results. What is needed is management to achieve optimum results.

To accomplish this, a Governor's Commission to Investigate Water Pollution Control has recommended the creation of a State service agency known as the Waste Acceptance Service to take over responsibility for treatment and disposal of all liquid wastes in the State. This proposed agency would in no way limit local control of land use and waste collection facilities. It would permit much greater flexibility in deciding how and where wastes would be treated and discharged, promote the direct incorporation of broad public goals into the day-by-day decision-making process, and provide substantial economies of scale in both construction and operation. A feasibility report on the Waste Acceptance Service has been prepared for early consideration by the Governor and General Assembly.

Many people will no doubt consider this paper to overly optimistic. However, man has had to make many adjustments as he first invented civilization and then made it ever more complex. These adjustments have been sociological and technological rather than biological. In time, evolution, with an assist from genetic engineering, could possibly produce a human with lungs inured to air pollution, body immune to infection, and senses that do not react to stench and disorder.

The purpose of this paper is to present some evidence that man is not taking this passive and chancy route but is again adjusting his institutions and technology--not to adapt to a degraded environment but to reverse the process of degradation.

MOVEMENT, GROWTH, AND MORTALITY OF BROWN SHRIMP *(Penaeus Aztecus)* MARKED AND RELEASED IN SWAN QUARTER BAY, PAMLICO SOUND, NORTH CAROLINA[1]

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ABSTRACT

Brown shrimp *(Penaeus aztecus)* were marked with injections of biological stains and fluorescent pigments and released in the Swan Quarter Bay tributary of Pamlico Sound, North Carolina, to obtain population dynamics information including movement, migration, growth, and mortality. From July to September, 1967, 6,163 shrimp were marked and released. Of these, 1,030 (16.7%) were returned. The average interval between release and recapture was 12 days, and the average distance traveled during this time was 3 miles. Only one shrimp was recaptured in the Atlantic Ocean. These data do not clearly indicate the most probable route or routes of movement from the study area to the ocean. Modes of size distribution curves were at 115 mm total length during the eight-week mark-release phase of the study, indicating an apparent "level of equilibrium" condition. This level was maintained by movement of larger individuals from the area, immigration of small ones from upstream reaches, and growth within the area. The mean growth curve indicates brown shrimp reach a count of 70-per-pound (headless) in 12 weeks, 50-per-pound in 14 to 15 weeks, and attain an average maximum size of 15-per-pound. Total mortality estimates for two separate experiments indicate 71% and 63% per week were removed by the combined effects of fishing and natural causes.

INTRODUCTION

The basic aim of current shrimp research in North Carolina is to obtain information that will permit application of management techniques resulting in the

[1]This study was conducted in cooperation with the U. S. Department of the Interior, Bureau of Commercial Fisheries under P. L. 88-309 (Project No. 2-26-R).

highest possible sustained yield of the shrimp resource. North Carolina fisheries regulations permit the Director of Conservation and Development to open shrimping seasons in specified areas when the major portion of shrimp reach commercial size. There is concern, however, as to whether maximum utilization of the resource is being made. Many commercial fishermen feel that season openings should be delayed to allow the shrimp to reach larger sizes and, therefore, command higher prices. The size that shrimp should attain before the maximum yield in weight and value can be realized has not been determined. The maximum yield potential may or may not occur at a shrimp size considered as commercial. To obtain this information, it is necessary first to measure shrimp growth and mortality, and to understand the relationship between these population parameters.

This paper includes the results of studies on brown shrimp *(Penaeus aztecus)* movement, migration, growth, and mortality conducted during the second year of a three-year project by the Research and Development Section of the North Carolina Division of Commercial and Sports Fisheries.[2] Shrimp were marked by injecting biological stains and fluorescent pigments, and released in Swan Quarter Bay, a nursery area tributary to Pamlico Sound.

The shrimp resource continues as the most important fishery resource in the economy of the coastal area of the State. Total dockside value of all North Carolina fishery products in 1967 was approximately $8.8 million. The shrimp fishery value was $1.8 million or approximately 20% of the total (personal communication, Branch of Fishery Statistics, Bureau of Commercial Fisheries, Beaufort, N. C.). The management of this valuable resource is an important responsibility of the North Carolina Department of Conservation and Development.

METHODS AND PROCEDURES

Study Area

The Swan Quarter Bay nursery area, located in northern Pamlico Sound, was selected for the brown shrimp mark-recapture experiments conducted during 1967 (Figure 1). Pamlico Sound is North Carolina's largest estuary and one of its most important shrimping areas. Approximately one-third of Swan Quarter Bay (upper area) was closed to commercial shrimping during the experiments and remained closed throughout the season.

Swan Quarter Bay is located 46 miles west of Cape Hatteras and contains about 6,000 surface acres. The mark-release area was located approximately in the upper one-half and contained about 1,500 acres. The bay has an average depth of approximately 3 feet at mean low water. The lunar tidal amplitude is less than 1 foot whereas normal wind-generated tides may have an amplitude of approximately 3 feet.

Collection and Handling of Shrimp

Brown shrimp, normally a nocturnal species in some areas, were readily collected during the early morning daylight hours in the study area. Collections were made with a 25-ft., 3/4 inch bar-mesh shrimp trawl towed from 5 to 20 minutes. Towing time depended on availability of shrimp, amount of detritus, and water temperature. As water temperatures increased to about 75° F, tows were limited to 5 minutes because greater mortality was evident in the longer tows. Water temperatures above 80° F occurred often during the mark-release phase of the study.

A shore-based box (4 x 8 x 2-feet deep), subdivided into four compartments and supplied with circulating seawater, was used for holding shrimp during and after marking. Seawater was sprayed onto the surface of each compartment to provide aeration. A 15-inch wide table, with shrimp measuring boards and inset plastic trays (12 x 10 x 5 inches deep) for holding small numbers of shrimp while marking, was attached to the holding box.

[2]The data contained in this paper were taken from the Shrimp Studies Project (Project No. 2-26-R) annual report (McCoy, 1968) submitted to the U. S. Bureau of Commercial Fisheries under the Commercial Fisheries Research and Development Act of 1964 (P.L. 88-309).

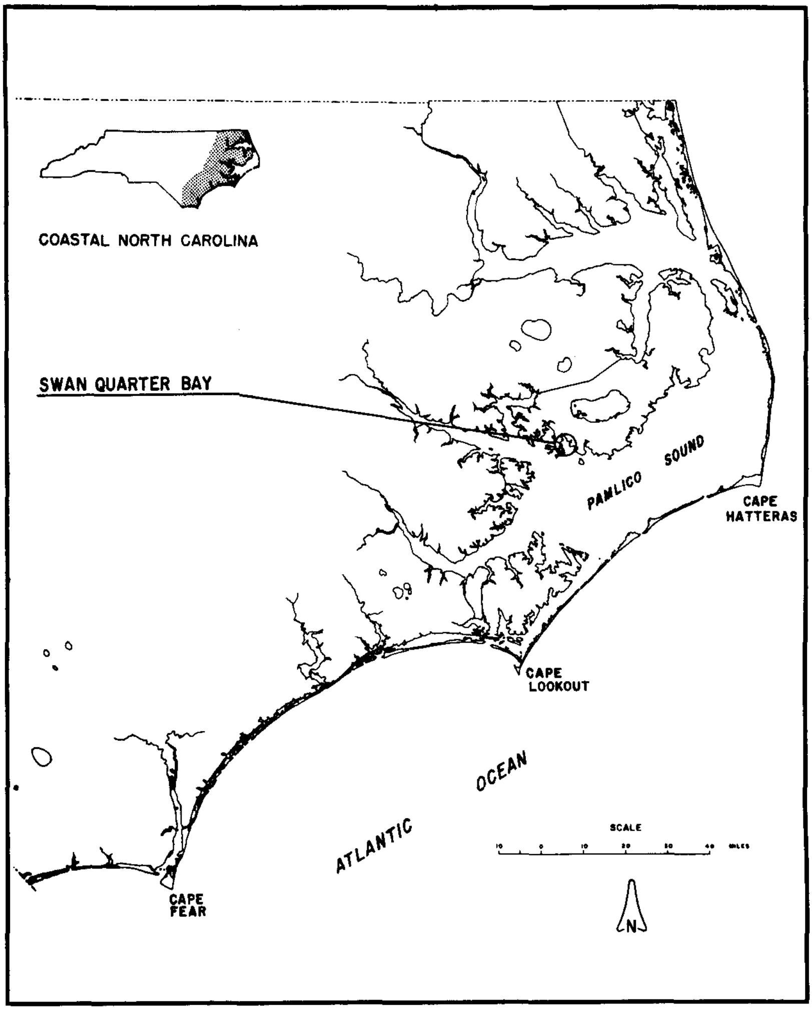

Figure 1. The 1967 brown shrimp mark-release area in relation to coastal North Carolina.

Marked shrimp were held in the shore-based holding box for 12 to 20 hours after marking to insure detection of individuals adversely affected. Those shrimp displaying no apparent sign of distress were transferred to holding boxes aboard the boat, transported to the area of collection and counted as they were released.

Marking Agents

Two biological stains (Fast Green FCF and Trypan Blue) and four fluorescent pigments (Neon Red A-12, Blaze Orange A-15, Arc Yellow A-16, and Saturn Yellow A-17), were used in the mark-recapture studies (Costello, 1964; Klima, 1965). Aqueous solutions of 0.5% Fast Green FCF or 0.25% Trypan Blue provided primary marks, and a 4.0% mixture of the fluorescent pigments in petroleum jelly provided secondary marks. The stains were expected to remain visible and the pigments detectable for periods of up to 8 months.

The two biological stains were classified as primary marks because they concentrate in the gills a short time after injection into the body and were easily seen by commercial shrimpers and shrimp headers. The fluorescent pigments were classified as secondary marks when used in combination with one of the primary stains. These secondary marks, normally not visible to shrimpers and headers, remained at the site of injection and were readily distinguishable under ultra-violet light. With two primary marks and four secondary marks, a total of ten separate combinations was possible by using each primary mark alone, and each secondary mark paired with each primary mark. Various combinations of marks were used in this study to identify mark-release experiments and/or groups within experiments (McCoy and Brown, 1967, a, b).

Mark-Release Periods

A mark-release period was designated as 1 week or less, and shrimp were marked and released no more than 5 days each period (usually Monday through Friday). The middle day of each period was selected as the date of release to be recorded for all shrimp marked during that period. All shrimp released contained a mark or combination of marks that permitted subsequent identification as to the period of release.

Since large numbers of marked shrimp are required to establish reliable movement and migration patterns, all shrimp collected were marked. In each mark-release period, shrimp were divided into two size-groups (with the mode as one group and all other shrimp in the second group) and identifying marks assigned to each.

On the first day of each period, the size distribution of a random sample of approximately 100 shrimp was recorded in 10-mm size-groups. The size-group representing the mode of the curve, or the group containing the largest number of individuals, was selected as the group from which growth and mortality information would be obtained. Weekly length-frequency distribution curves were obtained by combining daily individual measurements of all marked shrimp caught that week.

Shrimp collected for marking each day were individually measured, a primary mark injected through the articular membrane of the fifth abdominal joint, and separated into holding compartments assigned to each group. Following application of all the primary markings, individuals of the selected groups received identifying secondary marks injected through the articular membrane of the sixth abdominal joint.

Return of Marked Shrimp

All North Carolina shrimp houses were contacted, supplied with posters explaining the program, and visited periodically for returned shrimp. Forms to be completed with the date and place of recapture, and containers filled with 10% formalin for preserving recaptured shrimp, were also provided. In addition, news articles explaining the program and providing instructions for the return of recaptured shrimp were prepared and released.

A reward of $0.50 was offered for the return of each recaptured shrimp. Returned shrimp were placed under an ultra violet light to determine if they contained a secondary mark. Comparison was made with known fluorescent pigments to determine the exact color of the secondary mark. Date of capture, place of capture, mark or marks, total length, sex, distance traveled, and number of days between release and recapture were recorded for each returned shrimp.

Information on commercial shrimping effort was obtained by interviewing fish house owners and operators, and boat captains and crews, at least every other week.

RESULTS AND DISCUSSION

Movement and Migration

Release and recovery information on four mark-recapture experiments with brown shrimp in Swan Quarter Bay is presented in Table 1. The period of release, size at release (mid-point of the 10-mm modal group providing growth and mortality information and range of other groups), number released, number returned, percent returned, mean distance traveled, and mean number of days between release and recapture are shown for each mark-recapture experiment. The mean water temperature and salinity during each mark-release period are also presented.

A total of 6,163 brown shrimp was released from July to September, 1967. Of these, 1,030 (16.7%) were returned. The average interval between release and recapture was 12 days. Average distance from point of release to point of recapture during this interval was 3 miles.

The total number released, probable direction of movement, areas of recapture, and number recaptured per area are presented in Figure 2. Movement of brown shrimp from Swan Quarter Bay was toward the central and southern Pamlico Sound areas. Only one of 1,030 marked shrimp returned was recaptured in the Atlantic Ocean. This individual, recaptured between Ocracoke and Drum Inlets 49 days after release, established the movement record of 37 miles. These data do not clearly indicate the most probable route or routes of movement from the study area to the ocean, but they do suggest that relatively few brown shrimp from the northern and western areas of Pamlico Sound reach the ocean.

Length-Frequency Distribution

Length-frequency distribution curves obtained during each mark-release period and number-per-pound equivalents (headless) are presented in Figure 3. The length-frequency distribution curve had reached an apparent "level of equilibrium" condition with a mode of 115 mm by the time of the first mark-release period. McCoy and Brown (1967, a, b) describe this condition as resulting from movement of larger individuals outside the mark-release area, growth within the area, and immigration of small shrimp from upstream reaches into the mark-release area. This "level of equilibrium" condition, at a mode of 115 mm, remained throughout the 8-week study period in Swan Quarter Bay. The only noticeable change in the length-frequency distribution curves was a slight decrease in the percentage of small shrimp and a corresponding increase in the percentage of larger shrimp.

McCoy and Brown (1967, a, b) found the length-frequency "level of equilibrium" in Jarrett Bay and North River at a mode of 115 mm for brown shrimp. Recaptures of marked shrimp from Swan Quarter Bay again proved migration was occurring and dispelled the possibility of static populations. The condition of length-frequency distribution modes remaining constant during successive mark-release periods strongly suggests that each mark-recapture experiment actually involved a new and more recent population of individuals.

Williams (1955) found that brown shrimp in samples from bays near the mouth of Pamlico River were usually smaller than those taken in samples on the same day from the middle of Pamlico Sound or from near Ocracoke Inlet. Lindner and Anderson (1956), in their study of white shrimp *(Penaeus setiferus)* on the Atlantic coast, found in every locality a general progression the size of trawl-caught shrimp from inside to outside waters. Smaller individuals were taken farthest from the ocean. McCoy and Brown (1967, a, b), in their white shrimp experiments, found length-frequency distribution curves with larger modal groups in the study area nearest the ocean.

The foregoing data suggest the presence of a length-frequency "level of equilibrium" condition in all shrimp habitat of the State, with the possible exception of areas used as migration routes (McCoy, 1968). Further studies on the "level of equilibrium" in all areas should provide important management information concerning the regulation of commercial shrimping within the State.

TABLE 1

1967 release and recovery information for mark-recapture experiments with brown shrimp released in Swan Quarter Bay, tributary of Pamlico Sound, North Carolina.

				115-mm Modal Groups[b]			Others (75-165mm range)[c]							
Exp. No.	*Period Released*	*Mean Temp. °F*	*Water[a] Sal. ppt.*	*Number Relsd.*	*Number Retd.*	*Percent Retd.*	*Number Relsd.*	*Number Retd.*	*Percent Retd.*	*Total Relsd.*	*Total Retd.*	*Percent Retd.*	*Mean Travel Miles*	*Days Out*
1	24-28 July	83	18.6	638	149	23.4	1205	314	26.1	1843	463	25.1	3	15
2	7-11 Aug.	83	18.3	556	103	18.5	1365	305	22.3	1921	408	21.2	2	9
3	21-25 Aug.	82	18.5	365	39	10.7	865	83	9.6	1230	122	9.9	3	10
4	4-8 Sept.	74	17.2	377	15	4.0	792	22	2.8	1169	37	3.2	13	24
TOTALS		81	18.2	1936	306	15.8	4227	724	17.1	6163	1030	16.7	3	12

[a]Measured daily in the mark-release area

[b]Mid-point of 10-mm modal groups providing growth and mortality information

[c]Does not include modal groups

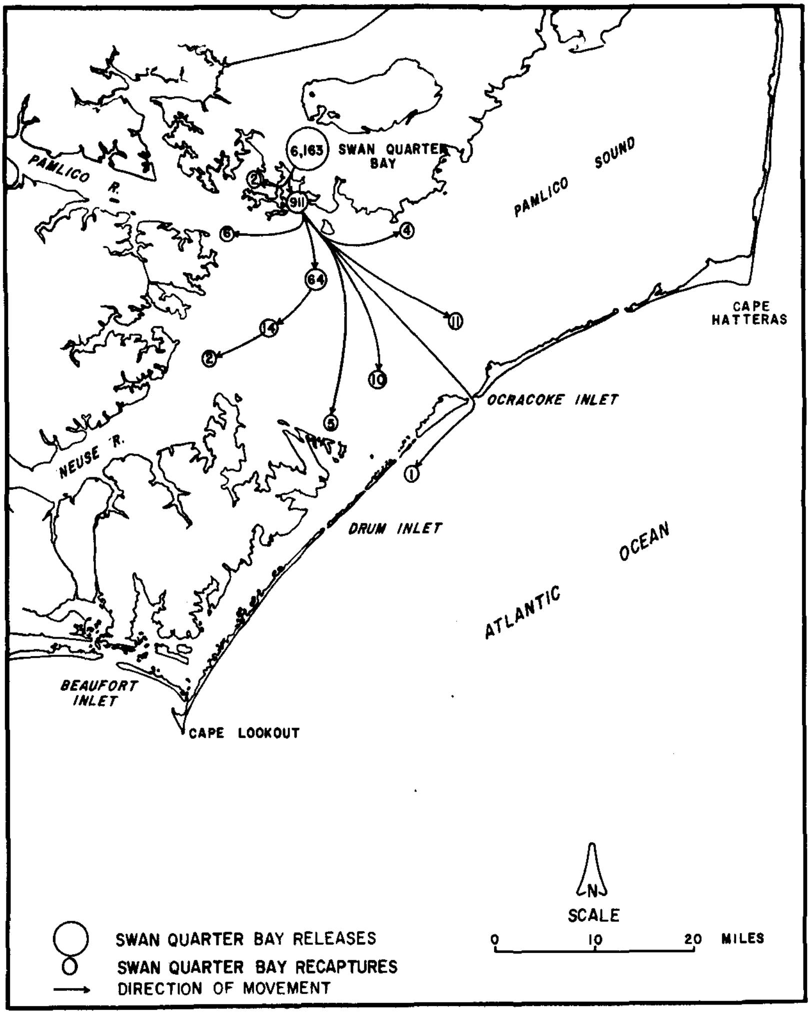

Figure 2. Brown shrimp release area, number released, probable direction of movement, and number recaptured per area during the period July to October, 1967.

Estimation of Growth

Given that differences do occur in growth rates of male and female shrimp, it was felt that "sexes combined" information, as presented herein, would provide more useful information for management purposes. As aptly stated by Kutkuhn (1966), the use of "sexes combined" statistics is justified in that they define the average growth pattern within the experimental population during that period when the age group represented is enjoying greatest biomass, is most accessible, and its sex ratio has not yet begun to indicate a preponderance of females.

The brown shrimp male/female sex ratio for the 115-mm size class marked for growth and mortality estimates was approximately 2.5:1. Growth estimates

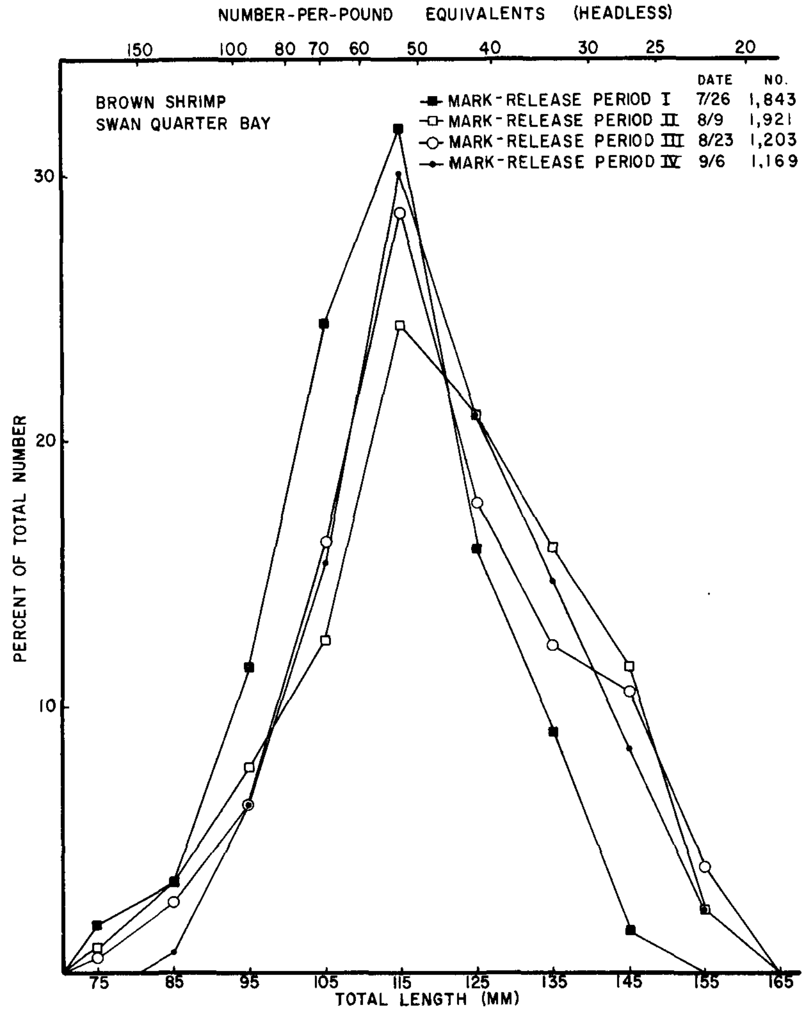

Figure 3. Length-frequency distribution curves and number-per-pound equivalents as obtained from length records of brown shrimp marked and released in Swan Quarter Bay, 1967.

presented herein may be viewed as lying intermediate between some upper value for females and a lower value for males with the data biased toward the lower value for males.

Kutkuhn (1966) points out that experimental length and weight data from a sexually heterogeneous population yield the most reliable growth-parameter estimates when the sex ratio of marked recaptures remains constant throughout the experiment. In all four Swan Quarter Bay brown shrimp mark-recapture experiments, *Chi-square tests at the 95% confidence level indicated no significant difference* between sex ratios established during each mark-release period and those found during the recapture periods (Snedecor, 1956).

Although possible shrinkage of shrimp preserved in formalin was not determined, Lindner and Anderson (1956) found no significant difference between the means of 5-mm size-groups of live and preserved white shrimp total lengths following preservation in formalin for 3 weeks. All growth data were obtained by measuring the total length of recaptured shrimp after they had been preserved in 10% formalin for 1 to 3 months.

The von Bertalanffy growth-in-length equation was used to calculate growth-parameter estimates (Beverton and Holt, 1957):

$$L_t = L_\infty 1 - e^{-K(t-t_o)}$$

Where: L_t = length at time t.

L_∞ = the average maximum total length.

e = base of the natural (Naperian) logarithm.

K = coefficient proportional to the rate of catabolism.

t = age in weeks

t_o = the hypothetical age at which total length would have been zero had the growth pattern always been the same as that indicated by the data. The growth pattern apparently had not always been the same; therefore, t_o was assumed to equal zero (Fabens, 1965).

The equation presented contains three parameters that are presumed effectively constant when describing growth over the greater part of the shrimp's life span: L_∞, K, and t_o.

Swan Quarter Bay recaptures provided adequate data for describing brown shrimp growth when returns were summed into successive 7-day recapture periods for Experiments I and II combined, and III and IV combined. It was necessary to sum the returns by combined experiments because the numbers involved in individual experiments were small (see Table 1).

Growth equations and a comparison of the resulting growth curves for mark-recapture Experiments I and II combined, and III and IV combined, are presented in Figure 4. The growth equation and resulting curve for all four experiments combined, which reflects the average growth rate encountered during the study period, are presented in Figure 5.

Growth curves in Figure 4 indicate that brown shrimp grew faster during the first half of the study period. This difference may have been caused by a decrease in the recorded mean water temperature during the second half of the study period (see Table 1). Zein-Eldin (1965) reports that postlarval brown shrimp held in laboratory experiments at 77°F for 30 days were almost twice as heavy as those held at 72.5°F and weighed almost 10 times more than those held at 63.5°F. He also indicated a reduction in the growth rate and survival at temperatures above 90°F.

The mean growth curve (all data combined, Figure 4) indicates the age of brown shrimp at the 70-per-pound (headless) size as 12 weeks, the 50-per-pound size as age 14 to 15 weeks, and the 30-per-pound size as 21 weeks. The estimated average maximum size was 15-per-pound (177.7 mm total length).

Williams (1955) used modes of length-frequency distribution curves to estimate growth rates of juvenile and sub-adult brown shrimp in North Carolina nursery areas. He reported an average total length increase of 11.7 mm per week (1.7 mm per day) during the period April to June. This growth is somewhat higher than that estimated for the same species in the present study (approximately 1.0 mm per day during a smiliar period).

Brown shrimp marked and released off the Mississippi coast during late June increased in size from 59-to 35-per-pound (headless) in 28 days (Klima and Benigno 1964), whereas approximately 35 days were required for a similar increase in the size of North Carolina brown shrimp. During the period 31 March to 4 July, 1965, brown shrimp stocked as postlarvae in a circulating-water artificial pond in Texas attained a mean total length of 97.4 mm for an average daily growth of 0.88 mm (Wheeler, 1966). This growth rate compares favorably with the results presented herein.

Estimation of Mortality

The basic assumptions involved in the estimation of mortality presented herein

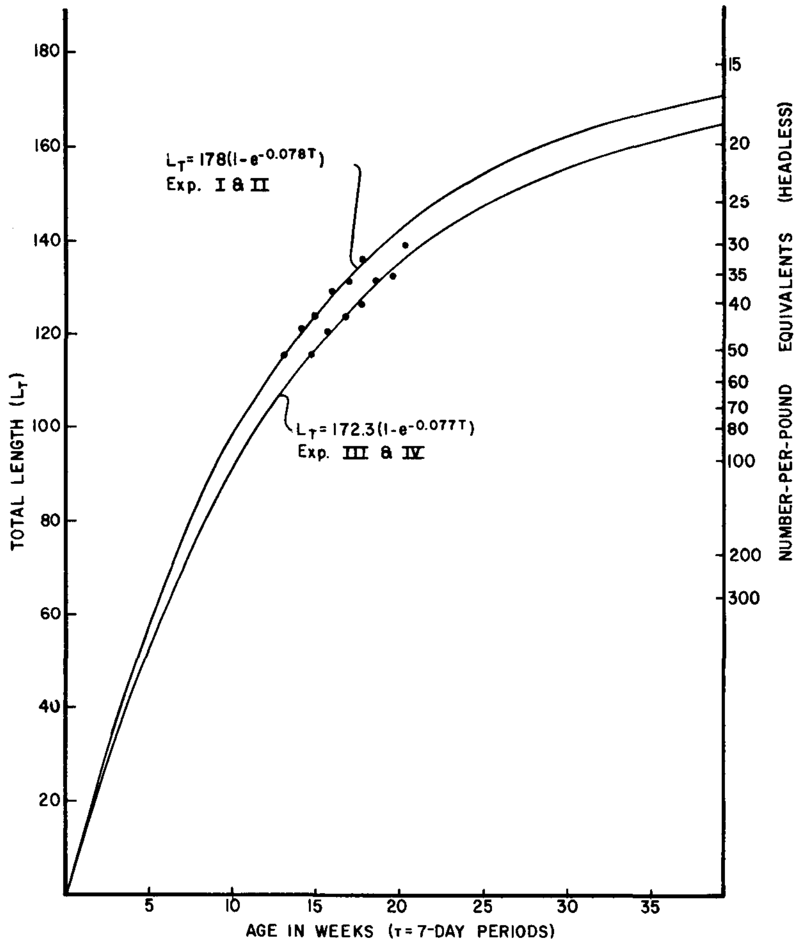

Figure 4. Comparison of growth in length of brown shrimp released in Swan Quarter Bay during mark-recapture Experiments I and II combined, and III and IV combined, 1967.

are: (1) No loss of marked releases caused by handling or after-effects of the mark or marks; (2) no movement of marked shrimp out of the fishing area; (3) no loss of recaptured shrimp because of failure of fishermen to return them, or the ratio of undetected to detected recaptures remained essentially constant during each experiment; and (4) all marked shrimp were available to the fishery. For detailed discussions of the theory underlying the assumptions concerning mortality estimates, the reader is referred to Beverton and Holt (1957) and Kutkuhn (1966).

Studies by Zein-Eldin and Klima (1965) and Klima (1965) indicated that when properly administered, biological stains and fluorescent pigments injected into shrimp do not effect their metabolic rate or survival. Only those shrimp that appeared in good condition and displayed no signs of distress 12 to 20 hours after marking were released. Therefore, handling and marking loss following release was considered negligible.

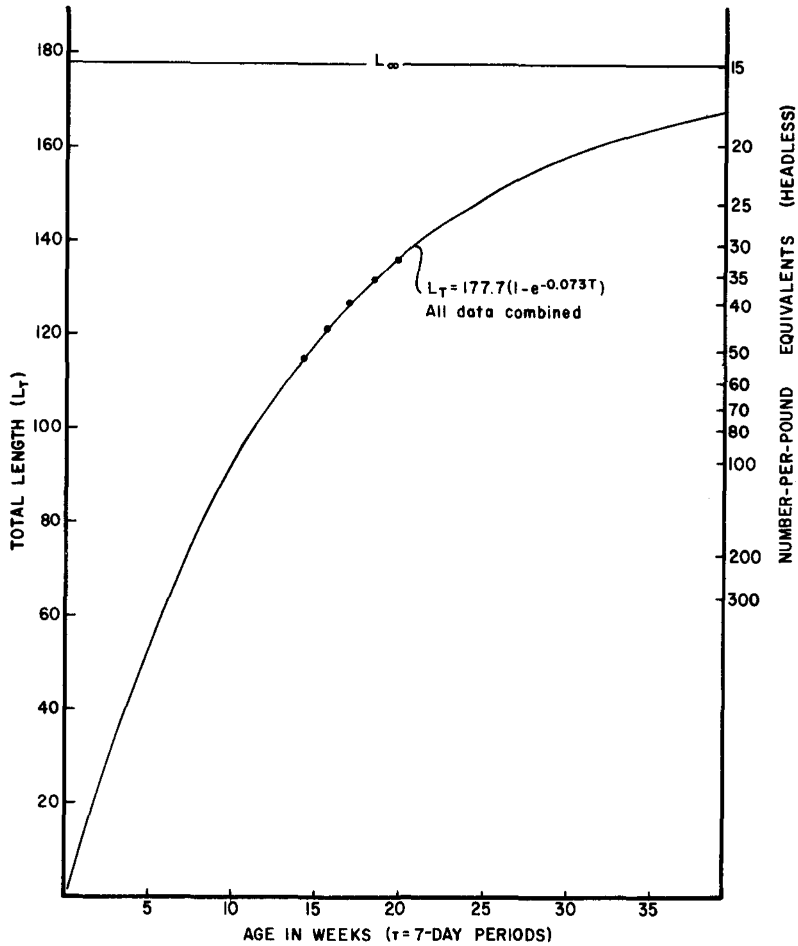

Figure 5. Average growth in length of brown shrimp released in Swan Quarter Bay during the 1967 mark-recapture studies.

Only one of 1,030 brown shrimp returned was recaptured outside Pamlico Sound. For the purpose of estimating mortality, the marked or experimental populations and the groups from which they came were, therefore, considered as contained within Pamlico Sound, and negligible movement from the fishing area was assumed.

The loss of recaptured shrimp because of failure of fishermen to return them was not determined. This loss is believed negligible however, because the incentive to return marked individuals was high and cooperation with commercial fishermen, fish house owners and operators, and shrimp headers was excellent. It was assumed that the ratio of undetected to detected recaptures did not change during the experiments.

Approximately one-third of the Swan Quarter Bay brown shrimp mark-release area was closed to shrimp trawling during the 1967 season. It was the general consensus that the closed area would have no detrimental effect on the experiments.

In the first experiment, however, the number of shrimp returned during the first week following release was less than the number returned during the second week. In addition, recaptures in Swan Quarter Bay by project personnel indicated that some marked shrimp remained in the closed area during the first recapture period of all four experiments. Movement of marked individuals from the closed area was assumed complete at the beginning of the second recapture period and returns during the second and succeeding periods of mark-recapture Experiments I and II were considered sufficient for valid total mortality estimates.

Total mortality (F + X = fishing plus natural mortality) estimates were obtained by fitting linear regressions to the natural logarithms of adjusted recaptures plotted against recapture time periods (Beverton and Holt, 1957). The recaptures were adjusted for unequal fishing effort (Table 2). The slope of the regression is the

TABLE 2

Brown shrimp recaptures adjusted to equal fishing effort, Swan Quarter Bay mark-recapture Experiments 1 and 2, 1967.

7-Day recapture Periods (t)	*No. Recaptured*		*Tot. Fish. Effort (thousands hrs)*		*Adj. Recaptures*		*Natural Logarithm of Adj. Recaptures*	
	Exp. 1	*Exp. 2*	*Exp. 1*	*Exp.2*	*Exp.1*	*Exp.2*	*Exp.1*	*Exp.2*
1	48	32	3.8	3.7	59	44	4.078	3.784
2	60	37	3.5	5.7	81	33	4.394	3.497
3	30	5	3.7	5.9	38	4	3.638	1.386
4	6	8	5.7	5.5	5	7	1.609	1.946
5	1	1	5.9	4.5	1	1	0.0	0.0
6	1	—	5.5	—	1	—	0.0	—

instantaneous total mortality rate. Instantaneous total mortality rates calculated for the 115-mm modal groups of Experiments I and II are presented in Figures 6 and 7, respectively. The instantaneous rates were 1.243 for Experiment I and 0.993 for Experiment II. When converted to weekly rates of mortality, these data indicate that 71% (Experiment I) and 63% (Experiment II) of those shrimp present at the beginning of a week were removed by the combined effects of shrimping and natural causes during that week.

These instantaneous total mortality rates compare favorably with those obtained by Klima (1963) with brown shrimp (F + X = 1.14, determined by back calculation of monthly rates of reduction) in the northern Gulf of Mexico, and by Kutkuhn (1966) with pink shrimp (F + X = 1.51) on the Tortugas shrimp grounds off Key West, Florida.

Figures 6 and 7 show that each regression enjoyed a reasonably good fit. The adjusted number of returns for the first recapture periods was not used in either of the experiments to calculate the linear regression because all marked releases were not available to the fishery. This condition invalidates the use of the techniques outlined by Beverton and Holt (1957, p. 190) to separate total mortality into fishing and natural mortality. Total mortality could not be separated because: (1) The number of marked shrimp that would have been recaptured had the whole area been opened to trawling, was not available; and (2) the numbers of returns during successive time periods are not independent.

SUMMARY AND CONCLUSIONS

The basic aim of the Shrimp Studies Project is to obtain information that will permit application of management techniques resulting in the highest possible sustained yield of the shrimp resource. Brown shrimp, marked with injections of biological stains or a combination of biological stains and fluorescent pigments, were released in Swan Quarter Bay, a nursery area tributary to Pamlico Sound, to obtain information concerning movement, migration, growth, and mortality rates.

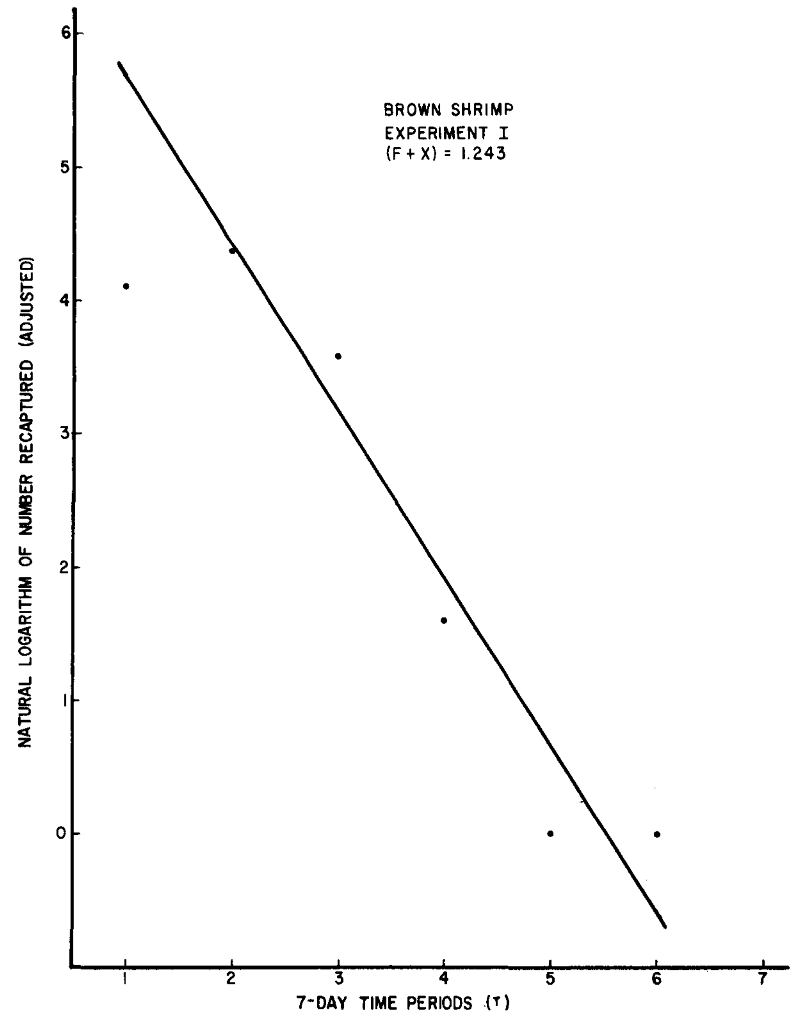

Figure 6. Total mortality of brown shrimp released in Swan Quarter Bay mark-recapture Experiment I, 1967.

A mark-release period was designated as 1 week or less and shrimp were marked and released no more than 5 days each period. The middle day of each period was selected as the date of release to be recorded for all shrimp marked that period. All shrimp released contained a mark or combination of marks that permitted subsequent identification as to the period of release.

A reward of $0.50 was offered for the return of each recaptured shrimp. Shrimping effort information was obtained by interviewing fish house owners and operators, and boat captains and crews every other week.

A total of 6,163 brown shrimp was released in Swan Quarter Bay from July to September, 1967. Of these, 1,030 (16.7%) were returned. The average interval

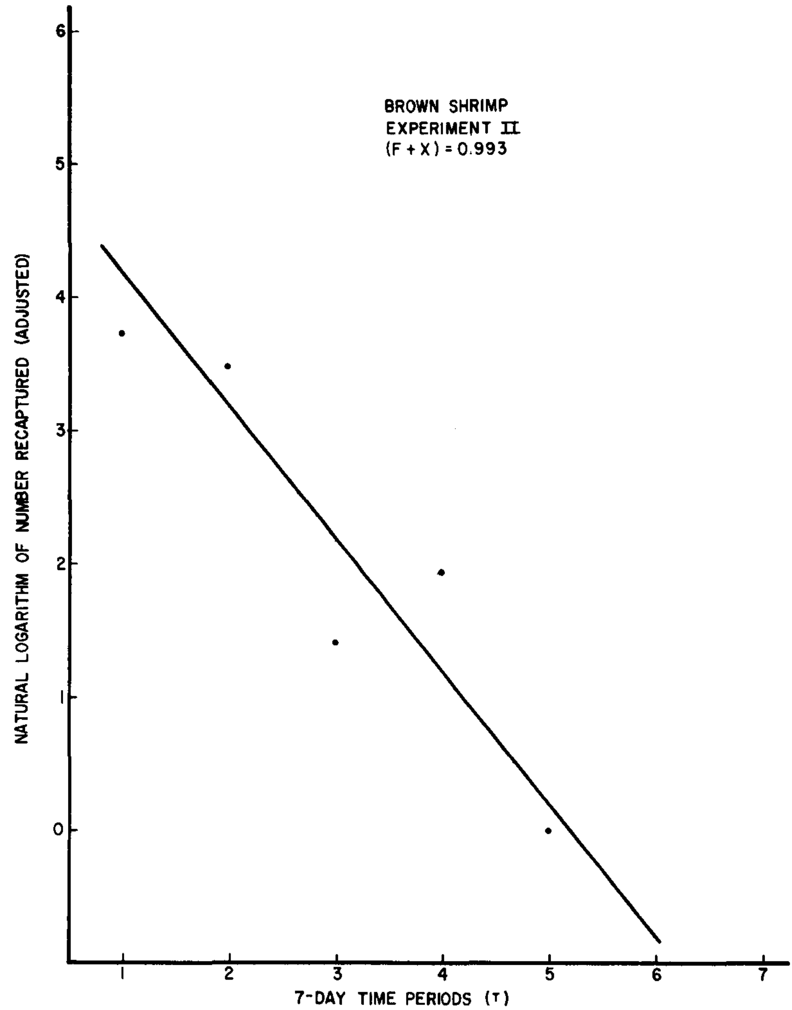

Figure 7. Total mortality of brown shrimp released in Swan Quarter Bay mark-recapture Experiment II, 1967.

between release and recapture was 12 days. The average distance from point of release to point of recapture during this interval was 3 miles. Movement was toward central and southern Pamlico Sound with only one marked individual returned from the Atlantic Ocean. These data do not clearly indicate the most probable route or routes of movement from the study area to the ocean, but do suggest that relatively few brown shrimp from northern and western Pamlico Sound reach the ocean.

Weekly length-frequency distribution curves were obtained by combining daily total length measurements of all marked shrimp. The modes of the length-frequency distribution curves remained at 115 mm during the 8-week study period indicating an apparent "level of equilibrium" condition in the mark-release area. This "level of equilibrium" condition apparently results from movement of larger individuals outside the mark-release area, growth within the area, and immigration of small shrimp from upstream reaches into the area.

The von Bertalanffy growth-in-length equation $L_t = L_\infty \; 1\text{-}e^{-K(t-t_o)}$ was used to calculate growth-parameter estimates. The mean growth curve indicated the age of brown shrimp at the generally accepted minimum commerical size of 70-per-pound (headless) as 12 weeks, size 50-per-pound as 14 to 15 weeks, and size 30-per-pound as 21 weeks. The estimated average maximum size was 15-per-pound (177.7 mm total length).

Total mortality estimates were obtained by fitting linear regressions to the natural logarithms of adjusted numbers of recaptures plotted against recapture time periods. The instantaneous total mortality rates calculated for the 115-mm modal groups of mark-recapture Experiments I and II were 1.243 and 0.993 respectively. When converted to weekly rates of mortality, these data indicate that 71% and 63% of those shrimp present at the beginning of a week were removed by the combined effects of fishing and natural causes during that week.

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TOXICITY OF SOME CHEMICALS TO STRIPED BASS *(Roccus saxatilis)*[1]

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ABSTRACT

The toxicity of eight chemicals to one week old and one month old striped bass, *Roccus saxatilis*, was determined. These chemicals included malachite green, acriflavine, formaldehyde, Diquat, sodium chloride, zinc, copper, and sodium sulfate. In addition the toxicity of artificial sea water and oil field brine based on chloride content was determined for one month old striped bass. Tests were conducted in one gallon wide mouth jars containing two liters of water. Reconstituted water held at 70 degrees Farenheit was used as the diluent. A wide range in toxicity between the two age groups was recorded for acriflavine, Diquat, sodium chloride and sodium sulfate. The one month old fingerlings were slightly more tolerant to malachite green, formaldehyde and copper than the larvae. Zinc was the only chemical tested that required a higher concentration to kill the larvae. The combinations of salts found in artificial sea water and oil field brine based on chloride content were less toxic than equivalent amounts of chloride as constituted from sodium chloride.

INTRODUCTION

Louisiana initiated a striped bass *(Roccus saxatilis)* stocking program in 1965. Since that time we have become interested in the effects of various water qualities, therapeutic agents and pollutants on striped bass. It is advantageous to stock fingerlings rather than fry. Methods of rearing, handling and treating these fish have to be developed. To kill aquatic vegetation in a pond, what can we use? To treat fish for parasites and diseases are the same chemicals and amounts commonly used in fish culture applicable? In what type of water quality will fingerlings survive?

These are just a few of the questions that have to be answered about striped bass before we initiate an intensive and extensive stocking program. The findings of this project will assist us and other research workers in obtaining the information necessary to achieve better survival in our striped bass stocking programs in Louisiana and other states.

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