1945

The Biology and Conservation of the Blue Crab, Callinectes sapidus Rathbun

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William and Mary and Commission of Fisheries

EDUCATIONAL SERIES No. 4

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COMMONWEALTH OF VIRGINIA
Division of Purchase and Printing
Richmond
1945

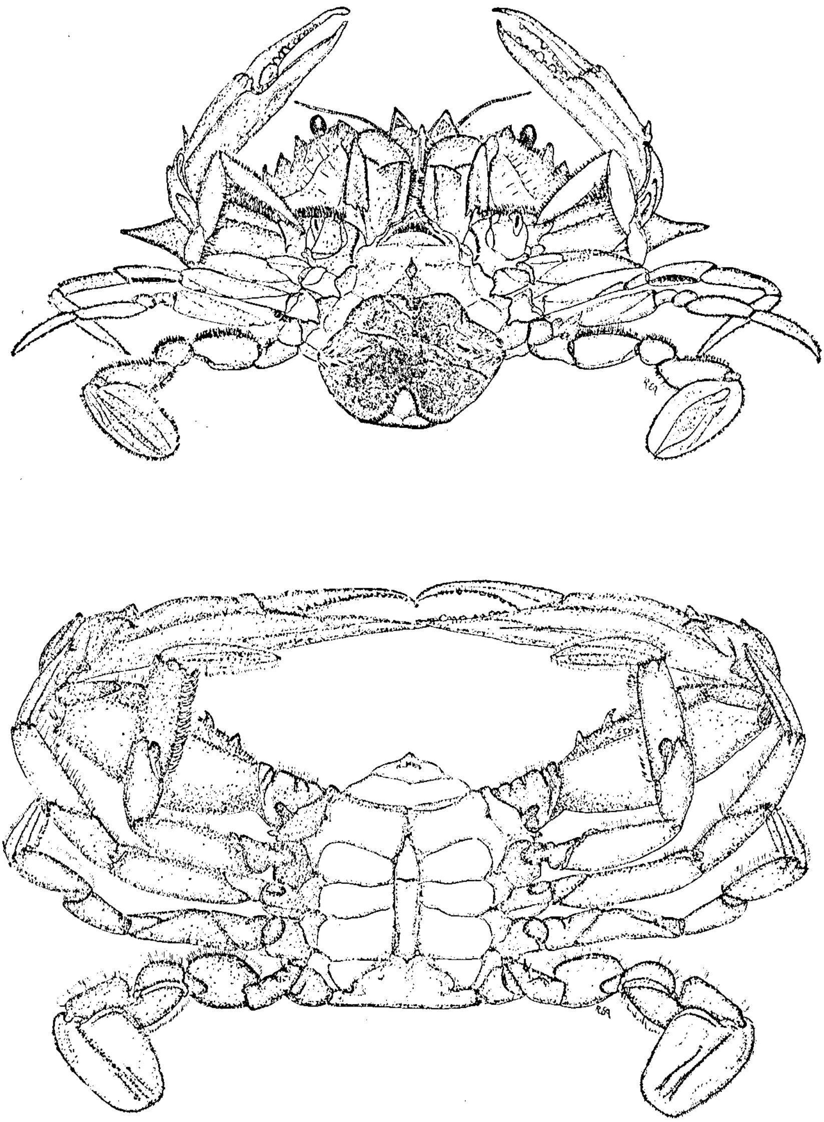

FIGURE 1.—Ventral (under surface) views of female and male blue crabs. Upper, female showing two bulb-like *eyes* at anterior (front) and large *sponge* at posterior (back) end; lower, male with carapace or shell removed, showing *five pairs of legs* on sides of the body and a pointed *apron* or *abdomen* in the center. See table I (*drawn by R. E. Allen*).

The Biology and Conservation of the Blue Crab, Callinectes sapidus Rathbun*

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CURTIS L. NEWCOMBE
Virginia Fisheries Laboratory

The number of blue crabs caught annually in the Chesapeake Bay States is about 200 millions. The annual poundage for the years 1929-1941 averaged approximately 51 millions with a corresponding value of $623,000. A peak production of about 65 million pounds, valued at approximately $1,193,000 was reported for 1931. In 1941 a low level was reached when the yield was only 30 million pounds, but the value was $1,188,000. Thus, prices were so high that less than one-half the poundage of 1931 brought approximately the same financial return ten years later.

Fluctuations in the abundance of crabs are of vital importance to the many persons engaged in the crab industry. The causes that underlie unusually high and low levels of abundance are not well understood. Biologists are seeking explanations of varying yields for the purpose of discovering ways of maintaining reasonably uniform levels of high production. Occasional high yields of crabs may serve to glut the market and hence may not necessarily result in a proportionately larger income to the fishermen. For industry to utilize them most effectively high annual yields must come in succession.

In order to bring about a more efficient handling and development of this Virginia resource an informed industry, including all those who participate in the production of this seafood, is essential. Conservation must be practiced by the crabber and the dealer as well as by the fishery officials.

This pamphlet presents a general description of the life history and structure of the crab, and shows how environmental conditions may affect the abundance of crabs. A general account is given of the ways in which crabs are caught, handled, packed,

*Requests for copies of the Educational Series should be sent to the Director, Virginia Fisheries Laboratory, Yorktown, Virginia.

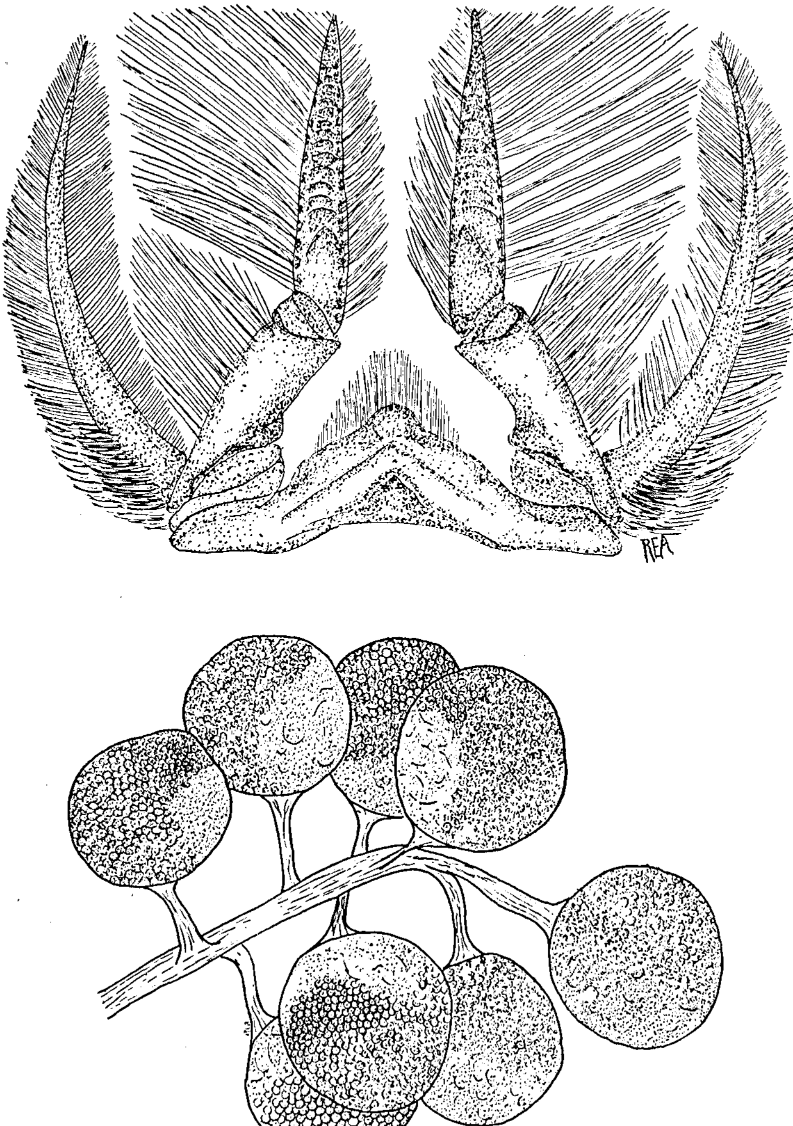


FIGURE 2.—Lower, eggs attached to hairs of pleopod, about eleven days before hatching (*drawn by R. L. Robertson*); upper, pleopod from abdomen of female, to which eggs become attached (*drawn by R. E. Allen*).

and shipped. Certain State regulations governing the prosecution of the fishery are reviewed and interpreted in light of their importance to the development of a larger and more profitable industry.

Information is presented in order to assist teachers of conservation, and the pamphlet is designed to accompany the fishery demonstration units which are provided free by the Laboratory for classroom use in Virginia schools.

Thanks are expressed to Mrs. Ruth Ellis Allen and Mr. Roy L. Robertson for the preparation of drawings and to the Virginia State Chamber of Commerce for making numerous photographs. Dr. S. H. Hopkins and Mr. John C. Pearson kindly read the manuscript and offered valuable suggestions.

LIFE HISTORY

Larval Crabs.—Crab eggs (0.01 inch in diameter), numbering around 2 millions in a single sponge or egg mass, are attached by a glandular secretion to hair-like branches of the appendages of the abdomen or "apron" (figure 2). About two hours are required to deposit a sponge and approximately two weeks for hatching under favorable conditions. During the first seven or eight days of the hatching period, the sponge is orange and yellow in color. Then the eggs become progressively darker until hatching time.

In Chesapeake Bay hatching occurs chiefly during the months of June, July, and August. The first larval stage or *zoea* is formed when the embryo emerges to the water. The empty egg shells remain for a time attached to the abdominal appendages, known as *pleopods.* The zoea larva is about 1/25 of an inch in length and has a conspicuous dorsal spine and prominent eyes and mouth parts (figure 3). The zoea probably molts five times, the period between two successive molts being known as an *instar.*

Following the last instar of the first larval stage, a molt characterized by conspicuous change marks the beginning of the second larval stage called *megalops* (figure 3). The megalops larva is somewhat more crab-like in appearance than the zoea larva, being broader in proportion to its length and having biting claws and pointed joints at the ends of the legs. This larva is about 1/7 of an inch in length, and results to date indicate that it molts directly into the "first crab" stage which has proportions more like those of an adult but is only about 1/10 of 1 inch in

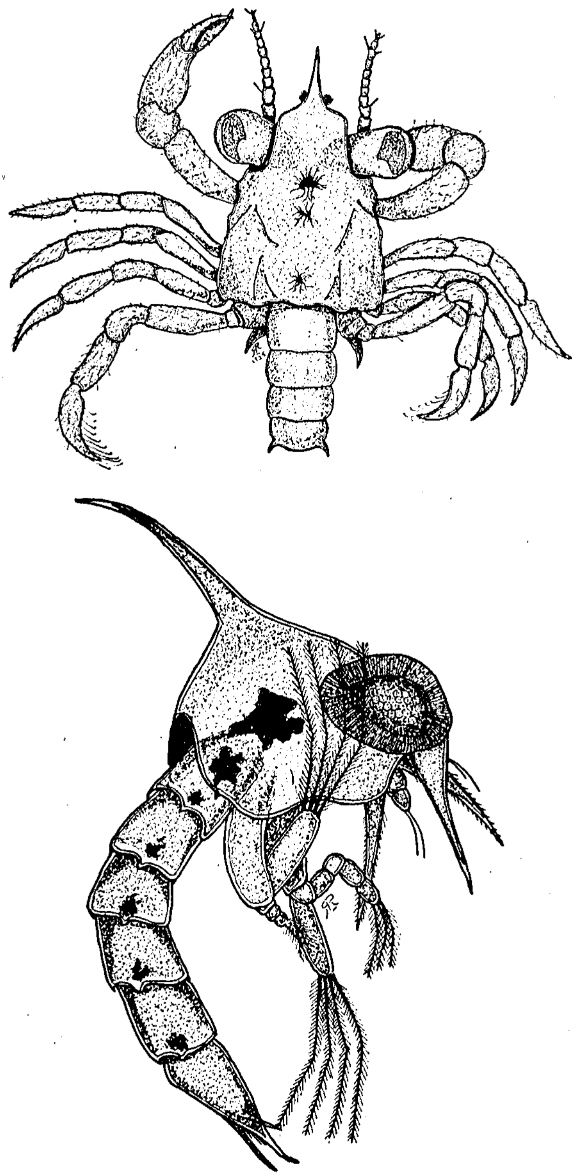


FIGURE 3.—Lower, first *zoea* larva of the blue crab, about three days after hatching; upper, the *megalops* or last larval stage of the blue crab (*drawn by R. L. Robertson*).

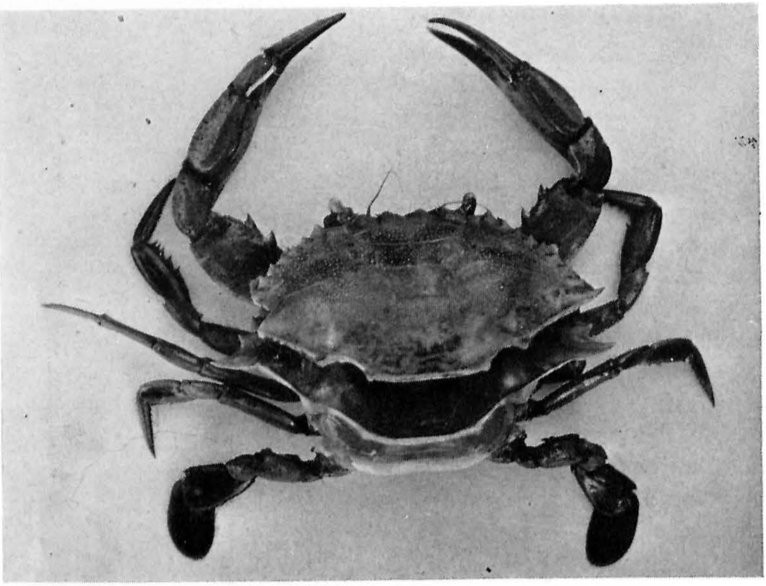
width. About one month is probably required to complete the *zoea* and *megalops* stages.

Egg-bearing crabs are most abundant in the southern waters of the Bay and the zoea larvae are most numerous near Cape Henry. In 1941, eggs were removed from the sponge mass and hatched into zoea larvae at the Laboratory in Yorktown. Thereafter, it was found possible to rear the larvae through the third zoeal stage and to find out what environmental conditions in Chesapeake Bay are most suitable for hatching and larval development. With this information the proper boundaries for a sanctuary to protect brood crabs can be established. Figure 9 shows the location and extent of the crab sanctuary established in 1941 by the Commission of Fisheries of Virginia to protect the egg-bearing crabs. Laboratory studies have shown that the salinity and temperature conditions in this area of the Bay are the best for development of zoeal or first larval stage crabs.

Experiments in the laboratory have shown that, while waters having salt concentrations ranging from about 22 to 28 parts per thousand are needed for normal hatching of eggs and for normal development of the zoea larvae, the amount of salt in the water does not need to be nearly as high for the survival and growth of the megalops larvae and the early crab stages of development. *Megalops* and small juvenile crabs may be reared in waters having salt content as low as five parts per thousand, which is the salinity that occurs in the upper brackish waters of the Tidewater rivers and in about the latitude of Baltimore in upper Chesapeake Bay.

Juvenile Crabs.—The "first stage" crab is about 1/10 inch in width*. Molting every three or four days at first and then progressively less often, the young crab reaches a marketable size in about one year. Durng the last four sheddings about twenty-five days may elapse between molts. Crabs around ½ inch in width, that have shed about seven times increase approximately 11 per cent during molting whereas those 4 inches in width increase as much as 40 per cent. The average intervening percentage increase is around 30. The increase in size during or immediately after the molt is due to a rapid intake of water probably by absorption through the general body surface of the

*Width of crabs is measured from tip to tip of the lateral spines or spikes.



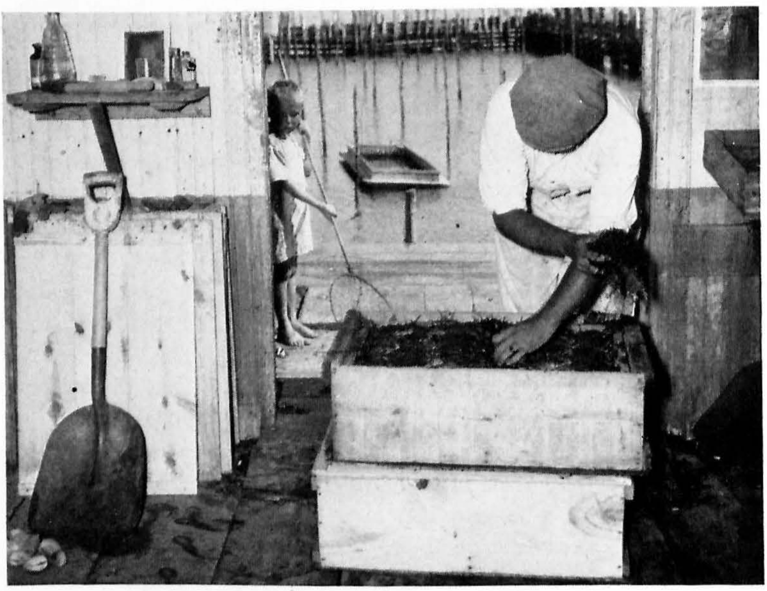


FIGURE 4.—Upper, a blue crab in the process of shedding its shell (*photograph by C. M. Coker*); lower, view of soft crabs packed with seaweed. A float used for shedding out peeler crabs is shown in the background (*courtesy of the Virginia Chamber of Commerce*).

crab. This increase in related crabs is known to be as much as 70 per cent of the body weight previous to molting. Altogether, the crab molts about eighteen times during its post-larval life. In search of better environmental conditions and protection, the molting crabs are present in largest numbers in shallow waters. Here the "peeler" crabs, those preparing to shed, and soft crabs are gathered for commercial purposes (figure 4). The legal size for "peeler" crabs is 3 inches and that for soft crabs is 3.5 inches. This phase of the fishery is known as the peeler crab or soft crab industry. It is concentrated in the middle section of the Bay near Crisfield, Maryland and Tangier Sound, Virginia.

Adult Crabs.—Adult crabs range in width from about 4 to 8 inches. The legal size for hard crabs is 5 inches or more in width. The length dimension is from about 40 to 50 per cent of the width. The female crab molts for the last time when it is sexually mature.

In observing living specimens in the laboratory, attention centers on the way the crab moves, on differences in the color of the body parts, both outside and inside, and in the particular kinds of appendages that serve for protection, feeding, walking, and for holding and aerating its eggs in the case of the female. Notice the position and movement of the eyes. If an eye is placed in a 7 per cent solution of sodium hydroxide for two or three hours, the thin layer, called the *cornea*, covering part of the eye may be readily removed and placed on a glass slide for examination under a microscope. The hexagonal facets of the eye will appear as in figure 5. They are the visual units of the eye, many hundred of which permit the crab to see in all directions without necessarily moving its eye. The outside covering or surface cuticle of the body is modified in the organ of sight to form a transparent lens through which light enters the eye. This lens is secreted by epidermal cells. Below it are the cells called facets that are very sensitive to light.

The usual color of the crab is dark greenish olive with considerable red and blue. One albino crab was brought to the Laboratory by a fisherman. It is not unusual to find young crabs that are brownish in color with conspicuous white markings. Under laboratory conditions, color changes have been observed within a few hours. These changes seem to correspond with changes in the color of the background. The cells which control the color changes are called chromatophores. They are located in the outside layers of cells that compose the membrane (hypodermis) that lies immediately under the hard carapace and other exoskeletal parts. In the molting process, the hypodermis produces the new exoskeleton. The chromatophores are activated by hormones which are internal secretions produced by glands (chiefly the sinus gland) located for the most part in or near the eyestalks. Little is known about the number and properties of the activating substances (chromatic neurohumors) contained in the secretions.

There are five pairs of thoracic appendages, three pairs of which are walking legs, an anterior pair bearing claws or chelae, and a posterior pair bearing paddles (figure 1, table I). Note their joints and how they operate during movement. The crab may be stimulated so that students are able to observe habits of movement and defense tactics. The function of the tentacle-like antennae (figure 6), projecting outward from the region of the eyes, and the uses made of the several mouth parts in feeding can be demonstrated to a class with good effect (table I, figure 7).

A comparison may be made of the crab and the crayfish. Both have a bright colored exoskeleton which is hard except for a few hours after they have molted. Both have a united head and thorax called the *cephalothorax*, the dorsal surface of which is covered by a shell called the carapace. The abdomen of the male crab is long and pointed (figure 1). The abdomen of the immature female crab is triangular in shape whereas that of the sexually mature crab is broad and rounded. The pointed abdomen of the male crab has, in all, six segments (figure 1). On the ventral surface the pleopods of the first abdominal segment consist of a pair of long, intromittent appendages called *cirri*, while those of the second segment are short. Both pairs of pleopods represent a profound modification of structure for mating purposes. Of the six abdominal segments of the female, each of the first four bears a pair of pleopods (figure 2). These pleopods hold the eggs which form the large mass called the sponge (figure 1).

The exoskeleton of crabs and their relatives consists of a hard cuticle that is non-living. The surface of the cuticle consists

TABLE I

Characteristics of the Body Parts of the Blue Crab

PARTS	Location	Color	Function	Comments
Appendages: Eyes (fig. 1).....	Project mid-dorsally from anterior edge of carapace.	Cornea blackish; movable stalk dark brown.	Sight organ; can see in all directions without moving.	Compound eye; hexagonal plates or facets form cornea.
Antennae 1 pair..	Between the eyes........	Light brown............	Sensory appendages; receive chemical and tactile stimuli.	Long, jointed feelers with many segments.
Antennules 1 pair.	Between the eyes but more centrally placed than the antennae.	Light brown.............	Sensory appendages; receive chemical and tactile stimuli; control equilibrium.	Shorter and thicker than antennae; segments longer and fewer in number.
Legs, 5 pairs: 1st pair (fig. 1)	Anterior and lateral; first pair of legs.	Chaelae or claws white to blue shades of reddish-purple at teeth; touches of red at joints.	Grasping and bringing food to mouth; protection against enemies.	Teeth of one claw are sharp, and those of other blunt.
2nd, 3rd and 4th pairs.	Extend laterally and posteriorly from under carapace—walking legs.	Light olive green (W.54) to blue (W.83) with tinges of red at the joints.	Locomotion.	Possess ability to cast these at will (autotomy) and can regenerate lost appendages.
5th pair called paddles.	Posterior-most pair of appendages.	Blue to gray (W.110); joints red (W.5).	Modified walking legs used for swimming.	Last segment noticeably flattened (paddle); color of paddle rim indicates stage prior to shedding.

TABLE I—Continued

PARTS	Location	Color	Function	Comments
Appendages (cont'd) Mouthparts—6 pairs:				
3rd maxilliped (fig. 6)	Ventral; outermost pair...	White; color of ventral surface.	Chemical, tactile organ, holds food; flabellum rakes gills.	Thin, calcareous and jointed.
2nd maxilliped.	Underlies 3rd maxilliped..	Similar to above.........	Similar to above.........	Similar to but smaller than the 3rd.
1st maxilliped.	Underneath 2nd maxilliped.	Similar to above.........	Similar to above.........	Similar to the 2nd but with flabellum.
2nd maxillae.	Underneath 1st maxilliped.	Similar to above.........	Create water currents in gill chambers.	Thin and membraneous.
1st maxillae..	Underlies the 2nd maxilla.	Similar to above.........	Similar to above.........	Similar to 2nd.
Mandibles...	Innermost of 6 pairs of mouthparts.	Similar to above.........	Crush food.............	Dense, solid bodies, with movable, 2 jointed portion.
Pleopods: Female, 4 pairs (fig. 2)	Abdominal appendages, ventral, attached to abdomen or apron.	Cream colored..........	Used for attachment of eggs.	Fringed with long hairs to which, during breeding season, the eggs are attached.
Male, 2 pairs.			Modified for transfer of spermatozoa.	Third and 4th pairs absent.

Carapace (fig. 4)......	Dorsal surface, forming shield-like covering.	Dark greenish olive (W.-21) spines red (W.5) at tips, two lateral spines red-brown.	Protective covering for anterior-dorsal surace of the body.	About 3 times as wide as long; anterior semi-circular margins shows 8 small serrations on either side and 2 large lateral spines.
Hypodermis (fig. 7)...	Membrane lying immediately under the exoskeleton.	Gray to dusky slate-violet (W.101).	Bears chromatophores; forms new exoskeleton on moulting.	Reabsorbs certain minerals from old shell before shedding.
Gills—8 pairs........	In body cavity on straight line with lateral spines.	Light olive-gray (W.22)...	Respiratory organs; remove oxygen from water and impurities from the blood to the water.	Covered by cuticle; finger-like and pyramidal in shape.
Stomach............	Middle anterior half of dorsal surface.	White, transparent.......	Digest food; contains a grinding organ called a gastric mill.	Held in place by several calcified rods called ossicles.
Hepatopancreas or liver.	Extends under the ovaries and along sides of stomach.	Light olive-yellow (W.127)	Produces digestive secretions and stores minerals.	Consists of a great number of tubules.
Heart...............	In the pericardial cavity near center of body, on dorsal surface.	White and somewhat translucent.	Pumps blood to various parts of the body.	Saddle-shaped.
Reproductive organs: Ovary (female)	Extend anteriorly and laterally around the outer edge of body cavity.	Gray to bright orange depending on the season.	Produces eggs..........	Consists of 2 lateral portions and a cross-bar.
Testis (male) (fig. 7).		White, somewhat translucent.	Produces spermatozoa....	Thin convoluted tube with two lateral portions and a cross-bar.

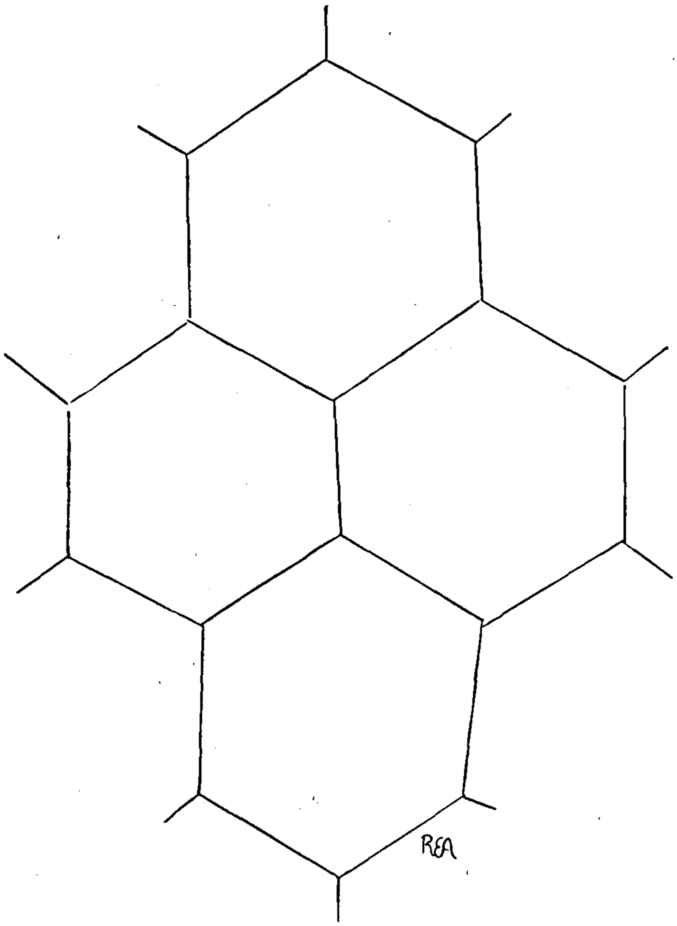


FIGURE 5.—Four hexagonal facets of the crab eye (*drawn by R. E. Allen*).

of a thin waxy layer which makes it waterproof. Below this is a heavier layer made up of *protein* and of *chitin*, a horny flexible substance which gives elastic properties to the exoskeleton. In the more rigid parts of the body the cuticle has a third and intermediate layer formed by an infiltration of parts of the first two layers and lime salts, chiefly carbonate and phosphate. Flexible joints are thus made possible by an alternation of rigid areas with flexible membranes which permits movement.

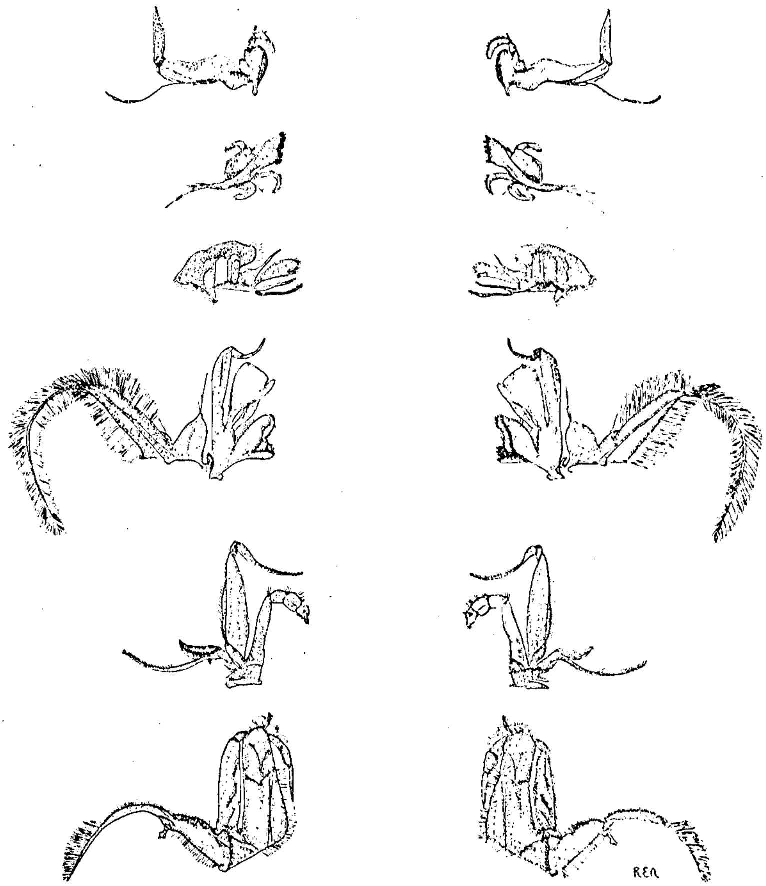


FIGURE 6.—Paired mouthparts are named in order, from top to bottom: mandibles, first maxillae, second maxillae, first maxilliped, second maxilliped, third maxilliped. See table I (*drawn by R. E. Allen*).

The underlying membrane or hypodermis that produces the exoskeleton is a most remarkable tissue (figure 7, table I). Water passes through it when absorbed by the body. In molting, some soft crabs absorb water amounting to 70 per cent of the body weight prior to the molt. The hypodermis resorbs some of the mineral salts and organic matter from the old cuticle before it is cast off. This resorption is believed to take place particularly at the posterior part of the carapace along the lines where it splits apart from the rest of the skeleton. In the case of a related crab, it has been estimated by English investigators that 79 per cent of the organic matter and 18 per cent of the mineral salts are withdrawn from the cast exoskeleton at the molt. It is believed that most of the phosphorus and some of the calcium are probably stored in the soft tissues of the crab for use in forming a *new* skeleton. It is known that soft crabs are able to *absorb*, through the epidermis, ions of calcium from the sea water. This calcium is likewise used in the formation of the new skeleton.

Figure 7 and table I show the appearance and function of the parts of the crab. By varying the background of this animal, color changes may be brought about and tabulated on the chart according to the Webster system*. The *carapace*, or broad dorsal covering, may be removed by cutting around the inner edge with scissors. Eight small spines lie between the eye and the large lateral spine. The tough, slate-colored membrane or hypodermis is covered with numerous light spots and underlies the shell. By carefully removing the hypodermis with forceps one can locate the paired, olive-gray, finger-like processes, pyramidal in shape, called *gills*. They are enclosed in a tough, transparent cuticle and radiate out from the center of the body cavity. Five pairs of gills lie above the bases of the legs and are visible, while three smaller pairs are deeper down in the body. The gills are located in the respiratory chambers on the sides of the crab. They take up oxygen and give off carbon dioxide to the water that is drawn in and out of the chambers through definite channels by movement of the flabella or *gill rakers* which are located on three pairs of the mouth appendages. At the bottom of the gill chamber and lying across the gills there are on either side three narrow flabella fringed on both sides with hairs that move up and down over the surface of the gills and create circulation.

The *hepatopancreas* or liver occupies an anterior position near the serrated margin of the carapace. It appears as a greyish yellow-colored organ that has lobes with branching lobules, the ends of which separate or fray out when submerged in water. The liver extends into the more central and deep parts of the body under the stomach and heart so that it fills a large part of the body cavity. In the case of other crabs in the same family

*Consult Color Charts of Webster's New International Dictionary, Second Edition, 1944.

as the blue crab, it has been found that there is a considerable storage of calcium phosphate in the hepatopancreas before molting time. After molting this supply is apparently used to harden the new exoskeleton. Part of the calcium content of other soft tissues is also used immediately after the molt.

The large transparent *stomach* occupies a middle anterior position under the carapace and in surface view is pear-shaped. Pairs of calcified rods, called ossicles, hold the stomach in place and some occur inside of it to make up the teeth of the *gastric mill*, a typically crustacean grinding organ. The stomach of a freshly killed crab may contain bits of food that are large enough to be recognized.

Located near the center of the body cavity there is a membrane called the *pericardium*. The pericardial cavity contains the heart which is a fleshy organ and is somewhat saddle-shaped. In living specimens, its light color and pulsating movements are noticeable. At the anterior end the sinuses may be seen. Through them aerated blood from the gills enters the heart and is thereby pumped into the arteries and thence to the different parts of the body.

The color of the reproductive organs or *gonads* of the mature female varies from light grey to bright orange in color depending on the stage of their development. There are two ovaries connected by a crossbar near the posterior end of the stomach and extending in linear fashion some distance posteriorly, but mostly in an anterior and lateral direction, around to and beyond the spines. When ripe, the ovaries are greatly distended and occupy a large part of the body cavity. They lie on top of the hepatopancreas. In the case of mated females, two large salmon colored sacs, called *seminal receptacles*, may be seen in a central position just anterior to the sides of the heart. They may store viable spermatozoa for a year or more. During spawning, eggs pass through the seminal receptacles and become fertilized on their way to the outside of the body.

Occupying a position similar to that of the ovary, there is, in the male crab, a string-like reproductive organ or *testis* in which the sperm cells are produced and stored. The testis consists of two small lateral tubes with a connecting cross-bar and is recognized by its characteristic folds. Leading from each side

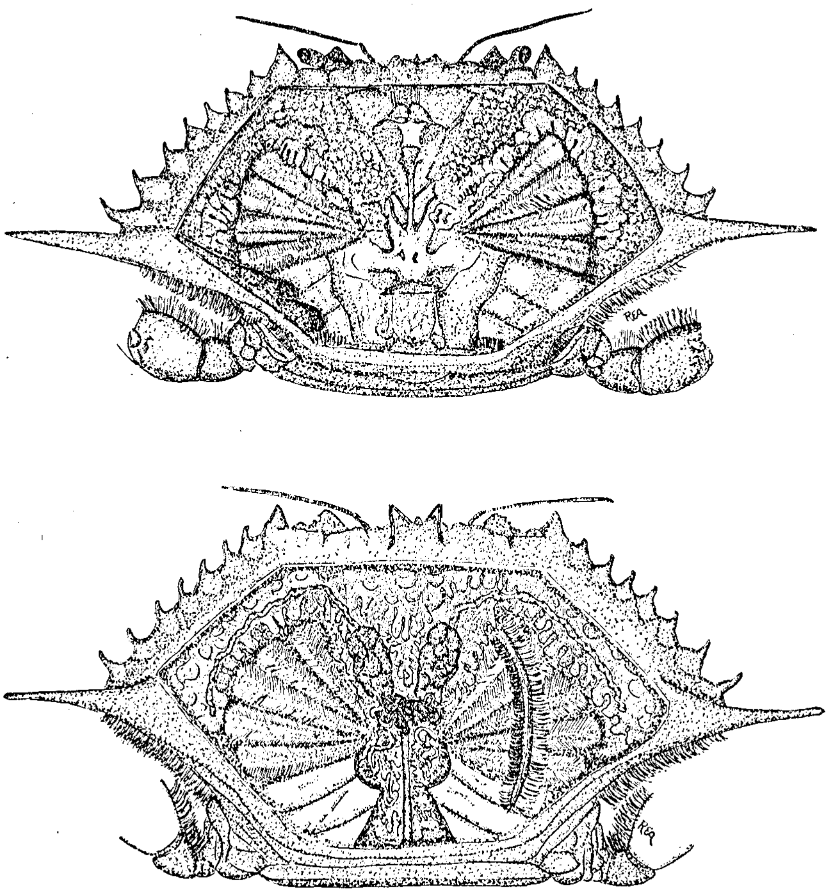


FIGURE 7.—Dorsal view of internal parts of male and female blue crabs. Part of carapace has been removed. Names of parts of female (above) listed in order starting at the top are: *stomach*, centrally located just below cut edge of carapace; *ovary*, extending anteriorly and laterally around outer edge of body cavity; *liver*, in form of tubules below ovary at edge of gills; *gills*, four pairs of which show on either side of the centrally located *heart; hypodermis*, a small portion showing inside cut edge of carapace. Lower, male crab with stomach removed; *testes*, convoluted tubes shown on liver; *intestine*, straight tube extending into abdomen; *gill raker*, crossing gills on right side. See table I (*drawn by R. E. Allen*).

of the testis and in a central body position are coiled tubes called the *vasa deferentia* which serve to hold and transport the sperm cells toward the outside of the body. Bean-shaped portions of the vasa deferentia are located on each side of the cavity. They are light pink in color (figure 7).

Food.—Little is known of the kind of food that larval crabs eat in nature. Studies at the Virginia Fisheries Laboratory show that blue crab larvae are highly specialized in their feeding habits. The zoea larvae feed on small plants and animals which they strain from the water. By feeding zoeae a specific protozoan in large quantities, it was possible in August, 1941, to induce them to molt under laboratory conditions. Megalops larvae reared under laboratory conditions feed on small pieces of crab, oyster, or clam meat.

Adult crabs consume a variety of foods, including plant and animal life. They will devour other crabs, fish, shrimp, and shellfish such as conchs, snails, and ribbed mussels. There are records indicating that they may eat roots of marsh grasses and sedges which occur in shallow estuaries.

Migratory Habits.—The migratory habits of crabs are determined by examining collections from different places at particular times of the year and observing the size and the relative numbers of males and females.

In general, crabs migrate toward deeper and warmer waters in the winter and toward shallower waters where food and shelter are favorable in the summer. Female crabs that have mated move from the brackish waters of tributaries and of Chesapeake Bay proper to the salty waters near the mouth of the Bay for egg-laying*. Egg-laying or sponge formation begins early in May and continues until September.

Young crabs from summer spawning are in the York River area by August at which time they may average around ½ inch in width. This generation continues its migration toward the less saline water of the estuaries and of the Bay. When the young peeler crabs reach 3 inches in width they are mainly in

*Reference is made to the crab population of Chesapeake Bay and its tributaries and not to that of the Seaside of the Eastern Shore.

the rivers and upper Bay and may be caught legally, put in floats for shedding, and sold as soft crabs. For this reason, the soft crab industry is centered up the Bay at Crisfield, near the interstate line, and not at the mouth of the Bay.

Crabs that hatch out in early summer may reach the York River region by August but they do not become saleable peeler crabs until the following summer, since they pause in their up-river, up-Bay migration to hibernate for the winter.

Upon reaching sexual maturity the following summer, the females mate and return to the river mouths in Virginia and to the more saline waters down the Bay. They are believed to have a more definite and direct migration than the males. Females that mate in early summer probably reach the lower Bay by fall, while others over-winter en route and renew migration in early spring. Spawning takes place as early as the first week in May.

Male crabs predominate in the brackish waters during summer. With the approach of cold weather, it is believed that considerable numbers migrate down the rivers and, to some extent, down the Bay to deeper and warmer water. There is a lack of information on the migratory habits of the male crabs during the fall and spring seasons, and little is known about the extent of the migration of crabs in and out of the Bay at the Capes. This information is greatly needed as a partial basis for determining a policy that will afford the best utilization of the commercial crab population.

In review, larval crabs are hatched out during the summer season in the lower Bay. Sexual maturity is reached in the up-river and up-Bay areas by the next summer, at which time mating takes place. Then, by the following summer, the females are back nearer the mouth of the Bay where spawning takes place, thus completing the cycle in two years, sexual maturity being reached at an age of about one year.

The question is sometimes raised as to what percentage of the population of crabs migrating to less saline water reaches waters north of the Potomac River. Some persons believe that a majority of crabs reach that far up the Bay, but actually there is no definite information on this question. Salinity experiments carried out in Yorktown indicate that the brackish river waters which empty into the lower Bay do not constitute a barrier against the last larval stage crabs (megalops) and the early true crab stages. Large numbers of early crab stages have been collected in these rivers. Furthermore, the breadths of the river mouths between Point Lookout (north shore of the Potomac River) and the south shore of the James total a distance approximately equivalent to that across the Bay at Point Lookout. Since the river conditions are favorable for development and since they contain at close range the fresher water conditions which the crab is supposedly seeking in its migration, it would seem reasonable to expect a predominant migration up the several large Virginia rivers with a natural overflow penetrating to the brackish waters of the upper Chesapeake Bay. If this were the true picture, then years of plenty would result in a relatively large escapage north of Point Lookout. Years of scarcity would be reflected most noticeably in the up-Bay catch. That just such a trend is revealed by available records of crab catches in Maryland and Virginia for the years 1939-40-41 is perhaps significant (figure 10). It would seem highly possible that the largest part of the Chesapeake Bay crab population may pass its entire life history in waters bordering Virginia.

COMMERCIAL UTILIZATION

Food Value.—Wartime needs for an increase in food production and utilization have led to a study at Yorktown of the amounts of edible and waste meats in blue crabs and the vitamin content of the several kinds of meat. While the number of crabs studied was insufficient to warrant highly specific conclusions, the general indications are of interest. Sue Christian, a graduate student at the Laboratory, made the weight determinations and the National Research Council provided the vitamin assays*.

The three principal grades of commercial crab meat are lump or back fin, flake, and claw. Lump meat is that muscle tissue which moves the paddles or fins. The smaller pieces of muscle tissue on the sides of the body that move the walking legs are called flake meat, whereas the large muscles of the chela or claws of the first pair of thoracic appendages make up the

*Acknowledgment is made to Professor Robert F. Griggs, Chairman of the Division of Biology and Agriculture of the National Research Council who arranged to have the assays made for the Laboratory.

brown *claw* meat. Table II gives an estimate of the differences in the relative amounts of different meats of mature males, mature females, and egg-bearing or sponge crabs.

TABLE II

WEIGHT IN GRAMS OF BODY PARTS OF COMMERCIAL PICKED AND LABORATORY PICKED BLUE CRABS THAT WEIGHED APPROXIMATELY 170 GRAMS

PART OF BODY	COMMERCIAL PICKED		LABORATORY PICKED		
	Male	Female	Male	Mature Female	Sponge Female
Commercial meat used:					
Lump	11.25	9.82	13.26	14.30	12.90
Flake	24.45	23.64	23.37	20.09	19.47
Claw	13.06	8.86	20.24	10.82	11.23
Commercial meat not used:*	9.15	7.14	....	....	....
Liver	9.77	7.86	9.68	8.48	15.20
Visceral waste	24.79	33.46	23.77	34.73	16.30
Shell	74.47	75.07	73.27	78.39	71.16
Sponge mass	....	....	....	....	34.12

*Amount of commercial meat left in the crab by the pickers, hence wasted.

The largest amount of edible meat is *flake*. As in every handling process, there is waste. It is estimated that the amount of commercial meat left behind by the crab pickers amounts to between 15 and 20 per cent of that removed. Visceral meat, composing about all the non-edible meat except the liver, amounts to around 50 per cent of the weight of the commercial meat used. The hepatopancreas or liver weighs anywhere from 7 to 20 per cent of the meat depending on the condition of the crab. Usually, the livers of buckram crabs are relatively small because this organ is used to supply body materials for growth during the period of recovery from molting. The water content of the crab tissues is around 75 per cent by weight.

If, for convenience, the annual output of hard crabs in Virginia is assumed to be 86 millions (1938 figures of the U. S. Fish and Wildlife Service), then the estimated commercial output of lump, flake, and claw meat is approximately 2¼, 4, and 2½ million pounds respectively, amounting in all to nearly 9 million pounds. Assuming that the average pre-war price at the packing house was 70 cents per pound, then the value of the meat as shipped from the packing house amounts to about 6 million dollars annually. The actual amount paid the fishermen for the hard crab catch in 1938 was nearly a half million dollars or about 8 per cent of the market value at the packing house.

The carapace of the crab that has been steamed for packing is coral (W.) in color. In some packing houses these shells are sold for use as containers in baking and serving crab meat. More often the shells, together with other wastes including the liver and visceral meat, are sold for about 5 or 6 cents per barrel (around 100 pounds). This waste material can be ground into fine meal and used for poultry food, since it contains from 30 to 35 per cent protein. The wholesale price of crab meal ranges from about 25 to 35 dollars per ton during normal times. About 250 pounds of crab scrap yield 100 pounds of meal whereas it takes about 180–200 pounds of whole crabs to yield 100 pounds of scrap.

Considering separately egg-bearing or sponge crabs, there is one additional element of food waste, namely, the sponge mass. Table III shows the relatively high weight of the sponge or egg mass which amounts in terms of wet weight to approximately 70 per cent of the weight of the commercial meat used, and expressed in dry weight, to sometimes more than the commercial meat recovered. The annual commercial crab meat production in Virginia may be estimated at around 9 million pounds wet weight

TABLE III

Approximate Weight of Body Parts of Blue Crabs Caught in Virginia*

PART OF BODY	Wet Weight in Grams Individual Crab	Estimated Yield in Millions of Pounds Virginia Fishery
Commercial meat used:		
Lump	12	2.27
Flake	21	3.98
Claw	13	2.46
Commercial meat not used	9	1.71
Liver	9	1.71
Visceral waste	24	4.55
Shell	73	13.84
Sponge mass	30	1.20

*The average size of the commercial crabs caught is, for present purposes, assumed to be about 6 inches in width.

or roughly 2.25 million pounds dry weight (table III). The dry weight of the wasted crab eggs probably amounts to about 1.2 million pounds, assuming that the catch of sponge crabs in Virginia amounts to 25 per cent of the trot line and crab pot catch. The possible significance of this waste of eggs, rich in nutrients, is discussed later.

Nutrient Value of Blue Crab Meats.—Crab meat is a highly nutritious food. The white meat is as rich as most seafoods in calcium, magnesium, phosphorus, iron, and copper. It contains about six times as much iodine as an equivalent sample of milk and over forty times as much as beef. A half-pound of white crab meat provides about 40 per cent of the daily requirements of an average individual for protein, 10 per cent of the requirement for fat, 23 per cent for calcium, 34 per cent for iron, 120 per cent for copper, and 50 per cent of the daily iodine requirement.

Crab meat is a rich source of vitamins, especially A, B, and C. One half-pound of crab meat provides about 29 per cent of an individual's daily requirement for thiamin or vitamin B_1, 14 per cent of the daily riboflavin or B_2 requirement, and 35 per cent of the daily needs for vitamin C, the antiscorbutic vitamin. During the summer of 1943, studies at the Yorktown Laboratory showed the relative amounts of waste meats of the crab (table III). One of these wastes, the liver, is nearly twenty times as rich in riboflavin as broiled shad and over eight times as rich in this vitamin as fresh oysters. The liver is nearly four times as rich in vitamin B as fresh oysters. Crab eggs far exceed the commercial meat in content of thiamin and riboflavin (table IV).

It has been indicated that over 1.0 million pounds of eggs are utilized, if at all, only for scrap. Furthermore, larger amounts of liver meat and other visceral wastes are likewise used only for scrap. Yet these wastes compare favorably with the edible commercial meats in certain important nutrients. Since scrap is sold for only a small fraction of one cent per pound at the packing house, and since the scrap by-product brings only about 1.5 cents per pound, it would seem worthwhile to explore the possibilities of finding new uses for scrap crab meat.

Industrial Practices.—The Chesapeake Bay crab industry in Maryland and Virginia is based on the use of soft and hard crabs

TABLE IV

THE VITAMIN CONTENT OF COMMERCIAL AND WASTE BLUE CRAB MEATS COMPARED WITH THAT OF OYSTERS, SHAD, AND BEEF*

MEAT	VITAMIN		
	A	B_1	B_2
	Milligrams per half pound		
Crab:			
Commercial meat	Good	0.52	0.34
Eggs (N.R.C.)†	0.57	0.81	3.85
Liver (N.R.C.)	1.14	0.24	8.73
Visceral waste (N.R.C.)	0.77	0.23	4.76
Oysters, fresh	0.30	0.57	1.04
Shad, broiled	0.20	0.17	0.45
Beef, round	0.04	0.33	0.58

*Modified by the writer from Taylor, 1942 and others.
†N.R.C. = U. S. National Research Council.

for food. It has been indicated that crabs grow by shedding their hard outer shell and emerging in a soft condition.

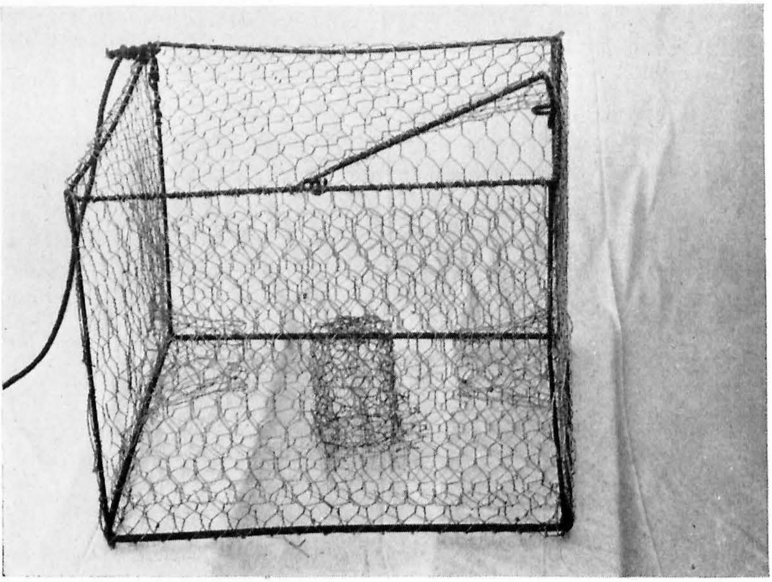
There are usually eight or more small shedding houses on the Eastern Shore of Virginia, and six large ones at Tangier Island, several on the Rappahannock River, and a few others that operate on a small scale. While some peeler crabs are handled as far down the Bay as Cape Charles, the soft crab packing center of the Bay is Crisfield, Maryland. The soft crab industry at Crisfield was established in 1873. Usually it handles about 12 to 15 per cent of the total Maryland and Virginia catch or around 22 million crabs (5.5 million pounds). Most of these crabs when caught are still hard but in the process of preparing to shed, in which condition they are called "peeler" crabs. The method of catching them is by an ordinary dip net operated from the bow of a small skiff that is pushed around the shore in shallow water, often with the handle of the net. A dip net is simply a scoop device with a wooden handle 8 or more feet in length. A net of 1-inch mesh is fastened to a ¼-inch iron loop about 1 foot in diameter. Crabs are also taken by a scrape which resembles a small oyster dredge, except that it is toothless and has a cotton-mesh bag. It is operated from a motor driven boat. After being landed at a shedding house, the "peeler" crabs are placed on wooden floats (figure 4) in water about 9 inches deep and are held there until they molt—sometimes for several days. The actual molting process may be accomplished in about half an hour or less. A commercial float is a wooden container usually with a bottom of close-fitting boards and with sides of slats to permit circulation of water. Encircling the float, about 9 inches from the bottom, is a wooden shelf 8 inches wide. The puprose of this shelf is to buoy the float to ½ its depth, thus preventing the escape of the crabs. The float is 12 by 3.4 feet by 18 inches in depth, and costs about $5.00.

Shortly before molting there is a "red line" around the edge of the distal segment of the paddle or back fin. The "red line" stage follows the "pink line" stage of shedding. By the time these stages are reached, *a well formed soft shell is under the hard outer shell* indicating that the crabs are developed far enough to warrant putting them in floats. The "white line" stage precedes the "pink line" stage and the earliest stage peeler crabs are called "green" crabs. White line and green crabs do not survive well on floats and, hence, should not be used. Analysis of figures reported by Maryland biologists (Beaven and Truitt) who made observations at Crisfield indicates that the mortality on floats, even under conditions of improved law enforcement, may amount to as much as 40 per cent of the total number of soft crabs sold. At the shedding houses as many as 3 or 4 hundred peeler crabs are placed in a shedding float. By sorting, crabs of a similar stage in the shredding process are kept together in one float. This segregation is important since "green" crabs, those requiring a long time to shed, will eat soft crabs. The floats are "fished" regularly by experienced crab men to remove those soft crabs that have hardened just enough to stand shipment but not hard enough to prevent their use as soft crabs. This preparatory hardening takes about two hours after the actual shedding. In nature soft crabs become hard in about eight hours. For some time they remain in a lean watery condition with inferior meats, hence they are of low market value. These crabs are called "buckrams". Their capture is prohibited by law and it needs to be discouraged further by a *united effort* on the part of crab catchers and dealers.

Soft crabs are graded according to size. Culls are about 3.5-4.0 inches in width; mediums, 4.0-4.5 inches; primes, 4.5-5.25 inches; and jumbos, 5.5 inches and over. An 80-pound box holds about 20 dozen mediums, 15 dozen primes, and 10 dozen jumbo soft crabs. They are carefully packed in a compact, oblique position so that moisture will not leave the mouth. The boxes contain trays between which a seaweed called eelgrass is packed. A sheet of parchment paper covers the layer of crabs to separate them from the seaweed. Each tray is sprinkled with a little finely crushed ice that helps to keep the crabs alive and in good condition during shipment. Being a highly perishable food, soft crabs must be shipped by motor-trucks or express, and if the distance is great, by refrigerator cars.

The principal gears for catching crabs in Virginia waters during warm weather are the trot line and crab pot (figure 8). The *trot line gear* consists of a ground line, ¼-inch manila rope, about 1,000 or more feet in length that is baited with tripe or salted eel. The line is run over a roller that extends from the side of the boat. Crabs hold on to the bait and are brought to the surface as the boat goes forward forcing the roller under the line. As the crab-bearing bait approaches the surface of the water, a dip net is used to take the crabs. A *patent dip trot line* differs in that a large conical bag made of netting is suspended below a metal frame which is situated under the roller in such a way that the crab automatically drops in the entrance to the net. Thus, dipping by hand is not required. This rig may use over a mile of line and is operated from a large boat ranging from 20 to 45 feet in length. The bait is fastened on the line at intervals of about 3 or 4 feet. Approximately 150 pounds of tripe are used to bait a patent dip rig and around 25 to 30 pounds per day are required to rebait. During normal times tripe costs about 4 or 5 cents per pound.

A crab fisherman may be expected to average around 1 to 2 hundred peeler crabs per day but the number varies tremendously. Normally, the fisherman receives about 2 or 3 cents a piece if the demand is fair. Patent dip trot liners average about 2 or 3 barrels (around 600 crabs) per day and get from 2 to 5 dollars a barrel. During wartime the price has soared to 10 or 15 dollars a barrel.



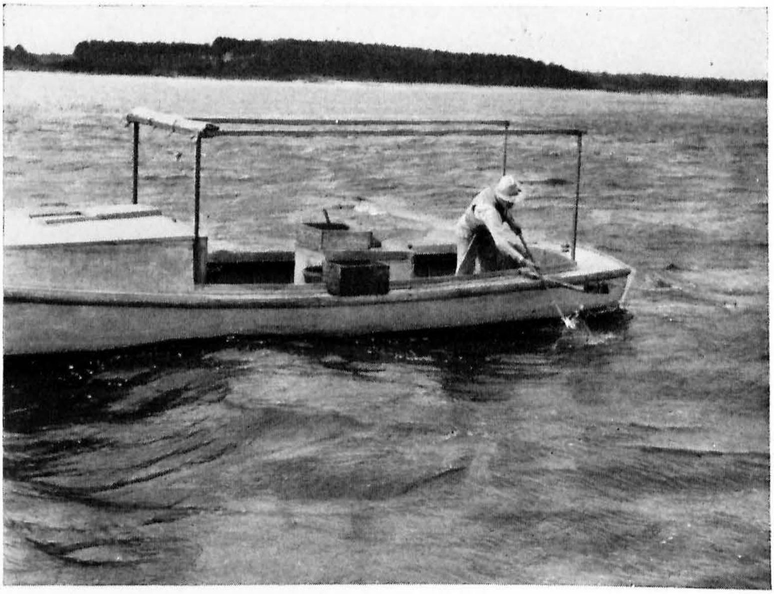


FIGURE 8.—Upper, a crab pot (*photograph by G. M. Moore*); lower, a trot-line crab fisherman (*courtesy of the Virginia State Chamber of Commerce*).

In recent years *crab pots*, cubical in shape, 2 feet on a side, and made of inch and a half mesh, number 18 gauge, double galvanized chicken wire have been used extensively for catching crabs (figure 8). One 150-foot roll of wire 2 feet wide will make nine crab pots. Frames made of 3/16-inch iron rod are often used for the pots. These can be used over and over and strengthen the pot considerably. The period that the crab pots last depends on the salinity of the water in which they are used. Near the mouth of the York River where the salinity is about 20 parts per thousand by weight (ocean salinity is around 35), four sets are used during each crabbing season whereas only two or possibly three are required in fresher waters. Tarring the pots makes them last half as long again. In normal times pots cost about $2.50 or $3.50 depending on whether or not the iron frame is used. Some crabbers weigh down the pots in the corners with cement. Crab pots are located by using floats or by tying them to stakes. Menhaden, herring, and sometimes toadfish are used for bait. In recent years many thousands of crab pots have been used annually in Virginia.

During the winter season crabs are taken in Virginia waters by a *dredge* that resembles a large oyster dredge except that the teeth are longer. The cost of the dredge is about $60 and the cost of the hoist, three dredges, chains, rollers, blocks, etc., that go to make up the dredging equipment of one boat amounts to between $1,200 to $2,000 depending on the size of the equipment. Dredge boats from 40 to 60 feet in length are used. Catches range from about 5 to 25 barrels per day and average around 8 depending on the month and the year. The winter dredge fishery for hard crabs takes an estimated 20 per cent of the total annual catch of hard crabs and is limited to the period December 1st-March 31st.

Hard crabs are transported to the packing house in barrels containing about 300 crabs each. The crabs are then placed in metal baskets that hold 4 or 5 barrelsful. Then they are steamed for around 15 to 20 minutes at 15 pounds pressure, removed from the pressure cooker, and taken in wheelbarrows to the packing room. Steaming results in a loss in weight of about 25 per cent. The meats are picked out usually by colored women and then packed in tinned-steel or paper containers with perforated bottoms.

Pound, half-pound, and quarter-pound cans are used. Deluxe is a good grade consisting of unusually large pieces of meat and generally sells for about 15 cents higher than lump meat. Ordinarily pickers receive from 4 to 5 cents per pound and they are able to pick from 40 to 60 or even more pounds per eight-hour day. A barrel of crabs (weight around 100 pounds) usually yields about 12 or 15 pounds of meat depending on the season. The high percentage of buckram crabs in late summer and fall reduces the yield to 8 or 10 pounds or less, while the summer catches of large male or "Jimmie" crabs from the rivers probably yield as high as 18 to 20 pounds.

During the late thirties, after careful research on canning methods, a successful commercial process was discovered whereby eastern blue crab meat could be canned*. Previous to 1938, practically all United States crab meat was marketed either as cooked or as frozen meat. In 1937, imported Japanese canned crab meat amounted in quantity to over 11 million pounds and in value to about 5 million dollars. In South Carolina and in one or two of the Gulf States, blue crabs are now canned successfully. It is possible that the fresh cooked crab meat industry of Chesapeake Bay could be supplemented with profit by a canning industry. Whether or not such a canning industry could be operated successfully would depend largely on the amount and uniformity of the commercial catch.

CONSERVATION

Legal Regulations.—The relatively abrupt fluctuations in the abundance of crabs in Chesapeake Bay has, perhaps, been largely responsible for the numerous laws and current debates pertaining to the prosecution of the fishery. Some of the more important Virginia laws pertaining to the crab fishery† are presented here.

All citizens of Virginia have the right to take crabs for their home consumption and State regulations apply to a resident of the State desiring to catch crabs for market or profit. Crabs are

*Acknowledgment is made to Mr. Sterling G. Harris of Port Royal, South Carolina, for valuable information on the handling and processing of crabs.

†For State regulations consult "Laws of Virginia Relating to Fisheries of Tidal Waters", Division of Purchase and Printing, Richmond, 1936. Additional information may be obtained by addressing the Commission of Fisheries, Newport News, Virginia.

taken legally throughout all seasons of the year by residents of Virginia. It is not permissible to catch crabs or other shellfish during Sunday or in the night-time between sunset and sunrise. While they may be taken at all seasons there are certain seasonal limitations with respect to type of gear and place of operation designed to leave enough crabs in the water to assure a sustained yield on a high level during future years.

Due to the relatively inactive state of crabs during cold weather, it is possible to catch crabs in winter by means of large dredges or scrapes. The dredging season extends from December 1st to March 31st. Crab dredging is not permitted at any time in rivers, estuaries, inlets, or creeks, but is legal in Chesapeake Bay, Hampton Roads, and the eastern or ocean side of Accomack and Northampton Counties. Only hard crabs are taken by dredges. The annual license fee for dredging is $5.50 for each power boat under 32 feet in length. For each power boat over 32 feet long the fee is $26.00, and it is $5.50 for a crab buy boat.

During the warm season hard crabs are taken by trot lines (hand dip and patent dip), by crab pots, scrapes, and dip nets, while peeler and soft crabs are taken mainly by scrapes and dip nets. The license fee for patent trot lines is $10.50. The annual license fee is $2.50 for taking soft crabs otherwise than by dip net and for catching hard crabs or peelers by net, ordinary trot line, hand rake, or hand scrape. Crab picking or crating houses are taxed $11.50 per year, while canning and packing houses are taxed $26.00. The legal size for hard crabs is 5 inches or above measured between tips of the large lateral spines; that for peeler crabs is 3 inches and that for soft crabs is 3.5 inches.

Sponge crabs may be taken legally on and between the following dates: April 1st and June 30th, subject to the discretion of the Commissioner of Fisheries. During the summer of 1941, the Commissioner, by proclamation prohibited the possession of, as well as the taking of, sponge crabs during July and August in an area of the lower Bay established at that time as a crab sanctuary (figure 9). This restriction was continued during July and August of 1942 and 1943. In 1944, by action of the Commissioner of Fisheries, the closed season was for the period April 1st to August 31st.

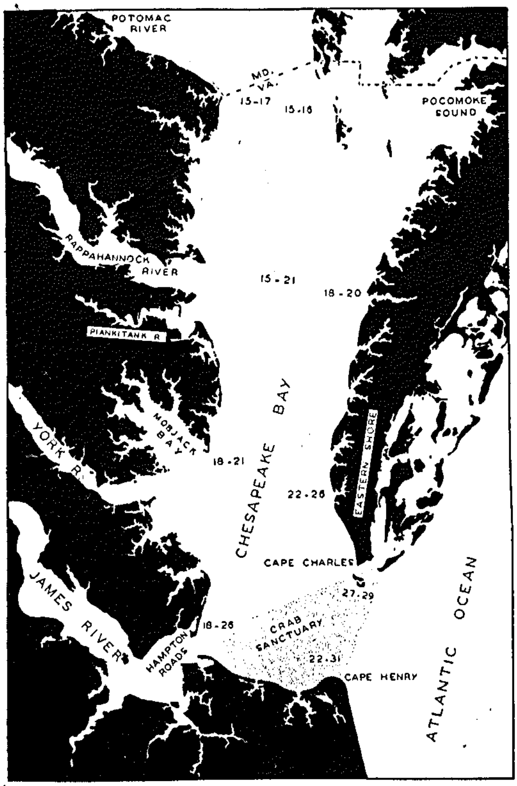


FIGURE 9.—Showing tidewater Virginia and the extent of the crab sanctuary established by the Commission of Fisheries in 1941 to protect egg-bearing crabs (*drawn by G. M. Moore*). Annual average surface-bottom salinity records are indicated (*after Wells, Bailey and Henderson, 1929*).

Crab licenses are issued by fishery inspectors of the Commission of Fisheries.

General Considerations.—Good conservation practice, in respect to a commercial fishery, embodies the idea of efficient utilization of that fishery. The rate and kind of utilization desired is that which assures a relatively uniform and high level of abundance. The importance of a sustained yield should not be lost sight of. Greater constancy of supply favors successful operation and development of any fishery industry. The crab industry of Chesapeake Bay is no exception. There are demands for

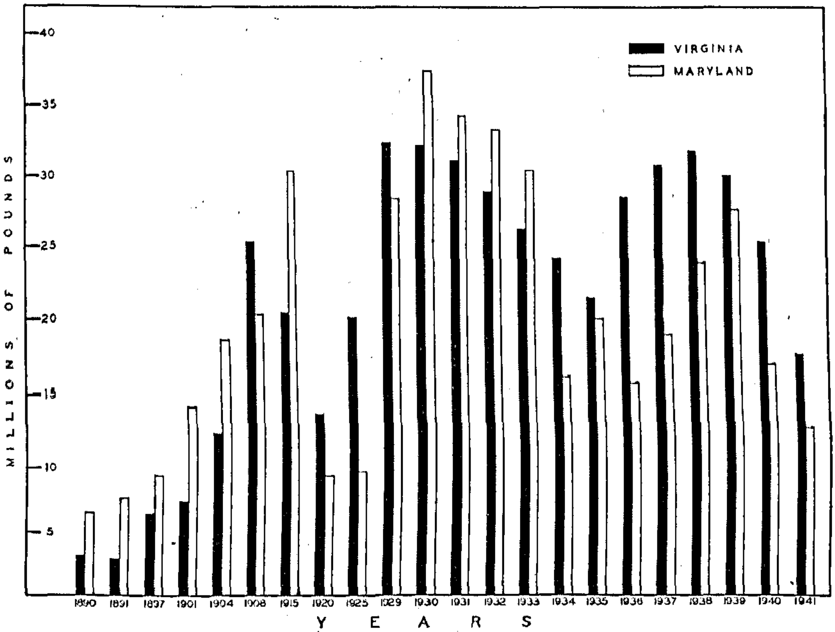


FIGURE 10.—Number of pounds of hard and soft crabs taken annually in Virginia and Maryland during period 1891-1941 (*drawn by M. R. Rogers and based upon U. S. Government statistical records*).

means of assuring high and sustained crab yields. Some groups insist that low levels of production can be eliminated and that the average annual level of the past twenty-five years can be raised. It is contended that in the future these levels can be supplanted by a sustained annual yield equivalent to the highest levels of production reached in previous years. Although past experience with methods of controlling the size of natural populations in different parts of the world offers little, if any, basis for believing that the above demands can be satisfied, the possibilities for substantially increasing the crab supply are good and certainly worth exploring. It should be stressed, however, that the occurrence of high and low levels of abundance of natural populations is a perfectly normal phenomenon brought about by natural environmental factors.

Vast tolls of the crab population are taken during some years by unusually low *temperature* conditions such, for example, as prevailed about twenty-seven years ago when whole boat loads of dead crabs were taken in winter by the dredge boats. Mortalities of a lesser magnitude are known to occur more frequently and are reflected in the commercial catches. Nature also works with reverse effect on the crab population. Years of favorable environmental conditions for the growth of crabs may result in peaks such as that of about 65 million pounds for Virginia and Maryland in 1931 (figure 9). Often such high yields result in low prices. This may be due in part to the sporadic nature of these increases which makes it difficult for the industry to arrange for handling above-average catches in a manner that will prevent low returns to the fishermen.

Salinity is an environmental factor of major importance in terms of survival of young crabs. Hatching of the eggs and growth of the first stage larval crabs are dependent on a favorable salt content in the water. It is entirely possible that those years during which unusually large areas of the Chesapeake Bay have salinity conditions favorable for embryonic and larval development of the crab are years of greatest abundance of young crabs. Furthermore, temperature and salinity play a direct role in the production of suitable microscopic food for the larval crabs.

While commercial populations are influenced by the temperature and salinity factors it is not possible to modify these conditions. It is important, however, that they be understood and recognized in all attempts to increase the commerical population and to preserve an adequate stock of brood crabs.

Factors affecting the natural population of marketable crabs, over which man *can* exercise some control, are *waste* and *catch restrictions*. Waste, in varying degrees, characterizes the several fishing industries and, although much of it is *unavoidable*, there is a large amount that is unnecessary. Some of the particular sources of waste that have been referred to in the past are enumerated.

"Green" and "white line" peeler crabs, or those too far removed from the shedding condition to justify placing them in shedding floats, are nevertheless purchased in large numbers as peelers. Reports from Maryland indicate that during some years 50 per cent or more of these crabs die on the floats. Considering the annual output of soft crabs for the Bay States during 1938, it appears that a catch of about 33 million crabs was required to yield 23 million soft crabs for the market. Crab buyers claim that they are forced to buy the "green" and "white line" crabs in commercial catches in order to keep the catcher from selling elsewhere. Obviously, if the dealer were not forced to handle these crabs with the resulting loss due to mortality, he would be able to pay the catcher a higher price for the legal peeler crabs. It is clear, therefore, that the crab catcher gains nothing by selling the "green" and "white line" crabs of his catch for shedding purposes. In the long run he really loses because these crabs, if left in the water, would soon contribute to the supply of legal marketable crabs. It would be in the interest of conservation to forbid the *purchase* and utilization of "green" and "white line" crabs in the soft crab industry.

An apparently necessary loss on the floats arises from breaking the claws ("nicking") of the peelers. This facilitates handling and prevents the early stage peelers from attacking other crabs. However, the breaking causes the soft membranes inside the shell to swell and hence, prevents the tissues from being readily pulled through the narrow joints during the shedding process. This produces either death or a legless condition (buffalo crabs). Also there is need for improving methods of transporting peeler crabs. These crabs are in a delicate stage of development and often mortality on the floats is traceable to faulty handling of the crabs while transporting them to the floats. On the basis of existing information it would appear that due to prevailing practices in the handling of peeler crabs the total *waste* may amount to 30 per cent or more of the peeler crab catch.

During some years, unrestricted catching of sponge crabs is believed to affect adversely the growth of the population. The extent to which these crabs should be protected for brood purposes has been the subject of considerable study and debate. The question is one of determining to what extent it is biologically and economically feasible to take egg-bearing crabs. The administrative problem is complicated by competitive economic aspects of the crab industry that is conducted in Maryland and Virginia and by lack of information on just how much protection of sponge crabs is warranted in different years.

During the period June-August, from 60 to 90 per cent of the hard crab catches in the lower Bay around Hampton Roads, Buckroe, Lynnhaven and Cape Henry are sponge crabs. Although these crabs are known to move in and out of the Bay at Cape Henry, the extent of these migrations is not known. The catch of sponge crabs results in the use of large quantities of crab meat that, otherwise, would be wasted since most sponge crabs are believed to die or leave the Bay at the end of the spawning season. Sponge crab catches also result in a waste, namely the destruction of large numbers of eggs which, if left in the water, would produce more crabs. Briefly, the question is: which waste is greater? It depends largely on the size of the sponge crab population. There is a relatively direct and linear relationship between increases in the quantity of sponge crabs and resulting increases in the quantity of meat available to the producer. The relation between quantity of sponge crabs and the numbers of their offspring that may be expected to reach a marketable size is indirect and curvilinear. It is indirect due to natural hazards, such as extremely cold weather, that govern survival and it is curvilinear because after a certain level of abundance has been reached the relative number of progeny produced declines. Obviously, there is a point at which it becomes uneconomical to save spawners. The problem is to find the level of abundance at which this point is reached. Steps can then be taken to maintain this level.

Virginia has undertaken to get needed biological information on the crab and, in the meantime, is following an intermediate course of administrative action characterized by partial protection of sponge crabs by means of a crab sanctuary. This refuge was established in 1941 by the Commission of Fisheries of Virginia at the request of the Hampton Crab Packers Association. As yet, the sanctuary has not existed long enough to yield complete information on the extent to which it affects the volume of the crab catch.

Considerable time is often needed in order to obtain the biological information required as a basis for conservation policies. This may result in a lower level of crab production for several years until facts are provided to guide administrative action. However, as unfortunate as this condition may appear, it is not as serious as that involving crab waste such as that in the soft crab industry and that arising from the use of buckram crabs. Edible crab meat can be conserved in Chesapeake Bay by a more efficient handling of soft crabs and by not taking buckrams. Hard crabs under 5 inches in width are not supposed to be sold, and peeler crabs under 3 inches are illegal. These size regulations are important since a catch of under-size crabs ultimately means an economic waste to the crabber himself. By leaving these crabs and also the thin watery buckrams in the water a little longer, the gain in amount of meat is sufficiencly large to justify postponing the time of capture. Those crabbers and dealers that aim to avoid waste and to practice conservation need the support of vigilant law enforcement. While time is required to get biological facts needed to solve some of the controversial crab problems in Chesapeake Bay, information pertaining to curtailment of waste is already available. It constitutes a challenge both to biologists and administrators.

In general, remedial measures involving curtailment of fishing intensity should not be restricted to a single branch of the fishery, thus making one particular group of crabbers, such as the crab pot fishermen, the winter dredge crabbers, or the soft crab fishermen, bear the burden of restrictions. The biology and migratory habits of the crab are such that an equitable distribution of the responsibility of saving crabs, in an effort to raise the level of production, can be made whereby all groups will share in a reasonable curtailment of their particular type of fishing. More information is needed to make such an equitable distribution possible.

Maryland does not permit the catch of crabs during November. This favors the migration of mated crabs southward. For the protection of the brood crabs that migrate southward into saltier waters to spawn, Virginia has established a crab sanctuary effective during the period April 1st to August 31st. Reasons have been offered above for believing that the crab population is predominantly in Virginia waters. A continuation of present crab investigations in these waters is expected to provide information that will lead eventually to a more efficient utilization of this important natural resource.

LITERATURE SOURCES

Beaven, G. F. and R. V. Truitt. Crab Mortality on Chesapeake Bay Shedding Floats. Cont. No. 33, Ches. Biol. Lab., Solomons, Md., 1938-1939.

Brooks, W. K. Handbook of Invertebrate Zoology. Bradlee Whidden, Publisher, Boston, 1890.

Churchill, E. P. Life History of The Blue Crab. Bull. Bur. of Fish., Vol. 36, pp. 93-128, 1917, 1918.

Cowles, R. P. A Biological Study of The Offshore Waters of Chesapeake Bay. Bull. Bur. of Fish., Vol. 46, pp. 277-381, 1930.

Hegner, Robert W. Invertebrate Zoology. The Macmillan Company, Publisher, New York, 1939.

Hopkins, S. H. The External Morphology of The First and Second Zoeal Stages of The Blue Crab, *Callinectes sapidus* Rathbun. Trans. Am. Micros. Soc., Vol. LXII, No. 1, Jan., 1943. Cont. No. 10, Va. Fisheries Laboratory.

Hopkins, S. H. The External Morphology of The Third and Fourth Zoeal Stages of The Blue Crab, *Callinectes sapidus* Rathbun. The Biological Bull., Vol. 87, No. 2, October, 1944. Cont. No. 20, Va. Fisheries Laboratory.

Newcombe, C. L. Observations on The Conservation of The Chesapeake Blue Crab, *Callinectes sapidus* Rathbun. Va. J. of Sci., Vol. 2, No. 1, 1940.

Newcombe, C. L. The Biology and Conservation of The Blue Crab. Div. of Pur. and Printing, Richmond, Va., 1943. Educational Series No. 3, Va. Fisheries Laboratory.

Pearson, John C. Decline in Abundance of The Blue Crab in Chesapeake Bay during 1940 and 1941, with Suggested Conservation Measures. Sp. Scien. Rept., No. 16, U. S. Fish & Wildlife Ser., Washington, D. C., 1942.

Sandoz, Mildred. Steps Toward Crab Conservation in Chesapeake Bay. The Commonwealth, Vol. 10, No. 7, 1943. Cont. No. 15, Va. Fisheries Laboratory.

Sandoz, Mildred, Rosalie Rogers and Curtis L. Newcombe. Fungus Infection of Eggs of The Blue Crab, *Callinectes sapidus* Rathbun. Science, Vol. 99, No. 2563, 1944. Cont. No. 17, Va. Fisheries Laboratory.

Sandoz, Mildred and Rosalie Rogers. The Effect of Environmental Factors on Hatching, Moulting, and Survival of Zoea Larvae of The Blue Crab, *Callinectes sapidus* Rathbun. Ecology, Vol. 25, No. 2, 1944. Cont. No. 16, Va. Fisheries Laboratory.

Wells, R. C., R. K. Bailey and E. P. Henderson. Salinity of The Water of Chesapeake Bay. U. S. Geol. Survey, Prof. Paper, 154-C, pp. 105-152, 1929.