1972

# Feasibility of increasing striped bass populations by stocking of underutilized nursery grounds : annual progress report 1971-1972

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ANNUAL PROGRESS REPORT

ANADROMOUS FISH PROJECT

PROJECT TITLE: Feasibility of Increasing Striped Bass Populations by Stocking of Underutilized Nursery Grounds.

PROJECT NO.: FA-Virginia AFS-6-2

PROJECT PERIOD: July 1, 1971 - June 30, 1972

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FEASIBILITY OF INCREASING STRIPED BASS POPULATIONS

BY STOCKING OF UNDERUTILIZED NURSERY GROUNDS

(FA-Virginia-AFS-6-2)

## INTRODUCTION

Numerous estuaries in the lower Chesapeake Bay region and coastal Virginia possess physical, chemical and biological properties favorable to their use as nursery grounds for striped bass. Many of them, however, are not so utilized because of the absence of associated spawning grounds. This project was designed to investigate the feasibility of stocking such underutilized nursery grounds as a management device, while monitoring population parameters such as age composition, mortality rates and relative abundance of year classes.

Objectives of this research are 1) to monitor age composition, mortality rates and relative year class strength of striped bass stocks in lower Chesapeake Bay, 2) to select one or more tributaries having suitable nursery grounds for striped bass, but inadequate or unutilized spawning grounds, 3) to experimentally stock a tributary and assess survival and growth of the fish, 4) to refine and adapt existing techniques for rearing striped bass larvae, with an assessment of optimal size for stocking, 5) to experimentally stock additional tributaries, 6) to evaluate stocking in underutilized nursery grounds of Virginia as a management tool and to estimate expected benefits from its implementation.

The present report summarizes progress within the above objectives for the second year of the project, July 1, 1971 - June 30, 1972. Results presented under Job 1 (Objective 1) include certain findings obtained from an earlier cooperative Anadromous Fish Act project (Grant, 1970).

Job 2 was completed during project segment 1 and is not reported herein. The detailed ecological assessment of latent nurseries will be included in the completion report. No progress was made under Job 5, since progress under Job 4 was marginal in project segment AFS-6-1 and during the first half of AFS-6-2. Job 6 will be included in segment AFS-6-3 and the completion report.

W. J. Hogman prepared the text for Job 1 while the remainder of this report was prepared by J. V. Merriner.

## PROGRESS WITHIN JOBS

### Job 1 - Monitoring of Population Parameters

Age composition of striped bass

In 1971-72 the methods of sampling striped bass in Virginia waters remained unchanged from those described in last year's annual report, FA-Virginia-AFS-6-1.

The 1970 year class which appeared several times larger than 1967-69 year classes at age I continued to dominate catches through age II. For the sampling year July 1971 to June 1972 they made up 79.6, 84.9 and 94.3 percent of the pound and fyke net catches in the James, Rappahannock and York Rivers respectively (Table 1.1). In previous years, age I+ fish have generally contributed 45 to 70 percent of the catch from the same gear.

The James River continued to fall well below the other rivers in production of striped bass. Only 98 fish were collected from commercial nets in the James River during 1971-72 as compared to 1915 in the York and 1174 in the Rappahannock. While not a direct measure of the extant populations, these figures at least reflect the approximate order of population differences between the rivers. For all gears combined, only 183 fish were obtained from the James whereas 2640 were obtained from the York and 1562 from the Rappahannock (Table 1.2).

Samples from the winter gill net fishery again indicated few old bass returning to spawn in the Rappahannock River. Of 150 bass sampled only 28 were age V or older (Table 1.3). Age II bass made up one-third of the gill net samples and age III bass another third[1].

Sport catches of striped bass taken from Cheatham Annex Naval pier and the vicinity of the Coleman Bridge in the York River showed young fish predominating the landings. From July 1971 to June 1972, 93.6 percent of the bass captured in this manner were from the 1970 year class (age I-II), and 5.4 percent were from the 1969 year class (Table 1.4).

The age composition of commercial and sport landings of striped bass indicate a heavy dependence on young fish, especially two-year-olds, in Virginia's rivers. This dependence would indicate severe exploitation of young fish. However, exploitation rates calculated by other means do not substantiate this, i.e. from tagging data the age II-IV fish are lightly exploited.

Tagging of striped bass

Greater numbers of striped bass were tagged during this contract period than in any preceding one. In the York 1844 were tagged and in the Rappahannock 2022, compared to 1785 and 809 in 1971 (Table 1.5).

Commercial gear in Virginia rivers continued to take the greatest percentages of tagged striped bass (Table 1.6). In the York River 78.9 percent of the fish tagged in 1971 were taken by gill nets, 3.2 percent by fyke nets and 12.4 percent by sports fishermen. In 1970, 66.3 percent of the returns from the York were from the sport catch.

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[1] In this report striped bass are considered to advance one year in age every January 1st. Thus the age II fish captured in March or April 1972 are of the 1970 year class.

In the Rappahannock River, pound nets captured 74.5 percent of the tagged fish in 1971 compared to 45.7 percent in 1970. The sport fishery returned 8.0 percent in 1971 and 13.3 percent in 1970. Returns to June 30, 1972 show the same pattern of catch returns from the fish tagged in 1972, with commercial gear dominating the percentages (Table 1.6).

The complete history of tagging and returns by year class and year is given in Tables 1.7 and 1.8 for the York and Rappahannock Rivers. The returns from outside the river of tagging are shown within parentheses and provide evidence for substantial migration of striped bass after age II. Strong year classes such as 1966 and 1970 seem to have left the river of origin in greater percentages than fish from normal or smaller year classes. Of 200 tags returned (up to June 30, 1972) from the 1970 year class tagged in the Rappahannock in January-March 1972, 25 were captured outside the river. Of 138 tags from York River fish (1970 year class) tagged over the same period, 32 were caught outside the river. In 1969, 17 of 33 returned tags from the 1966 year class were from outside the York.

Data from the four consecutive years of tagging can now be used to provide estimates of population parameters unbiased as to year class strength. The small sample formula of Ricker (1958, p. 128),

$$s_i = \frac{R_{12}M_2}{M_1(R_{22} + 1)}$$

estimates annual survival, s , from tag and recovery data extending over two years.

The calculated survival rates varied from 4.5 to 13.1 percent annually in 1970 compared to 1.9 to 3.5 in 1969 (Grant and Merriner, 1971). The components of this high mortality (Table 1.9) indicate that fishing mortality represents a small fraction of the loss of tagged fish. This fraction, i.e., the rate of exploitation, was 6.2 and 9.6 percent respectively for the 1966 and 1967 year class in the York in 1969, and 8.1 and 4.6 percent respectively for the 1968 and 1969 year class in 1970. In the Rappahannock River a greater rate of exploitation exists for all year classes, with 25.9 and 13.9 percent and 22.2 and 17.2 percent being captured from the same year classes in the same years as the York.

For both rivers the older fish are more heavily exploited than the younger fish. For example, exploitation of the 1966 year class in the Rappahannock was 25.9 percent at age III, 46.9 percent at age IV and 54.5 percent at age V. The 1968 year class in the Rappahannock were exploited at 8.6, 22.2 and 43.4 percent for ages I, II and III respectively from 1969 through 1971 (Table 1.9). The 1968 year class in the York experienced 8.1 and 17.7 percent exploitation in 1969 and 1970, respectively; and the 1969 year class 4.6 and 12.3 percent exploitation in 1970 and 1971. In all cases the youngest tagged fish were available that year to the gear.

Instantaneous rates of total, fishing and natural mortality indicate that the calculated survival rates from tagging are unreliable indices of actual population survival. For all age classes and years the calculated natural mortality ranges 60 to 90 percent of the total. The instantaneous fishing mortality rates account for only a small portion of the population decline within a river, yet the survival rates indicate that the population did indeed decline drastically for each year class. The high natural mortality coefficients (many above 3.0) are unreasonable for age II to VI striped bass. Instantaneous natural mortality in most intensive fisheries ranges between 0.15 and 0.8 and even rates from catch curve analysis of striped bass yield Z's well below the calculated Z's of Table 1.9.

The most reasonable explanation of high apparent natural mortality would be emigration of tagged fish from the river, which would affect the estimate of total mortality but not fishing mortality (Gulland, 1969). Tag returns from outside the river of release are shown in Tables 1.7 and 1.8, but these only represent 10 to 20 percent additional mortality. Survival rates calculated with all tag return data regardless of recapture location boost estimated survival to only 8 to 17 percent in the York and 5 to 21 percent in the Rappahannock. Rate of exploitation changes by approximately +6 to 13 percent. Thus, with any data adjustment the natural mortality component still remains beyond believable limits in either river.

The rate of exploitation is the most stable and convincing statistic describing the fishery by year class in each river. Age composition data presented in previous sections when interpreted relative to fishing rates on year classes, indicates the fishery presently captures a small percentage of available fish despite the dominance of young fish (age I-III) in the catch. In short, they escape the fishery to other areas but those that remain (or leave and return) are subject to increasing exploitation with age and growth. But even the maximum rate of exploitation (75 percent for the 1966 year class in the York in 1970) is within normal limits of sustaining populations for age IV to

VI fish.

Subsequent tagging work under this program will attempt analysis of several possible error sources in the natural mortality rate, such as loss of tags, death of fish after tagging, and non-mixing of tagged and untagged fish.

## Indices of Year Class Strength

### Minnow Seine Surveys

Young of the year striped bass were censused again in 1971-72 with minnow seines used semi-monthly at selected stations on the James, York and Rappahannock Rivers (Grant, 1970). Abundance indices calculated from the combined July to October total catch and effort were 2.21 for the James, 1.75 for the York, and 2.93 for the Rappahannock. These values are well below the 1970 abundance indices of year class strength (Figure 1.1) and thus indicate either a poorer hatch or greater juvenile mortality in 1971 compared to 1970. For the third year the York catch of age 0 striped bass has been below the other two rivers, although the 1971 catch did not differ greatly from the four year (1967-1970) average of 2.12.

### Young Fish Trawl Surveys

The winter trawling, catch per hour of age 0 striped bass was well below 1970 levels. Respective indices for the James, York and Rappahannock for 1971 were 0.75, 6.66 and 6.85 (Figure 1.2). These indices reflect only two to four hours of trawling time at selected stations from three cruises in January, February and March, and as such may not reflect the abundance of age 0 striped bass accurately.

## Entry Into Commercial Fishery

The contribution of younger fish to the commercial fishery (from age composition data) in the year following hatching has been discussed (pages 1 and 2). The use of percentage data to determine year class strength has been discontinued since variable year class strength disallows comparisons between years, and between it and other indices. A large year class automatically under weights the relative contribution of younger fish in subsequent years and may even indicate small year class establishment when in fact it was normal. Since the commercial data are not effort weighted but merely samples of the catch, they cannot provide quantitative index numbers.

## Winter Distribution and Abundance

A special winter census of benthic fishes was made between January 25 and February 14, 1972 on the James, York and Rappahannock Rivers. A 30 ft. otter trawl with a 1/4 inch cod end was towed four times at each five mile station. All tows were 1/4 mile (nautical) long and two were made with the tide and two against. The water temperatures ranged from 3.5 to 6.0°C and from previous winter trawling we know the fish are concentrated in the deeper water at these temperatures.

The overwintering population of young bass was high in the York and Rappahannock but very low in the James (Table 1.10). The young bass were most abundant between river mile 15 and 30 with salinities from 21.21 to 14.73‰ in the York and 15.77 and 9.17‰ in the Rappahannock (Figure 1.3). Most bass captured averaged 211-285 mm fork length. Fourteen young of the year bass were captured from mile 45 to 55 in the fresh water zone of the Rappahannock. From mile 10 to 30 the York catch averaged 7.55 bass/tow and the Rappahannock catch averaged 6.45 bass/tow.

The young bass were mostly age II and their size of 9-12 inches is the normal recruitment size to commercial and sport gear in Virginia rivers. The winter survey will be annually repetitive and we hope it will provide an index to striped bass abundance for each following year, exclusive of the spawning run in the spring.

Table 1.1. Percent composition by year classes of the striped bass caught in non-selective gear for the contract year July 1971 - June 1972.

| River System | Percent of Sample in Year Class 1971 | 1970 | 1969 | 1968 | 1967 | 1966 | 1965 | Sample Size |
|---|---|---|---|---|---|---|---|---|
| James (no samples Dec 71 - Feb 72) | 0 | 79.6 | 7.1 | 6.1 | 4.1 | 0 | 0 | 98 |
| York | 1.8 | 84.9 | 9.7 | 1.3 | 0.5 | 0.8 | 0.3 | 1915 |
| Rappahannock | 0.3 | 94.3 | 3.3 | 0.6 | 0.3 | 0.3 | 0 | 1174 |

Table 1.2. Age composition of striped bass sampled from Virginia rivers. All gears combined.

| 1970-71 | Year Classes 1971 | 1970 | 1969 | 1968 | 1967 | 1966 | 1965 | 1964 | Total(1) |
|---|---|---|---|---|---|---|---|---|---|
| York | - | 217 | 1347 | 190 | 43 | 11 | 1 | 2 | 1890 |
| Rapp. | - | 135 | 789 | 367 | 80 | 84 | 4 | 7 | 1481 |
| James | - | 1 | 131 | 65 | 67 | 12 | 2 | 1 | 200 |
| 1971-72 | | | | | | | | | |
| York | 95 | 2248 | 225 | 25 | 10 | 15 | 6 | 5 | 2640 |
| Rapp. | 112 | 1286 | 90 | 28 | 8 | 6 | 4 | 14 | 1562 |
| James | 53 | 111 | 7 | 6 | 3 | | | 1 | 183 |

(1)Totals include several fish older than 1964 year class

Table 1.3. Age composition of winter gill-net catches of striped bass, March and April 1972, Rappahannock River.

| Month | Year Classes 1970 | 1969 | 1968 | 1967 | 1966 | 1965 | 1964 | 1963 | Total(1) |
|---|---|---|---|---|---|---|---|---|---|
| March | 34 | 37 | 18 | 4 | 1 | 3 | 1 | 2 | 100 |
| April | 16 | 14 | 3 | 1 | 2 | 1 | 7 | 2 | 50 |
| Seasonal Total | 50 | 51 | 21 | 5 | 3 | 4 | 8 | 4 | 150 |
| Percent of Total | 33.3 | 34.0 | 14.0 | 3.3 | 2.0 | 2.7 | 5.3 | 2.7 | |

(1)Totals include several fish older than 1963 year class.

Table 1.4. Age composition of striped bass from sport catches in the York River, July 1971 - June 1972.

| Month | Year Classes 1971 | 1970 | 1969 | 1968 | Total |
|---|---|---|---|---|---|
| Jul | 0 | 44 | 7 | 0 | 51 |
| Aug | 0 | 86 | 9 | 0 | 95 |
| Sep | 0 | 85 | 2 | 1 | 88 |
| Oct | 0 | 121 | 6 | 0 | 127 |
| Nov | 0 | 50 | 0 | 0 | 50 |
| Dec | 0 | 45 | 10 | 0 | 55 |
| Jan | 3 | 45 | 4 | 0 | 52 |
| Feb | ---- No sample obtained ---- | | | | |
| Mar | 0 | 23 | 2 | 0 | 25 |
| Apr | 2 | 53 | 0 | 0 | 55 |
| May | 0 | 92 | 1 | 0 | 93 |
| Jun | 2 | 86 | 1 | 0 | 89 |
| Total | 7 | 730 | 42 | 1 | 780 |
| Percent of Total | 0.9 | 93.6 | 5.4 | 0.1 | |

Table 1.5. Age distribution and returns by gear of striped bass tagged in the York and Rappahannock Rivers in 1970-71 and 1971-72.

| | Year Classes | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1971 | 1970 | 1969 | 1968 | 1967 | 1966 | Totals |
| **York River** | | | | | | | |
| Number tagged | | | | | | | |
| Winter 1971 | 0 | 204 | 1493 | 79 | 8 | 0 | 1785 |
| Number returned | | | | | | | |
| ~~in 1971~~ | | | | | | | |
| Commercial gear | - | 3 | 162 | 16 | 2 | 0 | 183 |
| Sport gear | - | 2 | 24 | 2 | 0 | - | 28 |
| Unknown gear | - | 0 | 25 | 11 | 0 | - | 26 |
| Total | | 5 | 211 | 19 | 2 | | 237 |
| Number tagged | | | | | | | |
| Winter 1972 | 135 | 1696 | 13 | 0 | 0 | 0 | 1844 |
| Number returned* | | | | | | | |
| Commercial gear | 0 | 82 | 3 | - | - | - | 85 |
| Sport gear | 3 | 38 | 0 | - | - | - | 41 |
| Unknown gear | 0 | 9 | 0 | - | - | - | 9 |
| Total | 3 | 129 | 3 | | | | 135 |
| **Rappahannock River** | | | | | | | |
| Number tagged | | | | | | | |
| 1971 | | 204 | 432 | 136 | 26 | 11 | 809 |
| Number returned | | | | | | | |
| Commercial gear | | 23 | 103 | 54 | 15 | 6 | 201 |
| Sport gear | | 1 | 14 | 5 | 0 | 0 | 20 |
| Unknown gear | | 4 | 0 | 1 | 0 | 0 | 5 |
| Total | | 28 | 127 | 60 | 15 | 6 | ~~226~~ 224 |
| Number tagged | | | | | | | |
| 1972 | 21 | 1995 | 6 | | | | 2022 |
| Number returned* | | | | | | | |
| Commercial gear | 1 | 146 | 2 | 0 | 0 | 0 | 149 |
| Sport gear | 0 | 29 | 0 | 0 | 0 | 0 | 29 |
| Unknown gear | 0 | 13 | 0 | 0 | 0 | 0 | 13 |
| Total | 1 | 188 | 2 | 0 | 0 | 0 | 191 |

*Up to June 30, 1972.

Table 1.6. Percentage return of tagged striped bass from different gear types in the York and Rappahannock Rivers. Returns from outside river of origin not included.

| | Tagging Period | | | | | |
|---|---|---|---|---|---|---|
| | Winter 1970 | | Winter 1971 | | Winter 1972[a] | |
| | York | Rapp. | York | Rapp. | York | Rapp. |
| Pound nets | 6.7 | 45.7 | 0.5 | 74.5 | --- | 67.7 |
| Gill nets | 21.4 | 33.3 | 78.9 | 16.5 | 24.8 | 9.1 |
| Haul seine | 4.5 | 6.8 | 4.9 | 0.5 | 38.5 | 11.6 |
| Peeler traps | --- | 0.9 | --- | 0.5 | --- | --- |
| Fyke nets | 1.1 | --- | 3.2 | --- | 9.1 | --- |
| Sport gear | 66.3 | 13.3 | 12.4 | 8.0 | 27.5 | 11.6 |
| Total returns | 89 | 234 | 185 | 212 | 109 | 169 |

[a]Up to June 30, 1972.

Table 1.7. Numbers of striped bass tagged and tag returns by year class and year in the York River, all gears combined. Number of returns outside of river given in parentheses below each entry.

**Winter 1969**

| | 1968 | 67 | 66 | 65 | 64 | 63 | 62 | 61 | Total |
|---|---|---|---|---|---|---|---|---|---|
| No. tagged in year class | 9 | 594 | 259 | 15 | 3 | 3 | 1 | 1 | 885 |
| No. returned in 1969 | | 57 (16) | 16 (17) | | | | | | 73 (33) |
| No. returned in 1970 | | 6 (8) | | | | 2 | | | 8 (8) |
| No. returned in 1971 | | 3 | | | | | | | 3 |
| No. returned in 1972* | | | | | | | | | 0 |

**Winter 1970**

| | 1969 | 68 | 67 | 66 | 65 | 64 | 63 | 62 | Total |
|---|---|---|---|---|---|---|---|---|---|
| No. tagged in year class | 352 | 621 | 42 | 4 | - | - | 1 | - | 1020 |
| No. returned in 1970 | 16 (10) | 50 (12) | 8 (2) | 3 | | | | | 77 (24) |
| No. returned in 1971 | 3 | 5 (1) | | | | | | | 8 (1) |
| No. returned in 1972* | 0 (1) | 1 | | | | | | | ~~0~~ 1 (1) |

**Winter 1971**

| | 1970 | 69 | 68 | 67 | 66 | 65 | 64 | 63 | Total |
|---|---|---|---|---|---|---|---|---|---|
| No. tagged in year class | 204 | 1493 | 79 | 8 | - | - | - | 1 | 1785 |
| No. returned in 1971 | 3 (3) | 184 (20) | 14 (4) | 1 (1) | | | | | 202 (28) |
| No. returned in 1972* | | 4 | | | | | | | 4 |

**Winter 1972**

| | 1971 | 70 | 69 | 68 | 67 | 66 | Total |
|---|---|---|---|---|---|---|---|
| No. tagged in year class | 135 | 1696 | 13 | - | - | - | 1844 |
| No. returned in 1972* | 3 | 101 (28) | 3 | | | | 107 (28) |

*Up to June 30, 1972.

Table 1.8. Numbers of striped bass tagged and tag returns by year class and year in the Rappahannock River. (Returns from all gears combined and the number of returns from outside of river given in parentheses).

| Winter 1969 | 1968 | 67 | 66 | 65 | 64 | 63 | 62 | UNK | Total |
|---|---|---|---|---|---|---|---|---|---|
| No. tagged in year class | 128 | 922 | 108 | 1 | | | | 2 | 1161 |
| No. returned in 1969 | 11 | 128 (10) | 28 (2) | 1 | | | | | 168 (12) |
| No. returned in 1970 | 1 | 6 (2) | 1 (2) | | | | | | 8 (4) |
| No. returned in 1971 | 1 | 1 | | | | | | | ~~1~~ 2 |
| No. returned in 1972* | 1 | 1 | | | | | | | 2 |

| Winter 1970 | 1969 | 68 | 67 | 66 | 65 | 64 | Total |
|---|---|---|---|---|---|---|---|
| No. tagged in year class | 29 | 388 | 186 | 143 | 4 | 1 | 751 |
| No. returned in 1970 | 5 (1) | 86 (4) | 61 (7) | 67 (6) | | | 219 (18) |
| No. returned in 1971 | 1 | 12 ( ) | 4 (3) | 6 (1) | | | 23 (7) |
| No. returned in 1972* | | ~~1~~ 3 | 1 | 1 | | | ~~3~~ 5 |

| Winter 1971 | 1970 | 69 | 68 | 67 | 66 | 65 | Total |
|---|---|---|---|---|---|---|---|
| No. tagged in year class | 204 | 432 | 136 | 26 | 11 | - | 809 |
| No. returned in 1971 | 24 | 114 (7) | 59 | 16 | 6 | | 219 (7) |
| No. returned in 1972* | 1 | ~~6~~ 7 | 7 | ~~3~~ 4 | | | ~~17~~ |

| Winter 1972 | 1971 | 70 | 69 | 68 | 67 | Total |
|---|---|---|---|---|---|---|
| No. tagged in year class | 21 | 1995 | 6 | 0 | 0 | 2022 |
| No. returned in 1972* | 1 | 168 (20) | 2 | | | 171 (20) |

*Up to ~~June 30~~, 1972.

Table 1.9. Estimates of striped bass population parameters in the York and Rappahannock Rivers 1969-1971. Annual rates of survival, mortality and exploitation (s, a and u) in percent; Z, F, and M are instantaneous rates of total mortality, fishing mortality and natural mortality.

| Year Class | | York | | | Rappahannock | | |
|---|---|---|---|---|---|---|---|
| | | 1969 | 1970 | 1971 | 1969 | 1970 | 1971 |
| 1966 | s | 3.5 | -- | -- | 1.7 | 7.9 | -- |
| | a | 96.5 | -- | -- | 98.3 | 92.1 | -- |
| | u | 6.2 | 75.0 | -- | 25.9 | 46.9 | 54.5 |
| | Z | 3.35 | -- | -- | 4.07 | 2.53 | -- |
| | F | 0.07 | 1.39 | -- | 0.27 | 0.64 | 0.79 |
| | M | 3.28 | -- | -- | 3.80 | 1.89 | -- |
| 1967 | s | 1.9 | -- | -- | 1.1 | 3.5 | -- |
| | a | 98.1 | -- | -- | 98.9 | 96.5 | -- |
| | u | 9.6 | 19.0 | -- | 13.9 | 32.8 | 61.5 |
| | Z | 3.96 | -- | -- | 4.50 | 3.35 | -- |
| | F | 0.10 | 0.23 | -- | 0.15 | 0.40 | 0.93 |
| | M | 3.86 | -- | -- | 4.35 | 2.95 | -- |
| 1968 | s | -- | 4.5 | -- | -- | 7.0 | -- |
| | a | -- | 95.5 | -- | -- | 93.0 | -- |
| | u | -- | 8.1 | 17.7 | 8.6 | 22.2 | 43.4 |
| | Z | -- | 3.10 | -- | -- | 2.66 | -- |
| | F | -- | 0.08 | 0.20 | 0.09 | 0.25 | 0.57 |
| | M | -- | 3.02 | -- | -- | 2.41 | -- |
| 1969 | s | -- | 6.9 | -- | -- | 13.1 | -- |
| | a | -- | 93.1 | -- | -- | 86.9 | -- |
| | u | -- | 4.6 | 12.3 | -- | 17.2 | 26.4 |
| | Z | -- | 2.67 | -- | -- | 2.03 | -- |
| | F | -- | 0.05 | 0.13 | -- | 0.19 | 0.31 |
| | M | -- | 2.62 | -- | -- | 1.84 | -- |
| 1970 | s | -- | -- | -- | -- | -- | -- |
| | a | -- | -- | -- | -- | -- | -- |
| | u | -- | -- | 1.5 | -- | -- | 11.8 |
| | Z | -- | -- | -- | -- | -- | -- |
| | F | -- | -- | 0.02 | -- | -- | 0.12 |
| | M | -- | -- | -- | -- | -- | -- |

Table 1.10. Striped bass catch from winter survey 1972 with R.V. Langley in the Virginia rivers.

| | James | | | | York | | | | Rappahannock | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| River mile | Av./Tow | s[2] | Av. Length | Salinity ‰ | Av./Tow | s | Av. Length | Salinity ‰ | Av./Tow | s | Length | Salinity ‰ |
| 00 | 0 | - | - | 25.6 | 0 | - | - | 23.5 | 0 | - | - | 15.8 |
| 05 | 0 | - | - | 19.2 | 0.5 | - | 287 | 21.0 | 0 | - | - | 16.2 |
| 10 | 0.7 | - | 254 | 17.5 | 2.0 | 1.6 | 263 | 22.0 | 5.2 | 6.0 | - | 15.9 |
| 15 | 2.0 | 2.0 | 276 | 15.8 | 4.5 | 4.5 | 211 | 21.2 | 1.8 | 3.5 | - | 15.8 |
| 20 | 0 | - | - | 10.9 | 9.5 | 4.6 | 249 | 19.9 | 19.0 | 5.4 | - | 15.2 |
| 25 | 0 | - | - | 3.3 | 21.2 | 5.6 | 226 | 19.9 | 3.5 | 2.5 | - | 12.1 |
| 30 | 0 | - | - | 0.1 | 0.5 | - | 127 | 14.7 | 2.8 | 3.1 | - | 9.2 |
| 35 | 0 | - | - | 0.1 | 0.5 | - | 289 | 8.3 | 0.3 | - | - | - |
| 40 | 0 | - | - | 0.1 | 0 | - | - | 0.1 | 1.5 | 1.0 | 134 | 0.3 |
| 45 | 0 | - | - | 0.1 | 0 | - | - | 0.1 | 2.8 | 2.1 | 101 | 0.6 |
| 50 | 0 | - | - | 0.1 | 0 | - | - | 0.1 | 0.3 | - | 171 | 0.1 |
| 55[1] | 0 | - | - | 0.1 | 0 | - | - | 0.1 | 0.5 | - | 119 | 0.1 |

[1] No striped bass taken beyond mile 55 in any river.

[2] Standard deviation of average per tow.

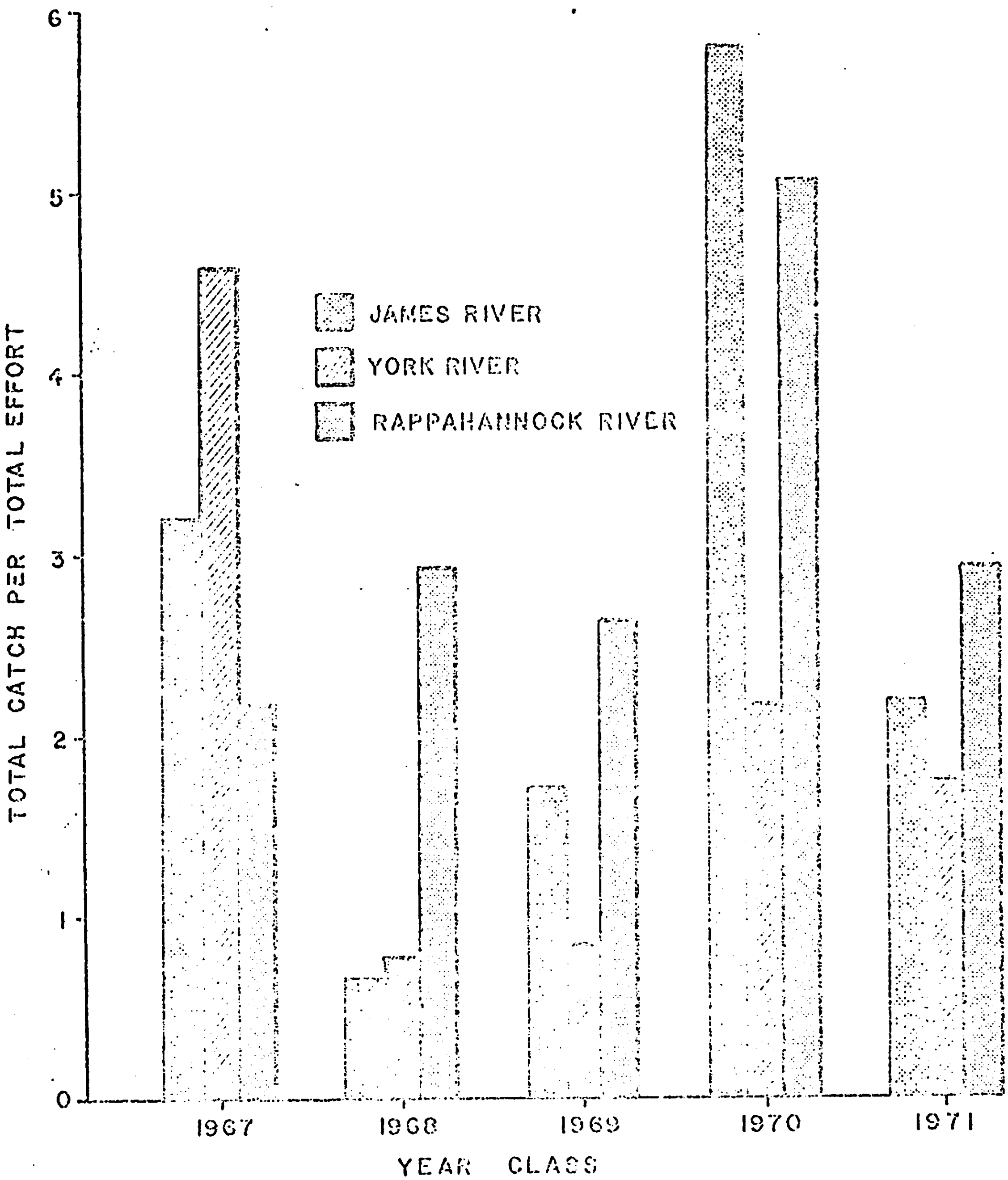


Figure 1.1. Catch per minnow seine haul of 1967-1971 young-of-the-year striped bass in the James, York, and Rappahannock rivers. Based on semi-monthly surveys, July-October.

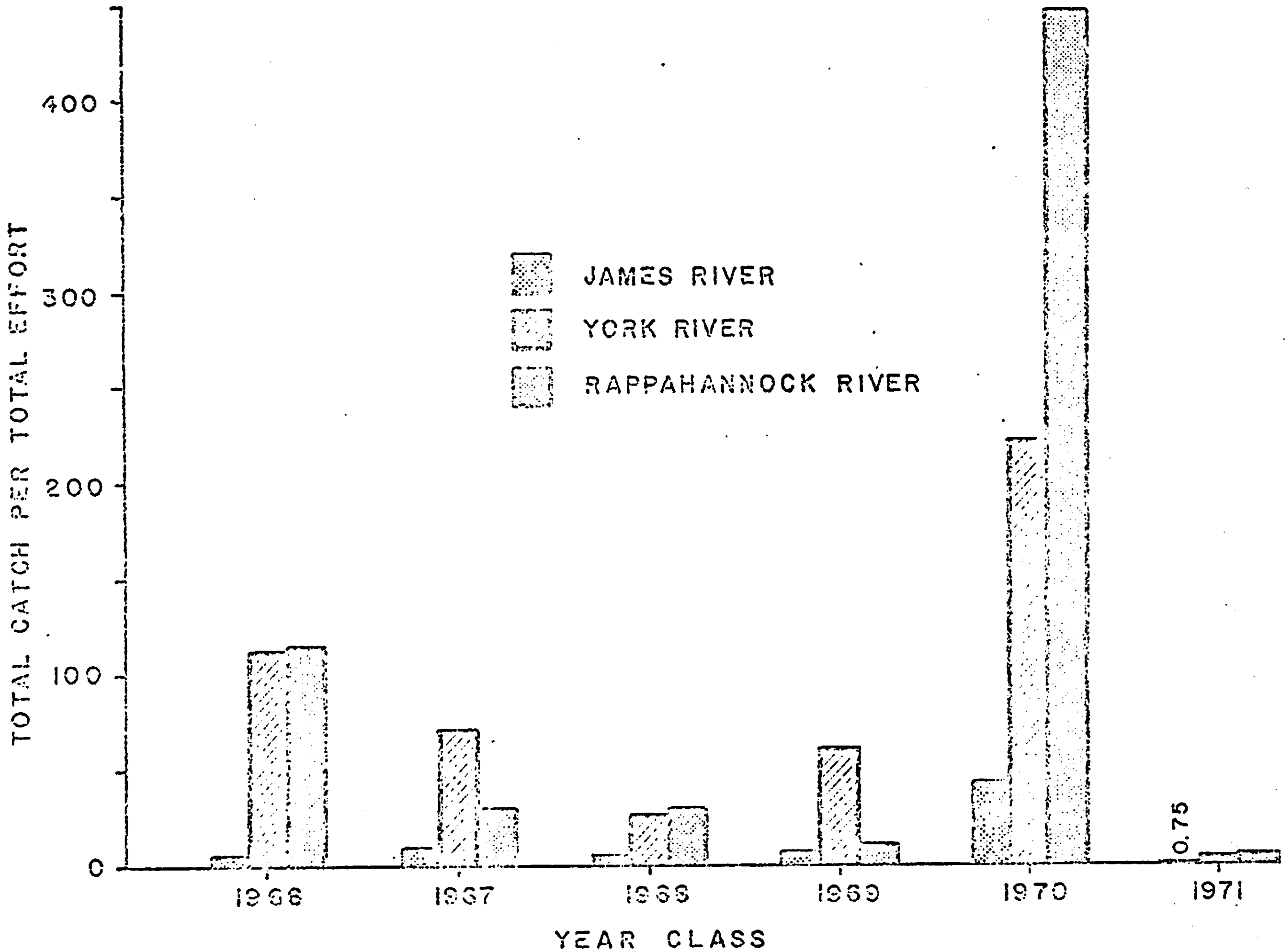


Figure 1.2. Catch per trawl four of 6 striped bass yearclasses in the James, York and Rappahannock rivers. Based upon 30-ft. semi-balloon trawl catches during January to March of calendar year following hatch.

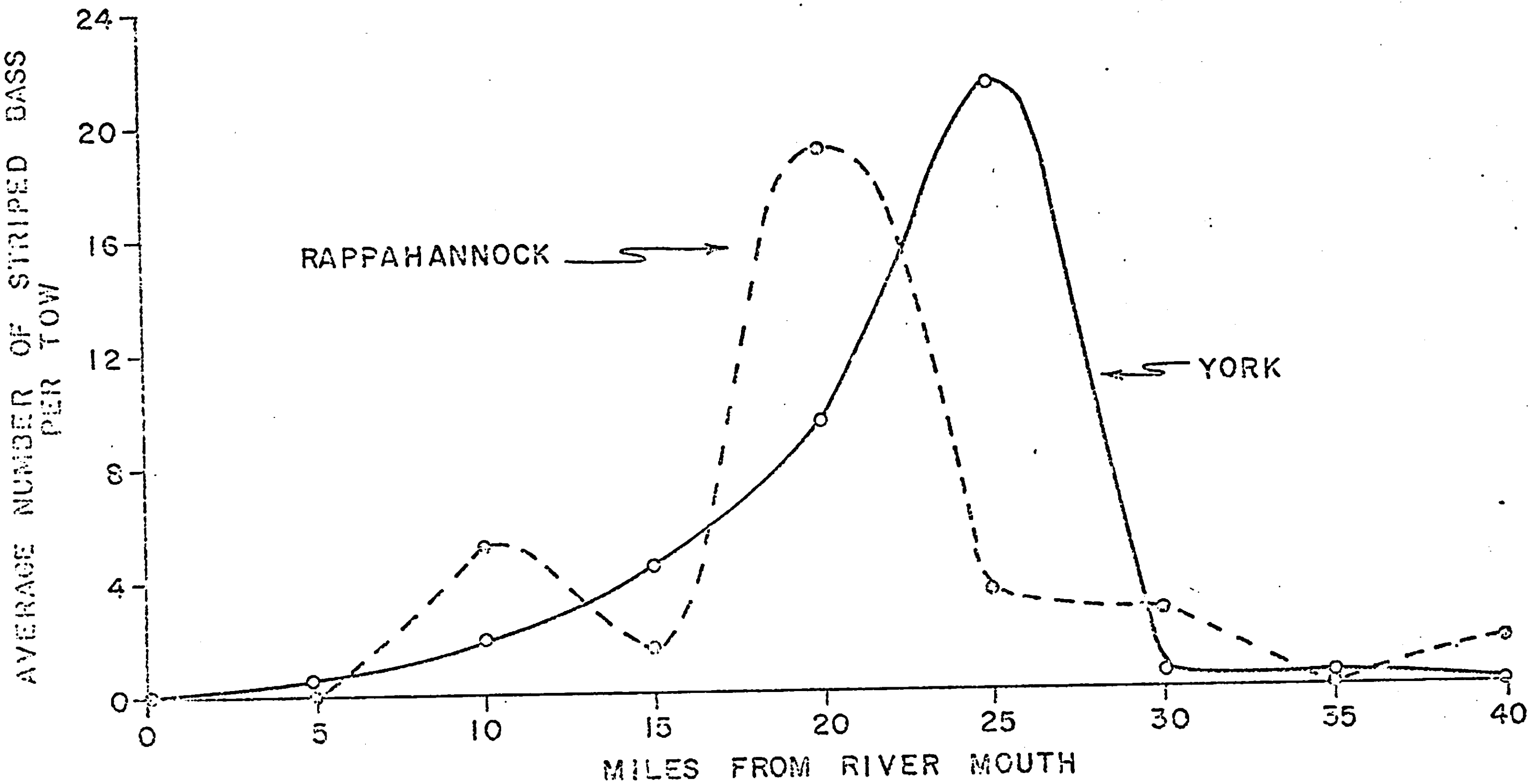


Figure 1·3. Average catch of young striped bass during January and February 1972 in the York and Rappahannock rivers. Data from Table 10.

Job 3. Stocking of selected tributary.

Survival of initial stocking and ecological survey. The initial stocking of the Ware River with one million sac-fry was performed on June 4, 1971. Distribution of fish and initial mortality estimates (43% first day mortality of controls) were described by Grant and Merriner (1971).

Despite the high mortality of control larvae held in the laboratory, sampling efforts were intensified in the Ware and East Rivers to follow growth of stocked versus naturally spawned striped bass in these streams. Sampling procedures for survivors included D-net sled tows for larvae in the upper reaches of the estuaries and bi-monthly at regular trawl stations, beach seining with 50 and 100 ft X 6 ft X 1/4" bar mesh nets within the estuaries and monthly trawling with a 16 ft semi-balloon trawl.

D-net collections preceeding the first stocking of striped bass and during the three weeks thereafter produced no striped bass. Six prestocking plus 17 post-stocking tows were made in the Ware River. Four post-stocking tows were also made in the East River (see Figs. 3.1 and 3.2). The East River will serve as a control stream throughout the stocking study. Salinity at the stations sampled ranged from freshwater (< 1‰) to oligohaline (5 ‰). No striped bass eggs or larvae were taken in any of the pre-or post-stocking tows. Forage organisms such as the free-swimming amphipod, Gammarus fasciatus, the tubiculous amphipod, Corophium lacustre, the snail, Amnicola sp., the water mite, Hydrocarinid, and the midge larvae, Tendipedidae, were abundant throughout the samples.

D-net collections made from July 1970 through June 1971 have been sorted and enumeration is underway. A partial listing of the species encountered is shown in Table 3.1. These data shall be combined with that collected during July 1971 to June 1972 to define epibenthic communities existing within the Mobjack Bay system relative to hydrographic parameters, seasonal patterns, and annual variation. Epibenthic collections terminated in June 1972 to allow adequate time to process the backlog of samples and provide two complete years of data for the ecological description of the system. A complete summary of the epibenthic data will be presented in the project completion report.

Beach seine collections for juvenile striped bass during the period July 19 to September 29, 1971, were made from the mouth of the Ware and East Rivers to the salinity transition zone. A total of 16 striped bass were taken in 27 tows in the East River for an average catch per tow of 0.57. Stations at which striped bass were taken and the total number at each station are summarized in Fig. 3.1. The Ware River collections produced 25 striped bass in 37 tows for an average catch per tow of 0.68. Stations and total number of striped bass taken at each are shown in Fig. 3.2. The length frequencies of the striped bass taken in the Ware and East Rivers are given in Table 3.2 and indicate two yearclasses were present. To date, we have been unable to discern the origin of juvenile striped bass caught in the Ware River. As reported earlier (Grant and Merriner, 1971) recruitment from the York River population may occur but is considered negligible except in years of a strong yearclass (i.e., 1970). The small number of fish and their size range in each tributary suggests a low survival of the fish stocked in the Ware River. The present sample size of striped bass from the Ware River is too small for valid statistical comparisons of growth or condition with the York River population. The specimens have been retained and data from them will be combined with similar data obtained after the 1972 stocking effort for analysis of growth and condition in the latent nursery relative to a utilized nursery. These data will be summarized in the completion report.

Trawl stations within Mobjack Bay and the Ware and East Rivers were retained for continuity of data. Four stations were trawled monthly in both rivers as were stations MJ 1-3 within Mobjack Bay. The new station in the East River is located approximately 1-1/4 miles above ME 3. Hydrographic data plus fish identification, enumeration and measurement were undertaken in the manner described by Grant and Merriner (1971). A sixteen foot semi-balloon trawl with a 1/4 inch bar mesh cod end was used for all trawling.

Hydrographic data obtained during 1971-72 followed the seasonal trends previously described and specific values were within the range reported earlier.

Collections at the three Mobjack Bay stations produced a total of 3698 fish representing 26 different species (Table 3.3).

*Anchoa mitchilli*, (2416 fish) was the most abundant species followed by *Leiostomus xanthurus* (611 fish), *Cynoscion regalis* (277 fish), and *Bairdiella chrysura* (189 fish). Other fishes were infrequently taken except for *Opsanus tau* and *Trinectes maculatus* which are resident estuarine species. The paucity of fishes during January through April (7 fish, 5 species) is even more pronounced within the river than in the bay stations. Forage fishes are quite abundant except during the winter months. A total of eleven *Morone saxatilis* were taken in the East River trawls during July, August and September.

The Ware River trawl samples included 3834 fishes representing 24 species (Table 3.5). *Anchoa mitchilli* again dominated the total sample with 3144 specimens captured. *Leiostomus xanthurus* was the only other species represented by over 100 individuals. The paucity of fishes during the winter was exceptional with only 55 specimens representing 5 species being taken in the December through April surveys. Only three striped bass were taken by trawl during this contract period. This low incidence provides virtually no indication of survival from the initial stocking.

Considering only trawl collections, fishes were grouped as planktivores, secondary carnivores, and piscivores for an approximation of trophic composition by numbers within the Mobjack system (Table 3.6). Weakfish, oyster toad, flounders, lizardfish, and striped bass were classed as piscivores. Alosids, anchovies, and menhaden were classed as strict planktivores; all other species were grouped as secondary carnivores.

The Ware River community contains only 2.1% piscivorous fishes while the East River contains 8.7% and Mobjack Bay stations showed 7.7% piscivores. In all cases planktivores, which are the principle forage for striped bass above 200 mm FL (Markle and Grant, 1970), constituted over one half of the fishes taken. From these data it appears that the Ware River could support a stocked population of striped bass without disturbing the balance of predator and prey fishes.

From D-net, beach seine, and trawl data the survival of striped bass from our initial stocking of sac-fry in the Ware River seems to be negligible. Therefore we have decided to make a second stocking in the Ware River during the summer of 1972. We will rear the fish to a length of 1 to 2 inches in the laboratory before stocking (see Job 4 for Methodology).

Assessment of natural spawning - 1972. Prior to stocking, gill net and D-net collections were made in the Ware and East River to assess natural spawning of striped bass. Weekly gill net sets were made in each river from March 7 through April 27, 1972. Water temperatures during this interval ranged from 10 to 20° C, thus bracketing the typical water temperature at spawning (Raney, 1952). A species list for gill net captures is given in Table 3 7. In the East River we obtained 26 striped bass with 17 gill net-days effort. From the Ware River 40 striped bass were taken with 25 gill net-days effort. No ripe female striped bass were obtained from either river with the gill nets, though seven ripe-running male striped bass were taken (Table 3.8). The overall sex ratio wastwo males per each immature female.

D-net tows for striped bass eggs and larvae from natural spawning were made between March 7 and May 23, 1972, in each river and their tributaries. A total of 126 samples were obtained in the areas shown in Figs. 3.1 and 3.2. No striped bass eggs or larvae were taken in these samples. Numerous forage species were taken including mudminnow, killifish larvae and adults, naked goby, and silversides. Leiostomus xanthurus larvae and Angüilla rostrata elvers were also taken with the D-net.

On May 7, 1972 a ripe running female striped bass weighing twenty pounds was caught by a sportfisherman near the mouth of Wilson Creek. Ova diameters from this fish and ease of ova extrusion confirm that the fish was prepared to spawn. No other reports of female striped bass in spawning condition were obtained from either river during the 1972 spawning season.

Food habits of 44 striped bass obtained by gill net sets in the Ware and East Rivers during March through May 1972 are summarized in Table 3.9. Due to the greater biomass per food item, fishes were the major food item of striped bass from the upper rivers (47.8% volume) followed by polychaetes (25% volume) and blue crabs (13.2% volume). An unusual aspect of food habits was the high incidence of the isopod Erichsonella attenuata, other isopods and amphipods in the stomachs of striped bass over 225 mm FL. Such an occurrence of feeding upon smaller food itmes would seem to be energetically wasteful for striped bass of this size range and it deviates from the usual food habits of striped bass (Raney, 1952 and Markle and Grant, 1970). The presence of Gammarus and Corophium in the food confirms that the fish had entered the freshwater reaches of the system even though the fish were caught in the oligohaline zone of the estuary.

On the basis of these data it is concluded that male striped bass ascend into the Mobjack Bay system during spawning season. But since no females in spawning condition were taken in the freshwater reach of the tributaries and no striped bass eggs or larvae were obtained in our D-net samples, successful spawning of striped bass is unlikely within the Ware River.

1972 Stocking of striped bass. Three-day-old sac fry were obtained from the Brookneal Hatchery (Brookneal, Virginia) on May 26, 1972. The fry were packaged in standard fish shipping containers and transported to V.I.M.S., Gloucester Point, Virginia. Water temperature in the bags upon arrival at VIMS was 19° C. The sealed bags were allowed to float on the surface in the culture facility tanks until acclimated to the tank temperature (17° C), which required approximately one hour. Fry were then released into the freshwater tanks. A total of 3.25 million fry were shipped and handled in this manner. Initial mortality due to shipping and handling was estimated at 33%.

Fish are being maintained in circular fiberglass tanks and a 10 ft diameter plastic swimming pool. Brine shrimp are being hatched and fed to the fish. Results are as yet incomplete, but the closed system we are using appears to be an excellent rearing facility (see Job 4 for a description of system). It is our intention to stock the resulting fingerlings at 1-2" size in the Ware River.

Figure 3.1. Diagram of the East River, Virginia, showing beach seine stations at which striped bass were taken during 1971-72 and areas in which D-net tows were made (arrow indicates seining station; after the arrow is the number of striped bass taken there; dashed line represents the downstream limit of pre- and post-stocking collections in the tributaries with a D-net).

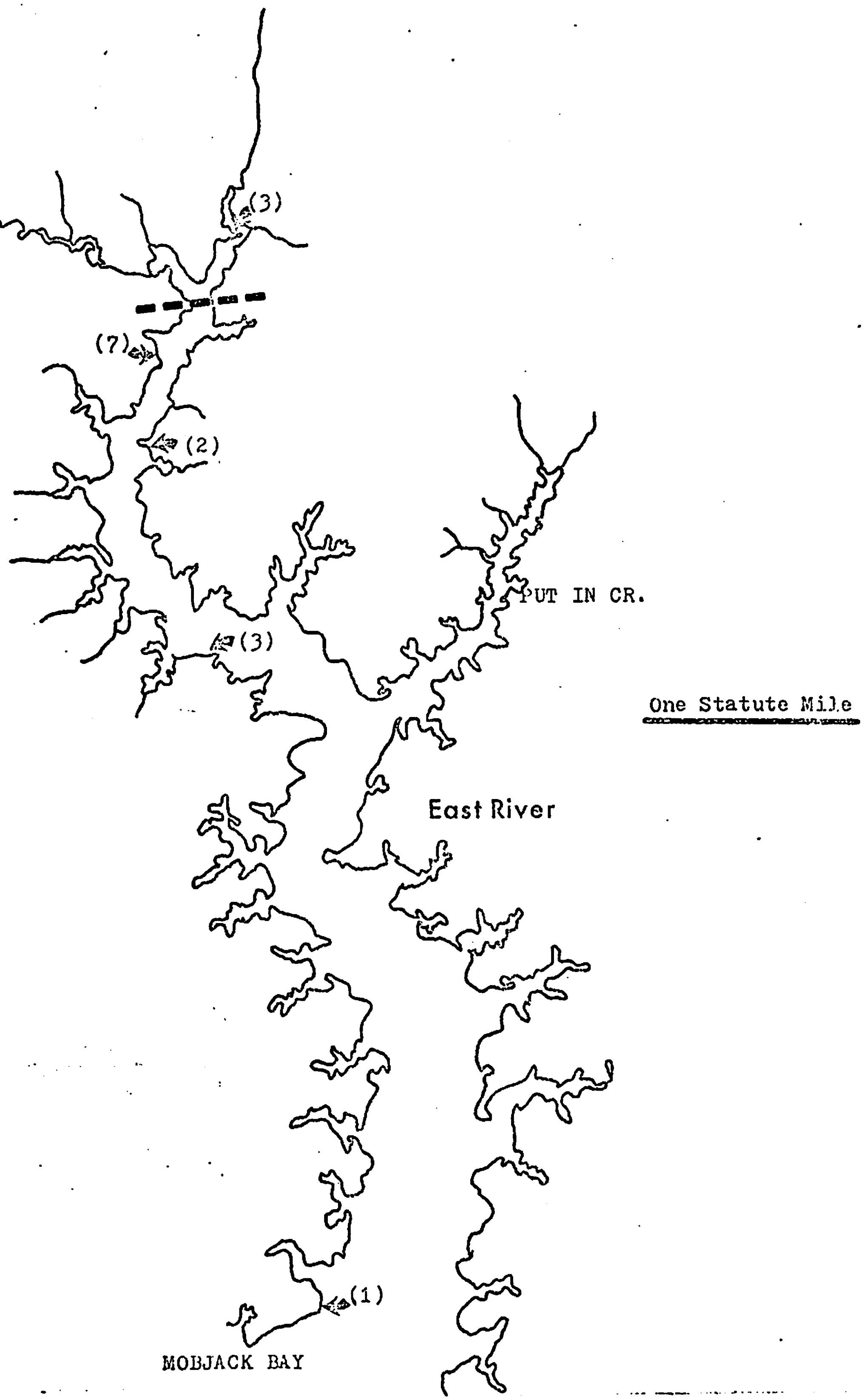
(3)
(7)
(2)
(3)
PUT IN CR.
One Statute Mile
East River
(1)
MOBJACK BAY

Figure 3.2. Diagram of the Ware River, Virginia, showing beach seine stations at which striped bass were taken during 1971-72 and areas in which D-net tows were made (arrow indicates seining station; after arrow is the number of striped bass taken there; dashed line represents the downstream limit of pre- and post-stocking collections in the tributaries with a D-net).

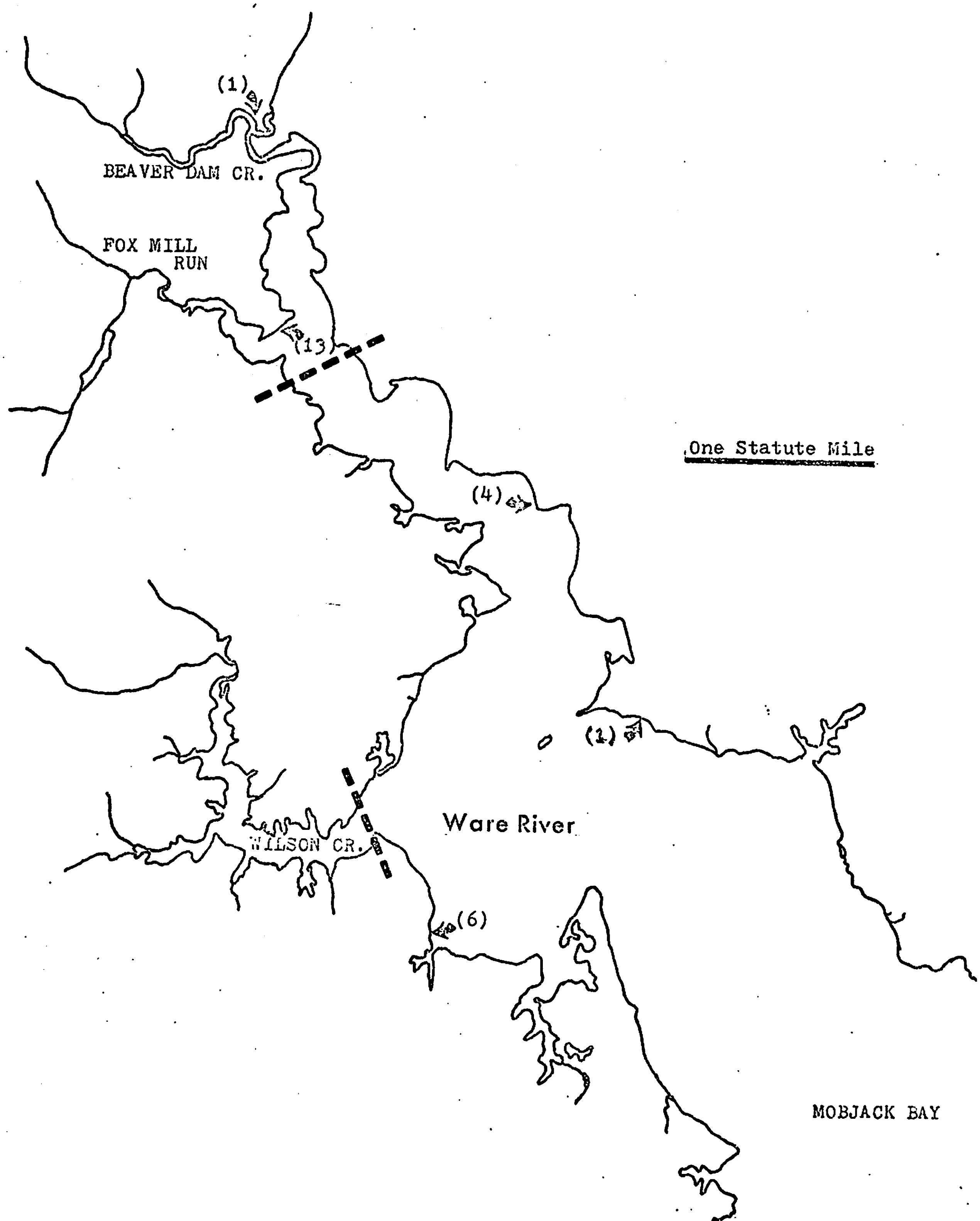
(1)
BEAVER DAM CR.
FOX MILL
RUN
(13)
One Statute Mile
(4)
(1)
Ware River
WILSON CR.
(6)
MOBJACK BAY

Table 3.1. Partial list of species for D-net collections July 1970 to June 1971 in the Mobjack Bay system.

Hydrozoa
- Bougainvillia carolinensis
- Bougainvillia rugosa
- Cunina octonaria
- Dipurina strangulata
- Dyamina cornica
- Eutima mera
- Eucheilota ventricularis
- Liriope tetraphylla
- Nemopsis bachei
- Obelia geniculata (colonies)
- Obelia sp.
- Phialucium carolinae
- Rathkea octopunctata
- Sertularia argentia (colonies)
- Turritopsis nutricula

Scyphozoa
- Aurelia aurita
- Cyanea capillata
- Chrysaora quinquecirrha

Ctenophora
- Mnemiopsis leidyi
- Pleurobrachia pileus

Polychaeta
- Larvae
- Syllidae

Mollusca
- Amnicola sp.
- Bittium sp.
- Crepidula sp.
- Larvae

Pycnogonida
- Callipallene brevirostris

Arachnida
- Unidentified mites

Ostracoda

Copepoda
- Acartia sp.
- Centropages
- Eurytemora
- Larvae
- Oithona
- Temora

Mysidacea
- Neomysis americana
- Mysidiopsis bigelowi

Cumacea
- Leucon americanus
- Oxyurostylus smithi

Isopoda
- Asellus sp.
- Cyathura polita
- Edotea triloba
- Erichsonella attenuata
- Lironeca ovalis
- Sphaeroma quadradentatum

Amphipoda
- Ampelisca abdita
- Ampelisca macrocephala
- Ampithoe longimana
- Batea catherinensis
- Caprella geometrica
- Cerapus tubularis
- Corophium lacustre
- Corophium tuberculatum
- Cymadusa compta
- Elasmopsis pocillimanus
- Erichthonius brasiliensis
- Gammarus fasciatus
- Gammarus minus
- Gammarus mucronatus
- Hyallela azteca
- Leptocheirus plumulosus
- Listriella barnardi
- Lysianopsis alba
- Melita dentata
- Melita nitida
- Monoculodes edwardsi
- Phoxocephalus holbolli
- Stenothoe minuta
- Unciola irrorata

Decapoda - Caridea
- Alpheus heterchelus
- Crangon septemspinosa (larvae and adults)
- Hippolyte pleuracantha (larvae and adults)
- Lucifer sp. (larvae)
- Ogyrides limnicola (larvae and adults)
- Palaemonetes sp. (larvae)
- Palaemonetes intermedius
- Palaemonetes paludosus (larvae and adults)
- Palaemonetes vulgaris (larvae and adults)

Table 3.1. (Cont'd.)

Porcellanid larvae*
Portunid larvae
Xanthid larvae
Ocypodid larvae
Majid larvae
Callianassidae
    Upogebia
Insecta
    Diptera
    Ephemeroptera
    Odonata
Echinodermata
    Cucumaria pilcherrima
    Larvae
    Ophiurae
Chaetognatha
    Sagitta elegans
    Sagitta emflata
    Sagitta hispida
    Sagitta tenuis
Urochordata
    Larvae
Vertebrata
    Anchoa mitchilli
    Anchoa hepsetus
    Cynoscion regalis
    Cynoscion nebulosus
    Bairdiella chrysura
    Syngnathus fuscus
    Syngnathus floridae
    Hippocampus erectus
    Microgobius thalassinus
    Gobiosoma sp.
    Gobiesox strumosus
    Hypsoblennius hentzi
    Chasmodes bosquianus
    Peprilus alepidotus
    Trinectes maculatus
    Gobionellus sp.

* Crustacean larvae have been retained for more specific identification.

Table 3.2. Length frequencies of M. saxatilis collected in the Ware and East Rivers, Virginia, by beach seining during 1971-72 post-stocking survey.

| mm FL | Ware River | East River |
|---|---|---|
| 50 | | 1 |
| 55 | | 2 |
| 60 | | 4 |
| 65 | | 1 |
| 70 | | |
| 75 | 1 | |
| 80 | 3 | 1 |
| 85 | 3 | 1 |
| 90 | | |
| 95 | 2 | |
| 100 | | |
| 105 | | 1 |
| 110 | | |
| 115 | | |
| 120 | 4 | |
| 125 | 2 | |
| 130 | 1 | |
| 135 | 1 | |
| 140 | | |
| 145 | 1 | |
| 150 | 1 | |
| 155 | 1 | |
| 160 | | |
| 165 | | 2 |
| 170 | | |
| 175 | | |
| 180 | | 1 |
| 185 | 1 | |
| 190 | | |
| 195 | | 2 |
| 200 | | |
| 205 | | |
| 210 | 1 | |
| 215 | 1 | |
| 220 | | |
| 225 | 2 | |
| | 25 | 16 |

Table 3.3. Species and abundance of fishes trawled in Mobjack Bay from July 1971 through June 1972.

| Species | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alosa aestivalis | | | | | | | | 2 | | | | | 2 |
| Alosa pseudoharengus | | | | | | | 3 | | | | | | 3 |
| Anchoa mitchilli | 540 | 14 | 105 | 40 | 75 | 1080 | 3 | 17 | 2 | 76 | 450 | 6 | 2416 |
| Bairdiella chrysura | 2 | | 74 | 36 | 7 | | | | | | 2 | | 121 |
| Brevoortia tyrannus | | | | | | 60 | | | | | | | 60 |
| Centropristis striata | 2 | 1 | | | | | | | | | 2 | | 5 |
| Chaetodipterus faber | | | 11 | | | | | | | | | | 11 |
| Cynoscion regalis | 3 | 52 | 184 | 35 | 2 | | | | | | 1 | | 277 |
| Dasyatis centroura | | | 1 | | | | | | | | | | 1 |
| Gobiosoma bosci | | 1 | | | | | | | | | | | 1 |
| Leiostomus xanthurus | 287 | 17 | 200 | 42 | 33 | | | | | | 32 | | 611 |
| Menidia menidia | | | | | | 1 | 16 | 1 | | | | | 18 |
| Menticirrhus americanus | 1 | 1 | 12 | 3 | 9 | | | | | | | | 26 |
| Microgobius thalassinus | | | | | | | | | | 1 | | | 1 |
| Micropogon undulatus | 1 | | | | 13 | | | | | | | | 14 |
| Opsanus tau | | 1 | 3 | | | | | | | | | | 4 |
| Paralichthys dentatus | | | | | 1 | | | | | | | | 1 |
| Peprilus alepidotus | 1 | | 7 | 1 | | | | | | | | | 9 |
| Peprilus triacanthus | 1 | | | | | | | | | | | | 1 |
| Prionotus carolinus | | | | | | | | | | 4 | 1 | | 5 |
| Pseudopleuronectes americanus | | | | | | | 1 | | | | | | 1 |
| Sphoeroides maculatus | | 1 | 2 | | | | | | | | | | 3 |
| Syngnathus fuscus | | | | | 1 | | | 1 | | | 1 | | 3 |
| Synodus foetens | | 2 | 1 | | | | | | | | | | 3 |
| Trinectes maculatus | 10 | 33 | 47 | 10 | | | | | | | | | 100 |
| Urophycis regius | | | | | | | | | | 1 | | | 1 |
| Total fish | 848 | 132 | 647 | 167 | 141 | 1141 | 23 | 21 | 2 | 82 | 497 | 6 | 3698 |
| No. of species | 10 | 10 | 12 | 7 | 8 | 3 | 4 | 4 | 1 | 4 | 7 | 1 | 26 |

Table 3-4. Species and abundance of fishes trawled in the East River, Virginia, from July 1971 through June 1972.

| Species | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alosa aestivalis | | | | | | 448 | | | | | | | 448 |
| Anchoa mitchilli | 191 | 18 | 45 | 154 | 239 | 11 | | 1 | | | 133 | 377 | 1169 |
| Anguilla rostrata | | | 2 | | | | | | | | | | 2 |
| Bairdiella chrysura | 2 | 4 | 87 | 96 | | | | | | | | | 189 |
| Brevoortia tyrannus | | | | | | | | | 3 | | | 76 | 79 |
| Chaetodipterus faber | | | 1 | | | | | | | | | | 1 |
| Chasmodes bosquianus | | | 2 | | | | | | | | | | 2 |
| Cynoscion regalis | 11 | 4 | 166 | 11 | | | | | | | 1 | | 193 |
| Cyprinodon variegatus | | | | | | | 1 | | | | | | 1 |
| Etropus microstomus | | | | | | | | | | | 1 | | 1 |
| Gobiosoma bosci | | | 3 | 1 | | 1 | | | | | 8 | | 13 |
| Leiostomus xanthurus | 213 | 37 | 143 | 52 | | | | | | | 299 | 8 | 752 |
| Menticirrhus americanus | | 2 | | | | | | | | | | | 2 |
| Microgobius thalassinus | | | 2 | 3 | | | | | | | 1 | | 6 |
| Micropogon undulatus | | | | | 4 | | | | | | 1 | | 5 |
| Morone saxatilis | 7 | 2 | 2 | | | | | | | | | | 11 |
| Opsanus tau | 11 | 13 | 31 | 2 | | | | | | | 2 | | 59 |
| Peprilus alepidotus | 19 | 11 | 1 | 1 | | | | | | | | | 32 |
| Syngnathus fuscus | | | | | | 3 | | | 1 | | | | 4 |
| Synodus foetens | 1 | | 1 | | | | | | | | | | 2 |
| Trichiurus lepturus | | | | | | | | | | | | 1 | 1 |
| Trinectes maculatus | 2 | 10 | 32 | 3 | 1 | 1 | | | | | 1 | 1 | 51 |
| Total fish | 459 | 101 | 518 | 323 | 244 | 464 | 1 | 1 | 4 | 1 | 448 | 463 | 3025 |
| No. of species | 10 | 9 | 14 | 9 | 3 | 5 | 1 | 1 | 2 | 1 | 10 | 5 | 23 |

Table 3.5. Species and abundance of fishes trawled in the Ware River, Virginia from July 1971 through June 1972.

| Species | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anchoa mitchilli | 155 | 1 | 750 | 275 | 1026 | 50 | | 1 | | | 663 | 223 | 3144 |
| Anchoa hepsetus | | | 2 | | | | | | | | | | 2 |
| Anguilla rostrata | | | 1 | 1 | | | | | | | | | 2 |
| Apeltes quadracus | | | | | | | | 1 | | | | | 1 |
| Bairdiella chrysura | 3 | | 47 | 32 | 3 | | | | | | | | 85 |
| Brevoortia tyrannus | | | | | | | | | | | 1 | 5 | 6 |
| Centropristis striata | | | | | | | | | | | 1 | | 1 |
| Chaetodipterus faber | | | 3 | | | | | | | | | | 3 |
| Chasmodes bosquianus | | | | 1 | | | | | | | | | 1 |
| Cynoscion nebulosus | | | 1 | | | | | | | | | | 1 |
| Cynoscion regalis | | 8 | 45 | 5 | 5 | | | | | | | | 63 |
| Gobiosoma bosci | | | | | 1 | | | | | | 1 | | 2 |
| Leiostomus xanthurus | 126 | 43 | 154 | 45 | 30 | | | | | | 41 | 8 | 447 |
| Menticirrhus americanus | | | 1 | | | | | | | | | | 1 |
| Micropogon undulatus | | | | | 23 | | | | | | 1 | | 24 |
| Morone saxatilis | 1 | | | 1 | 1 | | | | | | | | 3 |
| Opsanus tau | 3 | 5 | 4 | 2 | | | | | | 1 | | | 15 |
| Paralichthys dentatus | | | 1 | | 2 | | | | | | | | 3 |
| Peprilus alepidotus | 2 | 1 | 2 | 4 | | | | | | | | | 9 |
| Pomatomus saltatrix | | | | | | | | | | | | 1 | 1 |
| Prionotus carolinus | | | | | | | | | | | 1 | | 1 |
| Syngnathus floridae | | | | | | | 1 | | | | | 1 | 2 |
| Synodus foetens | | | 2 | | | | | | | | | | 2 |
| Trinectes maculatus | | 4 | 10 | | | | | | | 1 | | | 15 |
| Total fish | 290 | 62 | 1023 | 366 | 1091 | 50 | 1 | 2 | 0 | 2 | 709 | 838 | 3834 |
| No. of species | 6 | 6 | 14 | 9 | 8 | 1 | 1 | 2 | 0 | 2 | 7 | 5 | 24 |

Table 3.6. Numbers and percent of total catch of piscivores, secondary carnivores and planktivores in fish trawls in the Mobjack Bay system.

| | Mobjack Bay | Ware River | East River |
|---|---|---|---|
| Planktivores | 2481 (67.1%)* | 3152 (82.2%) | 1696 (56.1%) |
| Carnivores | 931 (21.2%) | 600 (15.6%) | 1066 (35.2%) |
| Piscivores | 286 (7.7%) | 82 (2.1%) | 263 (8.7%) |
| Total number | 3698 | 3834 | 3025 |

*entries listed as #(percent of total).

Table 3.7. Fishes taken by gill net in the Ware and East Rivers during March - April, 1972.

| Ware River | | East River | |
|---|---|---|---|
| Brevoortia tyrannus | 127 | Brevoortia tyrannus | 217 |
| Alosa aestivalis | 4 | Alosa pseudoharengus | 11 |
| Alosa pseudoharengus | 34 | Alosa mediocris | 2 |
| Alosa mediocris | 12 | Pomatomus saltatrix | 6 |
| Dorosoma cepedianum | 1 | Trinectes maculatus | 15 |
| Erimyzon oblongus | 1 | Cynoscion regalis | 15 |
| Cyprinus carpio | 1 | Bairdiella chrysura | 9 |
| Anguilla rostrata | 1 | Morone americana | 1 |
| Ictalurus catus | 6 | Morone saxatilis | 26 |
| Trinectes maculatus | 1 | | |
| Cynoscion regalis | 9 | | |
| Bairdiella chrysura | 1 | | |
| Morone americana | 11 | | |
| Morone saxatilis | 40 | | |
| Σ | 249 | Σ | 302 |

Table 3.8. Gonad condition of striped bass caught by gill nets in the Ware and East Rivers during spring 1972.

| Ware River | Immature | Maturing | Gravid | Ripe-running |
|---|---|---|---|---|
| Male | 1 | 9 | 8 | 7 |
| Female | 13 | | | |
| **East River** | | | | |
| Male | 1 | 11 | 2 | |
| Female | 10 | | | |
| *Unknown | 1 | | | |

*Specimen damaged beyond sexual recognition by crabs..

Table 3.9. Stomach contents of 44 M. saxatilis (227-395 mm, mean FL 281 mm) from gill nets in the Ware and East Rivers (March - May, 1972). Mean percent of volume is based on contents of 25 fish stomachs judged to be moderately full, full or very full.

| Group | Species | Incidence | Total Numbers | Percent Occurrence | Mean Percent Volume |
|---|---|---|---|---|---|
| Nemerteans | Cerebratulus sp. | 1 | fragments | 2.3 | 3.60 |
| Polychaetes | Nereis succinea | 15 | many frag. | 34.5 | 25.0 |
| Mysids | Neomysis americana | 2 | 5 | 4.6 | 0.20 |
| Isopods | Cyathura polita | 1 | 1 | 2.3 | |
| | Edotea triloba | 1 | 2 | 2.3 | |
| | Erichsonella attentuata | 10 | 31 | 23.0 | 4.60 |
| | Idotea baltica | 3 | 5 | 6.9 | 0.80 |
| | Lironeca ovalis | 1 | 1 | 2.3 | 1.20 |
| Amphipods | Corophium lacustre | 2 | 8 | 4.6 | 0.60 |
| | Gammarus fasciatus | 1 | 1 | 2.3 | 0.20 |
| | Leptocheirus plumulosus | 5 | 24 | 11.5 | 0.80 |
| | Listriella sp. | 1 | 1 | 2.3 | |
| Carids | Alpheus heterochelus | 3 | 6 | 6.9 | 3.40 |
| | Palaemonetes sp. | 4 | 5 | 9.2 | 0.40 |
| Brachyurans | Callinectes sapidus | 8 | 15 | 18.4 | 13.20 |
| Fish | Anchoa sp. | 6 | 7 | 13.8 | 9.60 |
| | Anguilla rostrata | 1 | 1 | 2.3 | 1.20 |
| | Chasmodes bosquianus | 1 | 1 | 2.3 | 1.20 |
| | Fundulus sp. | 8 | 14 | 18.4 | 24.60 |
| | Menidia sp. | 3 | 4 | 9.2 | 6.80 |
| | Opsanus tau | 1 | 1 | 2.3 | 1.20 |
| | Unidentifiable fish frag. | 8 | fragments | 18.4 | 3.20 |

Job 4. Techniques of rearing and stocking.

As described in AFS 6-1 progress report for 1971, the initial attempt to hold striped bass for experimental purposes failed. The present account of techniques and experimental data are derived from sac-fry received from Brookneal Hatchery on May 26, 1972. Although the contract year terminates on June 30, experimental work was not completed until late July. Therefore, we have included information in this report from the entire rearing period. On July 29, 1972 the fingerlings were stocked in the Ware River.

Facilities for rearing striped bass to fingerling size have typically included ponds. However, because of logistical problems, space restrictions, cost of construction and personnel needs, classical pond rearing of striped bass was considered impractical. Therefore, we have utilized a closed system requiring relatively little physical space, involving a minimal monetary outlay for production and providing good control of the water chemistry, feeding rate, and disease.

Cage Culture

An open-flow cage culture system was evaluated during this contract year. The cages were constructed from plywood and 2-inch lath with plastic screening along the sides and bottom (Fig. 4.1). A hatch on top of the cage allowed easy access for observations of the fish. Three cages were floated in the Ware River approximately one mile above Fox Mill Creek (Fig. 3.2). The cages were allowed to soak and develop micro-communities of aquatic invertebrates. Thus natural foods would be continuously available to the enclosed fish. Approximately 500 two-week old larvae from the main holding facilities at the laboratory were transferred to each cured cage. Examination of the cages one week later revealed no survivors.

The utility of these structures for growth of striped bass from sac-fry to fingerling size can not be concluded from our data. Manpower requirements for cage rearing are greater and control of water characteristics, disease or parasitism and feeding are more difficult than for the closed systems described later in this report. Therefore cage rearing of striped bass is not recommended.

## VIMS Culture Facility

The main fish culture facility for striped bass rearing and experimental studies was established in a garage at VIMS. Water supply for the building consists of a freshwater well with a "city water" back-up system. A general diagram of the facility is shown in Figure 4.2. Two closed system arrangements were tried within the facility. The first used 180 gallon fiberglass tanks and the second employed plastic-lined swimming pools.

## Fiberglass Closed System

Upon receipt of the striped bass sac-fry, 300,000 were placed in each of the 5 fiberglass tank systems. Brine shrimp nauplii were fed exclusively for the first two weeks. Subsequently brine shrimp were augmented with Tetramin* (prepared dry flake). Techniques of feeding and water maintenance were the same as described for the plastic pools.

Growth of the fish in these tanks was slow throughout the rearing study. Relatively high mortality occurred during the rearing period until the population within each tank approached 200 fish. The behavior of the fry within the tanks included a strong orientation to the sides of the tanks. The fish assumed a vertical position (head-up) relative to the wall and swam within one inch of it. After attainment of approximately one inch length the fingerlings schooled and swam around the bottom of the tanks.

Use of the above system of fiberglass tanks for small lots of experimental fish is recommended. Crowding is considered the major problem with this tank system. A stocking rate of 10,000 sac fry per tank would probably result in greater survival and more rapid growth rate of fish.

Swimming Pool Closed System

A circular wading pool with steel wall and vinyl liner, 10' in diameter by 2' deep was assembled on the concrete floor

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* Registered trademark. The use of trade names infers no approval or endorsement of the product by the granting or contracting agency, rather names merely identify products used in our study.

of the fish culture facility. After assembly the vinyl liner was throughly scrubbed and rinsed and then filled with well water (pH 7.6) to a depth of 18 inches (approximately 900 gallons).

Filters were fabricated from plastic "dish pans" (18"X12"X8" deep) into which approximately 300 holes (1/4") had been drilled. Wooden rails (30"X1"X2") were attached along the top "lips" of the long edges of the pans. Thus the filters could be mounted between two 2"X4"X10' boards laid across the rim of the pool. The bottoms of the pans were covered with a thin but continuous layer of fiberglass filter wool over which a layer of activated charcoal was added to form the basic unit. Water was circulated from the pool to the filter boxes by submersible pumps (capacity about 200 gallons pump$^{-1}$ hour$^{-1}$). Pumps were placed in a screened "cage" (1mmX1/2 mm rectangular mesh netting) to protect larvae from the intake of the pumps. The standard filtration system consisted of a single pump (with a single output line teed to service three filter boxes) (rate = 200 gph). The maximum filtration rate utilized was approximately 400 gallons/hour (two of the above units). The high filtration rate was very effective when water quality appeared to be deteriorating, but at this rate keeping food available to the fish for extended periods was a problem. At times even the standard rate was overeffective, particularly during the first hours following introduction of food. Periodically, filtration was stopped for short periods to provide maximum availability of food to the fish.

The average life of a filter box was three days due to clogging of the filter wool by brine shrimp. An efficient, longer lived filter was constructed by having a pump service three boxes, two of which contained only filter wool and the third only activated charcoal.

Twelve airstones were spaced around the edges of the pool for aeration and circulation of the water. Upon their introduction into the pool the striped bass larvae formed tight clumps or aggregations. This was probably due to the pattern of currents created by the airstones and enhanced by stemming behavior of the sac fry. Another submersible pump was added with the output directed along the surface of the water at the edge of the pool to maintain a constant clockwise (arbitrary direction) movement of the water. Thereafter the fish were more evenly dispersed throughout the system.

Water quality (as evidenced by clarity) remained good throughout most of the study. Cloudiness, which occurred periodically, was attributed to overfeeding of prepared foods (see feeding section) and was corrected by intensive filtration for 24-48 hours. Twice during the observation period it was deemed necessary to remove and restore about 50% of the water at one time. The normal daily draw down and replacement of pool water amounted to 25 gallons. This was coupled with siphoning dead fish and uneaten prepared food from the bottom. The circular flow of the pool water concentrated debris in the center of the pool and facilitated daily maintenance.

At regular intervals pH readings were taken. For the first five weeks pH was read from pHydrion paper and thereafter a Corning Model 7 pH meter was used. Based on meter readings it is apparent that the paper readings were consistently low.

Tabulated pH values (Table4.1) are estimated for the first four weeks based on comparative readings between paper and the meter. The freshwater source (well) was consistently near pH 7.6 and after addition of artificial salts the pool water ranged from pH 8.5-8.6 (meter readings).

Salinity was monitored with an induction salinometer. For the first two weeks fry were held in well water (0.2‰). During this period it became apparent that fish removed from the culture tank for experimental purposes (see Temperature-Salinity studies, Growth studies) grew more rapidly and appeared to feed better in water with salinity of 4 - 6‰. This was probably due to less crowded conditions for these experimental fish and greater survival of Artemia nauplii. Artemia survival time was increased from 3-4 hrs in well water to 3 days in 4‰, which provided the fish with an essentially continuous food supply. During the third week of the rearing operation salinity in the pool was raised to 4.7‰ by adding prepared salts (Aquarium Systems Inc.) to the well water. The salinity was raised to 5.6‰ during the eighth week.

No temperature control was employed. The volume of the system acted as a damper against rapid fluctuations in atmospheric temperature. Whenever possible temperature readings were made twice daily, at approximately 0800 and 1600 hrs. Mean weekly temperatures, ranges and maximum change over a 24 hour period are listed in Table 4.1.

Regular dosages of a prepared fungus remedy (Wardley's Stainless*) were were administered for preventative purposes. No evidence of fungus or epizootics was observed during the rearing interval. A sample of fish removed during the eighth week and examined by the parasitology section of V.I.M.S. proved to be free of parasites.

Food Source and Feeding-Brine shrimp hatcheries were constructed from 20 gallon plastic trash cans. A hole was drilled either in the center of the bottom or in the side of the can near the bottom. A plastic funnel was cemented into the hold with an epoxy compound. To each protruding stem an eight inch piece of neoprene tubing was attached and closed off with rubber tubing clamps. A hole was drilled in the lid of the can for passage of standard airline tubing. Aeration was provided by a single airstone placed at the bottom of each unit. To each hatchery 15 gallons of well water and sufficient table salt (NaCl) for a 4% solution were added. Up to one cup of dried *Artemia* eggs could be hatched from a single hatchery. Larger quantities were not attempted. The hatchery units were mounted on 2 X 4 stands with plywood tops drilled to accommodate the funnel stem. A stand accommodated two hatchery units and was provided with incandescent light fixtures under the cans. Three one hundred watt bulbs provided heat for the hatchery units on cooler nights but were not used during warmer weather. The units with side mounted funnels were placed on standard benches or shelving that could accommodate their weight. No temperature control was employed with these units. To maintain the food supply four hatcheries were in operation continuously.

During the initial weeks of the rearing operation one unit was charged each day. After three days, aeration was stopped and the water allowed to settle. The tubing clamp was then opened and the water was strained through fine netting to remove the shrimp nauplii. Using these hatcheries, one-half cup of dried brine shrimp eggs would normally produce 1 1/2 - 1 3/4 cups brine shrimp larvae (excess water removed). Seldom were more than 10% eggs observed in the material retained by the netting. These shrimp constituted the normal daily food ration for the striped bass larvae. Quantities of shrimp were increased with increasing age and size of the striped bass.

The lack of temperature control was a handicap, particularly in the hatcheries with the side mounted funnel. After relatively cold nights hatches from the bench mounted hatcheries were poor. During warmer weather the time from charging to draining a unit was reduced to two days. After nauplii were removed from a unit it was drained, cleaned and recharged.

The striped bass larvae began taking brine shrimp at 5 days of age. In addition to brine shrimp small quantities of Tetramin*, were offered. Although the behavior of the fish and subsequent examination of their stomachs indicated some fish were eating it, quantities fed were not increased due to the water fouling tendancy of the flakes which settled to the bottom. During the sixth week quantities of Tetramin* were increased and the fish fed vigorously when it was introduced. However, a large proportion of the flakes settled to the bottom of the pool after which they were not taken by the fish.

<u>Survival and Growth</u>-Initial mortality rates were based on the estimated number of dead fish removed from the pool during cleaning operations. The estimated mortality rate of 100,000

fish per week (Table 4.1) was observed through the end of the fourth week (25 days old). Major losses occurred then with the number of healthy fish being reduced to about 20,000 (8 - 10 mm) by the 27th day. From day 27 through day 53 the mortality rate was fairly low. The maximum number of dead fish over a 24 hour period did not exceed 50 and frequently only one or two dead fish were found during a cleaning operation.

From Table 4.1 it is evident that fish growth within the system was severely retarded relative to normal growth of young striped bass. The weekly increase in fork length was about 10% of the starting length except for the week following the major die-off. From day 34 until day 53 an average increase of 33% fork length was obtained and the population was rather uniform in size. By the end of the eighth week a growth differential between individuals became evident. Although most of the population was approximately 20 mm FL, about fifty fish were estimated to be between 30 and 40 mm in length. At the end of week IX approximately 500 large fish (30-50 mm) were seen actively feeding on the smaller fish. The toll of cannibalism was severe during the tenth week when 1,000 larger striped bass (a few exceeding 60 mm) had reduced the remaining stock to 3,000 fingerlings (20-25 mm).

Discussion of Pool System-The most important result of this work is to point out the potential of a closed system for rearing striped bass. The advantages of a simple economical system for maintaining animals for experimental purposes are obvious. More important, however, is the potential of the described system for rearing sac fry to fingerlings. We estimate that the system contained 12 to 15 thousand 20 - 25 mm fish before cannibalism became critical. This number compares favorably to results of the more elaborate rearing facilities that are now in operation (Wirtanen and Ray, 1970; Shell, 1972) and represents a substantial reduction in cost per fingerling. Further, the closed system approach allows a rearing facility to be temporarily placed in an area to be stocked. This would eliminate most transportation problems encountered in moving fry or fingerlings to and from established rearing facilities.

It should be understood that the original intent of this work was to design a facility that would meet certain requirements and fall within budget limitations. A more intensive investigation of the closed system and possible modifications described above is necessary before the feasibility of moderate scale production can be determined.

We consider overcrowding to be the cause of the high mortality rate and retarded growth encountered during the first four weeks of rearing. During the second week of the operation and again during the third week fish were removed from the culture tank and placed in gallon jars (8 - 10 fish/jar) at 4‰. The temperature was allowed to fluctuate with ambient and the larvae were fed only brine shrimp nauplii. In all cases survival within the jars exceeded that within the culture pool and fish growth was rapid (from 7 to 15 mm over a seven day period). Furthermore, fish used in temperature and salinity studies did not follow the growth and mortality patterns encountered within the system. Mortality was low in experimental fish samples removed from the rearing facility just prior to the die-off of day 25 and growth of these fish under certain experimental conditions was far greater than in the rearing pool.

Another factor that suggests overcrowding as the cause of our initial problems is the stabilization and growth of the population after the dieoff. Major mortalities were not apparent until losses due to cannibalism became critical.

Aside from physical redesigning of the described system the following procedural modifications should be considered:

1. Initial numbers of sac fry in the above system should not exceed 100,000 and fewer might be practical.
2. Salinity of the culture water should be increased from 0 to about 4‰ within a few days after the fish begin feeding on brine shrimp. This is most important in keeping shrimp alive until they are eaten.
3. Filtration rates should maintain water quality, however, care must be taken to insure against food removal before adequate feeding can occur.
4. Brine shrimp nauplii appear to be an acceptable food for juveniles up to 25 mm, provided the amounts offered are adequate.

With the above conditions the described system should be able to produce between ten and twenty thousand 20-25 mm fingerlings in considerably shorter time than was required for this study. If an adequate means of removing larger fish were found, it might extend the production potential with respect to fish size.

Temperature-Salinity Study

Temperature and salinity are considered as significant factors in determining the survival of striped bass stocked in an estuarine system. Studies by Albrecht (1964), Krouse (1968), Davies (1970), Hazel, Thomson and Meith (1971) and Turner and Farley (1971) have evaluated these factors either singly or in combination but each has utilized an acclimation period prior to testing. Therefore, an accurate test of the effects of temperature and salinity on striped bass stocking success would be obtained from an acute transfer of fish from ambient to experimental conditions. We designed an experiment to evaluate temperature and salinity factorially with striped bass at various ages. The objective was to define the optimum combination(s) of temperature and salinity for stocking striped bass into estuarine waters.

Apparatus-Three constant temperature water baths were fabricated from water-circulating soft drink coolers. Use of a thermocouple and relay allowed temperature control within 1° C. The three experimental temperatures employed were 12, 18 and 24° C. Salinities used in the experiments were 4, 12 and 20 ppt. and were maintained with filtered sea water and artificial sea salts. For each T-S combination (9) there were three replicates. The total number of vessels (gallon jars) per experiment was 27. Experiments were of seven days duration and the first four were conducted sequentially, allowing two days between each for clean-up and resetting the system.

Each replicate included 10 fish, each experimental combination had 30 fish and each experiment utilized 270 fish. An airstone was placed in each vessel to provide aeration during the experiment. Brine shrimp were added to each vessel shortly after addition of fish and were available to the fish throughout the experimental period.

Results-Statistical analysis of the data is underway but at present is incomplete. The completed data analysis[2] will be included in the completion report of this project. A total of six experiments were conducted and the mortality data is summarized in Table 4.2.

The general trends within the experiments may be summarized as follows:

- mortality in the 4 ‰ combinations was lower than either 12 or 20 ‰.
- mortality in the 12° C combinations exceeded that of 18 or 24° C.
- mortalities in the 12° C combinations increased in a step-wise fashion as fish grew older i.e. later experiments

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[2] This segment of the research program forms the basis of a thesis proposal by Mr. W. S. Otwell, a VIMS graduate assistant supported under this contract.

-mortalities in all salinity combinations at 18° C were below 20% for the first 4 experiments. No distinct differences between salinities was evident at this temperature.

-mortalities in 4 ‰ at 24° C were considerably lower than at 12 and 20 ‰ through the first four experiments.

From the data and the above trends it is concluded that with the above combinations temperature is of greater importance than salinity in determining survival of striped bass. With the temperatures employed, 18 and 24° C are considered acceptable temperatures for stocking striped bass from an ambient temperature of 18-22° C. At the higher temperature, low salinity (4 ‰) yielded lowest mortality of striped bass.

Successful stocking of striped bass, i.e. low mortality due to temperature or salinity, in estuarine systems can be expected if the water temperature at the time of fish introduction is between 18 and 24° C. At the higher temperatures the receiving waters should approximate 4 ‰ salinity to avert mortality due to salinity.

In our program the general mortality trend in response to salinity shown in the experiments was borne out by reduced mortality when we raised the salinity in the culture facility to 4.7 ‰ during the third week of rearing. Our stocking sites in the Ware River provided 4 - 10 ‰ salinity in the receiving waters, thus representing a field test of our laboratory data.

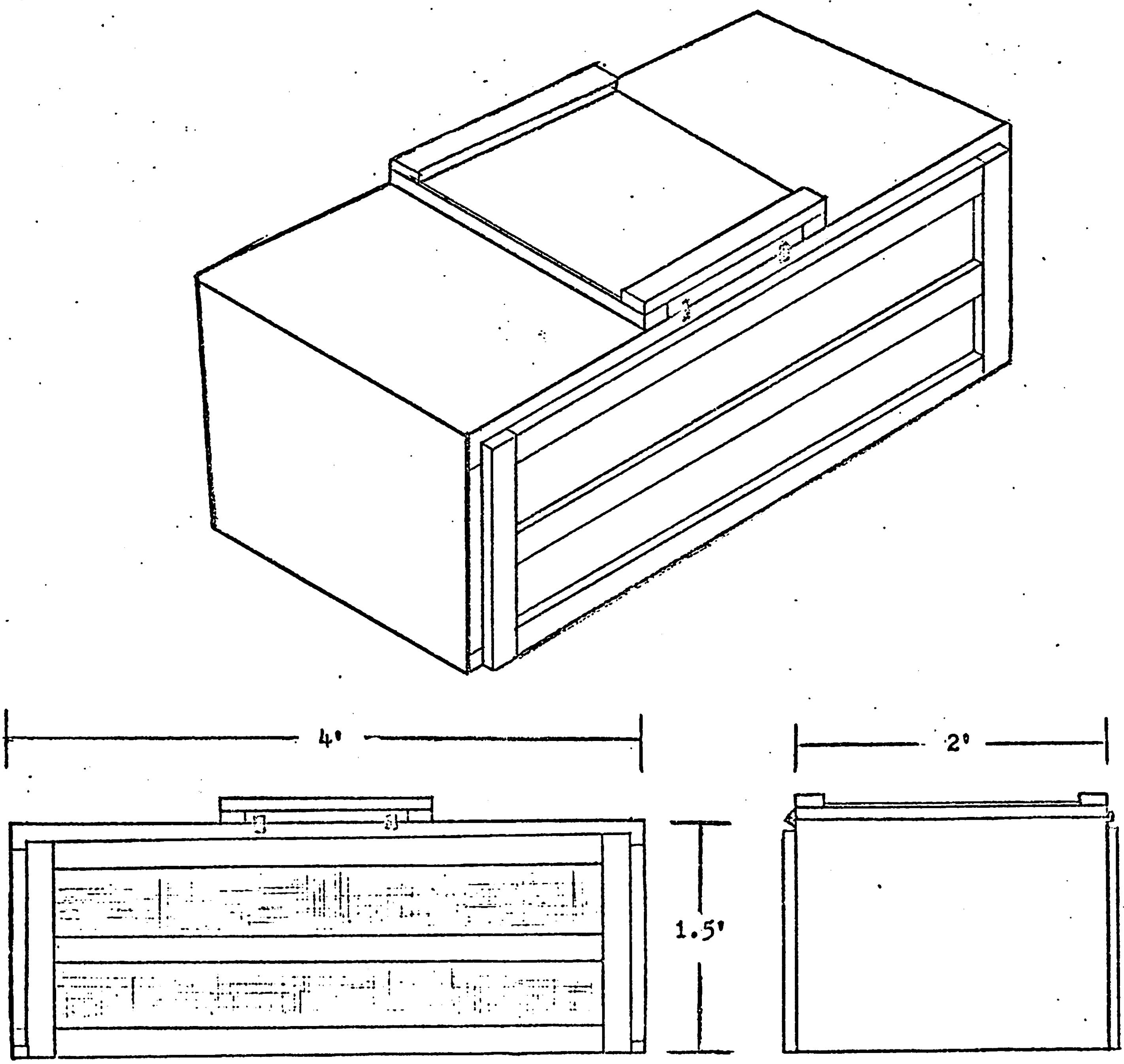
In conjunction with the T-S study, fish were measured after each experiment to assess growth response at the various

T-S combinations. These data are interpreted as growth potential for the various treatment combinations and as such indicate the depressed growth of striped bass under the crowded conditions within the main culture pool as cited earlier. The data are presented in Table 4.3. Data cited as ambient refer to the average length of fish in the rearing pool while control refers to the average length of fish held in jars at ambient temperature and salinity. Measurements were made with dial calipers under dissecting microscope magnification.

Fish growth in each experiment was greater at the higher temperatures. Growth in the 18° C combinations exceeded ambient stock growth even when the ambient temperature was above 18°C. This apparent paradox is attributed to the crowded conditions in which the ambient stock fish were held.

In the first two experiments growth of the fish was considerably greater at 4 and 12 ‰ than at 20 ‰. From these observations and mortality data presented earlier, we decided to raise the salinity in the rearing pool in hopes of increased survival and growth of the striped bass.

Figure 4.1. Diagrammatic sketch of culture cage for rearing striped bass.



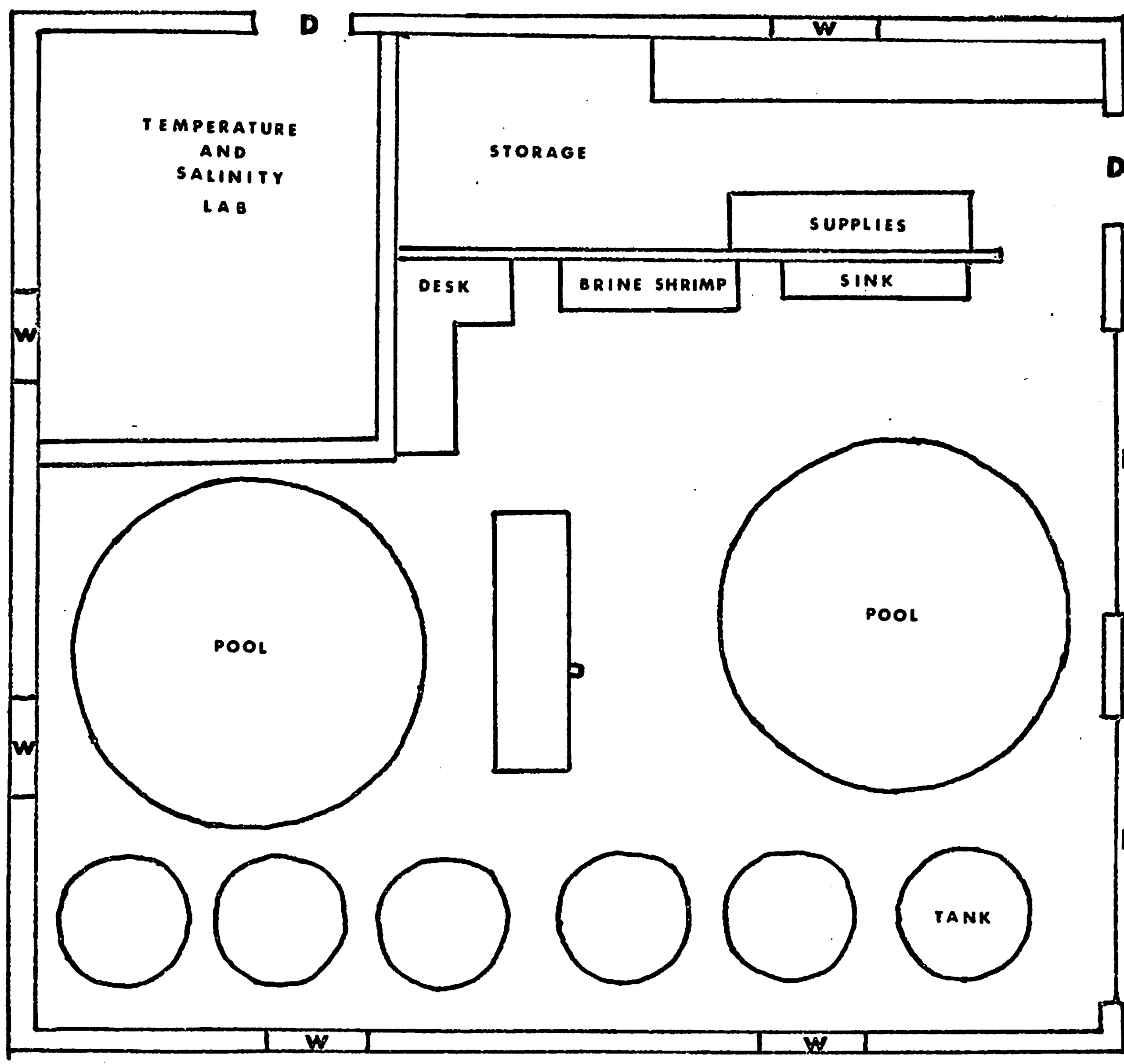



Figure 4.2. Schematic diagram of laboratory culture facility at V. I. M. S. (D = door and W = window).

Table 4.1. Weekly summary of physical and biological parameters in the rearing facility.

| Week | I | II | III | IV | V | VI | VII | VIII | IX | X |
|---|---|---|---|---|---|---|---|---|---|---|
| Dates | 24-27 May | 28 May 3 June | 4-10 June | 11-17 June | 18-24 June | 25 June 1 July | 2-8 July | 9-15 July | 16-22 July | 23-29 July |
| Fish age* (days) | 4 | 11 | 18 | 25 | 32 | 39 | 46 | 53 | 60 | 67 |
| Temp. °C | | | | | | | | | | |
| Mean | 17.0 | 19.5 | 21.5 | 22.5 | 23.0 | 21.5 | 21.5 | 22.5 | 26.0 | 27.0 |
| Range | 17-17.5 | 17.5-21 | 21-22 | 19-25.5 | 19-25 | 19.5-23.5 | 21-23 | 21-24 | 24/28 | 25.5-28 |
| Max. Change/24 hrs. | 0.5 | 1.5 | 1.0 | 2.5 | 2.0 | 2.5 | 1.0 | 1.5 | 1.0 | 1.0 |
| Salinity ‰ | 0.2 | 0.2 | 4.7 | 4.8 | 4.8 | 4.7 | 4.8 | 5.6 | 5.6 | 5.6 |
| pH | 7.6 | 7.8 | 8.6 | 8.5 | 8.8 | 8.5 | 8.5 | 8.6 | 8.5 | 8.5 |
| Food % | | | | | | | | | | |
| Artemia = BS | | BS90 | BS90 | BS90 | BS90 | BS70 | BS70 | BS50 | BS50 | BS50 |
| Tetramin = TM | | TM10 | TM10 | TM10 | TM10 | TM30 | TM30 | TM50 | TM50 | TM50 |
| Number of Fish* (thousands) | 1000 | 950 | 850 | 150 | 24 | 20 | 19 | 18 | 12 | 4 |
| Mean FL (mm.)* | 6.4 | 7.0 | 7.9 | 8.7 | 9.8 | --- | 15.8 | --- | 23.0 | 27.6 |
| Range FL (mm.)* | 6.1-6.6 | 6.8-7.4 | 6.9-9.0 | 7.8-9.9 | 9.3-10.5 | | 14.5-17.9 | | 20.0-26.5 (50)** | 24.0-40.5 (65)** |

Note. Fork Lengths are based on samples of 10 fish removed from the population at the end of each week.
* value is at end of week
**estimated FL for larger fish not included in measured sample.

Table 4.2. Average percent mortality of various ages of striped bass in a factorial design temperature-salinity study.

| Exp. No. | Fish Age (days) | Control Mortality | Temp. (°C) | Salinity (‰) 4 | 12 | 20 |
|---|---|---|---|---|---|---|
| I | 5-11 | 71% | 12 | 0 | 33 | 0 |
| | | | 18 | 7 | 10 | 7 |
| | | | 24 | 10 | 17 | 13 |
| II | 13-19 | 79% | 12 | 3 | 3 | 27 |
| | | | 18 | 0 | 7 | 17 |
| | | | 24 | 3 | 3 | 17 |
| III | 21-27 | 20% | 12 | 20 | 10 | 27 |
| | | | 18 | 3 | 7 | 0 |
| | | | 24 | 3 | 37 | 43 |
| IV | 28-34 | 12% | 12 | 30 | 57 | 100 |
| | | | 18 | 10 | 0 | 7 |
| | | | 24 | 7 | 10 | 13 |
| V | 43-49 | 100% | 12 | 100 | 100 | 100 |
| | | | 18 | 23 | 30 | 20 |
| | | | 24 | 0 | 0 | 0 |
| VI | 62-69 | 27% | 5 fish/experimental vessel<br>No mortality in any treatment combination | | | |

Table 4.3. Growth of striped bass in T-S experiments, data are the average total lengths of fish.

| | Control | Ambient | | | | | |
|---|---|---|---|---|---|---|---|
| | Final (mm) | Initial (mm) | Final (mm) | | Salinity (‰) | | |
| | | | | | 4 | 12 | 20 |
| **Exp. I** | | | | | | | |
| 5-11 days | 6.871 | 6.318 - | 7.056 | | | | |
| | | | Temp. (°C) | 12 | 6.404 | 6.465 | 6.578 |
| | | | | 18 | 7.834 | 7.779 | 7.857 |
| | | | | 24 | 8.681 | 7.781 | 7.442 |
| **Exp. II** | | | | | | | |
| 13-19 days | 7.683 | 7.156 - | 7.841 | | | | |
| | | | Temp. (°C) | 12 | 7.807 | 7.751 | 7.434 |
| | | | | 18 | 8.603 | 8.719 | 8.375 |
| | | | | 24 | 9.513 | 9.541 | 9.094 |
| **Exp. III** | | | | | | | |
| 21-27 days | 9.370 | 8.450 - | 9.163 | | | | |
| | | | Temp. (°C) | 12 | 8.517 | 8.802 | 8.678 |
| | | | | 18 | 10.416 | 9.885 | 10.138 |
| | | | | 24 | 10.800 | 11.303 | 11.317 |
| **Exp. I V** | | | | | | | |
| 28-34 days | 10.923 | 9.163 - | 9.753 | | | | |
| | | | Temp. (°C) | 12 | 9.059 | 8.809 | ---* |
| | | | | 18 | 9.720 | 9.682 | 9.815 |
| | | | | 24 | 9.600 | 10.885 | 11.021 |

Table 4.3 (Continued).

| Exp. V | Control | Ambient Initial (mm) | Ambient Final (mm) | | | Salinity (‰) 4 | 12 | 20 |
|---|---|---|---|---|---|---|---|---|
| 43-49 days | --- | 15.672 | - 15.792 | | | | | |
| | | | | | 12 | --- | --- | --- |
| | | | | Temp. (°C) | 18 | 17.597 | 17.290 | 16.482 |
| | | | | | 24 | 17.955 | 18.888 | 18.238 |
| **Exp. VI** | | | | | | | | |
| 63-69 days | 25.301 | 22.635 | - 26.872 | | | | | |
| | | | | | 12 | 23.696 | 22.367 | 23.978 |
| | | | | Temp. (°C) | 18 | 25.244 | 25.160 | 26.163 |
| | | | | | 24 | 25.506 | 26.203 | 24.087 |

*Dash indicates no survival in that experimental combination.

Job 5. Stocking of additional tributaries.

Though we contracted to stock other latent nursery areas, this undertaking was dependent upon success in Job 3. As described, our initial attempt at stocking the Ware River was unsuccessful. Therefore, our efforts have been directed toward a second stocking of the Ware River since we have the data base for analysis of the impact of stocked fish on the natural population.

Job. 6. Evaluation of the technique as a management tool.

Pursuit of this objective is scheduled for the 1972-73 project year. It will summarize and complete the analysis of stocking and its impact upon latent nursery areas.

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