C. nebulosus,* croakers, *M. undulatus,* porgy or scup, *Stenotomus chrysops,* sea bass or black will, *Centropristes striatus,* and two species of drum, red drum, *Sciaenops ocellatus,* and black drum, *Pogonias cromis,* are among the choicer forms found on the ocean front and on the high sea, out of the recently developed port of Ocean City, Maryland. It is doubtful if there is another point along the Atlantic Coast that can boast of such a rapid rise as that experienced by Maryland's oceanside resort in connection with the development of its fishery resources, especially that of sport fishing.

Marlin Set A Record. An official report released during 1938 was to the effect that eight large marlin were taken off Ocean City by a single party of four sportsmen, a feat held to be a record for the capture of this form throughout its range. These fish are tremendously powerful swimmers and are held by some students* to be among the swiftest fishes in existence, capable of maintaining a high rate of speed for long periods of time while able to give a burst of speed, in a matter of seconds, that has been estimated to reach forty-five miles an hour. Such speed equals the legal limit set for automobiles in Maryland, while it is greater than that reached by a torpedo fired from a battle-ship. The marlin represents one of the most effectively streamlined fishes in the sea, having its greatest thickness about half-way from the tip of the rostrum to the base of the tail, tapering in both directions from the point of greatest girth. Its free-moving parts are so placed

*Norman, J. R., and Fraser, F. C., 1938. Giant Fishes, Whales and Dolphins, Norton and Co., New York.

and arranged as to form efficient entering wedges or, if folded back, to fit into the general conformation in such a way as to greatly eliminate resistance to the water.

Capture of a marlin is the goal of a sport fisherman. Maryland's coast has an abundant supply of this fine fish some thirty miles off shore, as may be understood from William Akermann, Fishing Editor, Washington Post, Sunday, July 10, 1938, to quote: "All anyone needs to do to know how Ocean City stands in the big game fish world is to glance over the records of other ports. He will find that even on a day when seven or eight marlin are captured by the entire fleet, that day is accounted big, but on one day during the season of 1937, the boats from Ocean City came in with thirty-one white marlin—the all time record—and if we might go that far, with little chance of any other present-day fishing port approaching this number —a catch which placed the Maryland city as tops in the white marlin fishing of entire world." Peter Chamblis, of the Baltimore Sun, July 24th, 1938, wrote from Ocean City, as follows: "Breaking world's records for the number of marlin caught in a single day happened twice during the past week, when exactly one hundred and seventy-nine of the big game fish were taken.



The Marlin, Every Inch A Game Fish.

The first daily world's record went glimmering on July 16, when thirty-six marlin were taken. On July 21 the record was again smashed by the landing of thirty-seven of the fish.*

The average weight of marlin caught off Ocean City is seventy pounds, though in these waters they have reached sizes, based upon official records, ranging from one hundred and thirty pounds down to twenty-four and one-half pounds. During the season of 1938, thirty-one charter boats, ranging in length from 30 to 55 feet, cleared from Ocean City daily to take anglers marlin fishing. It is estimated that the average expenditure per person for fishing purposes is approximately fifteen dollars, from which it is concluded that marlin fishermen, alone, spent at Ocean City, Maryland, sixty thousand dollars during 1938. This amount does not include money spent on the many private cruisers whose owners and their friends enjoyed the sport during the season.

Ocean City A Fishing Center. The marlin, the bonito, *Sarda sarda,* and other larger game fish are highly seasonal, the first named being present in great numbers during July and August. Several species of sharks are desired by sportsmen and not infrequently they are sought with fine results along the Coast, being taken rarely in the Chesapeake Bay. The more substantial and lasting sport types of fish enjoyed by sportsmen out of Ocean City are the bluefish, two species of trout, the scup and the sea bass previously mentioned. Of equal popularity are the kingfish and the red drum or channel bass, both of which are commonly taken by shore fishermen casting into the breakers, or by those who enjoy fishing from a large pier built out over the ocean. It is estimated that 17,790 visitors tried their luck at fishing in the vicinity of Ocean City during 1938, thereby attesting to the popularity of this resort and the productivity of its waters.

Rock And Bluefish Are Bay Favorites. The rock unquestionably is the most eagerly sought-after sport fish of the Chesapeake Bay not only because of its gameness, but because it is present the year around, and the season of capture is a long one — from frost to frost. Bluefish come to the Bay seasonally from the ocean and are present in certain sections, such as South West Middleground, in great abundance at times, especially during late summer. The opinion of anglers, in general, is that the bluefish is somewhat more voracious, strikes the hook a bit more vigorously and puts up a shade better fight, than does the rock, when being reeled in. These fishes are noted, alike, for their fine food qualities and their size, as well as their gameness. Both rock and bluefish are taken by means of trolling in which, as a rule, an artificial lure is used. Many kinds of lures are employed. Most of them are of the spoon-spinner type, or some modification of it, and they are used in trolling from a slow moving boat. Chumming is practiced.

Current research at the Chesapeake Biological Laboratory indicates that Maryland produces and maintains its own population of striped bass, and is not, therefore, dependent upon other bodies of water for this fine fish.

*Later official records, Game Fishermen's Association, show 171 marlin captured on July 29, 1939.

On the other hand, rock of local origin migrate to Virginia and, to a more limited extent, to other states northward to Maine, in all of which sections it is a prized anglefish. Probably none of our marine fishes has received more constructive interest and thought on the part of sportsmen than has the rock, a fact that has been responsible, in a large measure, for the critical investigations that recently have been made to gather factual information upon which to base conservation practices.

Accurate records are not available for the number of sportsmen who resort to the Chesapeake annually. There are many persons, watermen as well as sportsmen, who feel that the Chesapeake should be developed into an exalted fishermen's paradise, and that under management in a given direction it could be made into a body of water without parallel from the viewpoint of sport fishing.

While under present conditions visitors to the Bay are not always assured of satisfactory catches, the number of sportsmen resorting to this body of water is surprisingly high, if not foremost in the nation when the size and type of body of water are considered. Observations made in 1933, by the Conservation Department of Maryland (Annual Report, 1933), indicated that 11,126 sportsmen resorted to Bay waters during the first week of August. Approximately 200,000 sportsmen fished with hook and line on the Bay during 1936.* The years of 1936 and 1937 produced a vastly improved type of fishing boat, larger in size (forty odd feet in length and with a beam from ten to twelve feet), more sea-worthy in construction, and, in general, better equipped for fishing purposes, with a consequent increase in fishing effort. Statewide records for 1937 and 1938 indicate that between 290,000 and 300,000 persons go to Maryland's marine fishing grounds annually to try their cunning and luck against the game types.

Sport Fishing A Major Industry

Efforts have been made during the period of sport fishing expansion to establish more accurately the facts concerning the quantity of fish taken by sportsmen in Maryland waters. By means of personal interviews on the part of the staff of the Chesapeake Biological Laboratory, made of the fishing guides and boat operators, and by the circulation of a questionnaire, it has been possible to secure much information as to the extent and value of sport fishing. It has been established that eighty-one fishing party boats hail from Solomons Island and vicinity, while seventy-one boats hail from the Tilghmans Island region. Herring Bay, Severn River, and the Tangier regions rank next in numbers of fishing party boats, with Deals Island, Rock Hall, Cambridge, Oxford, St. Michaels, Hoopers Island, Brooms Island, Galesville, Benedict, Baltimore, Kent Narrows, points on the Potomac, and many other sections sending out sizable fishing fleets. The average fishing party is made up of four-and-a-half persons and during the height of the season, a boat may make, though rarely, as many as five

*Truitt, R. V. and Vladykov, V. D., 1936, The Importance of Sport Fishing in Maryland. Trans. Am. Fish. Soc., Vol. 66.

CHESAPEAKE SPORT FISHING SURVEY

Your help in accurately compiling these records will be appreciated.

Size of Party .... How many previous trips made by party this year ....

Fishing Grounds .... Depth .... Feet

Character of Bottom:* Shells, mud, hard clay, sand, etc. ....

Date .... 193 .... Fishing Hours:* From .... A.M.—P.M. to .... A.M.—P.M.

No. of Hand Lines .... Hooks .... Trolling .... Hooks ....

Bait for Still Fishing .... For Trolling ....

Weather:* Calm, rough, rain, cold, warm .... Direction of Wind ....

CATCH

No. of Fish					Total Weight
.... Rock	- - -	ranging from .... inch	to .... inch.		.... lbs.
.... Hardhead	- -	ranging from .... inch	to .... inch.		.... lbs.
.... Bluefish	- -	ranging from .... inch	to .... inch.		.... lbs.
.... Gray Trout	- -	ranging from .... inch	to .... inch.		.... lbs.
.... Spot	- - -	ranging from .... inch	to .... inch.		.... lbs.
....	- -	ranging from .... inch	to .... inch.		.... lbs.
....	- -	ranging from .... inch	to .... inch.		.... lbs.

Remarks: (Kind and number of foods found in stomachs of different fishes. Do fishes possess well-developed or running spawn and milt? Add other pertinent information here

....

....

....

....

Name of Boat .... Size of Boat ....

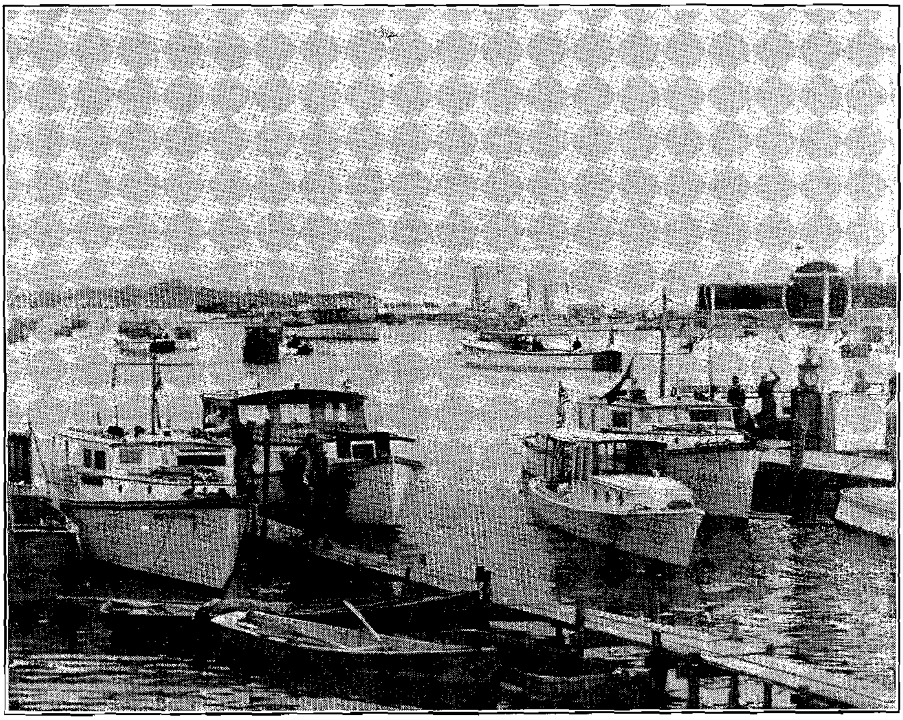
Owner's Name .... Address ....

Guide's Name .... Address ....

**Strike out terms not applicable.*

Copy of Form used in Gathering Sport Fishing Data trips to the fishing grounds in a single day. The season extends from late May to mid-November, although the main season ranges from the middle of June until the third week in October.

Records made during the past three years indicate that slightly under 45,000 sportsmen, including many repeaters, are transported to the fishing grounds out of Solomons Island and vicinity, a centre intensively studied, in a single season. While the fishing season has its ups and downs as to



Party Fishing Boats in a Mid-Bay Harbor.

catch, records to date indicate that at least 290,000 pounds of fish may be taken annually from Solomons Island, alone, by sportsmen. The catch at Tilghmans Island ranks well with that of Solomons Island. There is strong indication, from available statistics, that these two areas combined produce approximately thirty per cent of the entire catch taken by sportsmen from the waters of the State. Estimates based upon figures available from survey records up to 1938 place the annual hook-and-line, or sports catch of fish, at approximately 1,664,700 pounds. Some 630 boats are employed in the operation, either full-time or part-time, on a commercial basis, while hundreds of others carry private parties for which no records are available. Employment is given to more than one thousand persons on the water directly engaged as guides or boatsmen.

The charge for carrying fishing parties on the Chesapeake ranges from $5.00 to $15.00 for four hours. (Ocean fishing parties, covering greater territory, are charged about $35.00 for the day.) If more than five persons are taken, one dollar for each such person is charged. Using these figures as a basis for boat rental, as did Denmead*, $290,000 is now being paid for the use of boats yearly, exclusive of row boat, sail boat, canoe, and other lighter craft, all of lesser importance. Added to this income of the tidewater section of Maryland should be the still bigger outlay in cash for hotel and restaurant bills, fishing tackle, fuel, and other incidentals to sport fishing.

It is exceedingly difficult to estimate in dollars and cents the direct value of sports fishing to a community, while the indirect values that accrue to the sportsman from days on the stream, or afloat, are, of course, immeasurable. There is no way to appraise values that go with angling, such as painstaking preparation, patience, application of cunning, knowledge of fish life, and habits, adjustment to meteorological conditions, recreation, sportsmanship and, last but not least, the "proper frame of mind", and similar points that characterize the fisherman. Even fish stories have their place and value. With all these good points, however, there crop up negative values among those who angle for fish in the name of sport, for occasionally individuals take unreasonable quantities without consideration of use, or the future of the supply. Probably more destructive still is the not uncommon habit of taking small, useless fish rather than releasing them to grow and possibly contribute to the reserve of brood stock. Increased use of beardless hooks in Maryland typifies the best in fisherman sportsmanship, and with the more recent awakening to the seriousness of depletion, it is expected that the people who fish will of their own accord contribute most greatly to conservation programs. Without their help results are virtually impossible.

OTHER AQUATIC FORMS

There are many forms of life in Maryland's waters that contribute directly and, in the aggregate, greatly to the economic welfare of the State but which are known and discussed far less than the species enumerated up to this point. In addition, there are hundreds of types of animals which play no direct part in the economic structure but which, because of their beauty, their adaptations, their interesting habits, their small size, etc., are of inestimable value from biological and esthetic points of view. These abound, alike, in marine, brackish, and fresh water environments.

Where bodies of water penetrate land and to a degree inundate or partially submerge it, marshes are formed. The Chesapeake territory has a liberal supply of fresh marshes, while it abounds in salt marshes, formed in a large part by coastal sinking. These marshes constitute the year around habitat of highly prized and economically important forms, espe-

*Denmead, T., 1935. Report, Division of Angling, U. S. Bur. Fish. Trans. Am. Fish. Soc.

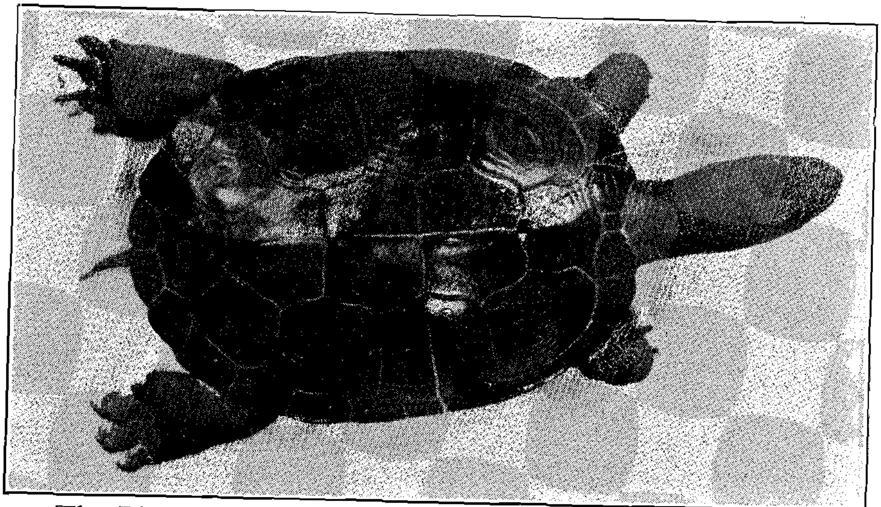
cially the black duck, *Anas rubripes,* the mallard, *Anas platyrhynchos,* the summer or wood duck, *Aix sponsa,* the blue-winged teal, *Querquedula discors,* the diamondback terrapin, *Malacylemmys* ~~contra~~ *concentrata,* and the muskrat, *Ondatra zibethica.* **concentra**

Wildfowl and shore birds are not permitted to be taken commercially, since wholesale destruction of them by "pot" hunters went hand in hand with commercialization, and the natural supply faced exhaustion. (Certain species were actually threatened by extermination.) This country-wide conservation pattern came through the U. S. Biological Survey after scientific study and interpretation of the facts gathered. When the constantly increasing number of sportsmen and untoward natural conditions threatened the supply later on, 1934-1937, further and very stringent regulations were initiated such as limiting the type of gun used, live decoys, baiting, shorter seasons, and the like. As a result of this alert action, and a policy of improving breeding grounds, there has been an almost phenomenal increase in nearly all of the species depleted. Maryland's aquatic bird resources are now being guided in a wholesome and promising fashion. There remain, however, two disturbing elements in this branch of conservation. In certain sections a few individuals have the tendency to destroy far beyond the legal limit. High powered long-ranged guns are still extant and with them as many as 175 ducks have been killed by a single firing. In a few places highly destructive duck traps still are being used illegally. Some of the gunners, many of them claiming to be sportsmen, have continued to over shoot the bag limit, and in cases the practice of baiting and live decoys have not been dropped. Efficient enforcement officers and an impartial judiciary, reaching out from Washington, give assurance that these weak points in water bird conservation will be corrected, and that the changing needs for their conservation will be met even though individuals here and there fail to comprehend that this resource is national and international in character.

Diamondback Terrapin

While Maryland is noted for her seafoods, having developed and controlled, in a large measure, the crab industry, and having produced in a single year more oysters than the rest of the world put together, and to do no more than recall the outstanding virtues of her wild-celery-fed canvassback ducks, it is her diamondback terrapin, *M.* ~~contra~~ **concentra** *concentrata,* that is considered to be the very epitome of epicurean delight. A measure of the esteem in which this form is held can be found in the fact that a single dozen of large Maryland terrapin has sold for as much as $112.00. For a number of years between 1895 and 1920 large terrapin commonly sold for sixty-five to eight-five dollars per dozen.

Terrapin live in and around salt marshes, the degree of salinity of which ranges from those near the sea to those located in the estuaries and upper reaches of the Bay where fresh conditions are approached. These reptiles are highly modified for their aquatic existence, since they can stand long submergence, have powerful muscles for propulsion, and their hind feet are webbed to a marked degree. Their food consists largely of worms, snails and crabs. Feeding is most actively carried on while the tide is up. During low tide they spend much of their time on the bottom or slightly imbedded in it. Feeding slows up late in September and by the time frost occurs in October they find shelter in the mud bottom for the winter period and activity practically ceases. On occasional warm spells during winter they may change quarters and even swim to the surface. The season of capture is from November 1 to March 31.



The Diamondback Terrapin, *Malacylemmys ~~contra~~ concentrata*
concentra

Diamondback terrapin have few enemies in the adult stage. However, during the egg period and in the early juvenile stage they are devoured in great numbers. Fish, birds, rats, and other mammals are the predators involved. At egg laying time, June, in Maryland, the mature female terrapin searches out a sandy or loamy area, usually on a hummock above the high tide line, and there digs a hole of sufficient size and depth to receive the eggs. There may be as many as eighteen eggs in a single clutch, although more typically nine or ten eggs are produced at a time. They lay eggs once a year. In exceptional cases two clutches have been observed.

The female builds the nest, in which operation she scoops the dirt out with her hind feet to a depth of about six inches and a width of three inches. Repeatedly she backs into the hole, scratches the dirt free, gathers it up between her hind feet, and pulls it to the surface and beyond. After the construction work is finished she backs down into the hole and deposition of the eggs take place. When this development is over she covers the eggs and completely fills the hole, leaving the eggs under about three inches of dirt. Beyond this no parental care is given to the developing eggs or to the newly hatched young terrapin. Predator animals, especially crows, find the freshly worked nests and peck into them only to devour the eggs. Foxes and racoons also are reported to be terrapin egg destroyers.

When young terrapin leave the nest late in August after an incubation period of approximately eight weeks, they are alert and able to swim effectively. However, they are still soft and they are comparatively defenseless. In their trip from the nest to the water's edge sometimes, though rarely, as much as a quarter of a mile must be traveled. It is at this time that they are destroyed most greatly. Occasionally young terrapin remain in the nests to over-winter. In any case, they do not consume food until the warm days of mid-spring following the hatching season.

Growth is slow and highly variable in the terrapin. It takes place at the rate of nearly an inch, lower shell, that is plastron measurement, a year during the first two years and thereafter it is slower until in the fifth year the increase is about one-half an inch. The sexes can not be determined until the third or fourth year is reached at which time a female is fully 25% larger than a male of the same brood, that is, about four inches long. At this time the females have a greater depth of body, while the head of the male is proportionally smaller. Another unfailing character found in mature specimens is the greater size of the body (proximal) end of the tail of the male in comparison with that of the female. Male terrapin reach maturity earlier than females, at which time the plastron measures about four inches. Females grow much larger. One specimen collected for the Laboratory had a plastron that measured 8.74 inches. However, six-and-one-half to seven inches marks the more common adult size.

The prices for which terrapin sell depend upon the size involved, small ones being a drag on the market. This means, of course, that a prize is placed upon the capture of the female, since she, alone, grows large. On the market males are known as "bulls", and they bring from four to eight dollars per dozen. The quality of food derived from them is considered less choice. Females are graded according to size. Those measuring between five and six inches, "half counts", sell for twelve to fifteen dollars per dozen, and those above six inches sell for correspondingly higher prices. The almost fantastic price already cited, $112.00 for a single dozen of terrapin, was paid for individuals which measured not less than eight inches. The great demand for female terrapin may account for the extreme depletion that has taken place in Maryland waters, although some compensation may be found in the fact that in the catch females are more numerous than males. This sex ratio is greater than two to one.

Biological facts necessary for the development of a comprehensive program to rehabilitate the terrapin industry in Maryland are not now available. The need of such facts, and a sound conservation policy based upon them for the development of this resource is apparent when it is considered that: (1) In 1904 there were 57 diamondback terrapin dealers in Maryland. (2) In 1916 there were 39 dealers in the State. (3) In 1937 there were only seven dealers in the State. (4) In Worcester County where some years ago there were four dealers not one is now in business. (5) St. Mary's, Calvert, Anne Arundel, Kent, Queen Annes, Talbot and Wicomico counties no longer produce terrapin in commerical quantities although once prolific areas. (6) It is known that a big number of the terrapin now shipped from Maryland is not of local origin, but is reshipped from the State after being brought in from southern points reaching to the Gulf, a condition brought about by depletion of native and superior stock.

Maryland's marshes, creeks, and shores are recognized as being second to none in the world for the production of choice diamondback terrapin, a form distributed in one species or another from New Jersey to Mexico. The State's natural areas in the main are as vast, as clean, and as fit for terrapin production as they were in the days when, according to reports, terrapin were so numerous as to be a nuisance to seine fishermen. At that time their abundance and low cost, three cents each, made them all too common for food with the result that many contracts for tidewater slave and indenture services provided that terrapin should not be served more than twice in one week. This form has entirely disappeared from several areas in the State where it once was common.

Hatching of terrapin and their husbandry has been shown to be feasible by the U. S. Bureau of Fisheries. Such work has been initiated at the Chesapeake Biological Laboratory in the hope of demonstrating this means of rehabilitation. Restoration in any event promises to be slow because of the rate of growth and long life cycle of the animal. The future of this valuable form will depend, largely, upon the policy formulated and carried out in its behalf.

Up to the present, attempts to maintain the terrapin have followed the general trend of conservation interest, that of "letting laws do it". Cold, bare laws, such as closing the season from April to October 31, prohibiting capture of terrapin measuring less than five inches on the bottom shell, and defining who may or may not be permitted to take them, cannot solve this problem alone. Human and biological factors must be considered for the industry's greatest good.

Muskrat

Maryland produces several kinds of fur-bearing animals and their capture brings profit to every county of the State. The muskrat, a semi-aquatic rodent, ranks first in its yield of fur, and in this resource the State ranks among the highest in the Nation. Estimates of the yield during the period of 1918-1922 have run as high as $5,000,000 per year. Mr. E. L. LeCompte, State Game Warden, in his effort to arrive at an accurate estimate of the value of the muskrat gave, in his revised edition of "Muskrat Industry of Maryland", 1930, the value as $2,500,000 annually. This sum is greater than that now realized from the depleted oyster grounds. Muskrats produce food as well as fur.

The common muskrat is a stocky built, short legged animal about 23 inches long, including a ten inch tail. The body is well adapted to water life, being streamlined, having hairy somewhat webbed hind feet, and with a laterally compressed tail. Its dense oil-slicked fur protects it from wetting and cold. Its mouth is so developed that the incisor teeth, those of most general use, are exposed, yet with the lips developed so as to exclude water when submerged, thereby enabling the animal to gnaw and to carry food or building material through its subterranean channels.

Muskrats are found throughout Maryland from the mountain streams of Garrett County to the coastal areas of Worcester County. They are present in greater concentrations, however, in the fresh or slightly brackish marshes bordering tidewater sections. Where there is an abundance of such plants as the three-square grasses (bullrushes,) *Scirpus americanus, S. olneyi* and *S. robustus;* broad-leaf cat-tail, *Typha latifolia;* narrow-leaf cat-tail, *T. augustifolia;* wild reed, *Phragmites communis;* salt grass, *Distichlis spicata,* and many other species of lesser importance, upon which they feed.

Animal matter is largely excluded from the muskrat's diet. They consume a wide range of plant species with marked preference for those named above. The productivity of a given area can be judged accordingly. During spring and summer the tender shoots and stems are eaten, and in the fall and winter the marsh is tunnelled in the gathering of roots for food. Muskrats are unusually clean in the matter of preparing their food, in their habits of defecation, and in their homes. Employing vegetation, they build platforms near their races to which they go with

Home of the Muskrat, *Ondatra zibeticus.*

food to be washed preparatory to eating. When these platforms are no longer used for feeding purposes they are converted into defecation stations. The animals do not pass their faeces indiscriminately to pollute the water in which thy live. The rats that live in banks along clear streams choose logs, tumps, or other projecting bodies upon which to pass their waste.

The home and the system of trails, canals, and tunnels constructed by the muskrat are extensive and intricate. Upstream dwellers, never abundant, burrow into banks and make their entrances below water level, thereby eliminating enemies. Those of the marshes build homes, or "beds", irregularly domed-shaped, from vegetation sometimes to a height of four feet and a width of seven or eight feet. The building material itself usually consists of stalks and roots placed on a solid base. This vegetable matter is transported in the animal's mouth and many hundreds of trips are necessary for a single bed, although the building of a big bed is not done in a single season, since the beds are added to in times of high water, during the period of gestation and upon the approach of winter. Usually there are two nests in a home, although not infrequently three are constructed. These nests are kept lined with fresh material. Always in building a nest the rat constructs below it a plunge hole to the tunnels and canals, thus making escape readily possible. There is no opening to the house above water.

Being essentially aquatic, muskrats depend primarily upon swimming for locomotion, thus they construct an elaborate system of waterways on, in, and under the marsh surface, known, respectively, as trails, canals, and tunnels. All three systems contribute to food gathering and transportation, while the last named serves as an avenue of escape being connected by plunge holes not only to the homes but to the trails and canals as well. Canals may interlock throughout marshes and serve communities as well as families. A tunnel is more limited to the use of a single family.

Muskrats are markedly nocturnal, although during spring and summer they are somewhat active in the afternoon. Under cloudy conditions they are very active. During severe cold spells they persistently remain in their nests. While under water these rats exercise a remarkable adaptation in that they are able to suspend breathing for comparatively long periods. Our own record indicates that they may remain submerged for nine minutes and eleven seconds. Frank R. Smith, in his report on investigations in Maryland, 1934,* reports an observers record of seventeen minutes submergence.

The breeding season of the muskrat extends from early March until September, although "kits", very young rats, are found occasionally the year around. Embryos are found infrequently in trapped animals at the start of the season in January. The peak of births takes place about May the first. The average number of young per litter is slightly above three though variations run from one to seven in Maryland marshes. Approximately four weeks are required for the developmnt of young after mating takes place. At birth the young are backward, comparatively helpless, nearly

*Smith, Frank R., 1938. Muskrat Investigations in Dorchester County, Md., 1930-34. Circular No. 474, U. S. Department of Agriculture.

naked ceatures whose eyes are not opened for ten or twelve days. Nursing continues for three weeks or more, by which time solid food has replaced milk. The sexes vary in different broods, but as a whole are evenly distributed. Trappers take more males than females, a condition that is wholesome for the industry, since polygamy is practiced.

A great many predators on the muskrat are reported, including reptiles, birds, and mammals. Following is listed those forms thought, by the trappers, to be greatly destructive: water snake, *Tropidonotus fasciatus;* black snake, *Coluber constrictor;* king snake, *lampropeltir getulis;* the bald eagle, *Haliaectus leucocephalus;* the marsh hawk, *Circus hudsonius;* red-tailed hawk, *Buteo borealis;* barred owl, *Strix varia;* great horned owl, *Bubo virginianus;* barn owl, *Aluco pratincola;* racoon, *Procyon lotor;* weasel, *Mustela noveboracensis;* and the fox, *Vulpes fulva.* Considering the nature of the environment, soft marshes criss-crossed by canals and tunnels, and the nocturnal and submergence habits, as well as the home construction with openings only to plunge holes, the muskrat would appear to be safe from practically all of the predators reported, except possibly in flood time when there is some exposure. Stomach analyses of these predators indicate that muskrat constitutes virtually no continued important item of the diet, except, possibly, in the fox. Parasites on muskrats are few and of little importance, while disease is rare. No epidemics have been reported in Maryland.


Muskrat Meat Prepared for the Market.

The pelt of a Maryland muskrat sells at varying prices, depending upon the quality and the size of the fur. Until about Christmas time the fur is coarse and thin, thus of inferior quality. Occasionally fur of this kind is taken in mid-winter. The pelts are graded as kits, mediums, and primes in some sections, and as primes and seconds elsewhere. Another factor influencing the value of the pelt is its color, which is brown or black with some gradation between the two. Only occasionally is an off color rat, such as an albino, captured. While the value of pelts fluctuates during the season there are still greater fluctuations from year to year, depending upon general economic conditions and the supply. A fair price is one dollar and twenty cents for a black pelt and seventy-five cents for a brown one. Muskrat fur is used for wearing apparel both in its original color and dyed. It is known in the fur trade as "hudson seal." The carcass of the rat, which weighs about two pounds and is used for food, sells for 15-25 cents. It is a delectable, rich food highly favored by connoisseurs.

The muskrat is the only form associated with water life in the State that has not suffered depletion. There have been years of very high productivity and conversely. These fluctuations largely seem to be traceable to physical conditions in the environment such as droughts and high tides. When the tide rises to a point of covering the beds, especially in late spring, the young are lost. Salt water invasions, in turn, adversely affects the vegetation upon which the rats feed. Too little water, as during the drought year, 1931, lowers the water level to a point that not only kills the food but takes away from the animal its avenues of travel and escape, as well as its drink. The fact that the catch, year in and year out, consists of more males than females in this polyagamous animal apparently helps to maintain a high level of production. Land owners and trappers, generally, recognize the need of closed seasons and the maintenance of a sufficient level of brood stock for maximum yields. They stop trapping operations even before the season, which is from January first to March fifteenth, is out if the supply runs low. They are opposed to gigging, shooting, and night hunting, all of which are illegal. Laws are obeyed both as to the spirit and the letter, a condition that might well be copied in the harvesting of natural resources state-wide.

SUMMARY

Gathering our wild life resources constitutes unique industries in that their contribution to man's well being is measured not only by vast employment but by millions of dollars realized through harvesting without sowing and cultivation. The fisheries, especially, afford employment to a sizeable portion of the American people and contribute most wholesome food to their diet. These resources are being handled, in many cases, after the fashion of our pioneering ancestors who, finding wild life in such abundance as to be in their way, killed recklessly. Little thought was given to future generations, a condition that still exists all too strongly in many quarters.

In his eagerness to develop America and set up giant wheels of industry, man has marred the face of the land and partially disembowelled it. He has destroyed the forests in no small degree without replanting them; he has slaughtered the fine animals that populated woods, fields, and streams whenever they crossed his purpose or whenever their destruction satisfied his whims. Fortunately, most of the waters of the country, and especially those of Maryland, are so exceedingly rich that they have been able to maintain their animal life in spite of the great drafts made on them by man. The time has come, however, when conservation in its fullest sense, "wise development and use", must be employed if our valuable water life, so greatly needed in the diet, is to continue to serve its utilitarian and recreational purposes. As the soil becomes thinner and thinner, denuded of its soluble elements by erosion and agricultural practices, America's waters will be called upon to supply food and to meet nutritional demands no longer possible from land grown crops. If it is true, as is claimed by certain well informed medical men, that thirty-five million Americans are suffering to some degree from food deficiency disorders of a type that can be prevented or corrected by seafood consumption, the time for conservation is here right now. The situation is challenging.

Laws are not sufficient to protect Maryland's water life from thoughtless and selfish people who persist in exploiting the fishery resources without giving consideration to the future. Just as encouragement through protection, reservations, and supplying food and homes is offered to birds and other types of wild life, there is strong need for an interest in water forms. A stone lying at the bottom of a steam represents a small world inhabited by a great many animals and plants; insect larvae, insect eggs, leeches, adult and young, along with their cocoons and eggs, small mollusks, mites, fish eggs or fry, tadpoles, and many other forms of life very often are found there. Many of these inhabitants cannot stand exposure to the rays of the sun and, if a disturbance of the bottom is made, the result may be the death of hordes of organisms which represent a definite link in the food cycle of some higher and more valuable form. Such disturbances, if exaggerated, may divert even schools of fish from their spawning ground, thus effecting conditions that react unfavorably to the production of commercial forms.

An individual may destroy some little natural setting, capture an undersized animal, or otherwise take a liberty for a definite purpose or just for fun. When we consider that such destruction, though not wanton, is practiced by most of the people who fish, the result is a tremendous drain on our resources. If we should allow a sufficient number of our valuable wild forms, regardless of species, to reach sexual maturity and reproduce at least once before they are captured, the supply would remain inexhaustable except as man alters the environment through such developments as drainage, pollution, or like factors. Where salt water fishing is concerned, in most cases, laws do not establish a limit for the capture of fish. Unfortunately, most of our sport fishermen capture fish as long as they bite the hook and whether or not there is need for the fish as food afterward. Not infrequently the commercial men will set their nets among immense schools of valuable fish and haul them in without regard to size and efficient marketing. In many cases such fish create a glut on the market and much of the supply that is captured is spoiled and condemned as unfit for food, thus becoming a total waste. Such fish, if left in the water, would, in most cases, augment later catches of larger fish and add to the brood stock to contribute to a higher level of production in years to follow. Outstanding ills in the management of our fisheries are those of the destruction of fish that are under size and the capture of unlimited and unuseable quantities of fish of merchantable sizes.

The people of Maryland condemn many of the destructive practices in our fisheries. Yet, almost unlimited fishing is allowed on the breeding grounds, innumerable small fish are taken along with the larger fish because the devices employed have meshes of sizes that do not permit them to escape, probably bringing about a destruction of undersized fish comparable in extent to the numbers of marketable fish taken. Barbed hooks tear and fatally injure many fish, a condition that could be relieved—by the use of barbless hooks—without affecting the sportsman or the fish. Hatcheries and artificial propagation cannot solve our fishery problems and keep apace with the improvements in transportation, facilities for capture, and the increasing numbers of those who would capture the fish for commercial purposes; or keep apace with the use of leisure time for fishing, which society is making available more and more for the average person. Especially difficult is the prevailing attitude of the average commercial fisherman, who holds to the point that if he doesn't take the fish today some other person will get it in his stead tomorrow. It is this attitude that accounts for the vast catches from intensive and extensive fishing for which there is no market; for the use of questionable gears; for the capture of fishes illegal in size; for poaching and other destructive activities. Fish left in the water are not a loss to the fisherman, but constitute an escapement that later on will contribute to reproduction, to growth, and to the development of sizes of fish for which there is a greater market demand.

Approximately one-half of the former oyster producing bottoms of the Chesapeake are now non-productive and of the remaining productive areas the yields, with certain sections excepted, are small and unprofitable. Only ten percent of the shells that accumulate annually from Maryland's oyster crop remain the property of the State to be returned to the beds where they are so badly needed to increase yields. Every shell from the entire industry is needed in any comprehensive attack on the problem of depletion of this resource. Leasing of barren oyster bars is not permitted, thus private initiative and available capital are not allowed to play a part in the rehabilitation of the industry, as in many other states. The general practices in preparing oysters for the market and the fact that extremely few large oysters are marketed from Maryland waters, except those brought in from remote regions of production and derived from oyster farming, militate against expanded consumption and sales. This in spite of the nutritional and therapeutic values of the molluscs and their low cost. The need of improvement in the methods of production, the methods of preparation and the methods of marketing are patent. There is no place in the entire program of conservation in Maryland where industrial leadership and political leadership are so completely challenged, especially since the extreme richness of the Bay offers potentialities almost without parallel world-wide.

The waste of the blue crab is equally marked and unnecessary even though the industry is of lesser importance than that based on oysters. The vast destruction of peeler crabs on floats and the use of green or poor crabs in the cooker in Maryland, and the almost unlimited capture of pregnant and egg-bearing crabs in Virginia, constitute a menace to maintenance of sound conservation and make continued high levels of production virtually impossible. Intelligent approach to this problem merely consists of assuring a constant and sufficient level of brood stock. Through cooperative effort on the part of the two states involved, in which wanton waste would be stopped and sanctuaries would be instituted, this species could be conserved for future use while the industry based upon it effectively could be rehabilitated.

Conservation has had a wide but more or less abstract appeal to the citizens of Maryland for many years as witnessed by the worthwhile plans that have been advanced to correct depletion of our natural resources and that have failed to become operative. During the period of depletion many new implements of destruction have been invented and perfected. Among them we should recall the gas motor, its application to boats and machinery, non-escape traps for muskrats, new types of pound and gill nets for fish, smokeless powder, pump guns, sink boxes, live decoys and baiting for water fowl, and more recently a fyke arrangement for the capture of crabs and terrapin, to name a few devices that have contributed to great depletion, especially when it is considered that the forms involved receive a minimum of encouragement, to offset capture, beyond the passage of laws good and bad, alike, the enforcement of many of which is impractical if not impossible. Probably a greater factor still in the depletion activities is the seemingly inherent nature of those who depend upon natural resources to capture almost without reservation and legal limitation. The problem of correcting the situation that exists, including the poorly functioning processes of law enforcement and justice, seems to depend, in no small measure, upon education, up to this time a neglected feature. This challenge stands before the leadership of the State. The future of Maryland's aquatic resources, from vast waters of known purity, richness, and high capacity for production, can be made to excel in quantity and quality and, better yet, they can be preserved at a high level to support great segments of the population on a better economic and social plane, including not only the present generation but those generations yet to come.