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Seasonal Abundance and Distribution of Juvenile Blue Crabs in Core Sound, N.C. 1965–68

ABSTRACT: Studies were made in Core Sound, North Carolina to determine the abundance and distribution of juvenile blue crabs, *Callinectes sapidus*, and their subsequent relation to the commercial fishery. Estimates of juvenile abundance were based on catches of small crabs in the marsh creeks bordering Core Sound. Young-of-the-year blue crabs (2.5–5.0 mm) begin to enter Core Sound estuary in early October. These small crabs move through the open waters of the sound and bays into the small marsh creeks and remain there until the following spring. At this time (April-May) the juvenile crabs move into the bays and sound proper where they remain to maturity.

Catch and effort statistics from Core Sound Commercial crab fishery were collected from November 1964 through June 1968. Landings of approximately 680,000 kg annually constitute the fishery.

Introduction

The blue crab, *Callinectes sapidus*, inhabits estuarine and nearshore waters along the east coast of the U.S. from Massachusetts to Florida and ranges north to Nova Scotia and south to Uruguay (Rathbun, 1930).

Blue crabs are an important commercial species second in value to Atlantic menhaden, *Brevoortia tyrannus*, along the Atlantic coast. Major fishing areas are Chesapeake Bay, Pamlico Sound in North Carolina, and the St. Johns River in Florida. Since 1960, landings of blue crabs along the Atlantic coast of the U.S. have averaged approximately 60 million kg, valued at about 8 million dollars annually.

During the last 50 years, particularly the past two decades, the blue crab fishery has experienced large and sudden fluctuations in abundance. To maintain a viable fishery it is essential that a method be developed for predicting the yearly number of crabs available for harvesting. A reliable index would enable the industry to prepare for the commercial catch in advance of the fishing season.

The Bureau of Commercial Fisheries began to study blue crabs in Core Sound, N.C., in November 1964. This paper presents information on the abundance and distribution of blue crabs in this esturarine system. Major objectives of this study were to (1) locate nursery grounds, (2) obtain information on the migration of young crabs into the nursery area and (3) develop an index of juvenile abundance and correlate this with the subsequent abundance of marketable crabs.

Life History of the Blue Crab

Blue crabs mature in approximately 18 months and about 27 molts following hatching (Van Engel, 1958; Costlow and Bookhout, 1959). Females mate once, but males may mate between each of their last three molts prior to maturity and after reaching maturity (Truitt, 1939). Preceding her last prematurity molt, the female is carried beneath the male, often for 2 or more days, until she sheds her immature shell. After shedding and during the female's soft condition, sperm from the male are transferred to the spermathecae of the female. Here the sperm are stored, remaining viable a year or more. During this time the sperm may fertilize one or more egg masses. During the spawning season (May through October), females congregate in high salinity waters (river mouths, inlets, and along ocean beaches) where their eggs mature and hatch (Sandoz and Rogers, 1944; Costlow and Bookhout, 1959). The number of eggs in a sponge (egg mass on abdomen) ranges from 700,000 to over 2,000,000 (Churchill, 1919; Truitt, 1939).

After hatching the larvae are either carried by currents or move offshore. The larvae, called zoeae, molt 6 to 8 times before transforming into the megalops stage of development. Metamorphosis to the first crab stage (carapace width, approximately 2.5 mm) probably occurs in the ocean. Plankton samples taken by the M/V *Theodore N. Gill* cruises in 1953 and 1954 revealed the occurrence of the advanced *Callinectes* sp. zoeal stages up to 40 miles offshore and of the megalops up to 80 miles (Nichols and Keney, 1963). About 6 months after hatching, we observed that young crabs (2.5–5.0 mm) make their way into the estuaries where they continue to molt (about 18–20 additional times) and grow to maturity. They enter the commercial fishery about 1 year after their movement into the estuary where they have attained a carapace width of 127 mm or larger.

Description of the Study Area

Core Sound, located in Carteret County, N.C., connects with the ocean through Barden and Drum Inlets and adjoins Pamlico Sound to the north and Back Sound to the south (Fig. 1). The sound covers an area of approximately 2,270 hectares and averages approximately 2 m in depth. The salinity averages about 30 o/oo and seldom drops below 20 o/oo. The normal annual temperature range is about 8 to 28 C. The mean tide range is about 30 cm.

Four general habitats in the study area are the sound, inlets, bays and tributary marsh creeks. The sound and inlets generally have a hard sandy bottom; the bays are about half sand and half mud bottom, and the marsh creeks have soft muddy bottoms. On the ocean side of the sound adjacent to the marsh creeks, there is a covering of eel grass *(Zostera marina)* approximately 1 km wide in 30–45 cm of water.

Materials and Methods

Sampling stations were located in Core Sound proper, Drum and Barden Inlets and many adjacent bays and tributary creeks (Fig. 1). In the sound, bays and inlets we made tows of 10 minute duration with a 6 m otter trawl which had 22 and 7 mm bar mesh in the body and cod end, respectively. We used two 3 m otter trawls at each station in the creeks. One net had 22 and 7 mm bar mesh and the other had 7 mm and 3 mm bar mesh in the body and cod ends, respectively. The large mesh net was towed for 5 minutes and the small mesh net for 3 minutes. Collections were made bimonthly, but a third sample was taken in the creeks when possible. The inlet stations were sampled only during 1965 and 1966. Catch counts, water temperature and salinity were recorded. Each crab was sexed and spine to spine carapace width was measured.

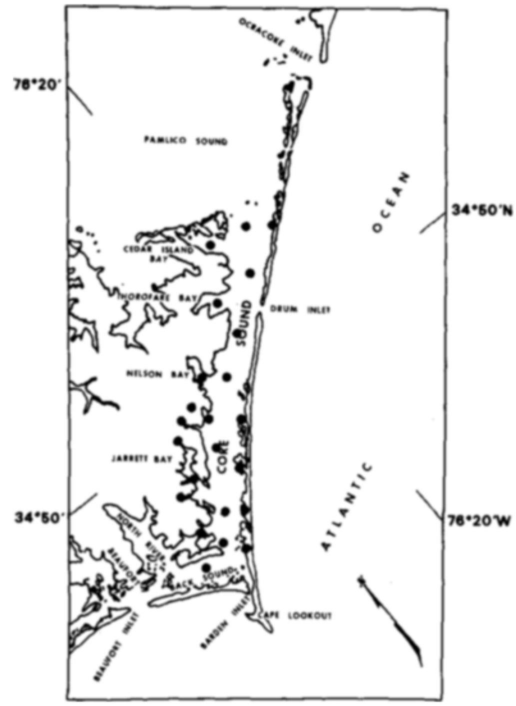

Fig. 1. Core Sound, North Carolina. Dots represent sampling stations.

Catch and effort statistics were collected for the Core Sound Commercial fishery, 1964–1968. Information was obtained on the number of crab boats (the number of fishermen per boat varies from one to three), on the catch weight of crabs, and on the number of pot-days. Reliable effort data were not available, so the commercial catch was used to estimate adult abundance. Commercial catch records were obtained from crab dealers.

Results and Discussion

SOUND AND OPEN WATERS

Samples at 11 sound, 3 bay and 2 inlet stations contained mostly mature crabs and only a small number of juveniles.

Juveniles were most abundant in the bay and sound from May through September (Fig. 2A). When the juvenile catch in these open waters for 1965 (Fig. 2B) and 1966 (Fig. 2C) is broken down into size groups, the 0–4 cm group constituted the smallest catch (5% in 1965, and 11% in 1966) and the 5–8 cm size group constituted the largest catch (49% in 1965 and 54% in 1966), whereas the 9–12 cm group had 46% in 1965 and 35% in 1966. Our data indicate that juvenile crabs leave the marsh creeks in the spring and move into the bays and sound where they remain to maturity.

CREEKS

The catch of juvenile blue crabs in the small creeks adjacent to the sound and bays was similar throughout the three study periods 1965–66, 1966–67, and 1967–68.

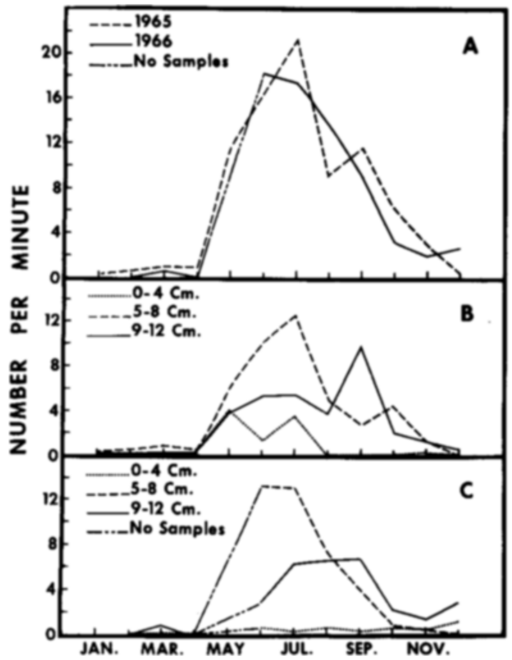

Fig. 2. A. Catch of immature crabs per minute in the sound and bays for 1965 and 1966, all size groups combined. B. Catch of immature crabs per minute in the sound and bays during 1965 by size groups. C. Catch of immature crabs per minute in the sound and bays during 1966 by size groups.

Juvenile abundance by year class was compared using the period from June through May, the approximate start of 1 year's hatching of larvae to the start of hatching the following year.

During the period June 1965 through May 1966, young-of-the-year blue crabs began to arrive in number in the small creeks in December and reached a peak during March (Fig. 3A). Juveniles in the 0–4 cm size group made up the largest catch from December through March and were the most abundant group (57%) throughout the study period. Crabs in the 5–8 cm size group represented a smaller total catch (20%) from December through March and consisted of a lesser total catch for the year (30%). The 9–12 cm size group were not common, probably because they migrate out of the creek into the bays and sound, as they mature. From December through March this size group made up the smallest catch (4%) and the lowest for the year (13%).

The influx of juveniles from June 1966 through May 1967 began in November and reached peak abundance during January (Fig. 3B). Crabs in the 0–4 cm size group made up the largest catch (81%) from November through March and a large part of the total catch (68%). Juveniles in the 5–8 cm size group were next in abundance (15%) from November through March, and second in total catch (23%). Again, the larger juveniles (9–12 cm) were least abundant and exhibited almost the same pattern as in 1965–66.

From June 1967 through May 1968 the catch pattern for juveniles was somewhat different than for the previous 2 years, due apparently to abnormally low water temperatures during the winter (Fig. 3C). We began catching juveniles in appreciable numbers in November and the catch rates continued to rise until extended cold weather drastically reduced our catch-per-minute in February. In March, however, water temperatures returned to normal and the highest catches per minute during the study were recorded. Crabs in the 0–4 cm size group were most numerous in the catch from November through March (75%) and represented the greatest part of the total catch (68%). The 5–8 cm size group accounted for a higher percentage of the catch (19%) from November through March this year, than during previous years and of the total catch (24%). As in past years, the 9–12 cm size group percentage remained low.

The monthly catch per minute of all size groups, i.e., 0–12 cm, in the marsh creeks was quite similar for all years (Fig. 3D). Only during the winter of 1968 did the catch per minute drastically decline, (probably due to cold water temperatures affecting availability rather than a reduction in abundance of crabs). We found that during extreme cold (water temperatures below 6 C), juvenile crabs were rarely captured by trawling. During January and February of 1968, when recorded temperatures were below the average for the same period the two previous years, catches of juveniles dropped to the lowest level observed during the study (Table 1).

Juvenile crab data showed that the Core Sound

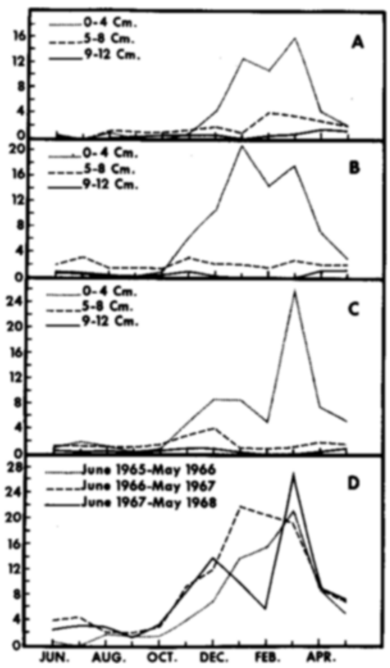

Fig. 3. A. Catch of immature crabs per minute in the creeks by size class, June 1965–May 1966. B. Catch of immature crabs per minute in the creeks by size class, June 1966–May 1967. C. Catch of immature crabs per minute in the creeks by size class, June 1967–May 1968. D. Total combined catch of immature crabs for all size groups.

TABLE 1. The monthly number of juveniles caught per-minute of trawling and average water temperatures in nine marsh creeks.

	1965		1966		1967		1968	
	No.	Temp. (C)	No.	Temp. (C)	No.	Temp. (C)	No.	Temp. (C)
Jan.	15.6	13.3	14.0	8.4	21.9	11.6	9.8	8.0
Feb.	24.1	13.6	15.7	13.2	15.3	11.6	5.9	4.8
Mar.	31.4	13.1	21.4	15.3	19.3	16.8	26.7	12.2
Apr.	17.4	18.9	9.0	18.6	9.6	20.9	9.7	18.0
May	4.2	21.0	5.2	22.6	6.7	20.4	7.2	21.8
June	.6	26.3	3.6	23.6	2.4	27.9	3.2	27.0
July			4.6	29.4	3.3	26.8		
Aug.	1.9	28.7	2.3	29.4	3.0	28.0		
Sept.	1.3	28.4	2.1	26.2	1.4	24.0		
Oct.	1.5	18.3	3.0	20.7	3.2	20.2		
Nov.	3.9	14.1	9.4	14.4	9.2	12.0		
Dec.	7.1	9.2	12.1	9.6	13.8	11.9		

TABLE 2. Catch of juvenile blue crabs and the commercial catch of the blue crab fishery in Core Sound, one year later.

	Catch of juveniles			Commercial catch	
Time	Catch per minute	Relative index no.	Time	Kilograms of crabs observed	Kilograms of crabs expected
June 1965–May 1966	81.6	1.0	June 1966–May 1967	763,197	
June 1966–May 1967	109.9	1.35	June 1967–May 1968	813,730	1,030,316
June 1967–May 1968	98.8	1.21	June 1968–May 1969	1,065,743	923,468

estuary had relatively little change in the influx of young-of-the-year crabs during 1966, 1967 and 1968 on the basis of seasonal relative abundance by size classes.

Correlation of Juvenile and Adult Abundance

Mean catch of juvenile crabs from the creeks was used as an index of juvenile abundance. The juvenile abundance index from June through May of any year should correlate with the abundance of adult crabs the next year. The index of juveniles from June 1965 to May 1966 and the commercial catch from June 1966 to May 1967 were used as a baseline to compare subsequent years. The juvenile index number was derived from the mean catch-per-minute from June 1965 to May 1966 (81.6) as equal to index of 1.0. The index for the period June 1966 to May 1967 thus was calculated by dividing the base year index into the June 1966 to May 1967 mean catch (109.9), giving an index of 1.35, etc. (Table 2). The catch for June 1967 to May 1968 was 21% lower than the catch predicted from the juvenile relative abundance index and for June 1968 to May 1969 it was 15% greater than predicted. The 1968–69 commercial season which had high landings was due primarily to high prices and scarcity of blue crabs in surrounding areas.

We believe that the juvenile index of abundance can be correlated with subsequent adult abundance and provide a forecast of future adult populations in Core Sound. More accurate effort data would improve the correlation.

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An Investigation of the Dynamics of Population Growth and Control in Scyphistomae of the Scyphozoan *Aurelia aurita*

ABSTRACT: Experiments were conducted to determine the effects of various factors on growth by budding of *Aurelia aurita* scyphistomae populations. Population growth appears to fit a sigmoid model and is reduced in high-density cultures, apparently by some soluble inhibitor of budding produced by the presence of polyps. Low temperature and starvation further inhibit the growth of polyp populations.

Introduction

The numerical decrease in growth rate of an animal population after a high initial rate is often the result of changes in the environment induced by the organisms themselves. These changes are diverse in nature and effect; they include mechanical jostling between individuals at higher densities (Adolph, 1931), higher growth of bacterial contaminants (Fulton, 1959), increased concentration of carbon dioxide or other excretory products (Allee, 1934), and chemical or hormonal substances secreted by organisms into the medium (Davis, 1966, 1967; Fiore, 1971).

Coelenterates such as *Hydra* constitute especially favorable material for investigating effects of medium conditioning on population growth. These organisms are cultured with little effort and they reproduce by budding, which is easily observable and can be used as a finite datum. *Hydra* exhibits a sigmoid curve of population growth, and the final culture densities are determined by the concentration of accumulated metabolic waste products of the polyps (Loomis and Lenhoff, 1956). Population densities are also adversely affected by low oxygen tension and extremes of pH (Loomis, 1954); there is also evidence for a substance secreted at high polyp densities which inhibits regeneration and budding (Davis, 1966, 1967).

To our knowledge no quantitiative investigation has been made of the factors which affect population growth in coelenterate scyphistomae. In the case of *Aurelia aurita,* the organism employed in this experiment, several stages of the life cycle occur in local York River waters; but scyphistomae have not been located. They were obtained, instead, from laboratory cultures of adult medusae. The fact that in some areas populations of *Aurelia* reach extremely high densities in rather quiescent waters (Galigher, 1925) suggests that conditioning of the surrounding medium, if it occurs, might exert important effects on population growth.

The author wishes to extend appreciation to Dr. C. P. Mangum for her careful reading of the manuscript and to Dr. R. E. L. Black for assistance and experimental material.

Materials and methods

Scyphistomae of *Aurelia aurita* obtained from laboratory stocks were employed in these experiments. Cultures were maintained in iodine-free artificial seawater in order to inhibit strobilation (Spangenberg, 1965, 1967). Experimental vessels consisted of small glass finger bowls 6 cm in diameter and 2 cm deep filled with 30 ml of the artificial medium. All water, including conditioned medium, was strongly aerated before initiation of cultures. Except for the experiment requiring low temperatures, cultures were uniformly maintained in dark, vapor-saturated chambers at 24 C. All polyps except for those in the starvation cultures were fed every third day with *Artemia salina* cultured in artificial seawater. Attempts were made to keep constant the amount of food per polyp in all cultures.

Polyps were counted prior to each feeding with a dissecting microscope and a background grid. Each polyp and visible bud was counted as one individual. No strobilation occurred during the 21-day period of the experiments.

EFFECT OF DENSITY ON POPULATION GROWTH. Cultures of polyps were initiated in densities ranging from 5 to 100 individuals per vessel (see Table 1 for the experimental design). The cultures were originally inoculated with fresh artificial seawater but the water was not then changed for the remainder of the experiment.

EFFECT OF CONDITIONED MEDIUM. To determine the effect of conditioned medium on population growth rate, two cultures of 25 polyps each were initiated. The first culture, designated in the results as "conditioned water", employed highly conditioned medium from original stock vessels instead of fresh artificial seawater. In the second culture the medium was replaced every other day with fresh, aerated