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# Observations on the Conservation of the Chesapeake Blue Crab, Callinectes sapidus Rathbun[1]

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It is a matter of common knowledge among conservationists that the blue crab supply of the Chesapeake is rapidly declining, being reduced from a level of about 17 millions in 1931 to that of about 10 million crabs in 1937. (Md. Rept. 1937). Numerous explanations have been advanced to account for this decline. One outstanding reason is the taking of such large numbers of "sponge" (berried) crabs and mated female crabs, a practice which undoubtedly reduces the potential supply of young crabs for the ensuing year.

Another menace to the survival of the blue crab lies in the way in which "soft crabs" are handled in the industry. The current methods of transporting and holding crabs on shedding floats are responsible for the loss of a very significant percentage of the total numbers taken. From a standpoint of practical conservation, no single one of our Chesapeake commercial fisheries merits more immediate attention than the blue crab fishery.

This paper embodies the results of observations made on the current practices followed by the industry in handling crabs, and the effect of these practices on survival rate from a conservation viewpoint. Field experiments have been conducted to show the extent of loss resulting from faulty methods and, furthermore, by careful observations made on crabs in commercial and experimental floats, it has been possible to give reasons for modifying certain industrial practices. Those applied phases of the study pertaining to moulting and growth are briefly described, the more theoretical aspects of the data having been treated elsewhere (Gray and Newcombe, 1938 and 1939). Emphasis is placed on the lines of study that need to be pursued and the current practices which should be modified in order to preserve the crab fishery (Compare Settee and Fiedler, 1925).

## MATERIALS

The Chesapeake Bay is the main center of the soft crab fishery even though the blue crab ranges as far north as Cape Cod,

[1]Joint contribution from the Biological Laboratories of the University of Maryland; and from the Virginia Fisheries Laboratory and the Department of Biology of the College of William and Mary (Contribution No. 2).

Massachusetts and south to the Gulf of Mexico. Specimens used in this study were collected near Solomons Island and maintained on typical as well as especially constructed floats. Additional observations were made on the commercial floats at Solomons Island and at Crisfield, Maryland.

Crabs were kept in specially constructed crab floats containing several compartments. The linear dimensions considered are as follows—*width*, "W", referring to the shortest distance between the ends of the lateral spines of the carapace; *length*, "L", meaning the perpendicular distance across the carapace from a point immediately posterior to the rostrum to a point just above the first segment of the apron; *eye-to-spine*, "E", implying the distance from the first anterior lateral serration posterior to the eye and the tip of the right lateral carapace spine (Fig. 1). Measurements were made with a vernier caliper reading to a tenth of a millimeter. Male and female specimens were compared in respect to their growth characteristics.

Instead of following the growth of individual specimens through the several stages, a method of grouping was used, the width interval being 10 mm. By means of the average growth ratios obtained by this procedure, it has been possible to establish certain dimensional and moulting characteristics of the species, age differences and, in particular, differences between male and female crabs. These facts are helpful in any regulatory efforts aiming to preserve the crab supply.

## Results

Individual observations of over 500 crabs in floats have indicated that there is a high death rate among "peelers" (crabs ready to cast their shells) kept on commercial floats. The lethal effect is due to a variety of causes. Polluted water surrounding the float constitutes one limiting factor in crab moulting. Efforts should be made to keep the floats in clean water, away from all refuse. The idea that a crab is a scavenger and normally consumes miscellaneous organic debris is a misconception. Although crabs do devour dead animals before decomposition begins, they avoid those that are in the later stages of disintegration. In an aquarium, the slightest morsel of decomposing material may subsequently prove fatal to the crab.

Another factor limiting survival in the floats is found in the common practice of breaking the claws. This *breaking* causes the soft membranes inside of the shell to swell, and hence, prevents the tissues from being readily pulled through the narrow joints (Hay, 1905). This produces either death or a legless condition (buffalo crabs). The claws are broken by the crabber in order to facilitate handling as well as to prevent cannibalism.

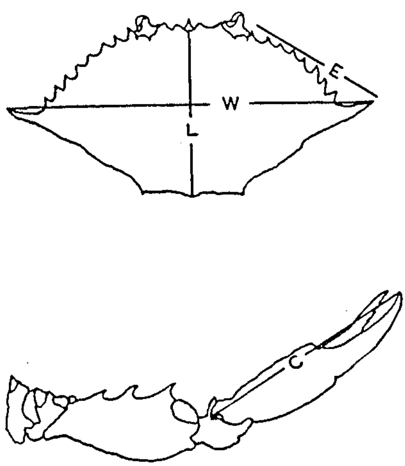


FIGURE 1. Outline drawing of the blue crab showing the dimensions measured. W = width; L = length; E = distance from eye-to-spine; and C = length of the propodite of the chaela.

A third factor that causes high mortality is the holding of "green line" crabs[2] on the floats. While these crabs are in the initial stages of moulting, a period of a week or *more* is frequently required before actual shedding takes place, hence they must have food to assure normal survival. Since they are not given food when on the floats, a large percentage (at least 25%) die of starvation. "Pink line" crabs are so close to moulting that food is not required until the process is completed. If only "red line" and "pink line" crabs, which do not eat, were kept on the floats, these last two causes of mortality would be automatically eliminated. In the study of over 500 crabs that were carefully handled on floats under favorable weather conditions, a 63% loss in the "green" crab moultings was observed and 27% loss in the "white line" crabs, as compared with 4% in the "pink

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[2] "Green line" crabs are those with a green line in the back "fin" (fifth pereiopods), indicating the commencement of moulting. Subsequent stages in moulting are designated "white line", "pink line", and "red line". The "red line" stage immediately precedes the actual shedding process; actual moulting crabs are known as "busters". Other designations are also used.

line" and 9% in the "red line" crabs. The increase in mortality of "red line" crabs over those in the "pink line" stage is due to the fact that "red line" crabs being more delicate are to a greater extent subject to injury. Crab dealers recognize the fallacy of holding "green" crabs on the floats but are obliged to do so for a practical reason, namely, the crabber demands the acceptance of his entire catch regardless of the stages represented.

A fourth factor causing high mortality results from the use of faulty methods by the crabber in transporting his catch to the commercial floats. "Buster" crabs are frequently carried in the bottom of his boat. This exposes them to the air and produces a so-called "blister" between the two carapaces which prevents moulting. Furthermore, "red line" crabs are especially subject to injury by careless handling. In many instances, tin buckets instead of wooden vessels are employed to convey crabs from their point of catch to the floats. It is well known that this tends to weaken the crab at a time when it requires maximum strength.

Size is used as a criterion for selecting marketable soft crabs. Legal sized small individuals, having an initial width range of about 75 to 85 mm., moult with greater facility and, if handled properly, have a lower death rate than those larger than 90 mm. in width. This may be attributed to the fact that the time required for moulting is shorter in small crabs and fewer structural changes take place. Because of the higher mortality among large crabs during moulting, it might seem to be more economical to use the slightly smaller ones, which are, according to many tests, just as palatable. It is recognized that the number of small crabs—75 to 85 mm. group—required to meet the soft crab demand would be greater than the number of large specimens. However, the increase is not likely to be particularly significant on account of the known higher mortality of the mature moulting crab. These and related points pertinent to the crab fishery are being given further study at the Virginia Fisheries Laboratory at Yorktown.

Biometrical studies of moulting crabs have shown that females having an initial width of over 90 mm. will usually mature at their next moulting. It is also easy to distinguish this point by physical characteristics. "Virgin" females require a longer time for shedding at this moult than at any other, evidently because of the excessive modifications of the exoskeleton, whereby the triangular apron becomes rounded, the spines straightened and lengthened and the body excessively thickened.

The corresponding point of sexual maturity cannot be so readily recognized in *male* specimens, because the external modifications are not as conspicuous. At this point, there is, however, a slight modification in the exoskeletal structure, since the spines tend to curve anteriorly. This observation substantiates the find-

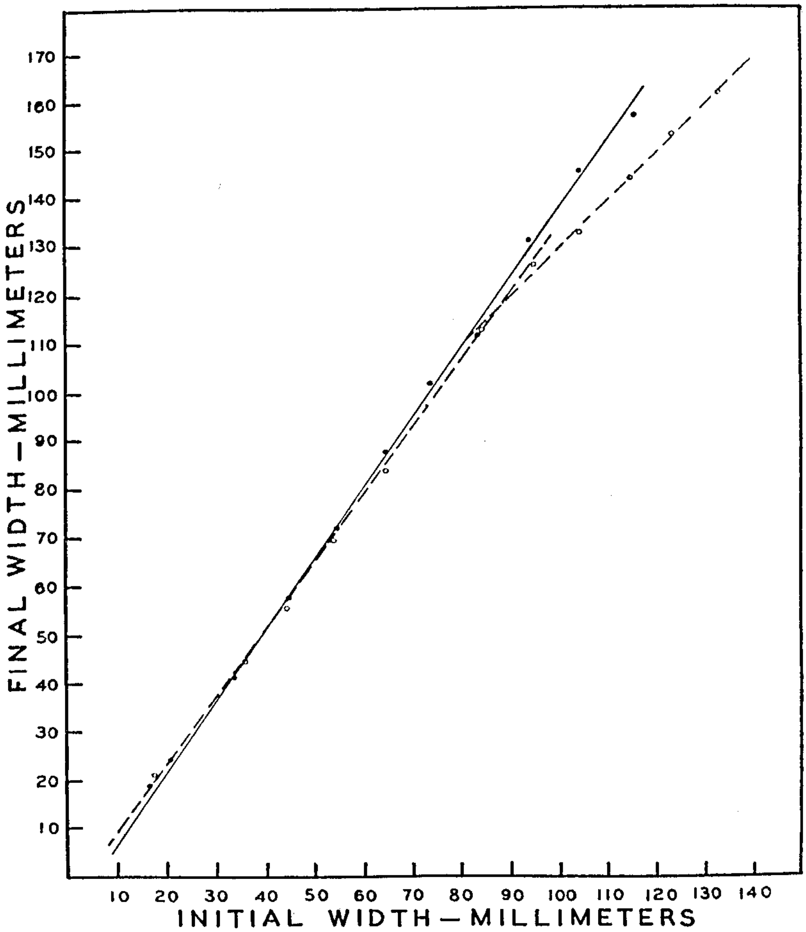


FIGURE 2. Showing the moulting increments of width in the blue crab. Continuous line = females; dashed line = males. Range of initial widths—males, 16.3 to 139.8 mm. and females, 13.0 to 119.4 mm. Observe the change in moulting characteristics of *males* at an initial width of 90 mm.

ings based on the following statistical data obtained during the period 1933-38 (Table 1).

It has been found that two distinct growth ratios, each representing a straight line relationship, prevail during the life of the *male* crab. The point of intersection, being at the initial width of about 90 mm., is evidently the result of physiological change in the organism that modifies the relative growth increments during moulting (Fig. 2). Identical conclusions may be reached by using

## Table I
### Moulting Increments of *C. sapidus*

| Group No. | Width Interval | No. | Mean Width Initial | Mean Width Final | Abso. Incr. | % Addition | Mean Length Initial | Mean Length Final | Abso. Incr. | % Addition | Mean Dist. Eye-to-spine Initial | Mean Dist. Eye-to-spine Final | Abso. Incr. | % Addition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Females** | | | | | | | | | | | | | | |
| I | 0— 9.9 | | | | | | | | | | | | | |
| II | 10— 19.9 | 8 | 16.76 | 18.76 | 2.00 | 11.93 | 8.92 | 10.53 | 1.60 | 17.93 | 6.15 | 6.93 | 0.78 | 12.79 |
| III | 20— 29.9 | 3 | 21.06 | 24.23 | 3.16 | 15.03 | 11.36 | 13.46 | 2.10 | 18.48 | 8.33 | 9.00 | 0.66 | 7.92 |
| IV | 30— 39.9 | 4 | 33.95 | 41.13 | 7.18 | 21.13 | 14.90 | 18.77 | 3.87 | 25.58 | 11.27 | 14.60 | 3.33 | 29.45 |
| V | 40— 49.9 | 29 | 45.31 | 57.93 | 12.62 | 27.86 | 22.13 | 28.05 | 5.92 | 26.75 | 16.47 | 21.77 | 5.32 | 32.17 |
| VI | 50— 59.9 | 52 | 55.38 | 71.90 | 16.52 | 29.82 | 26.83 | 34.04 | 7.22 | 26.88 | 20.71 | 27.04 | 6.33 | 30.59 |
| VII | 60— 69.9 | 66 | 65.02 | 87.52 | 22.50 | 34.59 | 31.23 | 40.22 | 8.99 | 28.78 | 24.65 | 33.46 | 8.81 | 35.55 |
| VIII | 70— 79.9 | 40 | 74.43 | 101.62 | 27.19 | 36.53 | 35.15 | 45.61 | 10.46 | 29.16 | 28.48 | 39.19 | 10.71 | 37.59 |
| IX | 80— 89.9 | 25 | 83.90 | 112.04 | 28.14 | 33.53 | 39.06 | 49.52 | 10.46 | 26.77 | 32.41 | 44.49 | 12.08 | 37.25 |
| X | 90— 99.9 | 14 | 94.56 | 131.33 | 36.77 | 38.87 | 43.16 | 54.02 | 10.86 | 25.15 | 36.96 | 51.90 | 14.94 | 40.43 |
| XI | 100—109.9 | 8 | 104.46 | 145.96 | 41.50 | 39.73 | 47.16 | 63.06 | 15.90 | 33.71 | 41.68 | 60.69 | 18.92 | 45.41 |
| XII | 110—119.9 | 5 | 116.34 | 157.58 | 41.24 | 35.44 | 50.34 | 64.24 | 13.90 | 27.65 | 50.16 | 74.32 | 24.16 | 48.16 |
| XIII | 120—129.9 | 3 | 122.00 | 165.13 | 43.13 | 35.35 | 55.00 | 67.96 | 12.96 | 35.75 | 48.93 | 67.56 | 18.36 | 38.08 |
| XIV | 130—139.9 | 2 | 131.50 | 176.25 | 44.75 | 34.03 | 57.25 | 69.90 | 12.65 | 22.09 | 54.00 | 70.90 | 16.90 | 31.29 |
| **Males** | | | | | | | | | | | | | | |
| I | 0— 9.9 | | | | | | | | | | | | | |
| II | 10— 19.9 | 5 | 17.62 | 20.10 | 2.52 | 14.38 | 9.20 | 11.04 | 1.84 | 20.00 | 6.54 | 7.80 | 1.26 | 19.26 |
| III | 20— 29.9 | 0 | | | | | | | | | | | | |
| IV | 30— 39.9 | 7 | 36.23 | 44.63 | 8.40 | 23.18 | 17.50 | 22.00 | 4.50 | 25.71 | 12.70 | 15.67 | 2.97 | 22.57 |
| V | 40— 49.9 | 13 | 44.81 | 55.78 | 10.97 | 24.48 | 21.79 | 27.26 | 5.47 | 25.10 | 16.62 | 20.37 | 3.75 | 22.58 |
| VI | 50— 59.9 | 25 | 54.43 | 69.40 | 14.97 | 27.50 | 26.42 | 33.19 | 6.76 | 25.60 | 20.84 | 26.26 | 5.42 | 26.02 |
| VII | 60— 69.9 | 31 | 64.91 | 83.96 | 19.05 | 29.40 | 31.40 | 39.53 | 8.13 | 25.92 | 24.91 | 32.92 | 8.01 | 32.14 |
| VIII | 70— 79.9 | 24 | 74.05 | 98.12 | 24.07 | 32.51 | 35.00 | 44.50 | 9.50 | 27.11 | 28.74 | 38.64 | 9.91 | 34.45 |
| IX | 80— 89.9 | 17 | 84.98 | 112.97 | 27.99 | 32.93 | 39.65 | 50.08 | 10.43 | 26.32 | 33.72 | 45.62 | 11.90 | 35.26 |
| X | 90— 99.9 | 12 | 95.41 | 126.08 | 30.67 | 32.14 | 44.65 | 55.75 | 11.10 | 24.84 | 37.02 | 50.28 | 13.26 | 35.81 |
| XI | 100—109.9 | 15 | 104.85 | 133.27 | 28.42 | 27.10 | 47.89 | 58.60 | 10.71 | 22.35 | 41.99 | 54.26 | 12.27 | 29.21 |
| XII | 110—119.9 | 19 | 115.22 | 144.33 | 29.11 | 25.26 | 52.80 | 63.52 | 10.72 | 20.31 | 46.17 | 57.33 | 11.16 | 24.17 |
| XIII | 120—129.9 | 13 | 123.69 | 153.45 | 29.76 | 24.06 | 55.76 | 66.70 | 10.94 | 19.63 | 39.74 | 61.32 | 11.53 | 23.27 |
| XIV | 130—139.9 | 8 | 133.40 | 162.27 | 28.87 | 21.65 | 58.96 | 69.43 | 10.47 | 17.72 | 53.28 | 64.18 | 10.90 | 20.46 |
| XV | 140—149.9 | 1 | 149.10 | 175.50 | 26.40 | 17.70 | 65.40 | 77.50 | 12.10 | 18.50 | 60.50 | 70.90 | 10.40 | 17.19 |
| XVI | 150—159.9 | 1 | 153.20 | 190.40 | 37.20 | 24.47 | 66.50 | 79.00 | 12.50 | 18.80 | 61.50 | 77.00 | 15.50 | 22.30 |

either the length, or the eye-to-spine dimensions. In these dimensions, the break occurs at a size (males) comparable to 90 mm. width. It is at this size that the male crab is believed to mature. In the case of female crabs, the difference in the moulting increments of width does not on the average exceed 4% until an initial width of about 89 mm. is reached. From this point on a significant sexual difference occurs. It has been pointed out above that in the case of male specimens a different ratio (initial width to final width) holds beyond the 89 mm. width. Female crabs maintain a fairly constant ratio throughout life as shown in Fig. 2.

In both sexes, the three dimensions measured exhibit a similar peak of expansion with respect to size. The peak in females corresponds with the size at which sexual maturity is reached and constitutes one reason for believing that the peak in the males also indicates the size of sexual maturity. (Table 1).

Variations in moulting between male and female crabs ranging in size from about 10 to 159 mm. are shown in Table 1. It is noted that differences exist between the sexes and also within the same sex depending on the initial sizes.

By means of the linear equations presented in Table II it is possible to determine the dimensions—length, eye-to-spine, and propodite of the chaela—corresponding to a specific width. One use of these equations is to estimate the percentage of crabs possessing regenerated claws and hence, may be helpful in solving the problem centering around the "buffalo" crabs.

The data that have accrued from this study permit a direct estimation from a width dimension, of the number of moults taking place in crabs exceeding 20 mm. in width. Using Fig. 2, the number of moults may be estimated for crabs ranging from 20 to 140 mm. in width. This result is shown graphically in Fig. 3. By way of illustration, a crab 20 mm. in width reaches, on moulting, a final width of 22 mm. (Fig. 2). Assuming this final width to be the next initial width, the corresponding final width after moulting is 24.8 mm. By continuing in this way, the number of moults for male crabs of this size has been calculated to be 11, being two more than the number for female specimens of the same initial size. (Table III).

In concluding this discussion of biometrical relations that typify crabs of this species, it should be recalled that significance is attributed here not to individual ratios and variations as occurring in living specimens observed during successive moultings, but rather, to the establishment of *group* ratios and *group* variations of known numerical values. To obtain moulting data of comparable accuracy by rearing individual crabs through to maturity would prove impractical on account of the inherent difficulties accompanying the rearing of such large numbers of crabs to a mature stage.

## Summary

This study has shown that certain of the current practices of handling crabs followed in the Chesapeake Bay are detrimental to the best interests of the crab fishery. These procedures have been studied together with certain statistical aspects of moulting in this species.

It is well known that the mortality among moulting crabs on commercial floats would be greatly lessened if the dealer would guard against polluted water, and make certain that the crabber properly transports his daily catch. Our results stress the importance of these preventative measures.

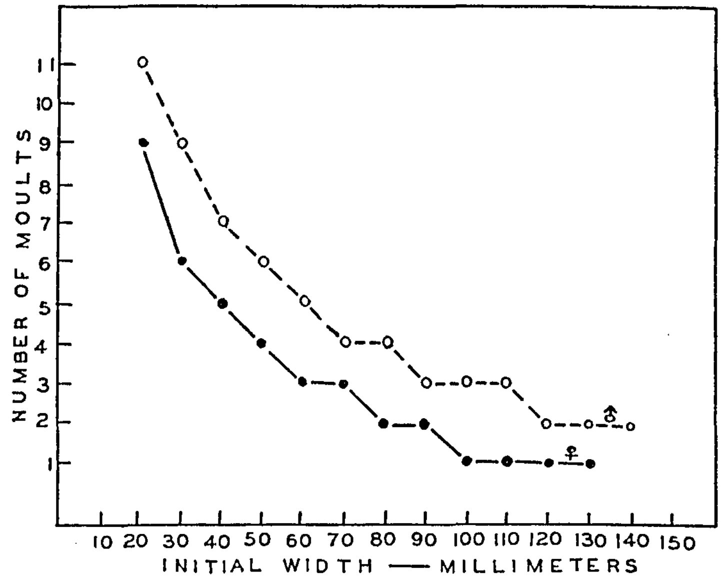


FIGURE 3. Relation of the initial width of the blue crab to the estimated number of moults. Continuous line = females; dashed line = males. Range of initial width, 20 to 140 mm.

Discontinuing the practice of holding so-called "green" or "feeding" crabs on floats, will save the current loss to the industry of more than 25% of the catch, a loss caused by starvation, cannibalism and broken claws.

Results of experiments in holding crabs on floats under favorable conditions have shown that there is a 63% loss in the "green" crab moultings and a 27% loss in the "white line" crabs, as compared with the 4% loss in the "pink line" and a 9% loss in the "red line" crabs.

The higher mortality of mature moulting crabs kept on floats has been pointed out and constitutes an important consideration in any study bearing on crab conservation.

The data provide evidence that the width of the male crab at sexual maturity is about 90 mm. The matter of preserving *male crabs* (most abundant in the upper bay) *of this size* may therefore be as vital to conservation as is the greatly agitated question of protecting the *female crabs* (dominant in Virginia waters) *in the "sponge" condition.*

These observations made in several of the principal crab packing houses of the Chesapeake indicate the need for improved methods, both of catching and of handling crabs throughout the entire region. They constitute only a few of the requirements of the crab industry that warrant serious consideration. Indeed, they strengthen our conviction that there is an urgent need for the dissemination of knowledge in matters pertaining to the applied aspects of the biology of the crab and for more comprehensive studies of the relative survival rates of mature and immature crabs kept on floats and, particularly, for a detailed investigation of the composition of the crab populations in widely different sectors of our waters.

At present, information is needed on the size-weight relations of *Callinectes*, on the composition of the commercial catch with respect to size frequency distributions, on the intensity of the present rates of fishing in relation to that which can be supported without danger of depletion, and on the *spawning reserve* essential to maintenance of the fishery. Steps should be taken immediately to find out our present rate of fishing and current trends in the fishery so that a basis may be established for interpreting future increases and declines and for the establishment of regulatory policies to effect sound conservation of this important fishery.

TABLE II

LINEAR EQUATIONS SHOWING THE RELATIONS OF THE DIMENSIONS OF THE BLUE CRAB, *Callinectes sapidus*.

| *No.* | *Sex* | *Group* | *Equation* |
|---|---|---|---|
| 1 | Male | | $L = 4.52 + 0.412\ W$ |
| 2 | Female | Lower Group | $L = 4.438 + 0.408\ W$ |
| 3 | Female | Upper Group | $L = 7.111 + 0.370\ W$ |
| 4 | Male | | $E = -2.213 + 0.4176\ W$ |
| 5 | Female | | $E = -3.836 + 0.4360\ W$ |
| 6 | Male | | $C = -10.805 + 0.6246\ W$ |
| 7 | Female | | $C = 1.982 + 0.4356\ W$ |

TABLE III

SHOWING METHOD OF ESTIMATING AVERAGE NUMBER OF MOULTS IN *C. sapidus* BY REFERENCE TO FIGURE 2.

SPECIMENS

| Males Initial Width 20 mm. Moults | | Females Initial Width 20 mm. Moults | | Males Initial Width 80 mm. Moults | | Females Initial Width 80 mm. Moults | |
|---|---|---|---|---|---|---|---|
| From | To | From | To | From | To | From | To |
| 20.0 | 22.0 | 20.0 | 22.9 | 80.0 | 106.0 | 80.0 | 108.2 |
| 22.0 | 24.8 | 22.9 | 26.9 | 106.0 | 135.2 | 108.2 | 148.8 |
| 24.8 | 28.5 | 26.9 | 32.6 | 135.2 | 164.2 | | |
| 28.5 | 34.0 | 32.6 | 40.8 | 164.2 | 195.2 | | |
| 34.0 | 41.6 | 40.8 | 48.4 | | | | |
| 41.6 | 52.0 | 48.4 | 63.5 | | | | |
| 52.0 | 66.8 | 63.5 | 84.2 | | | | |
| 66.8 | 87.3 | 84.2 | 114.2 | | | | |
| 87.3 | 126.5 | 114.1 | 156.9 | | | | |
| 126.5 | 155.1 | | | | | | |
| 155.1 | 184.0 | | | | | | |
| No. of moults, 11. | | No. of moults, 9. | | No. of moults, 4. | | No. of moults, 2. | |

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Thanks are also expressed to Commissioner G. Walter Mapp of the Virginia Commission of Fisheries through whose interest in the conservation of the Chesapeake crab fishery, these studies were continued in the lower waters of the Bay.

## LITERATURE CITED

Churchill, E. P. 1918—Life History of the blue crab. Bull. Bur. of Fish., Vol. 36, pp. 93-128, 1917, 1918.

Gray, Ellen H. and Newcombe, Curtis L. 1938—Relative growth of parts of the blue crab, *Callinectes sapidus* Rathbun. Growth, Vol. 2, No. 3, pp. 235-246.

—1939—Studies of moulting in *Callinectes sapidus* Rathbun. Growth, Vol. 2, No. 4, pp. 285-296.

Hay, W. P. 1905—Life history of the blue crab. *Callinectes sapidus*, Rept. U. S. Bur. of Fish. 1904, pp. 397-413.

Report, Fifteenth Annual, Conservation Department, 1937—Comparative report on peelers and soft crabs, p. 100.

Settee, O. E. and Fiedler, R. R. 1925—A Survey of the Condition of the Crab Fisheries of Chesapeake Bay. Prel. Report Sp. Mem. 1607-14, U. S. Dept. of Com., Bur. of Fish.

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