PRELIMINARY STOCK ASSESSMENT, NORTH CAROLINA: HARD BLUE CRABS, *Callinectes sapidus*

by

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ABSTRACT

A preliminary stock assessment of North Carolina's hard blue crab, *Callinectes sapidus*, was conducted from August, 1976 through June, 1977. Data on file with the North Carolina Division of Marine Fisheries and the National Marine Fisheries Service were examined for its suitability in forming a management base. Biological studies were conducted on juvenile and commercial blue crabs in habitats surrounding Pamlico Sound. An attempt to develop a voluntary statistics program was not successful. A brief life history and management recommendations are presented.

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INTRODUCTION

The blue crab *(Callinectes sapidus)* supports the largest crab fishery in the United States (Williams 1965), with North Carolina ranking third among Atlantic coastal states in terms of blue crab production. This fishery, centered around Pamlico Sound, has produced a 17-year average of 16.5 million pounds of hard crabs annually (Table 1), worth in excess of $2.41 million to the fishermen. In 1976, 2.77 million pounds of processed crab products brought $11.5 million to North Carolina processors. In addition, 30 processors purchased crabs from 650 fishermen and employed approximately 1,200 workers. The blue crab as a raw catch and processed product may well be the single most valuable marine organism in North Carolina.

Largely because of its great economic value, the blue crab has been the subject of a number of investigations and a tremendous volume of literature. States along the Atlantic coast (Van Engel 1958, 1962; Eldridge and Waltz 1977; Palmer 1974; and Tagatz 1968) and the Gulf coast (Oesterling 1976; Perry 1975; Adkins 1972; and More 1969), have conducted extensive studies on blue crab life history, migration, and fisheries.

In recent years, research on blue crabs in North Carolina has been conducted by the National Marine Fisheries Service concerning population analysis and migration (Fischler 1965; Judy and Dudley 1970, and Dudley and Judy 1971, 1973). In addition, several North Carolina State University projects have examined various aspects of handling and processing (Busta *et al.*, 1965; Thomson and Thomas 1966; Webb *et al.*, 1969; Miller, Webb, and Thomas 1974; and Giddings and Hall 1975, 1976). The North Carolina Division of Marine Fisheries has done little work on blue crabs in the past except to briefly investigate causes for mortalities during the late 1960s (Mahood *et al.*, 1970). Since that time, the Division has concentrated on monitoring abundance of juveniles in nursery areas (Spitsbergen and Wolff 1974, Wolff 1976, and Purvis 1976) because there appeared to be few resource problems with the fishery.

TABLE 1.--Reported hard blue crab landings, by gear, for North Carolina, 1960-1976 in thousands of pounds [1]

Year	Total catch	Pot catch	Percent	Trawl catch	Percent	Trot line catch	Percent
1960	14,937	6,073	40.7	3,045	20.4	5,744	38.5
1961	15,880	6,030	38.0	3,370	21.2	6,480	40.8
1962	12,221	4,964	40.6	2,300	18.8	4,957	40.6
1963	18,835	11,755	62.4	3,525	18.7	3,555	18.9
1964	24,092	13,297	55.2	6,050	25.1	4,745	19.7
1965	22,334	8,935	40.0	7,964	35.7	5,435	24.3
1966	18,914	7,966	42.1	8,027	42.4	2,920	15.4
1967	14,272	4,072	28.5	7,440	52.1	2,740	19.2
1968	19,170	7,820	40.8	8,358	43.6	2,965	15.5
1969	22,159	11,612	52.4	7,831	35.3	2,716	12.3
1970	20,881	13,149	63.0	5,468	26.2	2,263	10.8
1971	14,476	10,893	75.2	2,169	15.0	1,413	9.8
1972	13,479	10,925	81.0	1,435	10.7	1,119	8.3
1973	11,963	9,436	78.9	2,275	19.0	242	2.0
1974	13,163	11,174	84.9	1,555	11.8	435	3.3
1975	11,072	7,879	71.2	2,819	25.5	374	3.4
1976	11,732	8,005	68.2	2,427	20.7	572	4.9

[1] Data from NMFS - TIMS - Statistics Division, Beaufort, NC

The Division has no statistical data from which to derive reliable catch/effort information, nor are the statistics obtained by the National Mairne Fisheries Service suitable for such analysis. However, production has declined steadily for the last few years, for unknown reasons, causing serious problems for the crab industry. Accordingly, the Division proposed to conduct a preliminary assessment of the fishery to determine if a cause or causes for the decline can be established, to suggest remedial action, and to determine if some sort of management actions are necessary over and above those now in effect. The objectives of this project were:

1. To organize and summarize such statistical data as may currently exist,
2. To obtain biological and environmental data which may relate to changes in abundance of blue crabs,
3. To establish a statistical system for the blue crab industry, and
4. To prepare a completion report.

BRIEF LIFE HISTORY

The blue crab *(Callinectes sapidus)* ranges from Cape Cod to northern South America. Juveniles inhabit the more shallow estuaries, most often at very low salinities. They are most numerous in the estuaries from the late fall through the spring, moving into tidal marshes, bays, and areas adjacent to major bodies of water. Juvenile blue crabs mature in about 12 to 14 months.

In the spring, mature males molt first; soon afterward, females molt, and during this soft-shell period mating takes place. The females then move into deeper, higher salinity water. In North Carolina, this includes the larger bodies of water such as Pamlico and Core Sounds, as the females seek a salinity of 20 ppt or higher. During this period of female migration, males tend to remain in the brackish areas.

During this migration females begin extruding their eggs, which are fertilized by the sperm already stored in their seminal vesicles, forming an externally-visible "sponge." During the May through October spawning

season, females congregate in high salinity waters near the inlets where their eggs mature and hatch. The number of eggs in a sponge ranges from 700,000 to over 1.7 million, and they take approximately 15 days to hatch at 26°C.

The eggs hatch into a larval stage, called zoea, which are carried by currents offshore. Zoea molt six to eight times before transforming into the megalops larvae, which can either swim or crawl. Metamorphosis to the first crab stage probably takes place in the ocean at an approximate carapace width of 2.5 mm. Samples examined by Nichols and Keney (1963) revealed the presence of advanced *Callinectes* sp. zoeal stages up to 40 miles offshore, and of the megalops stage, up to 80 miles.

About six months after hatching, young crabs (3-10 mm) enter the estuary where they grow to maturity (approximately 18-20 molts). Blue crabs enter the commercial fishery about one year after their first entry into the estuary when they have reached a width of 125 mm (5 in) or larger. The crab is then approximately 18 months old.

Due to the hard outer shell, size increases only when the crab molts. This process takes place more frequently while the crab is small and periods between molts increase as the crab grows. Small crabs 5 mm wide may molt every 3 to 5 days, crabs 12 to 25 mm every 10 to 15 days, and crabs greater than 100 mm wide may molt every 20 to 50 days (Van Engel 1958). An interesting facet of blue crab growth is the fact that females complete their growth with a terminal molt at the same time they become sexually mature and breed their only time.

The actual process of molting and growth is fairly complex. Prior to shedding the old shell, a new shell begins forming underneath the old. With the time of molting approaching, the crab resorbs some carbohydrates, proteins, and calcium from the old shell. These are stored in the body for reuse in forming the new shell. Muscle attachments are loosened and re-attached to the forming shell. At this time all feeding ceases. Finally the old shell splits open along the line where the carapace joins the abdomen, and the crab simply backs out of the old shell. At this time the crab is very soft and defenseless. For these reasons, molting takes place in hiding and usually at night. Just prior to and immediately

after molting, large volumes of water are absorbed by the crab. This expands the new shell to a larger size than the previous shell. After two to three days, the new shell is completely hardened.

EXAMINATION OF FILE DATA

Procedures

Blue crab data on file with the Division of Marine Fisheries, consisting mostly of relative abundance of juveniles from earlier PL 88-309 projects and estuarine monitoring programs, were compared to examine their significance on a year-to-year and area-to-area basis. In turn, Division data were compared to data on file with the National Marine Fisheries Service, which consist principally of landings and location information, to determine their usefulness in forming a data base suitable for management purposes.

Processors were contacted and invited to supply appropriate data concerning resource utilization. Of particular interest was the amount of importing and exporting of live crabs that occurs each year in North Carolina.

I also reviewed the voluminous literature available on the blue crab in an effort to determine which studies were pertinent to North Carolina's present problems, and to utilize this knowledge rather than repeat earlier work.

Results

Data from selected stations sampled by the Division of Marine Fisheries from 1970 through mid-1976 were analyzed and found to be of such variability as to be virtually useless to form a management base. I could find little or no correlation between samples from study to study when comparing catch rates, mean lengths, and male-female ratios. Some of the obvious problems were: variation in nets used (both trawls and seines), sample size, effort expended, whether or not sex was noted, and whether or not crabs

were even recorded on data sheets.

National Marine Fisheries Service data on landings and location of landings appear to barely meet the needs for a sound management system. One frequently heard criticism by the crab industry is the four to five month lag in reporting. Also, landings from some areas were aperiodically absent, with no explanation for this lack. National Marine Fisheries Service record landing areas rather than catch areas, the latter of which is probably more important to resource managers. There is also the need to have better information on the extent of importing and exporting of live crabs to and from North Carolina, and its resultant effects.

I feel that a definite correlation exists between juvenile abundance and later adult harvest, even though earlier Division data do not support this concept. Better attention to crab sampling and recording, and more accurate effort data, would improve the correlation and predictive ability.

Examination of earlier blue crab studies has revealed much excellent work. Many of the reports involved life history studies into which North Carolina's blue crab populations fit, with little or no alteration. Two particular studies done earlier by National Marine Fisheries Service are of extreme merit when evaluating blue crab problems.

The first involved a nine-year tagging program in eastern North Carolina from 1957 to 1965 by Judy and Dudley (1970). They determined that crab movements are generally related to stages in their life cycles. One of their most significant observations is that blue crabs make infrequent exchanges between estuarine systems or widespread coastal area. Therefore, a commercial fishery for crabs in one area cannot depend on migration of commercial size crabs from another area.

A second study concentrated on Core Sound to determine the abundance and distribution of juvenile crabs and their relationship to the subsequent commercial fishery (Dudley and Judy 1973). Studies on juvenile abundance were conducted similarly to Division of Marine Fisheries estuarine sampling, but were species-specific for the blue crab. Again, their work revealed that a close correlation existed between juvenile abundance and harvestable adults. They theorized that an index of juvenile abundance from

June through May, of a given year class, should correlate with the abundance of adult crabs the next season.

BIOLOGICAL STUDIES

Methods

Sampling was conducted on juvenile and commercial blue crabs. Juvenile crabs were sampled with standard gear and procedures used in previously completed studies of North Carolina's estuaries by the Division of Marine Fisheries. The basic gear was a 4.0 m (13 ft) headrope, two-seam otter trawl of 6.4 mm (¼ in) bar mesh knotted wings and body, with 6.4 mm (¼ in) bar mesh knitted extension and tail bag. Trawl samples were made by outboard skiffs for one to five minutes at 4-5 km per hour. A minimum of 30 specimens were measured (tip to tip) and sexed. When less than 30 crabs were taken, the whole catch was examined.

Adult crabs of commercial size (>125 mm) were sampled by sub-sampling daily commercial catches by potters, trawlers, and trot-liners on a monthly basis. Again 30 crabs per sample were measured, sexed, and stage of maturity of females noted.

Sampling was conducted in areas of coastal North Carolina designated by the letter "A" through "F" on Figure 1. Juvenile crabs were sampled in areas A, B, and D. Commercial potters were sampled in Areas A through F, and trawlers in Areas B and E.

Results

There could have been no worse time than 1976-1977 to make a preliminary assessment of blue crabs in North Carolina. The catostrophic effects of the winter of 1976-1977 on the biological, economic, and social sectors of the crab industry are still being felt in North Carolina. The factors responsible for determining the size of catches usually are market conditions, migrations, and abundance. This is still so, as many times North Carolina's effort is controlled by conditions in, and demand from,

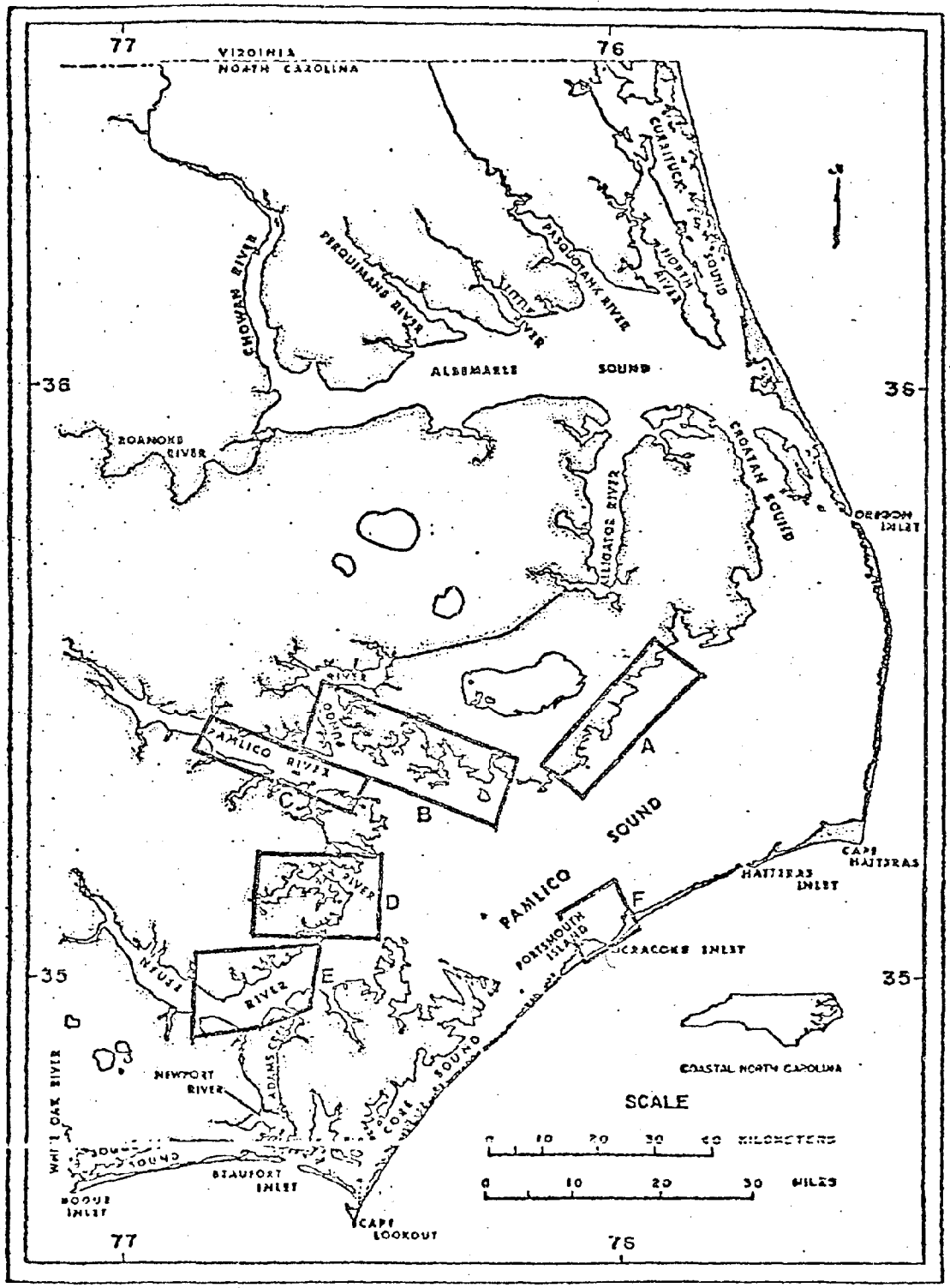

Figure 1.--Sampling areas for biological studies (A,B, and D) and commercial studies (A through E), 1976-77.

crab-producing states to the north.

Juvenile Sampling

Juvenile sampling from August to October 1976 revealed predominant sizes of blue crabs to be between 35 and 75 mm in width. Very small crabs (5-10 mm) peaked in Areas A and B in September and October. These same very small crabs were absent from catches in Area D until mid-October. Severe winter cold curtailed all juvenile sampling by mid-October. Sampling could not be renewed until mid-April. Again, very large numbers of 5 - 10 mm crabs occurred in late April in Areas A and B, while not appearing in Area D until late May.

Obviously, wind currents and tidal patterns cause post-larval crabs to reach nursery areas around Pamlico Sound at slightly different times, but in a similar yearly pattern. Catch records from previous studies examined in Job 1 indicated a similar pattern, though inconsistent from year to year. Also, juvenile length-frequencies indicate at least two peaks of activity during a normal spawning season. During a season stretching from February through October, spawning peaks appear to occur in March-April and June-July.

One conclusion is that most crabs spawned during spring and early summer reach a size of 5 to 15 mm in the ocean before they enter the nursery areas. Crabs hatched late in the spawning season encounter lower temperatures during their developmental stages and, therefore, grow slower. These late recruits would enter the nursery areas during the following spring.

Commercial Sampling

Several factors combined to reduce sampling of commercial crab catches as crabbing effort was substantially lower in 1976-1977. High shrimp catches and prices in the fall of 1976 caused many trawlers to forego crabbing, particularly in the Neuse and Pamlico Rivers. Prolonged,

severe cold weather from mid-October until early April kept many winter crab trawlers idle. Also, many boats that would normally enter the winter crab fishery, fished instead for flounders offshore north of Ocracoke Inlet. At the same time, trot-lining has essentially disappeared as a viable form of commercial crabbing. I was able to contact only one full-time trot-line operator, and his operation was part-time at best. All these factors combined to reduce commercial effort, and subsequent sampling effort, as stated in Project Amendment No. 1, effective 11 August 1977. Catch sampling concentrated on pot fishing which is the predominant catching method in North Carolina. No winter trawl sampling could be conducted.

Pot sampling data from Areas A,B, and C, and D and E were combined because of similarities in results. In Area ABC blue crabs were collected from potters from August through October, 1976, and April through June, 1977. At all times, males dominated the catch, particularly after female migration commenced in the spring. Mean width for crabs collected (sexes combined) was 150 mm in August, 153 mm in September and October, 137 mm in April, 135 mm in May, and 160 mm in June. Mean width for female crabs exceeded that for males each month by 5 to 7 mm. One oddity of the pot samples in Area ABC is that no sub-legal crabs of either sex were observed on any occasion.

In Area DE samples were taken from August to early October 1976, and May through June, 1977. Mean width for commercial crabs (sexes combined) was 150 mm in August, and 135 mm in September. All crabs measured during those two months were male. Mean widths were 139 mm in May and 122 mm in June. Females were dominant by number in the spring and summer, and began to decline in numbers by August. By fall, the commercial catch again was almost all male.

Area F was sampled in August and September, 1976, and May and June, 1977. Female crabs made up 96 percent of all crabs collected. Mean widths were 168 mm in August, 162 mm in September, 151 mm in May, and 159 mm in June. This area was the only one that continued to supply crabs throughout

the winter of 1976-1977, probably due to the warmer ocean waters allowing crabs to remain active.

Mean water temperatures for Areas A through E were at or above normal until late October. Temperature means were 14.3°C for October, 9.5°C (November), 8.5°C (December), 2.0°C (January), 5.3°C (February), 10.5°C (March), and 19.6°C (April). During all other months, mean temperatures were in excess of 21°C. Temperatures in Area F were consistantly 3 to 5°C above the other sample areas during the fall, winter, and spring. The major amount of blue crab activity appears to terminate at temperatures of about 10°C. Normal activity as indicated by pot catch did not resume again until April when water temperatures constantly exceeded 10°C.

Tremendous demand for blue crabs during the winter of 1976-1977 drove ex-vessel prices to record levels because the fisheries of more northerly states had poor landings. The average ex-vessel price for hard crabs was 20.5¢ per pound, compared to the previous record in 1975 of 13.1¢ per pound. Wholesale and retail prices for both live crabs and picked crab meat were at an all-time high during the year; on some occasions, live crabs and picked crab meat were not available at any price.

This demand caused some trawlers to make efforts in the Neuse and Pamlico Rivers in late February and March. From these efforts, reports reached the Division that winter crab mortalities were approaching 70 to 75 percent of the crabs brought in during this time. A cruise was completed in mid-March on a 20 m Division vessel using 10 m nets of 25 mm (1 in) mesh knotted construction throughout. I found mortality rates from 10 to 30 percent, with a mean mortality rate of 20 percent for 15 stations. Catches were not nearly as high as those made by commercial trawlers; the trip was made two to three weeks after the reported highest mortalities. Quite probably, severe winter adult blue crab mortalities lay between inflated commercial estimates and my own late under-estimated figures.

ESTABLISHMENT OF A STATISTICS PROGRAM

Methods

Members of the crab industry were contacted for input into the development of a catch and catch-effort system in order to establish a data base. Some sort of a "trip ticket" system was envisioned in which the Division would cooperate with crabbers, buyers, and packers to gather data.

Results

Crab processors were contacted during the winter of 1967-1977 in an effort to develop a data system. After initial favorable response, dealers were very negative about cooperating in any type of reporting system. During this winter period, approximately one-half of North Carolina's 30 crab plants were closed because of a lack of crabs, and therefore were unavailable for comment. The few contacted, reportedly handle over 60 percent of North Carolina's hard blue crabs (D. Hill, pers. comm.).

Many of the dealers felt that the onus of reporting should be placed on the fishermen themselves because only the fishermen know their true effort. Conversely, the fishermen interviewed felt that reporting should be a dealers' or packers' task as they are the ones who actually get the weights.

During the summer of 1977, the Law Enforcement Section of the Division circulated a questionnaire among active fishermen in an effort to find out how many commercial crabbers there were in North Carolina. This activity was unrelated to this project, but was conducted in response to a "sponge-crab" law controversy. Returns were received from 680 licensed fishermen, of whom 568 were potters, 99 were trawlers, and 13 were trot-liners. The 568 potters fished 64,349 crab pots, of which 427 full-time potters set 52,380 pots, 131 part-time potters set 11,856 pots, and 10 pleasure fishermen set 113 pots.

The 99 trawl boat operators who responded include 80 full-time, 16 part-time, and three pleasure operators. Only 13 trot-liners could be contacted, 10 of whom were part-time and three full-time.

The crab pot is now the dominant gear for blue crab fishing in both numbers fished and landings, as it has been since the late 1960s (Table 1). Trot-lining appears to have passed on as a significant factor in North Carolina's catch. Obviously this gear is not efficient at today's prices. The number of trawlers and otter-trawls used in crabbing seems to bear more on the success and duration of the shrimp season than on demand for, availability of, or price of crabs.

As with almost all the fishery resources of North Carolina, no data are available on the recreational component of the crab fishery. The number of people who engage in setting one or two pots, dip-net, or "chicken neck" is unknown as is their respective harvest.

The initially-planned objectives of this job were not being met as the project progressed. Therefore, Job III was terminated by Project Amendment No. 1, effective 11 August 1977.

A new statistics program under North Carolina's Office of Coastal Zone Management Fisheries Assistance Program grant, in cooperation with the revamped NMFS-TIMS Statistics Division should correct the shortcomings of Job III.

SUMMARY

1. The blue crab fishery in North Carolina harvests an average of 16.5 million pounds per year, worth in excess of $2 million. Processed product value adds another $11.5 million.
2. Data on file with the Division of Marine Fisheries were examined to see its suitability to form a data base, and its correlation to subsequent commercial landings. Previous data were found to be unsuitable for these tasks.
3. National Marine Fisheries Service landings data were found to be adequate though suffering from an inordinate time lag between reporting and dissemination, as well as somewhat incomplete location data.

4. A definite correlation exists between a juvenile population index and commercial catch, but only through better, more intense sampling.

5. Blue crab populations may be better managed by individual area or water body, rather than one large plan for the whole population.

6. The severe winter of 1976-1977 had an extremely detrimental effect on blue crab survival, commercial effort, and industry stability.

7. Sampling revealed two spawning peaks; one in March-April, and a second in June-July.

8. Juvenile blue crabs appear to tolerate severe cold, with less overall mortality than adults.

9. Average ex-vessel prices reached a record 20.5¢ per pound for hard blue crabs in 1976.

10. Development of a voluntary statistics program involving fishermen, dealers, and packers, was not successful.

11. A survey of crabbing effort showed that 680 people crabbed, with 508 full-time, 157 part-time, and 13 pleasure. A total of 568 potters fished 64,349 pots; there were 99 trawlers and 13 trot-liners. Numbers of recreational (unlicensed) crabbers are unknown.

RECOMMENDATIONS

1. An immediate need is a statistics program in cooperation with NMFS, showing landings, fishing effort, and fishing location.

2. A program of crab sampling for juveniles and sub-adults should be instituted. This should be similar to the Division's shrimp program as to specific species.

3. Studies should be instituted to check the effect of abandoned or "ghost" pots on the crab population.

4. In order to form a base year for adult management by area, individual indices of juvenile abundance should be collected for each major estuarine system.

5. Some adult tagging may be necessary to reaffirm migration routes and utilization areas.

6. All mature female crabs, regardless of size, should be allowed to be retained in the catch. A change in regulations would be needed to implement this recommendation.

ACKNOWLEDGEMENTS

I would like to express sincere thanks to all the biologists and technicians of the Division of Marine Fisheries who aided in the field work and file data research completed on this project.

I would also like to give my thanks to those commercial fishermen and dealers who allowed sampling of their catches, no matter how often we slowed them down in their work.

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