THE BLUE CRAB AND ITS FISHERY IN CHESAPEAKE BAY[1/]

Part 1 - Reproduction, Early Development, Growth, and Migration

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ABSTRACT

BLUE CRABS ARE ABUNDANT ON THE EAST AND GULF COASTS OF NORTH AMERICA, ON THE EAST COAST OF SOUTH AMERICA, AND HAVE BEEN REPORTED FROM FRANCE, HOLLAND, AND DENMARK, AND THE EAST COAST OF THE MEDITERRANEAN. IN CHESAPEAKE BAY, FISHING HAS BEEN INTENSIVE FOR OVER 80 YEARS; IN THE LAST TEN YEARS, THE AVERAGE ANNUAL PRODUCTION HAS BEEN ABOUT 60 MILLION POUNDS, VALUED ABOUT THREE MILLION DOLLARS, APPROXIMATELY TWO-THIRDS OF THE ENTIRE UNITED STATES BLUE CRAB HARVEST.

MATING OF BLUE CRABS BEGINS IN EARLY MAY AND CONTINUES INTO OCTOBER; SPERM LIVE IN THE FEMALE RECEPTACLES FOR AT LEAST A YEAR, AND MAY BE USED AS OFTEN AS THE FEMALE SPAWNS, TWICE OR MORE. AFTER MATING, FEMALES MIGRATE TO THE SALTIER WATERS OF THE SOUTHERN END OF THE BAY, SOME PASSING INTO THE OCEAN. SPAWNING IS DELAYED AT LEAST TWO MONTHS AFTER MATING, AND OCCURS FROM EARLY MAY THROUGH SEPTEMBER. EGGS ARE CARRIED ON THE ABDOMEN OF THE FEMALE FOR ABOUT TWO WEEKS BEFORE HATCHING.

THERE ARE TWO LARVAL STAGES--FOUR OR FIVE ZOEAL MOLTS AND THE "MEGALOPS"--LASTING ABOUT A MONTH. LARGE NUMBERS OF CRABS REACH THE "FIRST CRAB" STAGE EARLY IN AUGUST AND BEGIN MIGRATING INTO THE RIVERS AND TO THE UPPER BAY. ADULT SIZE MAY BE REACHED IN ONE YEAR TO A YEAR AND A HALF, SHEDDING 18 OR MORE TIMES AFTER THE LAST LARVAL STAGE.

TWO MAJOR MIGRATIONS OF ADULT FEMALES TO THE SOUTHERN END OF THE BAY OCCUR, IN OCTOBER AND NOVEMBER AND THE FOLLOWING MAY. NONE OF THESE FEMALES SPAWNED BEFORE THEIR MIGRATION. SCHOOLS OF "SEA-RUN" OR "OCEAN" CRABS, THAT HAVE SPAWNED BEFORE, MIGRATE FROM THE OCEAN OR THE VIRGINIA CAPES AREA INTO THE BAY IN MID-SUMMER. ADULT MALES REMAIN IN THE BRACKISH RIVER WATERS THE YEAR ROUND.

THE DIET OF BLUE CRABS INCLUDES FRESH AND DECAYING FISH OR MEAT, AND VEGETATION. YOUNG SETS OF CLAMS AND OYSTERS MAY OCCASIONALLY BE DESTROYED, BUT ON GROUNDS IN OPEN WATERS THE BLUE CRAB IS NOT GENERALLY CONSIDERED A SERIOUS PEST.

BACKGROUND

The blue crab, Callinectes sapidus Rathbun, belongs to the class Crustacea, which includes many familiar marine and fresh-water forms, such as lobsters, crayfish, shrimp, and barnacles. This crab is a common inhabitant of muddy and sandy shores of the East Coast and Gulf Coast of North America, from Massachusetts to Texas, and a few have been reported as far north as Nova Scotia and as far south as Uruguay on the east coast of South America (Rathbun 1930). Occasional specimens have been reported in European waters, from France, Holland, and Denmark, and it has become abundant in recent years on the Mediterranean coast of Israel, where the crabs were probably transported in the ballast tanks of ships (Holthius and Gottlieb 1955).

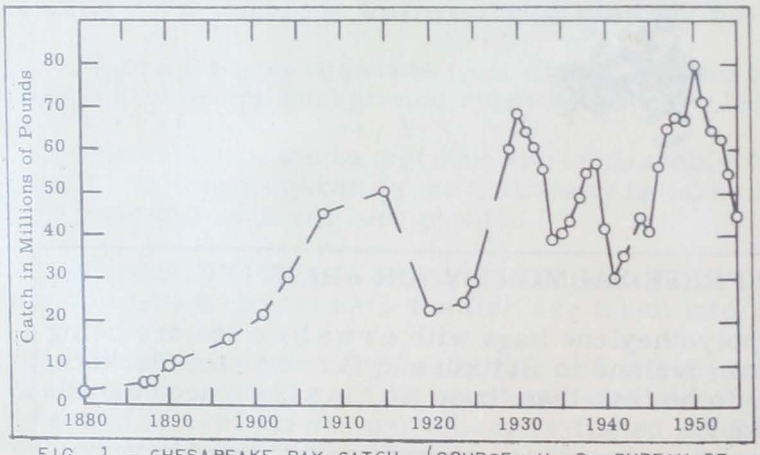

FIG. 1 - CHESAPEAKE BAY CATCH. (SOURCE: U. S. BUREAU OF FISHERIES, 1922-1941; U. S. FISH AND WILDLIFE SERVICE, 1942-1957.)

Commercial fishing for blue crabs has been especially intensive in estuaries like Chesapeake

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Bay. It is caught by many and diverse forms of fishing gear in salty, deep channels of the Bay and in brackish waters of its river tributaries, often quite far up the rivers in water of extremely low salinity.

Total catch in Chesapeake Bay has fluctuated considerably in its 80-year history (fig. 1), although in the early years, from 1880 to 1915, fluctuations were unnoticed. Since 1929, the average annual catch has been about 55 million pounds. In the last ten years, Chesapeake Bay has had an average annual production of about 60 million pounds, currently valued at about $3 million, approximately two-thirds of the entire United States blue crab harvest.

Many closely-related crabs have the same characteristic body form, the flatly-expanded final segment of the fifth leg, and nine pairs of spines lateral to the eyes. The best diagnostic character of Callinectes sapidus is a set of four, instead of six, teeth on the margin of the shell between the eyes (two frontal and two inner-ocular teeth)--Rathbun 1930. Detail which will not be repeated here may be found in the authoritative accounts on taxonomy and distribution (Rathbun 1896, 1930); anatomy and histology (Cochran 1935; Cronin 1942, 1947; Hopkins 1943, 1944; Pyle and Cronin 1950); bibliography (Cronin, Van Engel, Cargo and Wojcik 1957).

MATING

Sex of the blue crab is easily recognized by differences in shape of the abdomen, or apron as it is frequently called (fig. 2), and by the abdominal appendages. The male abdomen, long, slender and T-shaped, carries two pairs of appendages used in mating, two long intromittent organs and two shorter accessory organs. The abdomen of an immature male is tightly sealed to the ventral surface of the shell, while on a mating male the abdomen hangs free or is held in place by a pair of "snap-fastener-like" tubercles. In the young female the abdomen is triangular and sealed to the body, while in the adult it is broadly rounded, almost semi-circular, and free of the ventral shell. There are four pairs of swimmerets on the female abdomen: small, hairless rods on the immature and large, fringed rods on the adult. Abdomens of young females are grayish-white, adult females blue-green. In the last few days of immaturity, however, just before the young female sheds to become an adult, the dark green of the inner, soft, adult abdomen shows through the transparent whiteness of the hard, outer, immature skeleton.

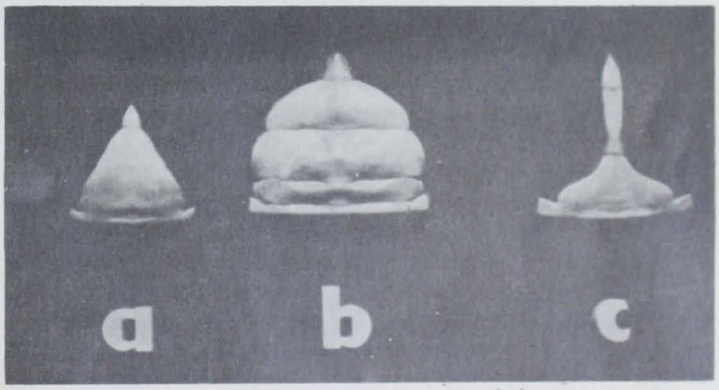


FIG. 2 - ABDOMENS OF IMMATURE FEMALE (A), MATURE FEMALE (B), AND MALE BLUE CRAB (C).

Young females sometimes are called "Sally" crabs, while an adult female is a "sook," a twist of the word "sow." Although millions of crabs were handled yearly in the last 75 years, only a few "adult" females were found with an inner, new skin showing beneath the outer skeleton, and where legs were missing, the buds of new legs often were found. All such crabs were abnormal and died before shedding was complete (Hay 1905; Churchill 1919; Cronin, personal communication). This is taken as proof that once the sook stage is reached, females cease to grow and molt.

Males, called "Jimmies," "Jimmy-dicks," or "Channelers," reach sexual maturity before they are fully grown, and during each of their last three growth stages may mate with more than one female (Truitt 1939). The female mates usually while it is in the soft crab state (Rathbun 1896), but not until after it has shed for the last

time. Mating two or three days after shedding, sometimes with two or more males in succession, occurs in experimental ponds, but in nature mating probably is seldom delayed this long. Summer is the mating season in Chesapeake Bay, beginning in early May and continuing into October, reaching a peak in late August and early September.

Having found a mate, the male cradle-carries the female beneath him by hooking his first walking legs and pinching claws between the first walking legs and pinching claws of the female (fig. 3). She is carried two or more days until she sheds her immature shell. While she is shedding, the male hovers over her. After the soft female emerges from the shed she turns over on her back and unfolds the abdomen to expose the two genital pores. Mating may occur day or night and may last from five to twelve hours. Sperm are transported in microscopic, oval-shaped bundles called spermatophores to a pair of sacs in the female called seminal receptacles or spermathecae. Sperm will live in the female receptacles for at least a year, to be used as often as the female lays eggs. After mating, the adult female is again carried, cradle-fashion, beneath the male, for another two days or more. While the male is carrying and mating with the female, the pair is called "doubler" or "buck-and-rider."

Since the female mates only once, in the soft-shell state or shortly thereafter, the cradle-carry is undoubtedly important to ensure that a male is present at the critical moment of shedding, and to protect the soft female until her shell is hard.

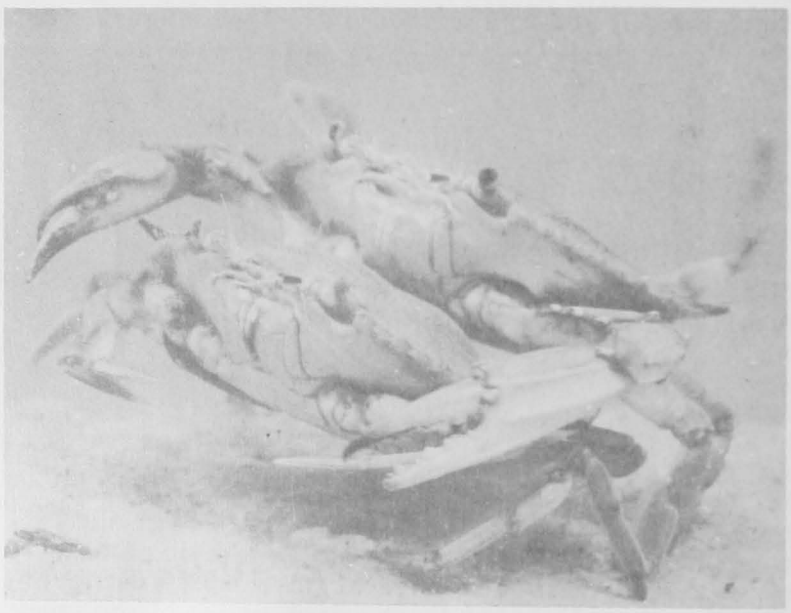


FIG. 3 - DOUBLERS. THE MALE CRADLE-CARRIES THE IMMATURE FEMALE FOR TWO OR MORE DAYS UNTIL SHE SHEDS.

Soon after mating, females migrate to the saltier waters of the southern end of Chesapeake Bay, some passing through the Capes into the ocean. This migration results in a concentration of adult females in the lower Bay; near the mouth of the Bay the catch is almost 100 percent female (Fiedler 1930; Truitt 1934).

SPAWNING

Two to nine months may elapse between mating and egg laying by the female (Churchill 1919). If mating occurs as early as May, the first egg mass may be laid in August. Although most females mature and mate in August and September, and eggs in the ovaries of each female develop almost to completion within the next two months, egg-laying is delayed until the following May or June. In early spring females in the southern end of the lower Bay move first shoreward to warmer banks and near river mouths, but by June begin to retreat from excessive shoal water temperatures to spawn offshore. Far upstream in low salinity waters of Virginia rivers and in Chesapeake Bay north of the mouth of the Rappahannock River, sponges (masses of eggs released by female crabs) seldom are seen except in unusually dry seasons (Truitt 1939). Egg laying is rapid and may be complete in two hours (Truitt 1939), eggs passing from the ovaries to the outside by way of the seminal receptacles where fertilization occurs. Outside the body, the fertilized eggs are attached by adhesives to hairs of

four pairs of appendages (swimmerets) on the abdomen. Appropriate names for egg-bearing females are sponge crab, cushion crab, lemon or orange crab, berry or berried crab, ballie, punk, and busted sook. In the same way that poultry pullets produce infertile eggs, unmated crabs may produce sponges of unfertilized eggs, but this is extremely infrequent for there is always an abundance of males, each capable of mating with several females.

When first laid eggs are bright orange in color, but during the two weeks before hatching they become yellow, brown, and then dark brown. These color changes are caused by a gradual absorption of yellow egg yolk by the crab embryo and development of dark pigment in the eyes. The dominant color of sponges changes from bright orange near river mouths to dark brown at the Virginia Capes.

A few sponge crabs may be seen before the end of April, but normally the first peak of sponge production occurs during the last week of May and the first two weeks in June. A second, smaller peak occurs in August, after which there is a rapid decrease in number of spawning females, and usually none can be found by the middle of September. On rare occasions a sponge crab has been caught as late as mid-December. Accompanying the rapid decrease in number of sponge crabs in September is an almost complete disappearance of females which had spawned. It is believed that most of them move to deeper waters of the Bay, or to the ocean, and die, or perhaps join an ocean-going population that may return to the Bay as "sea-run" or "ocean" crabs the following year. The few spent females that remain in the lower Bay over winter comprise five percent or less of the dredge catch. They are markedly different in appearance, with dark-colored shells, quite unlike the bright colored shells of newly-mated, down-river migrants, but devoid of the fouling organisms so characteristic of "ocean" crabs (Newcombe 1945; Hopkins 1947).

Some females may spawn twice or more. Those that mate in August usually produce their first sponge the following May or June and a second sponge the succeeding August, using only a portion of the sperm in the receptacles at each spawning. Empty egg cases on the swimmerets are conclusive evidence that a crab has spawned, but do not reveal whether the sponge was the first, second, or a later one to be released (Churchill 1919). Absence of egg remnants, on the other hand, is not proof that the crab has not spawned. Although remnants are most numerous immediately after the hatch, most are soon lost except for an occasional case at the bases of swimmeret hairs. However, proof can be obtained from a parasitic worm, the nemertean Carcinonemertes, whose spawning is intimately dependent on the crab laying eggs. The presence of only small worms on crab gills is evidence that the crab had not spawned; adult-sized worms are evidence of spawning. (Humes 1942; Hopkins 1947).

EGGS AND YOUNG

The number of eggs in a sponge ranges from 700,000 to over 2,000,000 (Churchill 1919; Robertson 1938; Truitt 1939). Many of the eggs do not hatch, and still fewer larvae and very small crabs live to become adults. On the average only one ten-thousandth of one percent (0.000001) of the eggs survive to become mature crabs. Eggs may be killed by a fungus, may be eaten by small worms, suffocate in stagnant or slow-moving water, or die from temperatures too high or too low (Couch 1942; Humes 1942; Rogers-Talbert 1948).

After hatching the young crab passes through two larval stages, zoea and megalops, before it takes the form of a crab. The zoea looks like a shrimp and bears a heavily-spiked hood, while the megalops looks like a miniature toad that still retains its tadpole tail (figs. 4 and 5). The zoeal form lasts about a month, during which it molts at least four times, growing from $\frac{1}{100}$ to about $\frac{1}{25}$ of an inch in width

(Churchill 1919, 1942; Hopkins 1943, 1944; Sandoz and Rogers 1944). It has been impossible to rear larvae in the laboratory past the third instar, but some zoea identical with the third, except for larger size and better developed appendages, have been tentatively identified as "fourth zoea." These have been found among the numerous, minute organisms found in surface water near the mouth of the Bay. It has been suggested that there may also be a "fifth zoea" (Hopkins 1944), and perhaps a sixth intermediate form, a metazoea, preceding the megalops stage (Snodgrass 1956).

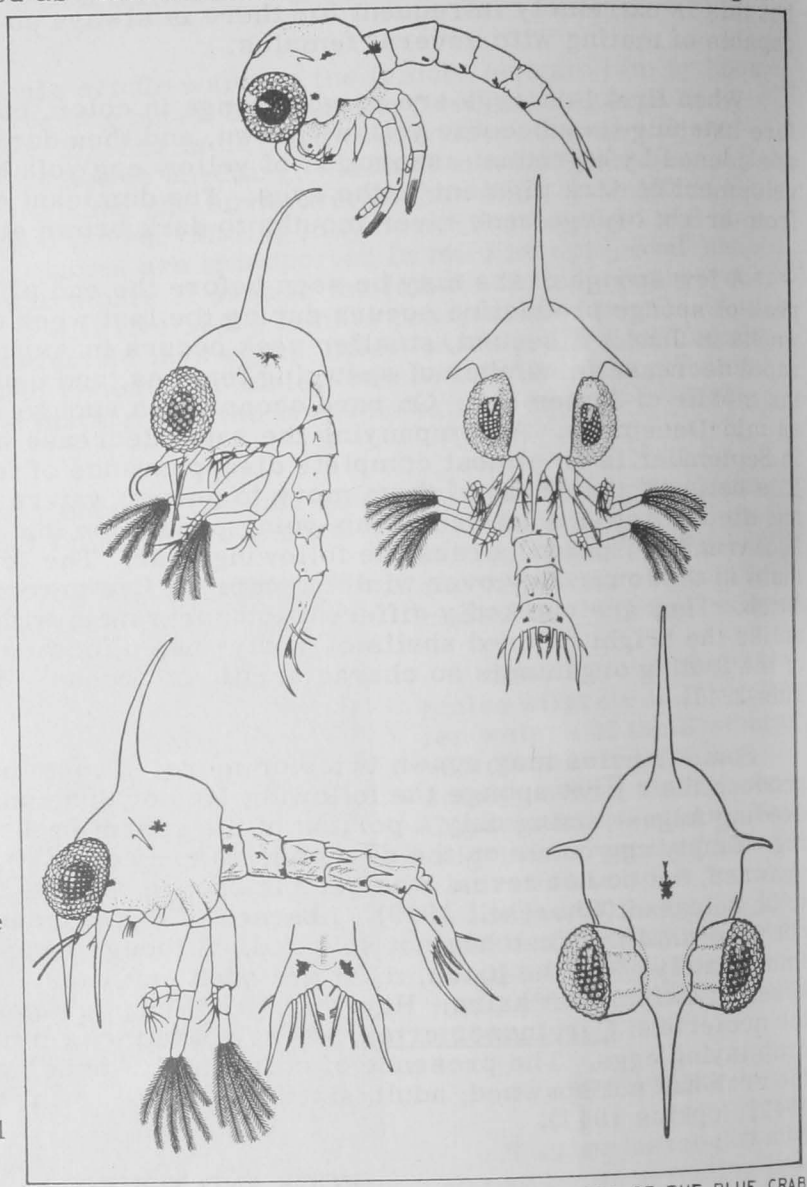


FIG. 4 - PREZOEA, FIRST ZOEA, AND SECOND ZOEA OF THE BLUE CRAB. FROM CHURCHILL 1942.

When the water has a very low salinity, larvae hatch prematurely and die in a prezoeal stage. Those that hatch normally at average or high salinities may be eaten by jellyfishes, comb-jellies, fishes, and many other enemies. Survival should be best in the southern part of Chesapeake Bay because salinity, temperature, and food conditions there compare well with optimum conditions determined for hatching and growth in the laboratory (Sandoz and Rogers 1944). The greatest concentrations of zoeae are found in the channel region between Cape Charles and Cape Henry and diminishing numbers both up-Bay and seaward. Almost no zoeae have been found up-Bay above the Virginia-Maryland line (Truitt 1934, 1939; Churchill 1942; Graham and Beaven 1942; Sandoz and Rogers 1944). Thus the horizontal distribution of zoeae is consistent with experimental evidence that salinity has an influence on success of hatching. An attraction to light may also have survival value. Concentration of zoeae in the upper levels in open waters is consistent with experimental evidence that zoeae reared in darkness do not molt (Sandoz and Rogers 1944).

Following the fourth (or fifth) molt is the megalops stage. Many of the larvae that hatch in early June reach this stage by mid-July or the first of August.

Little is known of the conditions that are most favorable for survival and development of megalops. A few have been caught in the southern part of the Bay and on the ocean coast, on the bottom in 20- to 40-foot depths, near the surface in open water, but none at intermediate levels (Truitt 1934; Robertson 1938; Goellner 1941; Churchill 1942). It is attracted to light, but settles to the bottom when swimming

ceases (Robertson 1938; Van Engel, personal observation). Occasionally in late August or early September large numbers of megalops appear along the ocean front at Virginia Beach, biting swimmers with their minute pinching claws and giving rise to numerous complaints of "water fleas" (Truitt 1939). No explanation has been offered for these concentrations of megalops in breaking waves.

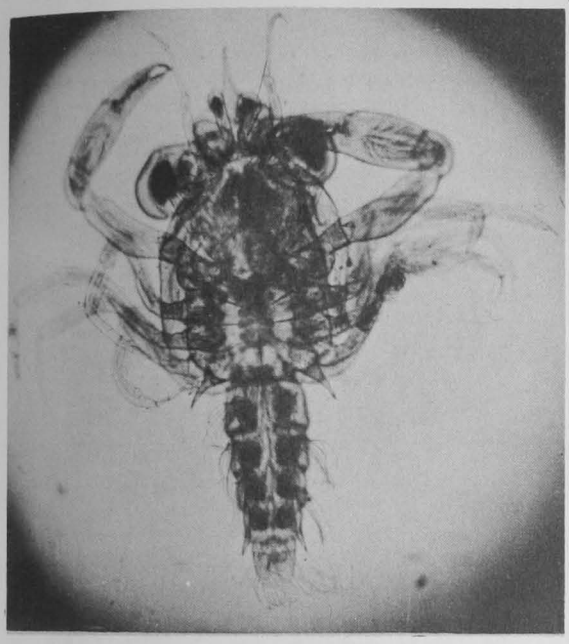


FIG. 5 - MEGALOPS OF THE BLUE CRAB.

The megalops stage lasts only a few days. When it molts the "first crab" appears, with the typical body shape of an adult crab.

Migration of large numbers of adult females past the Capes to the ocean, and subsequent appearance of megalops along the ocean beaches, suggest that a substantial amount of spawning may occur outside the Bay. As yet, no estimate of the importance of this ocean spawning in providing crabs to the Chesapeake Bay supply has been possible.

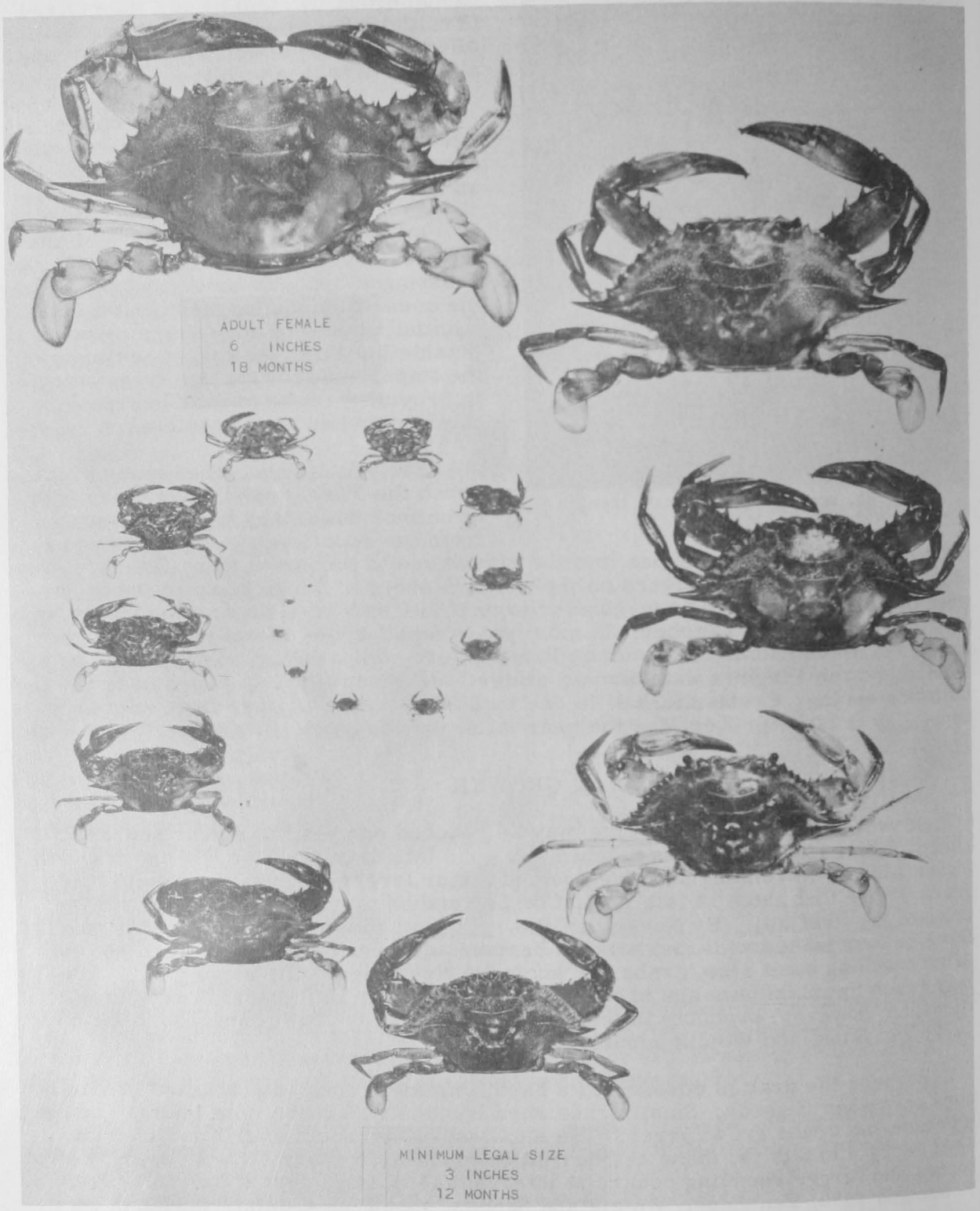
Early in August, when many crabs reach the "first crab" stage, one-tenth of an inch wide, they begin migrating from the southern part of the Bay and the ocean adjacent to the Capes into the rivers and to the upper Bay. The first wave of migration reaches the rivers on the western shore of Virginia about the third week of August, and crabs one-quarter to one-half inch in width are commonly seen during September and October. In most years small crabs do not migrate farther north than the mouth of the Potomac River before cold weather begins, and most of them remain in Virginia waters over winter. Movement up-Bay is resumed the following spring. Crabs one-half to one inch in width usually are first seen in the upper Bay in late April or May the year following the hatch (Hay 1905; Truitt 1934, 1939).

GROWTH

Growth is rapid and adult size may be reached one year to a year and a half after hatching (fig. 6). Those hatched early, in late May, become two and one-half inches wide by November and five-inch adults or larger by August the following year. Those that hatch in late August or September may reach only one-half inch in width the first fall. By November the next year these will have become only three or four inches wide and will not become adult until May of the third summer. After reaching adult size, crabs are known to live at least one more year, and a few may reach the maximum age of three to three and one-half years. The average life-span, however, probably is less than one year (Hay 1905; Churchill 1919; Truitt 1939; Van Engel and Wojcik unpublished data).

Because the crab is covered by a hard, inflexible shell, an increase in size occurs only when it sheds. Small crabs shed frequently, but the time between molts increases as crabs grow larger. The smallest crabs, about one-fifth inch wide, shed every 3 to 5 days, those one-half to one inch wide every 10 to 15 days. At four inches and larger shedding occurs at intervals of 20 to 50 days (Churchill 1919; Robertson 1938; Van Engel, Wojcik and Sandoz, unpublished data). Shedding does not usually occur in Chesapeake Bay from November through the first week in April, although on rare occasions a soft crab has been caught in deep water in December.

In preparation for shedding, a new shell is formed beneath the hard, outer shell, becoming darker in color as it develops and visible through several parts of the outer shell, especially in the last two sections of the fifth pair of legs, the swimming



paddles. Around the outer edges of those sections are many fine hairs, called setae, at the base of which there is a thin, dark brown line which represents the outer edge of the hard shell. It is just inside this brown line that the color of the new shell can be observed.

The earliest recognized color stage is the "white-rim," which requires the longest time to shed, from one to two weeks. The following stage, "pink-rim," may be expected to shed in 3 to 6 days, while the "red-sign" peeler will shed in 1 to 3 days. "Peeler" is the name given by most watermen to the red-sign crab, although the term is sometimes loosely applied to all crabs showing color signs of approaching shedding.

To free the developing new skeleton from the old, some carbohydrates and proteins and about five percent of the calcium are resorbed from the base of the old shell. These are stored in the soft tissues of the crab, principally in the hepatopancreas, and may be used for building and later hardening the new shell (Hecht 1914; Scheer 1948, 1957). Muscle attachments on the old shell are loosened and shifted to new origins on the future exoskeleton. Feeding ceases, sometimes a day or two before shedding, probably as a result of weakened muscles and inability to grind food, and in preparation for the eventual loss of the stomach lining at shedding.

When shedding starts, the outer shell cracks along definite lines so that the upper and lower halves of the shell may gape. The cracked-shell stage is called a "buster." Once this stage is reached, the crab slowly backs out of the partially-opened shell; shedding of 4- to 5-inch crabs is completed within 2 or 3 hours. When completely free from the old shell, the crab is called a "soft crab." During the few minutes preceding and immediately following shedding large amounts of water are taken in by the crab. Absorption of water occurs through permeable membranes, in many crustaceans the gills, and in some the stomach (Robertson 1957). Expansion to full size, when all wrinkles in the new skin are smoothed, is completed about two hours after shedding and the soft, pliable covering then begins to harden. Over the next 9 to 12 hours the shell has a papery or leathery texture and the crab then is called a "paper shell." During the next 12 to 24 hours the shell becomes stiff and brittle, and the crab is referred to as a "buckram." More and more frequently, "paper shell" and "buckram" are being used as synonyms for the stage between soft and hard crab, with less attention being given to whether the shell is leathery or stiff and brittle. Another three days will pass before the shell is rigid. Since the interval of time between molts is less for small than for large crabs, time intervals between various peeler and hardening stages are much shorter than those given above. In the post-molt period, the shell thickens and hardens with the addition of new layers and deposition of calcium and some organic substances. About 95 percent of the minerals are absorbed directly from the water or derived from food (Hecht 1914; Scheer 1948; 1957).

At each normal shedding, there is an increase in width one-quarter to one-third the initial size (Churchill 1919; Gray and Newcombe 1939; Van Engel, Wojcik, and Sandoz, unpublished data). Amount of increase may be genetically controlled in part, but it is believed that environmental conditions have an equal if not greater influence. Unfavorable water conditions, inadequate food, and injuries, such as the loss of one or more legs, result in smaller percentage increases, as low as 5 to 10 percent and possibly even no increase in size. In normal soft crabs, an increase in size is due to swelling of the body by absorption of water. Since the amount of water absorbed is related to the salt content of the surrounding water, greater increases in size should occur in water of low salt content (Baumberger and Olmstead 1928; Scheer 1948; Knowles and Carlisle 1956). That this is probable is demonstrated by the large size of crabs in tributaries of low salt content and the small size of crabs along the salty ocean coast of the Eastern Shore (Newcombe 1945; Henry 1951; Porter 1955). It has been shown that the eyestalks of certain crabs produce a water-regulating hormone (Knowles and Carlisle 1956).

It is possible that the number of molts is fixed and that a crab stops growing after shedding a certain number of times. Thus, the great difference in size of crabs of the same age, or of adult crabs, may be simply the result of different percentage increases in size at each molt.

Recent studies on other crustaceans show that the eyestalks and the second maxillae produce hormones which either prevent or encourage molting (Kleinholz 1957). The quantities of these chemical substances are partly controlled by temperature, light, and by other hormones (Knowles and Carlisle 1956). The failure of blue crab larvae to molt when reared in darkness (Sandoz and Rogers 1944) may be an example of hormonal regulation. Molting may also be controlled by hormonal secretions from the ovary, which develops rapidly following the last molt, or from the eggs after they are laid (Donahue 1955).

Definitions of Blue Crab Terms

1. Abdomen or apron--the "tail" of a crab.
2. Ballie--sponge crab, a female with an egg mass beneath the abdomen.
3. Berried crab or crab in berry--sponge crab.
4. Buck and rider--pair of mating crabs; a doubler.
5. Buckram crab--having a pliable, leathery shell, following the soft crab condition.
6. Buffalo crab--soft crab with large claws missing, often lost in shedding.
7. Busted sook--sponge crab.
8. Buster--shedding crab which is beginning to emerge from its shell.
9. Channeler or chandler--large male that remains in the deeper channels of a river during the summer; jimmy crab.
10. Cushion crab--sponge crab.
11. Doubler--pair of mating crabs; buck and rider.
12. Fat crab, green crab, or snot crab--these terms are used by most watermen in referring to a crab approaching the shedding period and showing a white-rim color sign just within the margins of the two outer segments of the swimming legs; the terms are more popularly used in referring to any hard crab with firm meat, somewhere between the buckram and peeler phases.
13. Green crab--white-rim crab.
14. Hard crab--crab having a hard shell; following the buckram condition.
15. Jimmy crab, jimmy dick, or jimmy channeler--a very large male crab; channeler.
16. Lemon crab--sponge crab.
17. Life history stages--there are four main stages: the egg, zoea, megalops, and crab. The zoeal and megalopal stages combined are called larval stages, while the crab stage is a post-larval stage.
18. Megalops--crab larva, between the zoeal and crab stages; about $\frac{1}{25}$th of an inch wide.
19. Metazoea--larval stage thought to occur between the fifth zoea and megalops stages; should have well developed thoracic appendages.
20. Nicking a crab--to break the movable fingers of the claws to prevent the use of the claws as pincers.
21. Orange crab--sponge crab.
22. Paper-shell crab--having a hard shell which is easily cracked, following the buckram stage.
23. Peeler crab--hard crab which has a fully formed soft shell beneath the hard outer shell; a red-sign crab. Sometimes applied to white-rim, pink-rim, and red-sign crabs.
24. Pink-rim--following the white-rim condition; there is a thin pink line along the inner border of the back fin; may be expected to shed within a week.
25. Punk--sponge crab.
26. Rank peeler--red-sign peeler just before the shell begins to crack; almost a buster.
27. Red-sign peeler--following the pink-rim stage; there is a thin red line along the inner border of the backfin; may be expected to shed within two days.
28. Sally crab--young female crab; an immature female.
29. "Seconds"--crabs that have just turned from a white-rim to a pink-rim condition.
30. Shed--meaning either the empty shell or the casting off of the shell.
31. Snot crab--white-rim crab named because of the watery substance which issues from the break of the crab claws when they are nicked.
32. Soft crab--crab which has just emerged from the old shell and has a new, soft, pliable shell.
33. Sook--an adult female crab.
34. Sponge crab, ballie, berried crab, crab in berry, busted sook, cushion crab, orange crab, punk, and lemon crab--names given to the female carrying an egg mass on the abdomen.
35. Swimmerets--the finlike attachments to the underside of an adult female crab, on which the eggs are carried until they hatch.
36. White-rim crab--the fat, green, or snot crab condition; there is a thin white line along the inner border of the back fin; may be expected to shed within two weeks.
37. "Ticky" crab--one that smells of iodoform, probably because it had eaten a marine bottom animal called Balanoglossus.
38. Zoea--the larva that hatches from the crab egg: about $\frac{1}{25}$th of an inch long.

Females in the family of swimming crabs (Portunidae), of which the blue crab is a member, may be the only crustaceans known to complete their growth in size at the time they become sexually mature. Males in this family and both sexes of many other crustaceans continue to molt and grow after the gonads are fully developed.

The female blue crab becomes sexually mature and stops growing after 18 to 20 molts, not counting the 4 (or 5) molts in the larval stage (Van Engel, unpublished data). As stated previously, this event is accompanied by a change in shape of the abdomen, from triangular to semicircular. Internally, however, few abrupt changes occur, since the growth of tissues is gradual throughout the life of the female (Cronin, 1942): the seminal receptacles grow to full size in the interval between the last two molts; the ovary expands to full size after the last molt (Van Engel, unpublished data).

Sexual maturity in males is probably reached in about 18 or 19 molts following the last larval stage, but growth does not cease, for they may shed 3 or 4 more times. One male reared from the megalops stage reached six and one-half inches in width after 23 post-larval molts, after almost 3 years of confinement in laboratory aquaria (Van Engel, unpublished data).

MIGRATIONS

Two major migrations of sooks have been observed along the western shore of Chesapeake Bay, the first in October and November, following the peak of the mating season, and the second the following May. The fall migrations results in a concentration of sooks in the lower Bay in the deep channels which are the continuations of the river channels. Large schools occasionally have been seen passing through the Capes into the ocean, where they have been taken by crab dredges and fish trawlers close to shore in depths less than 40 feet, but rarely in deeper waters farther offshore (Truitt 1934).

Schools of adult females migrating down river in May consist in part of females recently mated, but mostly of those that mated late the previous fall and were forced by low temperatures to over-winter en route to the lower Bay. Large concentrations of these migrants are caught in May near the mouths of the rivers of the western shore.

Some schools are especially noticed because the crabs are unusually large, and because often many are heavily fouled with ribbed mussels (Hay 1905; Van Engel, unpublished data).

Apart from the migration of sooks each fall and spring toward the southern end of the Bay prior to first spawning, schools of "sea-run" or "ocean" crabs appear in late July or early August in the Lynnhaven Roads area. Familiar to commercial fishermen along the southern shore of the Bay, these schools of old-looking, moss-covered, barnacle-encrusted females crowd close to the beaches, where they remain from one to four weeks (Newcombe 1945). Large concentrations occasionally migrate into the James River, where, as in the summer of 1954, they may add substantially to the commercial catch. These crabs usually are sighted first in the ocean as they move north toward the Capes. The growth of fouling organisms on their shells is in marked contrast to the brilliant blue and white colors of down-river migrants. On rare occasions, following strong northerly winds, the remains of many thousands of dead "ocean" crabs litter the beaches (Hay 1905; Truitt 1939; Newcombe 1945).

Crab dredgers report that in winter in the vicinity of Cape Henry crabs are often of strong odor, have shells deeply pitted, and produce a very small quantity of very inferior meat, and catches of this kind are quickly dumped overboard. These crabs may be the remnants of "ocean" schools (Truitt 1939). Those with a strong odor are called "ticky" crabs, possibly because the odor is similar to iodoform which in turn is similar to the odor of bed bugs (bed ticks).

When females migrate down-river to the lower Bay, adult males remain in brackish river waters and many move farther upstream, mating with other females. In the first 20 to 25 miles upstream from the mouth of the York River the sexes are about equal in numbers, but the percentage of males increases gradually with distance upstream (Wojcik, unpublished data). This distribution is probably dependent on the salinity gradient and may vary seasonally and between rivers.

FOOD

The diet of blue crabs includes fresh and decaying fish or meat, as well as vegetation. Roots, shoots, and leaves of common seaweeds are regularly eaten, especially parts of eelgrass (Zostera), ditch grass (Ruppia), sea lettuce (Ulva), and salt-marsh grass (Spartina)--Truitt 1939. Destruction of young quahogs (Venus) and seed oysters (Crassostrea) in experimental ponds and tanks has been frequently reported (Lunz 1947; Loosanoff and Chestnut 1948; Carriker 1951; Carver 1957). On clam and oyster grounds in open waters, however, the blue crab cannot be considered a serious pest, although transplants of young sets may be destroyed

when other food is less available (Loosanoff and Chestnut 1948; Menzel and Hopkins 1956).

Because its diet is varied, the blue crab is attracted to almost any bait; tough trash fish or slaughterhouse trimmings are preferred for trotlines, but oily fish are preferred for crab pots.

The food requirements of larval crabs are not well known. Zoeae will eat many microscopic plants and animals but will not grow unless fed certain protozoans, the yellow dinoflagellates (Robertson 1938; Sandoz and Rogers 1944). The megalops is omnivorous, however, and may be fed bits of fresh fish or shellfish or green aquatic plants.

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NEW BEDFORD SCALLOP FISHING FLEET

There are about 70 or 80 boats of the New Bedford fishing fleet rigged for sea scalloping. They range from 60 to 100 feet long and are powered by Diesel engines up to 550 horsepower. All are equipped with depthfinders, Loran navigating sets, and ship-to-shore radiotelephones. Almost all of them are fairly new and extremely seaworthy craft. A winter gale on Georges Bank will soon seek out the weaknesses of any vessel. Construction and deck arrangement is very similar to the usual medium-size New England dragger. Many of the boats change over from trawling to scalloping and back again to accommodate themselves to changing fishing and marketing conditions. Any well-found dragger can rig up for sea scalloping by removing the nets and otter boards and taking aboard the shucking boxes, wash tank, and the booms necessary for handling the dredges. The same double-drum fishing winch, wire rope, and forward gallows frames are used.

--Fishery Leaflet 442,
Sea Scallop Boats and Gear (August 1957).