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Progress on Blue Crab Research in the South Atlantic

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Abstract

Research on blue crab in the South Atlantic was initiated by the Bureau of Commercial Fisheries on a limited scale in 1957. It was not until 1961, however, that money was appropriated specifically for a blue crab program. Prior to the initiation of this study very little was known concerning life history, migration, distribution, racial identity, abundance, recruitment, and general biology of the species in the South Atlantic area.

Population studies in the Neuse River, North Carolina, have investigated methods for estimating the size of crab populations. Tagging of adult crabs in the Newport River, North Carolina, in three estuaries in South Carolina, in the St. Johns River, Florida, and at various coastal locations in North Carolina, South Carolina, and Florida, is providing valuable information on the movements of blue crabs. Present indications are that there is very little migration between estuaries, and the blue crab fishery in a particular estuarine system cannot depend on recruitment from other geographical areas.

Studies of blue crab larvae are being conducted both in the laboratory and in the field. Analysis of plankton collections taken in estuaries and offshore from Florida to North Carolina provides evidence that development through the early life stages may take place at considerable distances offshore. Blue crab larvae have been successfully hatched and reared in the laboratory under various conditions of salinity and temperature. Mortality of the zoeal stages does not appear to be directly associated with either salinity or temperature. Recent work has established that mortality and rate of development of the megalops, that stage just prior to the first crab, are considerably affected by temperature and salinity.

The Blue Crab Fishery

THE BLUE CRAB FISHERY is one of the most valuable fisheries in the United States. It is extensive in terms of landings, number of fishermen, and area fished. From its beginnings in the Chesapeake Bay area more than 80 years ago, it has expanded southward along the Atlantic Coast to Miami, Florida, and along

the Gulf Coast from Florida to Texas. Landings of blue crabs in the United States in 1960 totaled more than 150 million pounds, valued at 9 million dollars. This catch represented the efforts of some 10,000 fishermen and provided employment for many other persons in processing plants and allied industries.

In the southeastern Atlantic states, more than 40 million pounds of blue crabs were landed in 1961. This poundage was more than for any other food fish species, and was exceeded in value by food species only by shrimp.

When we speculate on the future of this valuable resource, it is alarming to find that our knowledge of the species is not commensurate with our estimate of its economic importance and is not sufficient to answer questions now of major concern to the industry. Scientific knowledge on which to base effective management practices, or which would permit predicting fluctuations in abundance, is lacking.

Development of the Blue Crab Program

The lack of knowledge concerning the resource prompted the blue crab industry, working through the Atlantic States Marine Fisheries Commission, to request the Bureau of Commercial Fisheries to undertake scientific studies on the biology of the blue crab. The basic problem of the proposed research program was the determining of factors affecting the abundance of marketable crabs.

One of the factors affecting the abundance of a species is the survival rate of the early stages of life, and variation in survival rate often is a major cause of fishery-independent fluctuation in exploited fish populations. Accordingly, the Blue Crab Program began with a study of the early stages in the life cycle and, in 1957, a contract was awarded to the Oyster Institute of North America for this purpose. In 1959, this contract was transferred to Duke University, and work on larval forms has continued at the Duke Marine Laboratory until the present time.

With the curtailment of the Shad Program, some funds and personnel were made available for blue crab research. In 1958 and 1959, a study was conducted of the movements of blue crabs in the coastal waters of South Carolina. This was a cooperative study between the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, North Carolina, and the Bears Bluff Laboratories, Wadmalaw Island, South Carolina. The objective of this project was to determine if commercial-size crabs migrate from one estuarine system to another, or if the crabbing industry in a particular estuary is independent of the migratory movements of crabs.

A total of 4,353 blue crabs of 5 inches or greater carapace width were tagged and released in 3 estuaries and at 2 coastal locations in South Carolina. Locations of 530 returns indicated that most of the crabs did not migrate between estuaries, but limited their movement beween the lower estuary and adjacent coastal waters. Only 3% of the tagged crabs recaptured were recovered in estuaries other than those in which tagged. This indicated, at least for South Carolina waters, that the blue crab fishery in a particular estuary could not depend upon recruitment of marketable size crabs from other geographical areas. It also indicated that management measures might be confined to individual estuarine systems rather than large coastal regions (Fischler and Walburg, 1962).

In 1961, Bureau funds were made available specifically for a Blue Crab Program. Studies were begun in the Newport River and adjacent sounds in

North Carolina, and in the St. Johns River, Florida. Operations in North Carolina are conducted from the laboratory at Beaufort; the St. Johns work, from a field laboratory established at Green Cove Springs, Florida.

Prior to the initiation of the Blue Crab Program, almost no information was available on migration, distribution, racial identity, abundance, recruitment, and general biology of the species in the southeastern Atlantic states. Suggested reasons for this lack of information have been: (1) studies are made difficult because the fishery is pursued by many small operators working over a very large geographical area, and (2) the life history of the species is complicated and only recently have some phases been described.

Distribution of Callinectes Species

Four species of the genus *Callinectes* are known to occur in the coastal waters of the southeastern Atlantic states. These are *C. sapidus, C. ornatus, C. danae,* and *C. marginatus*. Generally speaking, only the blue crab, *C. sapidus,* is classified as a commercial species. This economic classification is made strictly on the basis of minimum maturity size, and noncommercial species which are of marketable size are not culled from the catch, but are processed as blue crabs.

Rathbun (1930) described each species and reported that the northern limit of the range of each was: (1) *C. sapidus,* Nova Scotia; (2) *C. ornatus,* New Jersey; (3) *C. danae,* Indian River Inlet, Florida; (4) *C. marginatus,* Florida Keys.

Lunz (1958) reported that the morphological features usually given for taxonomic separation of the species are variable, and individuals matching any of the frontal outlines given by Rathbun can be found in South Carolina waters. Lunz also stated that only 30% of the crabs caught by trawlers on the South Carolina coast are the blue crab, the remainder being presumably C. *ornatus* and *C. danae*.

We have found that along the coast of the southeastern Atlantic states, the non-commercial species are common at most times during the year, but appear to be restricted to waters of higher salinity than are blue crabs. Those taken in North Carolina are *C. ornatus,* and possibly *C. danae,* and those taken in the St. Johns area are *C. ornatus, C. danae,* and possibly *C. marginatus*.

In any event, the distribution and identification of the non-commercial species, and the composition of the crab populations in our study area, are uncertain. Identification of the larval forms of the different species is even more complicated, and this creates a definite problem in our work, since determination of the distribution of blue crab larvae requires correct identification.

Larval Studies

The larval studies are basically of two types: (1) laboratory studies to determine the effects of environmental factors on larval survival and rate of development, and (2) field studies to determine the distribution and abundance of larvae.

In the laboratory, larvae of the blue crab have been reared from hatching to beyond the first crab stage (Costlow, Rees, and Bookhout, 1959). Larvae are now being reared under a variety of controlled conditions to determine how salinity, temperature, and diet affect the survival of the larval stages and their rate of development to the crab. There is considerable variability in the survival

of larvae obtained from hatching the eggs of different female blue crabs. Survival has ranged from less than 1% to approximately 40%, even when all larvae are maintained under identical environmental conditions. This has made it difficult to show any direct correlation between survival of the zoeae and conditions which would normally be encountered in nature. It is possible that this variation in survival is associated with intrinsic factors such as diet of the female crab prior to egg laying, environmental factors at the time of egg laying, or genetic differences. Studies are underway to determine if variability of larval survival is associated with nitrogen content or other organic constituents of the eggs and larval stages. Additional work is needed to determine the cause of this variability in survival, and how the physiological condition of the female affects egg and larval development.

Recent work has established that mortality and rate of development of the megalops stage (that stage just prior to the first crab) are considerably affected by temperature and salinity. At 15C, the megalops rarely develop to the crab stage, while at 20, 25, and 30C, as high as 80% survive and complete metamorphosis to the crab stage. The rate of development is slower in megalops maintained in lower temperatures and lower salinities. This stage may be the most critical stage in larval development, as far as its tolerance to physical conditions of the environment is concerned.

Progress is also being made in hatching and rearing the noncommercial species of *Callinectes* and other closely related species in the laboratory. This work is essential if the larval forms from nature are to be correctly identified to species.

In our field studies, regular plankton collections are being made in estuarine and offshore waters in North Carolina and Florida. In addition, plankton collections from the Florida Straits to Cape Hatteras, North Carolina, taken over a 2 year period by the Bureau of Commercial Fisheries research vessel THEODORE N. GILL, were made available.

Our analysis of these plankton collections reveals the following:

(1) In the estuaries, only early stage zoeae and megalops occur. There is a tremendous drop in numbers from first to second stage zoeae. This may be comparable to the heavy mortality between first and second stage zoeae observed in laboratory rearing experiments.

(2) In the inlets, all larval stages occur. This suggests that some complete development takes place in these waters.

(3) The most productive waters for the combined larval stages are offshore. In Florida, Georgia, and South Carolina, large numbers of early stage zoeae occurred near the beaches, but the most productive areas for the combined larval stages were 20 and 40 miles offshore. It is surprising to find relatively large numbers of late stage zoeae and megalops occurring 60 miles offshore, and some as much as 80 miles offshore.

These findings raise many questions to which we do not have the answers. Among them are:

(1) How can one account for the presence of megalops in the estuaries in the absence of late-stage zoeae in these areas? It seems unlikely that the megalops can make their way into the estuaries from 40 to 60 miles offshore before metamorphosis occurs.

(2) Do these larvae which are carried offshore, and this appears to be a large percentage of the larvae which are produced, successfully complete

development to the crab and subsequently contribute to the estuarine population of juveniles and adults?

(3) Are the crabs which result from the development of these offshore larvae lost to the fishery, or do they become part of an offshore population of *Callinectes* crabs?

We believe that these and many other questions will be answered as the result of our continuing larval studies. Such studies will also help us determine why fluctuations in abundance occur.

Immature Crab Studies

We are routinely collecting information on the ecology of juvenile blue crabs. Since most of the gear employed in the commercial fishery is selective for adult crabs, we must do our own fishing for immature crabs. This involves trawling with fine-mesh trawls in the estuaries and offshore, and the use of haul seines in the shallow bays and tributaries.

The immature crab studies have four major objectives: (1) To locate the nursery grounds for immature crabs and to determine their abundance, food, predators, and competitors. (2) To determine recruitment rates by measuring the abundance of immature crabs in certain size ranges. (3) To determine growth increment, time, and mortality between molts of the blue crab. (4) To develop a means of forecasting crab abundance in advance of the fishing season.

These are continuing studies conducted on a year-round basis so that sufficient data can be collected to be meaningful.

Movements of Adult Crabs

The movements of sexually mature blue crabs are being determined from tagging studies. Approximately twenty thousand have been tagged and released throughout our study areas. During tagging, a representative sample (usually every fifth individual) is placed to one side and the gonads examined for the stage of sexual maturity. This additional information makes it possible to correlate the movements of the adults with mating activity.

It has previously been indicated that there is very little movement of blue crabs between estuaries. There is, however, considerable movement of crabs within a particular estuary and into the adjacent coastal waters. The pattern of these movements is similar in the two areas under study—Newport River, North Carolina, and St. Johns River, Florida—therefore, a description of the results obtained in the St. Johns River will suffice.

Our studies in the St. Johns cover an area extending from the mouth of the river to Astor, Florida, a distance of 135 miles. Thirty miles from the mouth of the river, the salinity is zero, and about two-thirds of the St. Johns River blue crab fishery takes place in freshwater.

Mating of the St. Johns River blue crab occurs throughout the 135 miles of the river under study. The period of mating is primarily March through November. Female blue crabs mate only once and this occurs immediately after the female sheds for the last time, and while she is still in the soft-shell state. Sperm will remain viable in the seminal receptacles of the female for at least a year, to be used as often as she lays eggs, which is usually more than once.

Females which mate during the fall months in fresh water begin their migration to waters of low salinity in December. This results in a congregation of females in December and January about 20 miles from the mouth of the river. In February, the females migrate to waters of higher salinity about 10

miles from the mouth of the river and develop a sponge of eggs on the abdomen. During March and April, sponge females migrate into the ocean where the eggs hatch. The majority of these ocean migrants pass through the Inland Waterway (5 miles from the mouth of the St. Johns) and enter the ocean via the Ft. George and Nassau Rivers, approximately 6 and 15 miles to the north of the St. Johns. Soon after the eggs hatch, spent females re-enter the St. Johns, the Ft. George, and Nassau Rivers to develop a second sponge. The second sponge develops rapidly, and these females return to the ocean during June and July for the hatching of the eggs. Following the hatching of this second sponge, the females do not normally return to the river, but remain in the ocean and presumably die soon afterwards.

The foregoing describes the movements of one group of females that mates in September and October, and migrates to the ocean the following spring. However, there are three distinct groups of females in the St. Johns during any one year. A second group mates in spring and migrates to the ocean in the summer, while a third group mates in summer and migrates to the ocean in the fall. Each of these groups may be reinforced in the lower river and ocean by second-sponge females from the preceeding group.

Males which mature in fresh water, 35 to 135 miles from the mouth of the river, likewise migrate downriver toward and into higher salinity waters, throughout the year. This may be due, in part, to the presence of mateable females which are more closely associated with the saltier water of the lower river. Males in the lower 25 miles of the river usually remain in the area, but some movements do occur into the ocean and the Ft. George and Nassau Rivers throughout the year. In late fall and early winter, a concentration of males appears in the waters of the lower St. Johns and immediately off the mouth.

These migrations are reflected in the sex ratio of the commercial catch. In the lower 25 miles of the river, 45% of the catch is male and 55% female; from 25 to 75 miles from the mouth, the sex ratio is 80% male and 20% female; from 75 to 135 miles from the mouth, the catch consists of 88% male and 12% female.

From the studies of the larvae, juveniles, and adults described above, it is believed that a fairly complete picture of the complicated life history of the blue crab will emerge. This information, augmented by laboratory studies on the survival requirements of the various life history stages, will provide a foundation for the scientific management of the species.

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