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HYDROGRAPHIC AND ECOLOGICAL EFFECTS OF ENLARGEMENT OF THE CHESA--ETC(U)
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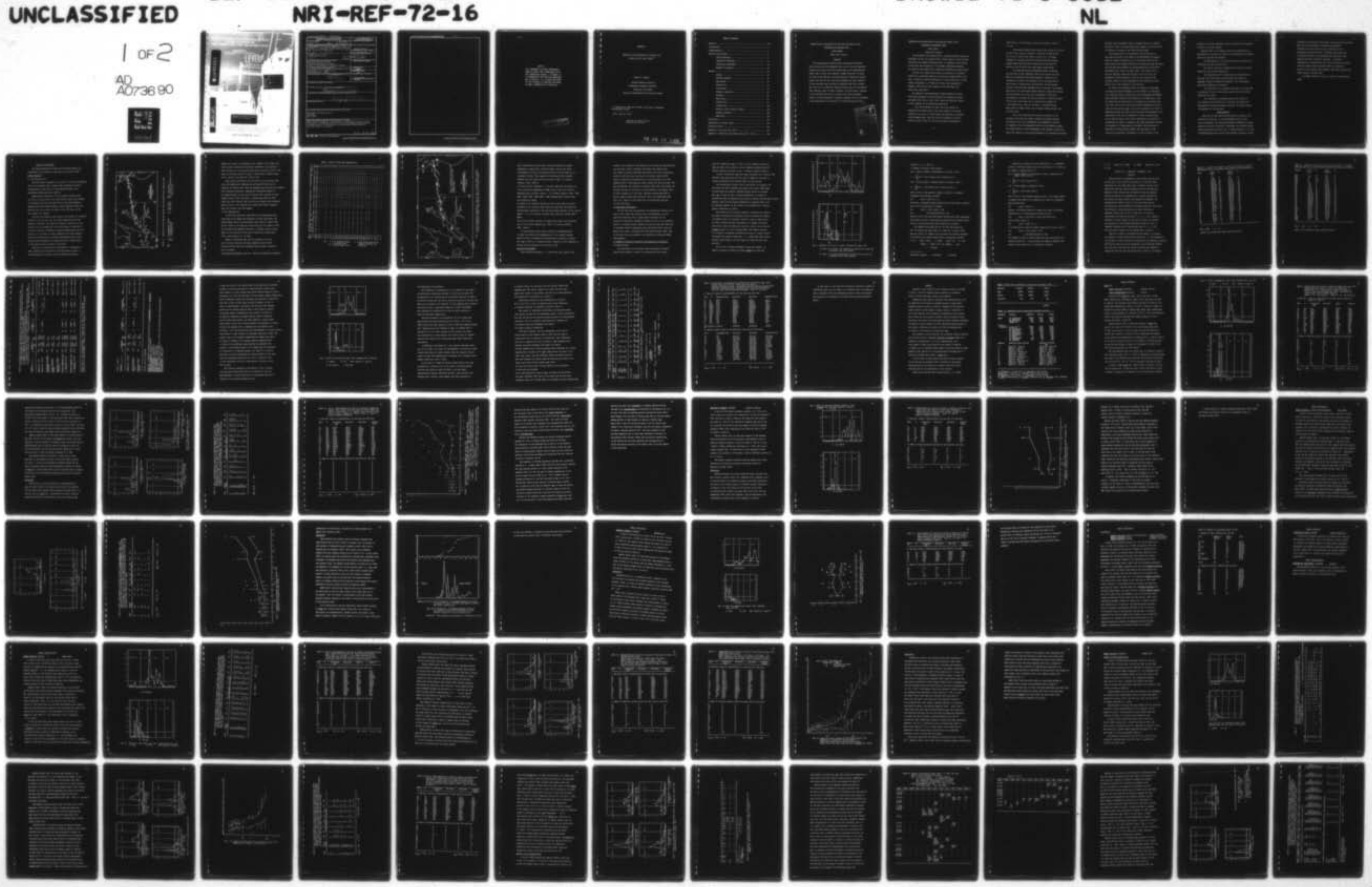

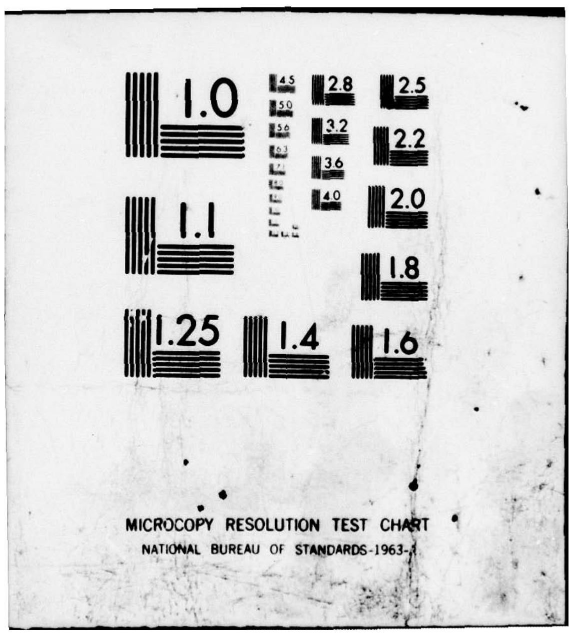
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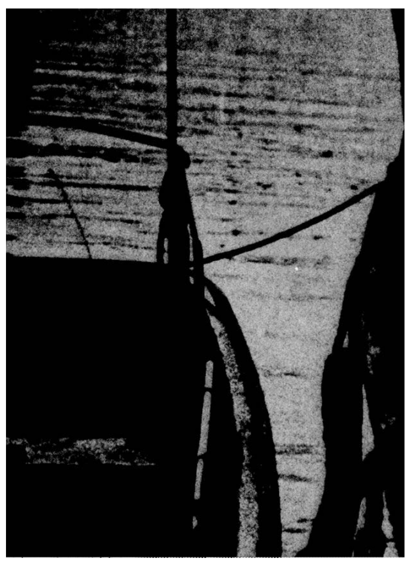

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Appendix I 6 the

2. GOVT ACCESSION NO.
and

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
Hydrographic and ecological effects of enlargement of Chesapeake ~~&~~ Delaware Canal. Appendix I. Production and distribution of fish eggs and larvae in C and D Canal.

5. TYPE OF REPORT & PERIOD COVERED
Appendix 1971-72

6. PERFORMING ORG. REPORT NUMBER
N.R.I. Ref No. 72-6

7. AUTHOR(s)
Johnson, Robert Karl / Johnson
10

8. CONTRACT OR GRANT NUMBER(s)
15 DACW61-71-C-0062

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Natural Resources Institute
Chesapeake Biological Laboratory
Center for Environmental & Estuarine Studies

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army, Corps of Engineers Philadelphia District
Customs House, 2nd & Chestnut Sts.
Philadelphia, Pa. 19106

12. REPORT DATE
11 Sep[redacted]73

13. NUMBER OF PAGES
143p

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
12 149p.

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
For Public release; distribution unlimited
14 NRI-REF-72-16

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
9 Rept. for 1971-1972

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Chesapeake and Delaware Canal
Fish eggs
Fish larvae

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
Eggs, larvae and juneniles of 20 species of fishes found in the C & D area are observed to determine precise location of spawning areas especially of stripped bass and the determination of production and distribution of fish eggs within C & D system.

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APPENDIX I.

PRODUCTION AND DISTRIBUTION OF FISH EGGS AND LARVAE IN THE C AND D CANAL[1/]

Robert K. Johnson

Natural Resources Institute

Chesapeake Biological Laboratory

University of Maryland

Center for Environmental and Estuarine Studies

1/ Contract No. DACW-61-71-C-0062, Army Corps of Engineers, Philadelphia District

N.R.I. Ref. No. 72-16

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CHESAPEAKE AND DELAWARE CANAL

FINAL REPORT

Robert Karl Johnson

ABSTRACT

ABSTRACT

The Chesapeake and Delaware Canal connecting the Delaware River estuary with the Chesapeake Bay is one of the more important spawning and nursery areas for striped bass in the Chesapeake Bay region. Eggs, larvae, and juveniles of ~~than~~ 20 species of fishes are found in the C&D area, and young fishes of varying (by season) species are found in the canal area throughout the year. Analysis of data resulting from two years of sampling effort has revealed this area to be a common low salinity nursery area for fish species that variously spawn in fresh, brackish, or marine waters. Analysis of all available data fails to indicate that purely hydraulic effects of canal enlargement, presently underway, will be detrimental to the reproduction of any species of fish utilizing this area.

PRODUCTION AND DISTRIBUTION OF FISH EGGS AND LARVAE IN THE CHESAPEAKE AND DELAWARE CANAL

Final Report

Robert Karl Johnson

The Chesapeake and Delaware Canal, a man-made waterway connecting Chesapeake Bay and the Delaware River, extends almost 14 miles through the head of the Delmarva Peninsula (Fig. 1). Summaries of the history of the canal and an analysis of its present commercial importance are given by Gray (1967), Anon. (1970) and Pritchard and Cronin (1971).

In 1927, the original lock canal was converted to a sea-level canal with a controlling depth of 14 feet and a channel width of 150 feet. In 1938 the canal was enlarged to 27 feet by 250 feet. In 1954 furthur enlargement, to 35 feet by 450 feet, was authorized by Congress. This work was 85% complete in 1970 (Pritchard and Cronin 1971, Wang 1971).

An analysis of the hydrographic changes expected to result from canal enlargement has been provided by Pritchard (Pritchard and Cronin 1971, and In: Anon. 1970). Among the important results of this analysis are the following predictions:

(1) A net difference in mean tide level between the Chesapeake and Delaware ends of the canal results in net water transport to the east, in effect making the C&D Canal a tributary of the Delaware River. This net flow was estimated to be 1000 ft^3/sec (= 283.2 m^3/sec) in the 27 foot canal and increased to

2700 ft^3/sec (= 764.6 m^3/sec) in the 35 foot canal; a ratio of 1: 2.70.

(2) Average maximum tidal velocity, 88.4 cm/sec (ca 1.8 kt), in the 27 foot canal was expected to increase to 108.8 cm/sec (ca 2.2 kt) in the 35 foot canal; a ratio of 1: 1.23 (both estimates for eastward direction; westward direction average maximum tidal velocities were estimated to be 69.5 and 85.3 cm/sec for the 27 and 35 foot canal depths respectively).

(3) Discharge from the Susquehanna River, accounting for some 46% of total freshwater input to the bay and for some 90% of the freshwater input above Annapolis, results in the freshwater (or nearly so) conditions seen in the upper bay in the vicinity of Turkey Point, the Elk River, and the western portion of the C&D Canal throughout most of the year. The Delaware River end of the canal almost always exhibits a higher salt content than the western end of the canal. Enlargement of the canal was expected to increase the vertical gradient in salinity between the two ends of the canal and to intensify the tendency for a two layered water flow in the canal, an eastward flowing upper layer of fresher water, and a westward flowing deeper layer of saline water.

(4) It was determined that natural variability in the salinity of the upper bay likely exceeded any possible changes in salinity due to canal enlargement (and consequent diversion of freshwater from the Susquehanna River into the Delaware system). The maximum effect of canal enlargement on the salinity of upper bay waters was expected to occur during periods of low freshwater discharge

and while canal enlargement might at maximum result in a salinity increase of 3 ppt in the bay above Pooles Island, this increase was not expected to exceed 0.2 ppt below the Bay Bridge.

The present study of the production and distribution of fish eggs and larvae in the region of the Chesapeake and Delaware Canal was largely prompted by the recentdiscovery that the C&D Canal exhibited the highest densities of striped bass eggs and larvae that had been found anywhere in the Chesapeake Bay region (Dovel and Edmunds 1971, Cronin In: Anon. 1970). The striped bass is the most important commercial and sport fish in the bay, and especially in Maryland waters of the bay, and concern of the possible effects of canal enlargement on the production of this species led to the initiation of this project.

To assess the biological effects of changes in hydrography resulting from canal enlargement is very difficult. As described in a following section, construction of the Chesapeake and Delaware Canal apparently benefited the production of striped bass to such an extent that the canal system, in existence (at sea level) only since 1927, may be one of the most important spawning and nursery areas for this species. Eggs, larvae, and juveniles of at least 20 additional species are found in the C&D system and assesment of the importance of this area to production of each of these species was an important goal of this study. Necessarily the question of determining the impact of changes in the canal environment involves the weighing of a large number of variables. The C&D system is physically and biologically complex, and enlargement of the canal may be beneficial, detrimental, or have no effect on the production of various individual species but would not be expected to affect all species equally.

Specific goals of the present study of the production and distribution of fish eggs and larvae in the Chesapeake and Delaware Canal area included the following:

(1) Determination of the species utilizing the C&D area as a spawning site and/or nursery area.

(2) Precise location of spawning areas within the system, especially those of the striped bass.

(3) Determination of the production and distribution of fish eggs and larvae within the C&D system with respect to geography, season, and physical parameters of the environment, especially temperature and salinity.

(4) Assessment of the possible importance of the C&D area to production of each of the several species within the entire Chesapeake Bay region.

(5) Integration of knowledge gained from studies of the production and distribution of fish eggs and larvae with hydrographic information hopefully leading to an optimal scheme of management for the C&D area.

ACKNOWLEDGMENTS

This work has been made possible through the support, both financial and advisory, of the Philadelphia District, Army Corps of Engineers. The Chesapeake Biological Laboratory, Natural Resources Institute, University of Maryland, has provided working space and physical assistance. Drs. L. Eugene Cronin, T. S. Y. Koo, and Raymond Morgan have provided much material assistance, advice, information and criticism. John Wilson and Jim Rasin have provided much aid and encouragement. Preliminary hydrographic information has been provided by Mr. Thomas Hill of the Experimental Waterways Station, Vicksburg, Mississippi, and Mr. Bernard Gardiner of the Chesapeake Bay Institute, Johns Hopkins University, Baltimore, Maryland. I gratefully acknowledge the cooperation of the various assistants connected with this project whose persistence made its completion possible: Carla Barrett, Melvin Beaven, John Cooper, George Gray, Thomas Johnson, and Peter Zeni.

I am deeply grateful to Mr. W. L. Dovel who initiated this study.

MATERIALS AND METHODS

The methods employed in taking and processing samples were established by and similar to those described by Dovel (1964)

Field Techniques

1. 1971 Sampling Year.

The C&D Transect extended ca 75 km (Fig. 1) from the Susquehanna flats to the Delaware River. Twenty-eight established stations, corresponding in most cases to fixed navigation buoys, were distributed evenly along this transect.

Sampling gear consisted of 24 inch diameter plankton mesh (ca .41 by .76 mm aperture, dry, unstretched) conical nets affixed to iron hoops. The nets were towed with 17 foot Boston Whalers supplied with 60 hp Johnson engines. During sampling the boat was directed into the current, the engine set at 1500 rpm, and the nets fished for 5 minutes.

Two nets were fished at each station. The surface net, hereafter referred to as the 'top' net, was fished immediately below the surface of the water. The deep net, hereafter referred to as the 'bottom' net, was fished with ca 22.9 mwo (meters of wire out) = 75 feet of wire out, yielding an estimated sampling depth of 4.57 - 6.10 m (= 15 - 20 feet), or about middepth in the canal channel. The top and bottom nets were fished synchronously with all tows taken in about midchannel. No attempt was made to sample nearer to the channel bottom or nearer to the shore.

Each net was supplied with a TSK flowmeter. Calibration of these flowmeters was performed at the known-velocity flume at the Chesapeake Bay Institute, the Johns Hopkins University.

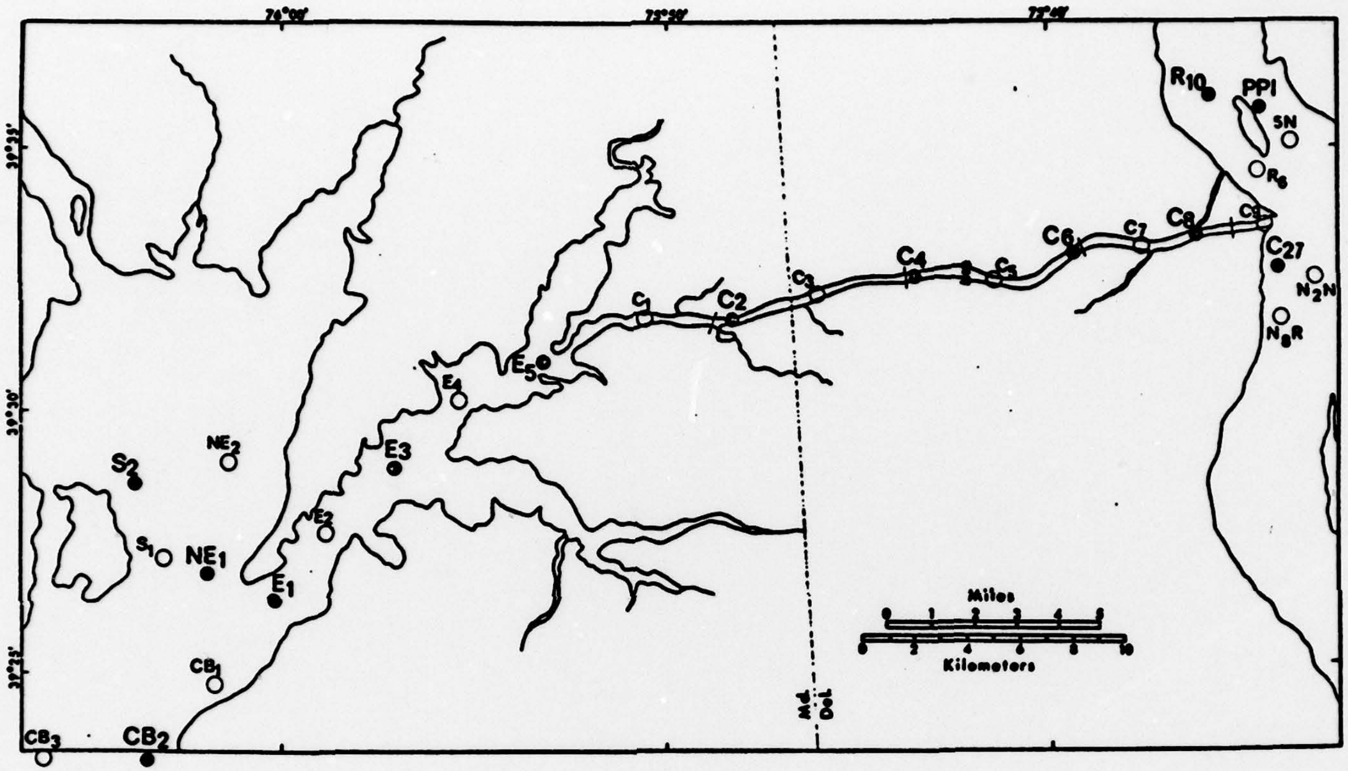

Figure 1. Location of fish egg and larvae stations during 1971 sampling year.

Key	S = Susquehanna River	E = Elk River	PPI = Pea Patch I .
	NE = Northeast River	C = C&D Canal	C27, R10 etc correspond to navigation buoys.
	CB = Chesapeake Bay		

Despite the attempt to standardize tows, flowmeter data (taken with each net haul) indicated considerable variability in the amount of water filtered per tow around the mean value of 94.52 $\pm$ 2.54 m^3 / tow (based on 165 tows, April 23 to May 1, 1971) with an extreme range of 70 - 130 m^3 / tow (94.52 m^3 = 3337.5 ft^3).

Each station consisted of two net hauls (top and bottom) taken once each sampling day. Sampling was initiated 31 March and the transect was sampled every other day thoughout April and May and somewhat less frequently thereafter. Sampling was terminated December 8. As explained below, we were able to process only a portion of those samples taken in 1971, and table 1, illustrating effort in 1971, shows only those sampling days from which any samples were processed. Results from the 1971 sampling year include data from 49 sampling days, 641 stations, and 1236 samples.

2. 1972 Sampling Year.

In 1972 most hauls were taken with the so-called double net, consisting of two single nets identical to those used in1971, but yoked together with a 25 inch distance from center to center. This net was fished in the same way as the bottom net was fished in 1971, but increased drag probably resulted in a slightly shoaler towing depth. On one occasion we were able to measure the towing depth (via a ruled line) at 13 - 15 feet.

Figure 2 illustrates what will be referred to as the 8 and 11 station transects. Our major sampling effort in 1972 occupied two days each week throughout April and May. Activities were as follows:

(1) Complete hydrographic data for 1 and 20 foot depths were gathered

Table 1. Effort during 1971 sampling year.

Date	No. Stn.	No. Sml.	S2	S1	NE2	NE1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	R10	PPI	R6	N5	C27	N2N	N8R
March																														
31	14	28	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
April																														
6	12	24	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
9	14	28	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
13	17	34	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
April																														
15	17	34	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
17	23	46	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	+	+	-	+
19	28	56	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
21	24	46	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	B	+	+	+	+	+	-	-	+	B	+	-	-
23	17	34	-	+	-	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
25	15	30	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
27	25	48	+	+	+	+	+	+	+	+	+	+	+	+	+	+	S	+	+	+	+	S	+	+	+	-	-	+	-	+
29	18	34	-	-	-	+	-	-	+	+	+	+	+	+	+	+	+	+	S	S	+	+	+	-	-	-	-	+	+	-
May																														
1	20	40	+	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	-	+	-	-
3	14	27	-	-	-	+	-	-	-	+	+	+	+	+	+	+	S	+	+	+	+	+	-	-	-	-	-	-	-	-
5	17	29	+	-	+	+	-	-	-	+	+	+	-	+	+	+	+	B	+	+	+	B	B	-	-	-	-	-	-	-
7	23	45	+	+	+	+	+	+	+	+	+	+	+	+	+	+	S	+	+	+	+	+	-	+	+	-	-	+	-	-
9	17	34	+	-	-	+	-	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-	-	-	-	+	-	-
11	16	31	+	+	-	+	-	+	-	+	+	+	-	+	-	+	S	+	-	+	-	+	-	+	+	-	-	+	-	-
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19	14	27	+	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	+	-	-	+	-	-
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31	13	23	+	-	-	+	-	+	-	+	-	S	-	+	-	S	-	S	-	+	-	+	-	+	+	-	-	+	-	-
June																														
2	2	3	-	-	-	-	-	-	-	-	-	-	S	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	15	29	+	-	+	-	-	+	-	+	-	+	+	+	+	+	-	+	-	+	-	+	-	+	S	-	-	+	-	-
6	2	4	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	11	22	-	-	-	+	-	-	-	+	-	+	-	+	+	+	-	+	-	+	-	+	-	-	+	-	-	+	-	-
10	2	4	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	8	14	-	-	-	+	-	-	-	+	-	+	-	+	-	+	-	+	-	S	-	S	-	-	-	-	-	-	-	-
23	13	24	+	-	-	+	-	+	-	S	-	+	-	+	-	+	-	+	-	+	-	B	-	+	+	-	-	+	-	-
30	13	25	+	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	B	-	+	-	+	+	-	-	+	-	-
July																														
7	13	26	+			+		+		+		+		+		+		+		+		+		+	+			+		
15	13	24	+			+		+		+		+		B		+		B		+		+		+	+			+		
22	10	18	-			+		+		+		+		+		+		+		B		+		-	B			-		
27	10	20	-			+		-		+		+		+		+		+		+		+		+	+			-		
August																														
4	13	24	+			S		+		S		+		+		+		+		+		+		+	+			+		
11	10	19	-			+		-		+		+		+		+		+		+		S		+	+			-		
18	12	24	+			+		+		+		+		+		+		+		+		+		+	+			-		
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9	8	12	-			-		+		S		+		+		S		S		S		+		-	-			-		
23	7	14	-			-		-		+		+		+		+		+		+		+		-	-			-		
October																														
6	10	20	-			-		-		+		+		+		+		+		+		+		+	+			+		
19	7	13	-			-		-		+		+		+		S		+		+		+		-	-			-		
November																														
3	13	26	+			+		+		+		+		+		+		+		+		+		+	+			+		
17	13	26	+			+		+		+		+		+		+		+		+		+		+	+			+		
December																														
8	11	22	-			+		-		+		+		+		+		+		+		+		+	+			+		
Total	641	1236	46	12	12	69	10	52	24	86	37	90	46	89	49	85	32	82	31	83	34	80	29	46	46	4	5	47	4	6
Top		623	23	6	6	35	5	26	12	44	18	46	23	44	24	44	18	41	16	42	17	40	14	23	24	2	2	23	2	3
Bottom		613	23	6	6	34	5	26	12	42	19	44	23	45	25	41	14	41	15	41	17	40	15	23	22	2	3	24	2	3

Key:
- \- = no available sample
- S = top sample only
- B = bottom sample only
- \+ = both surface and bottom samples available and processed

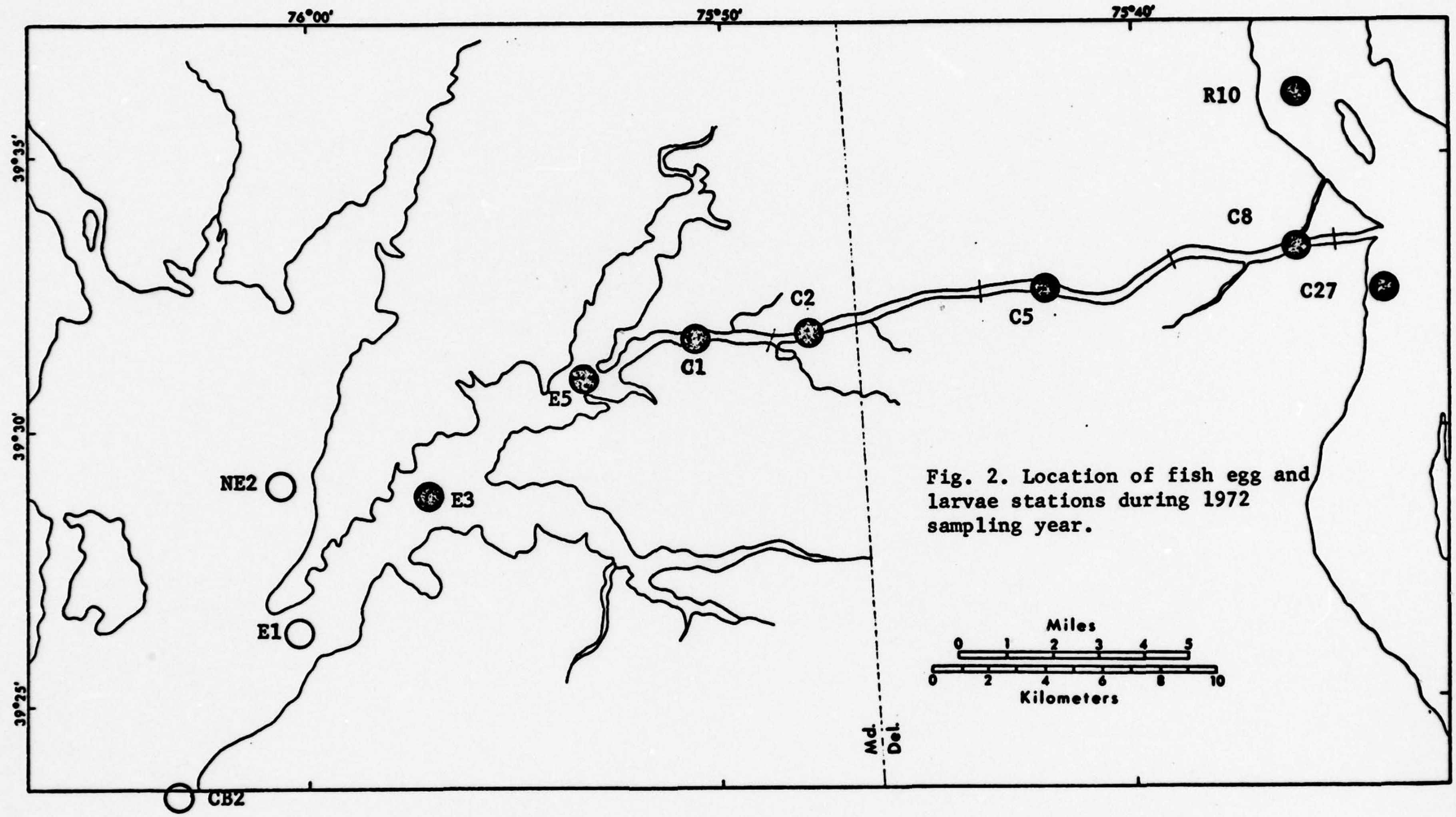


Fig. 2. Location of fish egg and larvae stations during 1972 sampling year.

Key: Station designations explained at fott of Fig. 1. Closed symbols indicate 8 station transect. Closed + open symbols indicate 11 station transect.

with a Martek Water Quality Meter. Measured parameters included temperature, conductivity, dissolved oxygen, and pH. The latter two parameters could not be measured after the initial month due to instrument failure. Water samples for determination of suspended sediment load were taken during this period. (Day 1; 11 station transect; 1200 - 1600 h).

(2) Four transects (Transects I - IV) were taken with the double net over a 24h period commencing at 1200h on day 1 with a new transect beginning every six hours. (Days 1 - 2; 8 station transect; 1200 - 1800, 1800 - 2400, 2400 - 0600, 0600 - 1200; Delaware River stations were not occupied at night).

(3) Hauls at two stations (usually E5 and C1) were made at two hour intervals by the alternate boat. Hauls were made with the double net and provided a replicate of the tows made during Transects II,III, and IV. (Days 1 - 2; 2 or 3 stations occupied every other hour between 1800 - 0600).

(4) A final transect (Transect V) employed the single top and bottom nets as in the 1971 sampling year. (Day 2; 11 station transect; 1200 - 1700 h).

At times weather and/or debris conditions precluded working at night and limited full implementation of our intended program. Effort in 1972 is indicated in the discussion of capture of striped bass eggs in 1972 in a following section. Sampling in 1972 commenced in January and was terminated on the sixth of July.

Laboratory Techniques.

The concentrated samples, 1 - 4 pints each, were fixed in 10%

formalin, and returned to the laboratory for sorting and identification. All fish eggs, larvae, juveniles, and adults were removed from each sample processed, identified and counted. The rate of processing proved so slow that only a portion of the samples taken in 1971 could be processed and analyzed prior to the beginning of the 1972 sampling effort. Processing was nearly complete for April and May, 1971, and considerably less complete for samples taken after this period. The decision was made in June 1972 to end processing of the samples taken in 1972 on August 31 of this year. Therefore we have been able to process samples taken after mid-April, 1972, for striped bass eggs only, and I report in this paper only the striped bass egg data for the 1972 effort.

3. Statistical Techniques.

For the most part non-parametric and ennumeration statistics are used in this study. They require few or no assumptions, and are quick and relatively easy to apply without any great loss of statistical efficiency. Parametric methods are used to set confidence limits to arithmetic means. Standard statistical texts have been used as reference material (especially Tate and Clelland 1957, Dixon and Massey 1957, Downie and Heath 1959, and Sokal and Rohlf 1969). Much of the data has been processed on the University of Maryland UNIVAC 1108 Computer.

4. Comments on Methods of Analysis and Presentation of Results.

(1) Capture Index

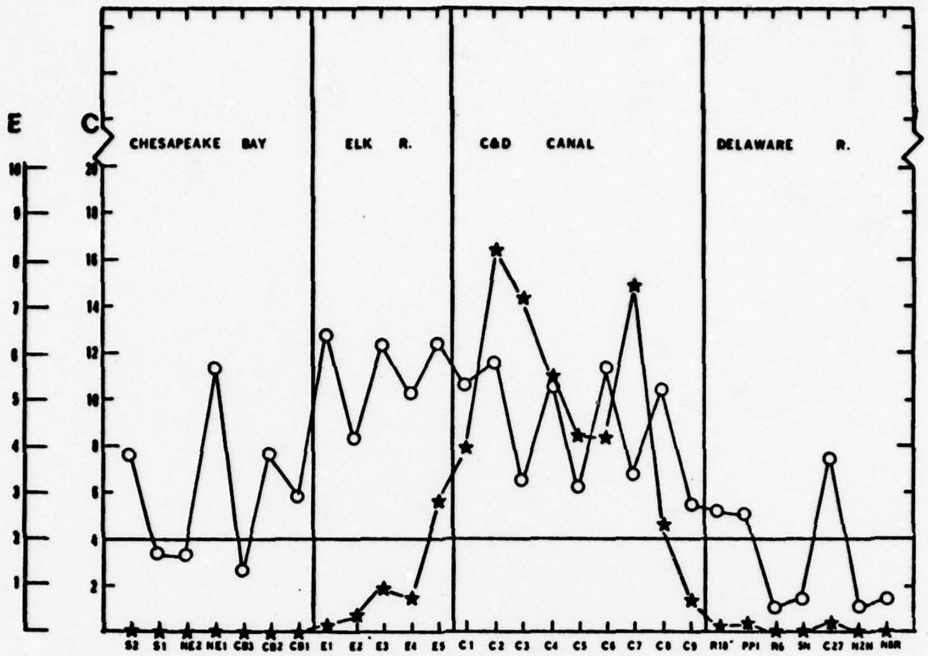
The calculation of the capture index used herein to present capture with refemnce to effort is illustrated by 1971 capture data for striped bass eggs. In 1971, a total of 60030 striped bass eggs was taken. The raw data is given in Appendix Tables A8 and A9. Station positions are given in Fig. 1. Effort is given in table 1.

In 1971, striped bass eggs were taken from April 15 to June 13. The inclusive time period from the first day of capture to the last is termed the Effective Time Interval (ETI) for that species.

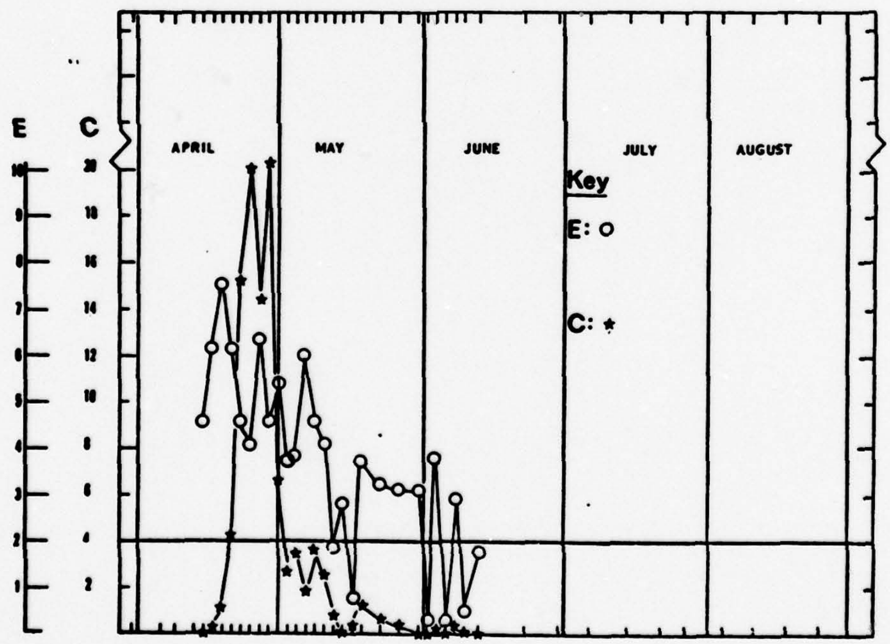
The distribution of effort (as % total effort, 747 samples, top and bottom net hauls combined) and capture (as % total, 60030 eggs, top and bottom net captures combined) during the ETI for striped bass eggs is given in Fig. 3. Marked differences in captures of striped bass eggs are apparent from station to station and from date to date. However, there are also marked differences in sampling effort, and the question remains: to what extent do the differences in capture reflect differences in effort?

The solution to this problem requires a combination of capture and effort information to eliminate as much as possible the effects of different effort at different stations or days on capture data for those stations and days. One method is to compare the actual catch with a model distribution of catch vs. effort. As we lack any *a priori* reasons for a more complex model, the simplest solution is to assume a rectangular distribution of catch vs. effort in both the spatial and temporal dimensions, i. e. assume that equal effort produces equal catches, and then compare the observed catch with the model.

In the case of capture information along the transect, ie comparing catches at different stations *summed* over some time



A



B

Fig. 3. Comparison of catch vs. effort. Striped bass eggs. 1971.

'E' Scale: % of effort (747 samples) by station (A) or date (B) corresponds with open symbols.

'C' Scale: % of catch (60030 eggs) by station (A) or date (B) corresponds with closed symbols.

interval T (= < ETI), if

S = number of stations along transect

c(i) = capture (number of individuals) at station i over T

$$C = \sum_{i=1}^{S} c(i) = \text{total capture over S stations over T}$$

e(i) = effort (number of samples taken) at station i over T

$$E = \sum_{i=1}^{S} e(i) = \text{total effort over S stations over T,}$$

then if ce(i) is the expected capture at station i, assuming a rectangular distribution, we have:[1]

(1) ce(i) = (e(i)/ E) * C

from which a convenient capture index CI(i) for the catch at station i over T can be constructed as follows:

(2) CI(i) = (c(i)/ ce(i)) * 100

(3) = ((c(i)*E)/(e(i)*C)) * 100.

Values of CI(i) less than 100.0 would indicate that fewer individuals were taken at station i than would be expected from the model whereas values of CI(i) greater than 100.0 indicate the converse.

For example from tables A8 and 1 we find that during the ETI for striped bass eggs (April 15 - June 13), a total of 3408 eggs was taken in 46 samples (top and bottom net captures combined) at station E5. The capture index CI(E5) is computed as follows:

S = 28 c(E5) = 3408 C = 60030 e(E5) = 46 E = 747

CI(E5) = (3408 * 747 / 46 * 60030) * 100

= 92.1922.

---

[1] Arithmetic symbols: * = multiply / = divide

Similarly for capture over time information, i. e. comparing catches on different sampling days over some time T (=< ETI), if

D = number of sampling days in T

c(i) = capture (number of individuals) on day i, summed over all samples taken on day i

$$C = \sum_{i=1}^{D} c(i) = \text{total capture over } T$$

e(i) = effort (number of samples) on day i

$$E = \sum_{i=1}^{D} e(i) = \text{total effort over } T,$$

then if ce(i) is the expected capture on day i, if an equal number of samples were taken on all sampling days, then the rectangualar model predicts that

(4) $ce(i) = (1/ D) * C.$

However, if differing numbers of samples were taken on different sampling days, a correction must be made such that

(5) $ce(i) = ((1/ D)*C) + ((e(i)-(E/ D))*(C/ E))$

which readily reduces to

(6) $ce(i) = (e(i)/ E) * C$

as in equation (1). Thus the capture index CI(i) for day i will be

(7) $CI(i) = (c(i)/ ce(i)) * 100$

(8) $= ((c(i)*E)/(e(i)*C)) * 100.$

For example on April 27, 8606 striped bass eggs were taken in 48 samples (Tables A8, 1: top and bottom net captures combined). The capture index CI(April 27) is calculated as follows:

D = 27   c(April 27) = 8606   C = 60030   e(April 27) = 48

E = 747

$$CI(April\ 27) = (8606*747\ /\ 48*60030) * 100$$
$$= 223.107.$$

Capture indices corresponding to each station and date over the ETI (and in some cases over portions, T, of the ETI) were calculated for each stage (egg, larva, juvenile) of each of the numerically important species captured in 1971 in the C&D area. Separate capture indices were calculated for top net captures, bottom net captures, and combined (top + bottom) captures.Top and bottom net capture indices were compared via Kendall's tau (illustrated in Tables 2 and 3) in all cases where the top and bottom nets each contributed a substantial portion of the total catch (Table 4). Where calculated tau values indicated an agreement between the two sets of ranks was at a level of significance less than the 01 level (i. e. $p > .01$), separate diagrams of capture indices for top and for bottom net captures are presented in the following discussion. Where the level of agreement exceeding the 01 significance level (i. e. $p < .01$), only the capture indices for the combined data are given.

There are a number of problems with this method: (1) Ideally the capture vs. effort index should include tow - to -tow differences in the amount of water filtered (as indicated by the flowmeter readings). This has not been done and the differences (in m^3 filtered) between tows from day to day and from station to station are assumed to average out over any long time period (ETI or long T). (2) Capture

Table 2. Comparison of capture, top net vs bottom net, by date. Striped bass eggs: N = 60030. ETI: 15 April - 13 June, 1971.

Date	CI(i) Top	R	CI(i) Bottom	R
15	.38	3	.65	3
17	1.20	5	2.45	5
19	14.64	10	17.02	12
21	67.83	21	66.65	17
23	347.60	24	324.63	24
25	377.64	25	572.82	26
27	346.36	23	142.60	22
29	500.85	26	418.70	25
1	91.22	22	143.68	23
3	23.84	11	105.57	21
5	36.15	17	105.32	20
7	33.32	15	29.61	14
9	67.48	20	86.82	19
11	32.00	18	76.41	18
13	46.99	19	54.44	16
15	.74	4	.90	4
17	34.84	16	16.84	11
19	31.53	14	32.03	15
23	25.25	12	24.97	13
27	4.46	7	15.08	10
31	0	1	.20	2
2	10.53	8	3.02	6
4	2.70	6	3.09	7
6	11.34	9	6.03	9
8	27.55	13	3.29	8
13	.20	2	0	1

Tau = .806 $p < .01$

June 10 (no striped bass eggs captured) omitted

Table 3. Comparison of capture, top net vs bottom net, by station, over ETI (April 15 - June 13, 1971). Striped bass eggs: N = 60030.

Station	CI(i) Top	R	CI(i) Bottom	R
NE2	0	2.5	.34	1
NE1	.08	5	.67	3
CB3	0	2.5	6.43	8
CB2	0	2.5	2.01	4
CB1	.29	6	2.83	5
E1	.35	7	3.81	7
E2	1.94	8	28.78	14
E3	7.83	11	48.63	17
E4	7.16	10	43.87	16
E5	54.74	17	115.01	19
C1	65.87	18	196.46	22
C2	361.77	24	242.93	23
C3	522.08	26	398.65	25
C4	227.33	22	193.75	21
C5	292.60	23	275.85	24
C6	134.56	21	164.64	20
C7	408.81	25	442.46	26
C8	98.11	20	90.59	18
C9	74.70	19	33.54	15
R10	8.26	12	17.49	10
PPI	15.61	14	22.24	13
R6	3.24	9	19.10	12
N5	25.11	16	16.09	11
C27	14.58	13	12.20	9
N2N	16.20	15	3.02	6
N8R	0	2.5	.67	2

Tau = .738 $p < .01$

S2,S1 (no striped bass eggs captured) omitted.

Table 4. Calculated tau values from comparison of CI(i) for top and bottom net captures in 1971.
CT = number (and %Σ) taken in top net hauls CB = number (and %Σ) taken in bottom net hauls.
D = number of sampling days in ETI (minus excluded days)
S = number of stations along transect (minus excluded stations)
E = exclusions, dates or stations at which no individuals (of a given species) were taken in either top or bottom net hauls. ** significant at $p < .01$ NS non-significant (at 05)

Species	Capture			By date			By station			ETI
	C	CT %Σ	CB %Σ	D	Tau	E	S	Tau	E	
Alosa spp. eggs	4927	334 6.78	4593 93.22	-	-	-	-	-	-	April 9 - May 27
Alosa spp. larvae	19027	15304 80.43	3723 19.57	30	+.393**	1	24	+.377 $.01 < p < .02$	1	April 23 - Aug. 18
Brevoortia _tyrannus_ juveniles	325	303 93.23	22 6.77	-	-	-	-	-	-	April 17 - July 27
Anchoa _mitchilli_ larvae	2352	2047 87.03	305 12.97	-	-	-	-	-	-	June 23 - Nov. 17
Anguilla _rostrata_ juveniles	328	69 21.04	259 78.96	-	-	-	-	-	-	March 31 - May 27
Morone _americana_ eggs	8121	1020 12.56	7101 87.44	24	+.522**	2	22	+.442**	2	April 6 - June 4
_M_. _americana_ larvae	17545	1953 11.13	15592 88.87	29	+.515**	3	24	+.120NS	3	April 19 - July 27
Morone _saxatilis_ eggs	60030	23329 38.86	36701 61.14	26	+.806**	4	26	+.738**	4	April 15 - June 13
_M_. _saxatilis_ larvae	4196	587 13.99	3609 86.01	24	+.380**	5	25	+.429**	5	April 21 - June 30

[1]except:July 27, Aug. 11;R6,N5,N2N,N8R. [2]except: May 31, June 2; R10,PPI,N2N,N8R
[3]except:June 2,10;R6,N5,N2N,N8R. [4]except: June 10; S1,S2. [5]except: June 2,10; N5,N2N,N8R

Table 4. Cont'd.

Species	Capture			By date			By station			ETI
	C	CT %Σ	CB %Σ	D	Tau	E	S	Tau	E	
Morone spp. larvae	7511	193 2.57	7318 97.43	-	-	-	-	-	-	May 15 - July 7
Perca flavescens larvae	2125	1185 55.76	940 44.24	21	+.569**	6	25	+.328 $.02 < p < .05$	6	April 9 - May 27
Gobiosoma bosci larvae	576	7 1.22	569 98.78	-	-	-	-	-	-	June 30 - Sept. 23

[6] except: May 19; S2,R6,N2N

Alosa spp. = "herring" cf alewife and blueback herring (A. pseudoharengus and A. aestivalis)
Brevoortia tyrannus = Atlantic menhaden
Anchoa mitchilli = bay anchovy
Anguilla rostrata = American eel
Morone americana = white perch
Morone saxatilis = striped bass
Morone spp. = larvae of striped bass or white perch (see white perch discussion below)
Perca flavescens = yellow perch
Gobiosoma bosci = naked goby

of eggs and larvae of all species found in the C&D area is extremely variable in both time and space, ie upon the actual stations and dates sampled. An ideal capture index would combine capture vs effort information for both time and space into one scheme, perhaps through some form of weighting. Because the variation from station to station and from date to date is quite high in terms of numbers (if not in terms of rank-abundance, see below), and since the 1971 sampling scheme did not involve replicate tows, I have chosen to present the capture index as formulated in this section. (3) There is an important difficulty in simply summing capture information over any long time period,T, and then computing a capture index based solely on this sum, in that variations in abundance at a given station from sampling date to sampling date are masked by this procedure. If it can be shown that the rank-abundance of a given station with respect to other stations is concordant from date to date, the capture index is an acceptable simplification. Where this cannot be shown, the meaning of the capture index as formulated here is thrown into considerable doubt and must be discussed. The methods of establishing whether or not ranked data are concordant are discussed in a following section. (4) While it is easy to show that the actual distribution of capture differs in all cases from the rectangular model (via K-S, etc.), I know of no way to test differences in CI(i)'s from station to station or from date to date.

The strongest advantage of this method is that it allows easy and rapid visualization (Fig. 4) of periods or areas of peak abundance, ie those localities or time periods that over T resulted in the largest captures per tow.

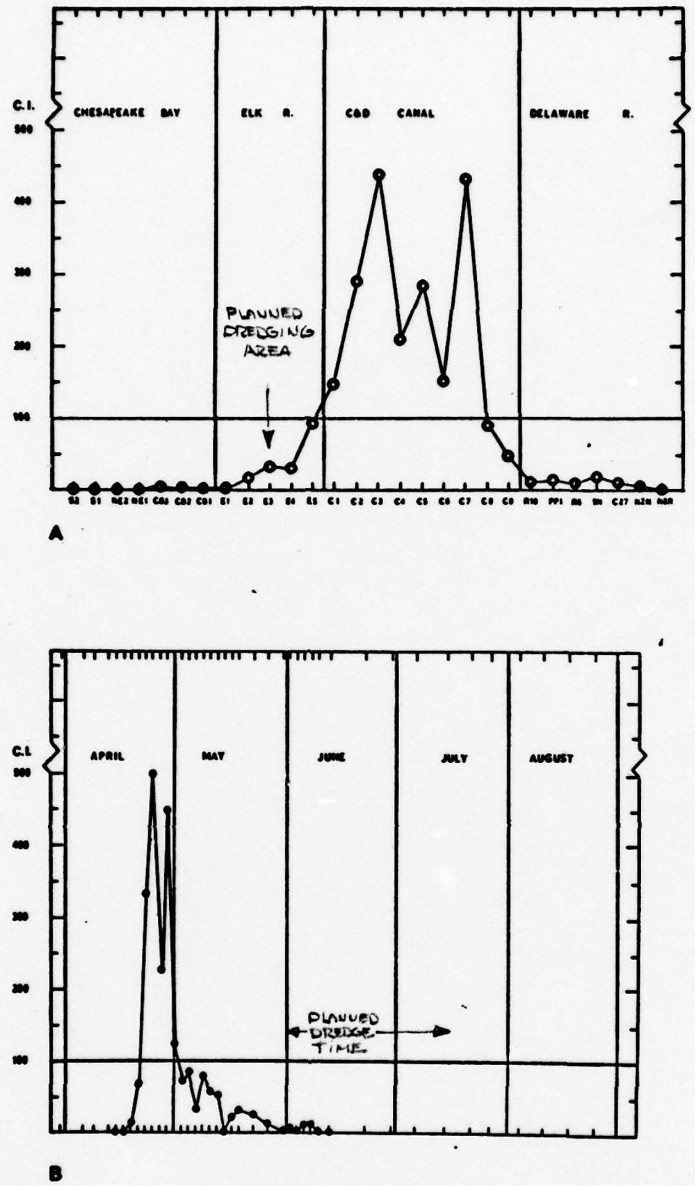


Fig. 4. CI(i) for striped bass eggs. 1971. Combined data, over ETI.

C = 60030 E = 747 ETI = April 15 - June 13.

A. By station. B. By date.

(2) Calculation of Concordance

The coefficient of concordance, W, is a measure of the degree of relationship (similarity) between 3 or more sets of ranks. The calculation of W is illustrated for striped bass egg data in Table 5. It should be noted that two factors dictate the choice of stations and dates to be included in the analysis: (1) all sampling dates selected were days on which a significant number (5 or more) individuals were captured; (2) calculation of W does not allow inclusion of blank (no available sample) data.

The data included in the calculation of W for striped bass eggs includes the time interval April 23 to May 1. Of a total 60030 striped bass eggs captured in 1971, 76.62% were captured during the 5 sampling dates (=m) included in table 5. Although only 15 stations (= n) of 28 total stations in the transect (the others were excluded due to blank values), the catch at these 15 stations accounted for 99.06% of all striped bass eggs taken during this time period.

A significant concordance ($p < .05$) indicates agreement among the sets of ranks, ie in terms of rank-abundance, the rank of a given station with respect to other stations along the transect tends to remain the same from sampling date to sampling date (although actual numbers caught can, and do, vary).

In the case of a number of species, blank values in the data precluded the calculation of W as in table 5. For these species the data were pooled as shown in table 6, for four zones: Chesapeake Bay stations, Elk River stations, Canal stations, and Delaware River stations. These numbers were then converted to to capture indices for each zone over the transect within each sampling date. The capture indices for a given date were then ranked with respect to one another, and the set of ranks generated were compared for concordance as in table 5.

Significant values for W are tabulated up to a matrix: M= 30 by N= 10, in size. For matrices with larger dimensions, a chisquare technique is available as shown in table 5.

The results of concordance calculations are discussed within each species account, but the surprising result of these calculations was that the data for all species analyzed proved to be significantly concordant. This is a powerful justification for analysis via the capture index used throughout this report.

(3) Length Frequency Information

With rare exception, the only information on the size of larvae present in C&D samples taken in 1971, was the range in total length (TL) of specimens in a given haul. This information was used to construct the size of larvae vs time (sampling date) diagrams scattered throughout this report as follows:

(a) Only samples with 2 or more specimens were considered. For a given sampling date, the mean of the upper range limits, the mean of the lower range limits, and the confidence limits associated with each mean were computed. An overall range for each date was taken as the lowest lower limit and the largest upper limit.

(b) Only those dates with 5 or more numbers in the calculation of each mean are included.

(c) On each diagram the overall range, the upper and lower means, the upper confidence (05) limit for the upper mean and the lower confidence limit for the lower mean, are included for each included date.

Table 5. Calculation of concordance for striped bass egg data, 1971. Ranks given in this table are based on raw data given in table A8. Dates include: April 23,25,27,29, May 1.

Date	Number Taken	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9
		(rank-abundance by station)														
23	9136	14	15	10	12	9	7	13	11	5	4	3	2	1	6	8
25	12042	13.5	15	13.5	12	11	10	9	8	7	6	3	4	1	2	5
27	8466	15	12	14	9	13	11	5	1	2	3	4	7	6	10	8
29	12098	14	15	13	8	11	5	4	1	2	3	6	9	7	10	12
1	3822	14.5	13	14.5	7	12	4	1	3	2	5	9	11	10	8	6
Sum of ranks		71	70	65	48	56	37	32	24	18	21	25	33	25	36	39
$R(i)^2$		5041	4900	4225	2304	3136	1369	1024	576	324	441	625	1089	625	1296	1521
$D(i)$		31	30	25	8	16	3	8	16	22	19	15	7	15	4	1
$D(i)^2$		961	900	625	64	256	9	64	256	484	361	225	49	225	16	1

$m = 5 \quad n = 15$ Expected sum of ranks, $Re(i) = ((m*n*(n+1))/2)/n$ $= 40$ $\qquad D(i) = |Re(i) - R(i)|$

Concordance, $W_{m,n} = (12*\Sigma D(i)^2)/(m^2 * n * (n^2 - 1))$

$$= \frac{12\ (4496)}{25(15)(224)} = .642 \quad p < .01$$

Chisquare, $\chi^2_{(n-1)} = ((12 * \Sigma R(i)^2)/\ (m*n*(n+1))) - (3*m*(n+1))$

$$= \frac{12 * 23496}{5 * 15 * 16} - 3*5*16 = 44.96 \quad p << .01$$

Table 6. Calculation of concordance for pooled data. Striped bass eggs, 1971. Capture data from table A8. Effort data from table 1. Stations included in zones: Chesapeake Bay (S2,S1,NE2,NE1,CB3,CB2,CB1); Elk River (E1,E2,E3,E4,E5); C&D Canal (C1,C2,C3,C4,C5,C6,C7,C8,C9); Delaware River (R10,PPI,R6,N5,C27,N2N,N8R). April 23 to June 8.

A. Raw data: given as capture(effort for each zone for each date.

Date	N	Chesapeake Bay	Elk River	C&D Canal	Delaware River
17	73	0(10	14(10	15(18	44(8
19	727	0(14	190(10	250(18	287(14
21	2512	1(14	770(10	1724(17	7(5
27	8606	8(14	107(10	8359(16	132(8
29	12227	12(4	1004(10	11084(16	118(4
1	3984	5(8	388(10	3433(18	158(4
7	1121	41(14	236(10	808(15	36(6
9	2176	9(6	241(10	1926(16	0(2
11	1456	11(8	822(8	617(9	6(6
19	699	8(6	357(7	222(8	113(6
23	485	0(6	55(6	407(8	23(4
27	198	3(6	41(6	148(6	6(5
4	68	1(6	14(8	39(10	14(5
8	223	2(6	113(6	106(10	2(6
$\sum$=	34537(511	101(122	4352(121	29138(185	946(83

B. Capture indices: given as CI(i)(rank for each zone for each date.

Date	Chesapeake Bay	Elk River	C&D Canal	Delaware River
17	0(1	88.22(3	52.51(2	346.58(4
19	0(1	146.36(3	106.99(2	157.91(4
21	.13(1	141.57(3	186.45(4	2.57(2
27	.32(1	5.97(2	291.39(4	9.20(3
29	.83(1	27.94(3	192.78(4	8.21(2
1	.63(1	38.96(2	191.49(4	39.66(3
7	11.76(1	94.74(3	216.24(4	24.09(2
9	2.34(2	37.66(3	188.09(4	0(1
11	2.93(2	218.77(4	145.96(3	2.13(1
19	5.14(1	196.71(4	107.04(3	72.64(2
23	0(1	45.36(3	251.75(4	28.45(2
27	5.81(1	79.38(3	286.53(4	13.94(2
4	7.11(1	74.63(2	166.32(4	119.41(3
8	4.19(1	236.47(4	133.09(3	4.19(2

$W_{14,4} = .622$ $p < .01$ $\chi^2_3 = 26.143$ $p < .005$

In some cases a 'true' mean was estimated by measuring a number of individuals taken from one sample on one sampling date. No attempt was made to randomly choose the individuals measured. These latter means are presented on the diagrams as the mean and associated confidence limits.

RESULTS

Cumulative total results for all stages and species are shown in table 7. The 1971 sampling effort resulted in a processed total of 134,845 fish eggs, larvae, and juveniles.

Cumulative total results, effective time intervals (ETI), and an indication of the period of maximum capture for numerically dominant species are given in table 8. Although the C&D sampling effort resulted in the capture of eggs, larvae, or juveniles of 25 or more species, only 18 species are discussed in this report, and of these 18, the 9 species listed in table 8 account for more than 99% of the catch of all fish eggs and larvae combined. Discussion of capture of these 9 species in 1971 consumes the major portion of this report. Discussion of results from the 1972 sampling year is limited to the capture of striped bass eggs.

Not included in this report are the occasional adults of species such as white perch or hogchoker (*Trinectes maculatus* (Bloch and Schneider)) adventiously taken by our sampling gear, nor a small number of small larvae which we were unable to identify to family, nor the somewhat larger number of eggs and larvae so badly damaged during capture as to be unidentifiable (although most of these were probably white perch or *Alosa* spp.).

In the account of each species the results based on capture in the C&D area are presented first, followed by a discussion relating capture in the C&D area to reports from other recent investigations on the reproduction of that species.

Common and scientific names follow Bailey et. al. (1970).

Table 7. Total catch, cumulative, 31 March to 8 December, 1971.

Category	Surface	Bottom	Total
Eggs	24683	48395	73078
Larvae	21555	39478	61033
Juveniles	375	359	734
			134845

Table 8 Cumulative Catch, numerically dominant species.

Category	Species	Surface	Bottom	Total
Eggs:	M. saxatilis[1]	23329	36701	60030
	M. americana[2]	1020	7101	8121
	Alosa spp.[3]	334	4593	4927
Larvae & juveniles:	Alosa spp.[4]	15304	3723	19027
	M. americana[5]	1953	15592	17545
	M. saxatilis[6]	587	3609	4196
	A. mitchilli[7]	2047	305	2352
	P. flavescens[8]	1185	940	2125
	G. bosci[9]	7	569	576
	A. rostrata[10]	69	259	328
	B. tyrannus[11]	303	22	325

Species	Effective Time Interval	Capture of Middle 50%
1	April 15 - June 13	April 25 - April 29
2	April 6 - June 4	April 21 - May 5
3	April 9 - May 27	April 27 - May 7
4	April 23 - August 18	June 4 - June 13
5	April 19 - July 27	May 1 - June 4
6	April 21 - June 30	May 1 - May 17
7	June 23 - November 17	July 7 - August 25
8	April 9 - May 27	April 17 - April 27
9	June 30 - September 23	July 7 - August 25
10	March 31 - May 27	April 9 - April 21
11	April 17 - July 27	May 7 - May 19

M. saxatilis = striped bass. M. americana = white perch.
Alosa spp. = "herring" cf. alewife, and blueback herring.
A. mitchilli = bay anchovy. P. flavescens = yellow perch.
G. bosci = naked goby. A. rostrata = American eel. B. tyrannus = Atl. menhaden

FAMILY CLUPEIDAE

ALOSA SPP.

Alosa aestivalis (Mitchill) — blueback herring

Alosa pseudoharengus (Wilson) — alewife

A total of 4927 *Alosa* spp. eggs (334 in top nets = 6.78%; 4593 in bottom nets = 93.22%) was taken in 1971. Raw data are given in table A1. The effective time interval was April 9 to May 27. Six consecutive sampling days, April 27 to May 7, resulted in capture of 64.72% of the total number of herring eggs taken. Water temperatures on May 1 varied between 17.5 (bottom) to 20.5° C. (top) and salinities from 2.1 ppt (bottom, C&D Canal near Summit Bridge) to 0.4 ppt (bottom, Elk River) (Table B1).

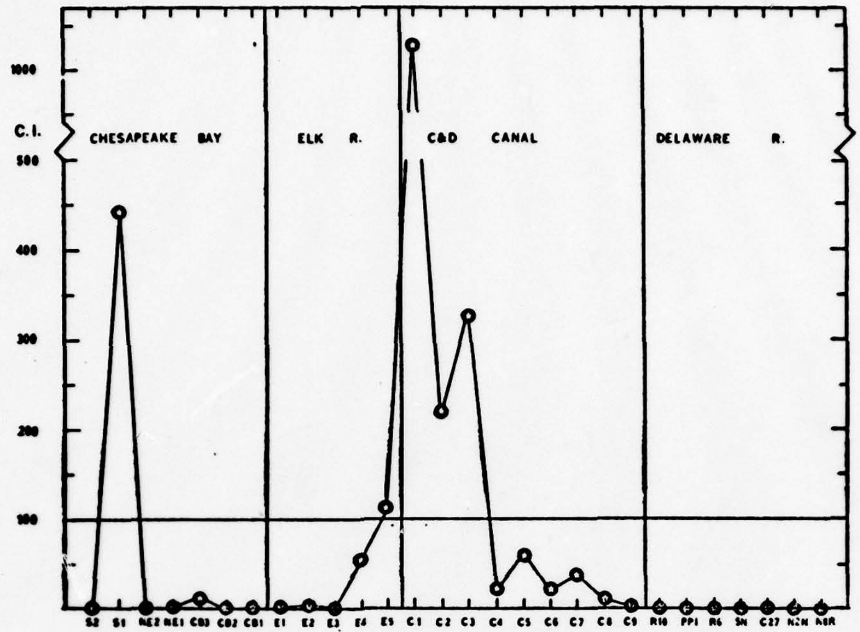
Capture indices (Fig. 5) show peak captures of *Alosa* spp. eggs in the canal at C1 (50.62% of the total herring eggs taken in 1971, were captured at this station). The raw data (Table A1) reveals that captures at station C1 were consistently the highest of any station from sampling date to sampling date. A peak at station S1 is almost entirely the result of the capture of 318 herring eggs in one net haul (bottom) on April 23, accounting for 86.9% of the total herring eggs taken at this station.

The rank-abundance data for herring eggs is presented in Table 9. The concordance value ($.01 < p < .025$) is significant. No herring eggs were taken in the Delaware River stations, and the canal was divided into two zones (C1 - C4; C5 - C9) for purposes of pooling the data.

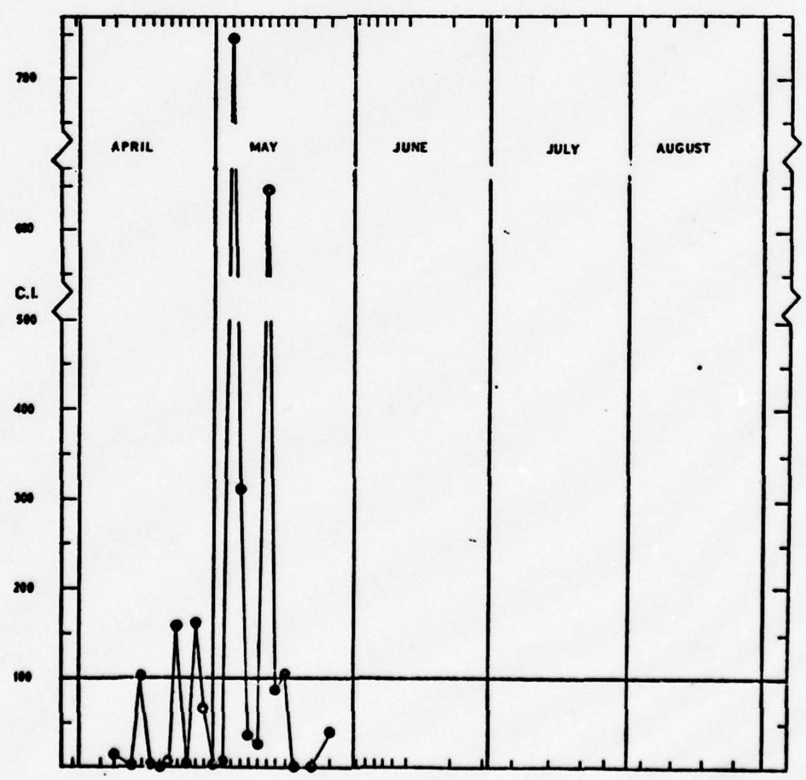
A total of 19027 *Alosa* spp. larvae (15304 in top nets = 80.43%; 3723 in bottom nets = 19.57%) was taken in 1971. Raw data are given in Table A2. Comparison of captures in top and bottom nets revealed

Fig. 5. CI(i) for <u>Alosa</u> spp. eggs. 1971. Combined data, over ETI.

C = 4927 E = 711 ETI = April 9 to May 27



A By station



B By date

Table 9. Rank-abundance by station of capture of Alosa spp. eggs, 1971. Capture data from table A1. Effort data from table 1. Pooled data for 15 sampling dates included accounts for 85.7% of total catch of Alosa spp. eggs. Chesapeake Bay and Elk River Zones defined in Table 6. Canal I : C1 - C4 inclusive. Canal II: C5 - C9 inclusive.

A. Raw data: given as capture(effort for each zone for each date. April 15 - May 27.

Date	N	Chesapeake Bay	Elk River	Canal I	Canal II
15	243	5(6	10(10	228(8	0(10
17	15	11(10	0(10	0(8	4(10
21	39	0(14	0(10	38(7	1(10
23	378	328(6	0(10	0(8	50(10
25	7	3(2	2(10	2(8	0(10
27	538	22(14	18(10	438(7	60(9
29	160	0(4	21(10	73(8	66(8
1	6	0(8	0(10	2(8	4(10
3	14	0(2	0(10	0(8	14(8
5	1499	0(6	55(8	1444(7	0(8
7	972	6(14	312(10	648(7	6(8
9	93	1(6	2(10	90(8	0(8
11	59	16(6	22(8	21(5	0(4
15	128	0(4	21(8	63(5	44(4
27	70	0(6	6(6	64(4	0(2

B. Ranks of resulting capture indices for each zone for each date.

Date	Chesapeake Bay	Elk River	Canal I	Canal II
15	2	3	4	1
17	4	1.5	1.5	3
21	1.5	1.5	4	3
23	4	1.5	1.5	3
25	4	2	3	1
27	1	2	4	3
29	1	2	4	3
1	1.5	1.5	3	4
3	2	2	2	4
5	1.5	3	4	1.5
7	1	3	4	2
9	2	3	4	1
11	2	3	4	1
15	1	2	4	3
27	1.5	3	4	1.5

$W_{15,4} = .228 \quad .01 < p < .05$ $\qquad \chi^2_3 = 10.28 \quad .01 < p < .025$

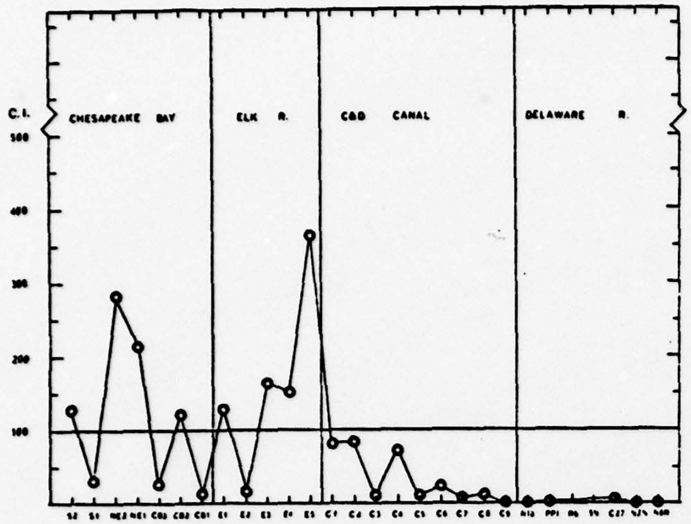
significant agreement with respect to time and geography (Table 4). The effective time interval was April 23 to August 18. Five consecutive sampling dates, June 4 - 13, resulted in capture of 67.19% of the total number of herring larvae taken. Water temperatures on May 1 varied from 17.5 to 20.5° C. and on June 22 from 25.5 to 30.2 C.; salinities varied from 0.4 ppt to 2.1 ppt on May 1 and from 1.0 to 2.1 ppt on June 22, both are bottom readings from the Elk River and from the C&D Canal near Summit Bridge respectively (Table B1).

Capture indices (Fig. 6) show peak captures of herring larvae at NE2, NE1, and E5, and in general show Alosa spp. larvae to be most abundant in the low salinity or freshwater areas of the C&D transect. Rank-abundance data for herring larvae is presented in table 10, and was calculated for both raw data and for pooled data. In both cases the sets of ranks are highly concordant ($p < .005$).

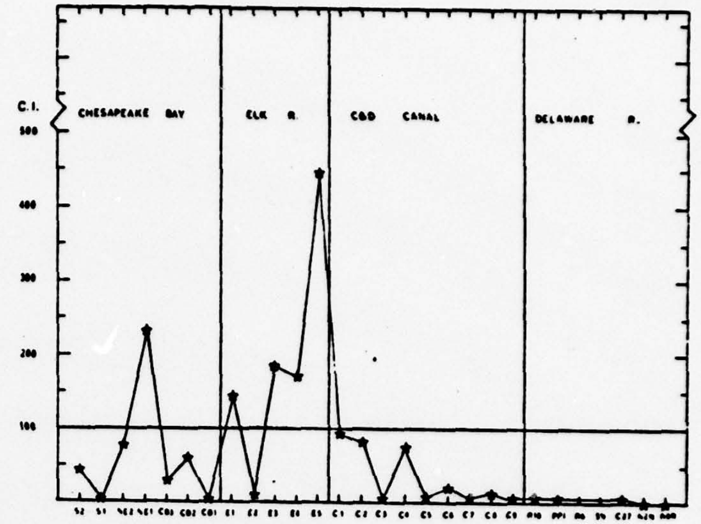
The length-at-capture data (Fig. 7) shows that at first appearance in C&D samples in April, the herring larvae captured are most 4 - 5 mm TL. The subsequent divergence between the two lines (connecting upper and lower range-means) reflects the growth of Alosa spp. larvae (upper line) and the continued input of smaller larvae due to the long combined spawning period of the two species. (lower line).

Discussion.

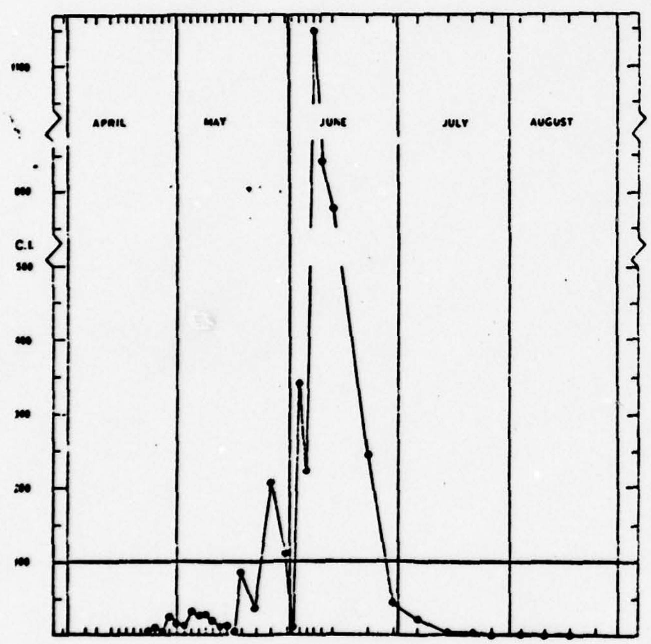
There exists no practical method for distinguishing the eggs and small larvae of the alewife from those of the blueback herring (Dovel 1971, Mansueti 1962, Mansueti and Hardy 1967), and thus the data for Alosa spp. recorded here are almost certainly based upon specimens of both species. The size of herring eggs



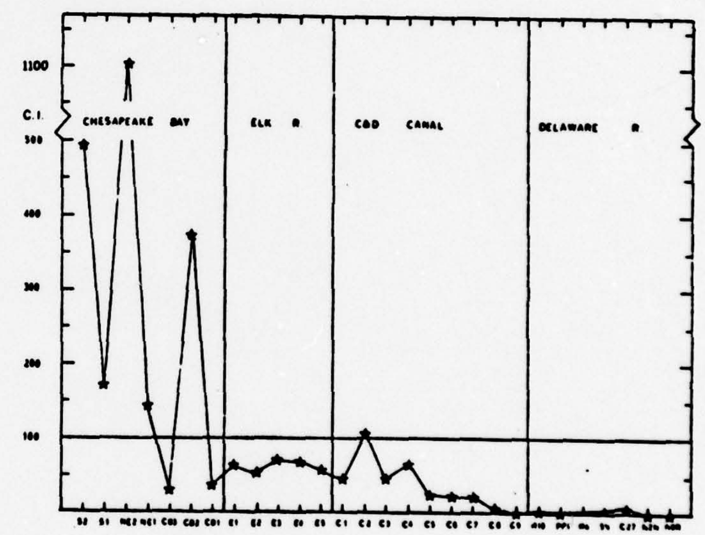
A By station. Combined data.
C= 19027. E = 771



C By station. Top net captures.
C = 15304 E = 388



B By date. Combined data.
C = 19027 E = 771



D By station. Bottom net captures.
C = 3723 E = 383

Fig. 6. CI(i) for <u>Alosa</u> spp. larvae. 1971.
Data over ETI: April 23 - August 18.

Table 10. Part A. Rank-abundance by station of capture of *Alosa* spp. larvae, 1971 Ranks given in this table are based on raw data given in Table A2. Dates include April 27, May 7 - 31, June 4 - 30, July 7. These 10 sampling dates accounted for 33.13% of the total *Alosa* spp. larvae, and the 13 stations included accounted for 94.29% of the herring larvae taken on these 10 dates.

Date	Number Taken	S2	NE1	CE2	E1	E3	E5	C2	C4	C6	C8	R10	PPI	C27
		(rank-abundance by station)												
27	76	9.5	11.5	9.5	13	11.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
7	326	13	2.5	2.5	9	5	7.5	12	10.5	2.5	2.5	7.5	10.5	6
11	146	5	10	8.5	11	8.5	12.5	7	12.5	6	2.5	2.5	2.5	2.5
19	555	8	12	13	10.5	10.5	9	1.5	7	5.5	5.5	3.5	1.5	3.5
23	225	12	10	13	5.5	5.5	8	9	11	7	2	4	2	2
31	640	12	11	13	7	3	10	8	9	4.5	1	4.5	2	6
4	2448	10	12	6	11	9	13	8	7	5	4	1	3	2
23	1467	10	11	9	12	13	8	1	4	6	5	2.5	7	2.5
30	281	3	6	1	4	6	10	13	12	2	11	8	6	9
7	155	10	12	2	5	6.5	13	8	9	11	6.5	2	4	2

$\chi^2_{12} = 44.57$ p .005

Table 10. Part B. Rank-abundance by station of capture of Alosa spp. larvae, 1971. Capture data from table A2. Effort data from Table 1. Pooled data for 17 sampling dates includes 75.36% of total catch of Alosa spp. larvae. April 27 - August 4. Zones as defined in Table 6.

A. Raw data: given as capture(effort for each zone for each date.

Date	N	Chesapeake Bay	Elk River	C&D Canal	Delaware River
27	76	52(14	16(10	8(16	0(8
29	210	25(4	41(10	144(16	0(4
1	165	10(6	85(10	70(18	0(4
7	326	214(14	12(10	86(15	14(6
9	230	71(6	101(10	58(16	0(2
11	146	40(8	66(8	49(9	0(6
19	555	400(6	137(7	14(8	2(6
23	225	155(6	13(6	56(8	1(4
27	1153	522(6	459(6	171(6	1(5
31	640	521(6	51(6	48(6	20(6
4	2448	919(6	1209(8	306(10	14(5
8	6267	1045(2	3889(6	1323(10	10(2
23	1467	582(6	832(5	26(7	27(6
30	281	16(6	52(6	172(7	41(6
7	155	45(6	61(6	47(8	2(6
15	18	5(6	11(6	2(7	0(6
4	10	0(5	1(5	4(8	5(6

B. Ranks of resulting capture indices for each zone for each date.

27	4	3	2	1
29	3	2	4	1
1	2	4	3	1
7	4	1	3	2
9	4	3	2	1
11	2	4	3	1
19	4	3	2	1
23	4	2	3	1
27	4	3	2	1
31	4	3	2	1
4	4	3	2	1
8	3	4	2	1
23	3	4	1	2
30	1	3	4	2
7	3	4	2	1
15	3	4	2	1
4	1	2	3	4

$W_{17,\,4} = .402 \quad p < .01 \qquad \chi^2_3 = 20.51 \quad p < .005$

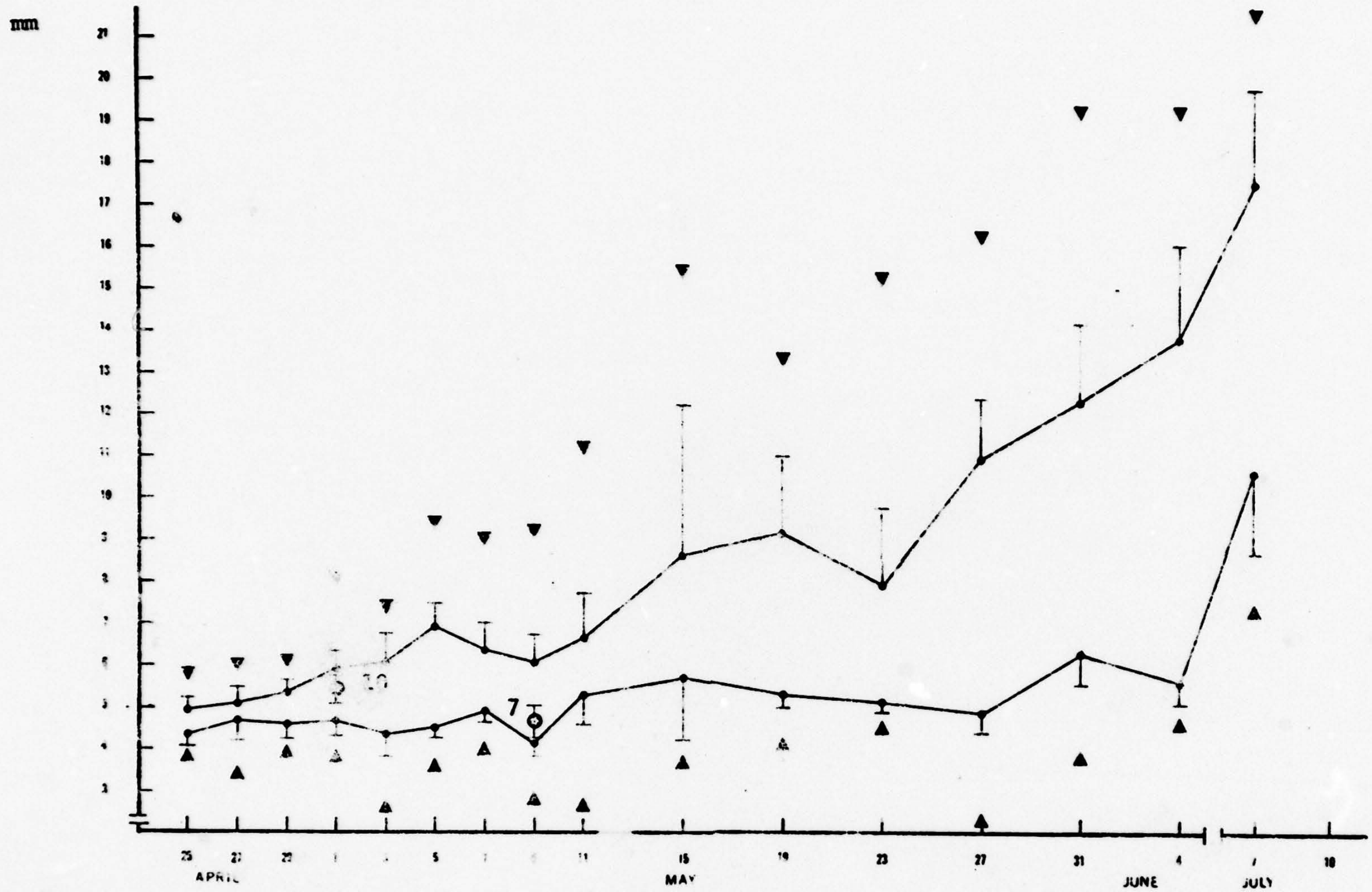


Figure 7. Length-at-capture diagram, *Alosa* spp. larvae, 1971.
Key: closed circles = means of upper and lower range limits (see Methods)
vertical lines = 95% confidence limits for these means, shown are upper confidence limit for upper mean and lower confidence limit for lower mean.
triangles = apices (erect or inverted) of triangles enclose overall range for a given sampling date.
open circles = mean and associated 95% confidence limits for a number of specimens (number printed beside mean) from a single haul on the indicated date.

recovered from C&D samples (ca 1.0 mm) indicates that these are not the larger eggs of the hickory shad (Alosa mediocris) or the considerably larger eggs of the American shad (A. sapidissima). (Mansueti 1962, Mansueti and Hardy 1967). The rarity of young stages of the hickory shad throughout the Chesapeake Bay region has been documented by Mansueti (1962), and I feel confident that the vast majority of eggs and larvae reported here are those of A. aestivalis and A. pseudoharengus.

Alewives and blueback herring are coastal anadromous species spawning in fresh or brackish waters and found in virtually all tributaries of the Chesapeake Bay as well as in the Delaware system (Mansueti and Hardy 1967). Dovel (1971:4) stated that eggs taken in ichthyoplankton samples from the upper bay were deposited upstream, and had been dislodged and transported down the tributary streams by freshwater run-off.

Peak spawning of alewives apparently precedes that of blueback herring by 2 - 3 weeks. Smith (1971) found that both species utilized the same spawning grounds in 4 tidal creeks tributary to the Delaware River, but that the peak of alewife spawning was in the last two weeks of April (1969) at 12 - 20° C. whereas that of blueback herring was in the last two weeks of May at 19 - 24° C. The C&D data indicate peak captures of herring eggs in mid-May but it should be noted that the demersal eggs of these two species are probably spawned upstream in tributary creeks and that the localities sampled during this study and the methods used almost certainly do not adequately sample production of Alosa spp. eggs. It is of some interest to note that Mansueti and Hardy (1967:48) describe the eggs of A. aestivalis as slightly adhesive whereas the eggs of A. pseudoharengus are described as non-adhesive (p. 57). If true, this plus the spawning periods indicated by Smith (1971) would suggest that the peak of herring eggs taken in the C&D samples during mid-May is based largely on capture of alewife eggs. Smith (1971) noted the larvae and young of the two species were common in his collections throughout July but had largely disappeared by August, although capture of 50 - 105 mm FL juveniles in May and June suggested that at least some individuals overwinter in the Delaware River estuary. Smith used seining and trawling gear in his studies and the later appearance and disappearance of larval and juvenile herring in his samples than in the C&D samples is not surprising.

<u>BREVOORTIA</u> <u>TYRANNUS</u> (LATROBE) Atlantic menhaden

A total of 325 Atlantic menhaden juveniles, 25 - 40 mm in TL (303 in top nets = 93.23%; 22 in bottom nets = 6.77%) was captured in 1971. Raw data is given in table A3. The effective time interval was April 17 - July 27. Two consecutive sampling days, May 19 and 23, accounted for 58.77% of the total number of Atlantic menhaden juveniles taken. Water temperatures and salinities taken in 1971 are given in table B1.

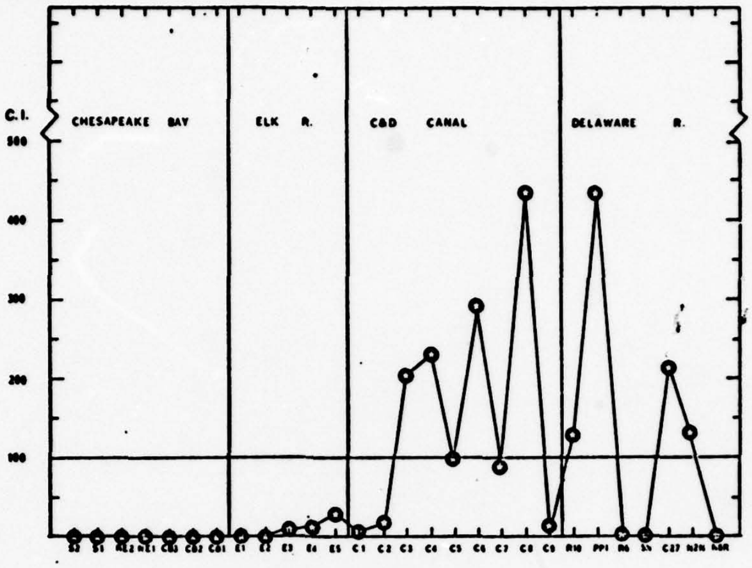
Capture indices (Fig. 8) show peak captures in the Delaware River and Delaware end of the C&D Canal. Rank-abundance data for Atlantic menhaden juveniles is given in Table 11. The set of data exhibits a highly significant concordance ($p < .005$). The size-at-capture diagram (Fig. 9) shows that at first appearance in C&D samples in any numbers of individuals, Atlantic menhaden juveniles are 26 - 31 mm TL.

The Atlantic menhaden recovered from C&D samples were easily identified by characters provided by Hildebrand (1963) and Mansueti and Hardy (1967).

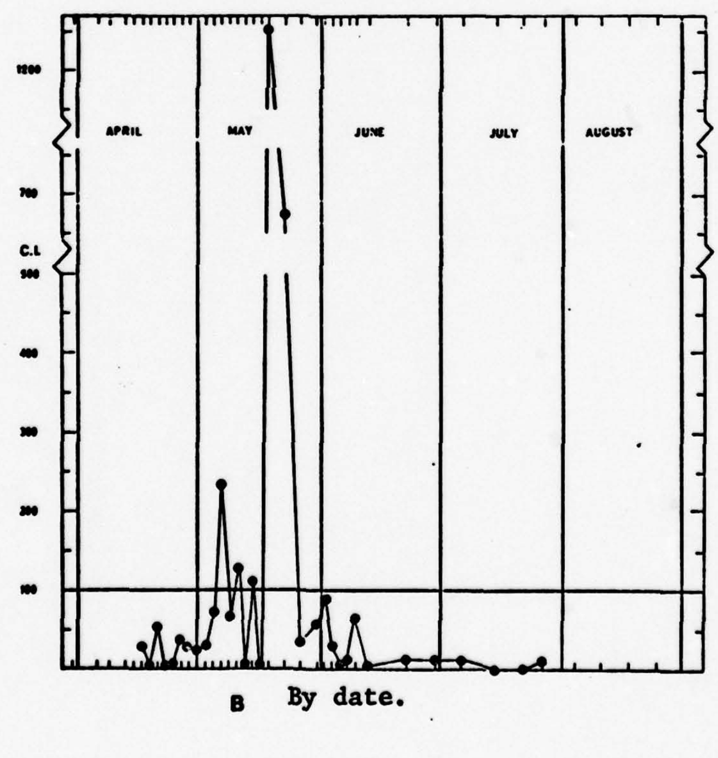
<u>Discussion</u>

Atlantic menhaden are coastal schooling fishes occuring from Nova Scotia to Jupiter Inlet, Fla. (Dahlberg 1970). Spawning occurs at sea and larvae enter adjacent estuaries and migrate upstream to the fresh or low salinity waters of tributary streams. Discussion of aspects of the life history of this species can be found in Hildebrand 1963, Pacheco and Grant 1965, Dovel 1971, June and Chamberlain 1959, Smith 1971; Massmann, Ladd and McCutcheon 1954, and Mansueti and Hardy 1967. Larval menhaden are pelagic.

Fig. 8. CI(i) for Atlantic menhaden juveniles. 1971.
Combined data, over ETI: April 17 - July 27.
C = 325 E = 851



A By station



B By date.

Table 11. Rank-abundance by station of capture of menhaden juveniles, 1971. Capture data from table A3. Effort data from Table 1. Pooled data for 9 sampling dates includes 86.46% of total catch of menhaden juveniles. April 17 - May 31. Zones as defined in Table 6.

A. Raw data: given as capture(effort for each zone for each date.

Date	N	Chesapeake Bay	Elk River	C&D Canal	Delaware River
17	5	0(10	0(10	5(18	0(8
21	10	0(14	0(10	9(17	1(5
27	7	0(14	0(10	2(16	5(8
7	40	0(14	0(10	9(15	31(6
9	8	0(6	2(10	4(16	2(2
11	15	0(8	0(8	9(9	6(6
19	129	0(6	0(7	113(8	16(6
23	62	0(6	1(6	38(8	23(4
31	5	0(6	1(5	1(6	3(6

B. Ranks of resulting capture indices for each zone for each date.

17	2	2	4	2
21	1.5	1.5	4	3
27	1.5	1.5	3	4
7	1.5	1.5	3	4
9	1	2	3	4
11	1.5	1.5	3.5	3.5
19	1.5	1.5	4	3
23	1	2	3	4
31	1	3	2	4

$W_{9,4} = .657 \quad p < .01$ $\qquad \chi^2_3 = 17.73 \quad p < .005$

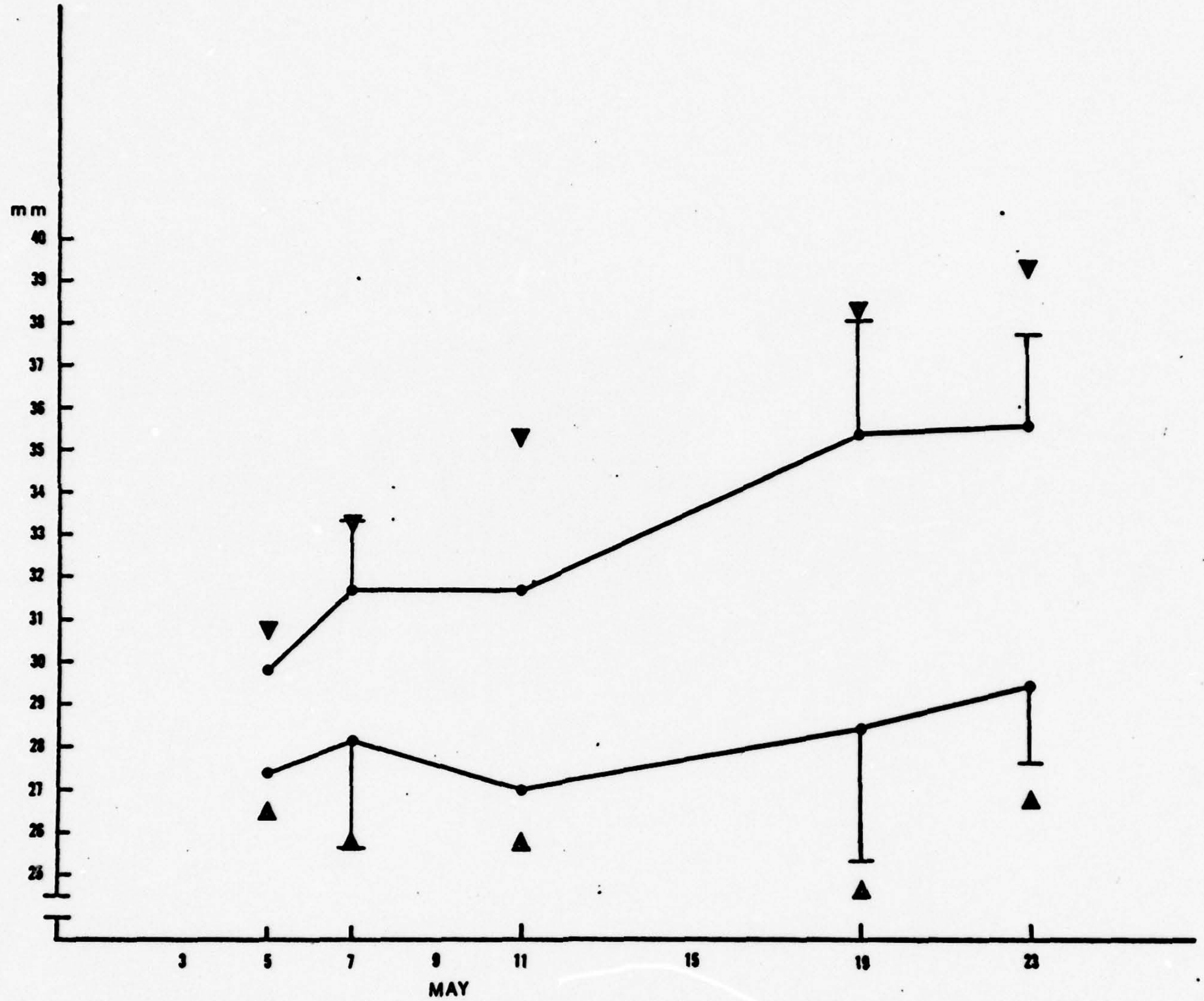


Fig. 9. Length- at - capture diagram, Atlantic menhaden juveniles, 1971.
Explanation of symbols at base of Fig. 7.

Massmann et al (1954) using fixed 1m plankton nets reported a capture ratio of 200:1 of surface:bottom nets. The C&D capture ration of Atlantic menhaden juveniles is about 14:1 surface: bottom (= middepth) nets.

Pacheco and Grant (1965:9) reported that the smallest menhaden juveniles, ca 22 mm TL, entered their White Creek (a tributary of the Indian River, Delaware) study site in May (1958). Dovel (1971) reported that larval menhaden are about 25 mm TL when first encountered in the upper Chesapeake Bay and that these fishes had probably been spawned and had entered the estuary the previous fall or winter. Dovel (1971: 12) also notes that of 2322 specimens of young menhaden examined by him from the upper Chesapeake, only 25 specimens were less than 20 mm TL, and that 24/25 of these had been taken in one sample, June 5, 1967, in the C&D Canal. Dovel suggested that this was related to the short access to the Atlantic Ocean afforded by the C&D Canal and Delaware River estuary. Smith (1971) reported the following number of specimens and size range of Atlantic menhaden taken from 4 tributary tidal creeks of the Delaware System in 1969: May (1: 29 mm); June (117: 19 - 47); July (1397: 21 - 63); August (15: 27 - 99); September (3: 70 - 99).

It appears that Atlantic menhaden use the C&D Canal as an access to freshwater tributaries of the canal and perhaps actually use the canal as a route to Chesapeake Bay. Our catch data strongly suggests that most of the Atlantic menhaden recovered from C&D samples had migrated up the Delaware River estuary.

A recent analysis of Atlantic menhaden populations, their status and ecology with special reference to the menhaden fishery, is provided by Henry (1971).

FAMILY ENGRAULIDAE

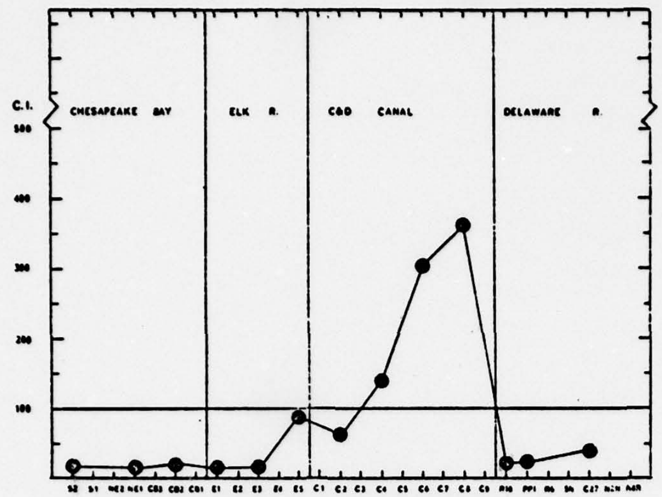
ANCHOA MITCHILLI (CUVIER AND VALENCIENNES) BAY ANCHOVY

A total of 2352 bay anchovy larvae (2047 in top nets = 87.03%; 305 in bottom nets = 12.97%) was taken in 1971. Raw data is given in table A4. The effective time interval was June 23 to November 17. Although captures were quite evenly spread over the effective time interval, the 4 consecutive sampling days in August accounted for 38.82% of the total catch. Water temperatures and salinities taken in 1971 are given in Table B1.

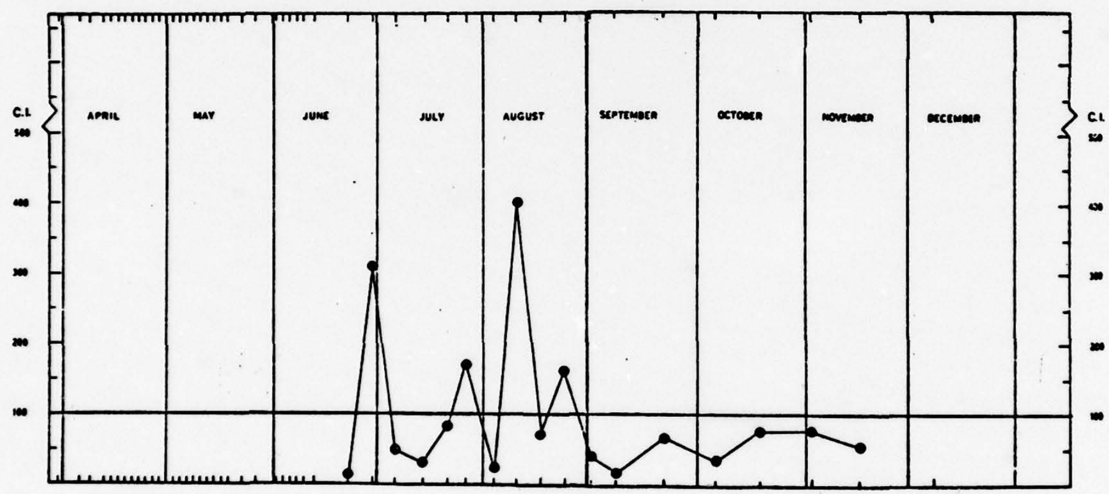
Capture indices (Fig. 10) show peak captures in the Delaware portion of the Chesapeake and Delaware Canal. It should be noted that for sampling dates after June 10, 1971, samples from only one-half the transect stations and one-half of the sampling dates were processed. Therefore only 13 stations are indicated on Figure 10A. Examination of the raw data (Table A4) reveals that captures of bay anchovy larvae were consistently highest in the C&D Canal, and of the Canal stations, were highest at C6 and C8. This consistency is confirmed by the significant concordance exhibited among sets of both raw data (Table 12A: $.025 < p < .05$) and pooled raw data (Table 12B: $.01 < p < .025$).

The size-at-capture diagram (Fig. 11) shows that at first appearance in C&D samples, bay anchovy larvae are 10 - 20 mm TL.

Bay anchovy larvae recovered from C&D samples were identified by characters provided by Hildebrand (1963A) and Mansueti and Hardy (1967). Two additional engraulid species, Anchoa hepsetus (Linnaeus) and Anchoviella eurystole (Swain and Meek) are encountered in the Delaware Bay area, but occur in higher salinity waters than usually



A By station



B By date.

Fig. 10. CI(i) for bay anchovy larvae. 1971. Combined data over ETI.

C = 2352 E = 352 ETI = June 23 to November 17

Table 12. Part A. Rank-abundance by station of capture of Anchoa mitchilli larvae, 1971. Ranks given in this table are based on raw data given in Table A4. Dates include July 27, August 4, 11, 18, 25. These 5 sampling dates accounted for 42.64% of the total bay anchovy larvae, and the 9 stations included aacounted for 98.60% of the bay anchovy larvae taken on these 5 dates.

Date	Number Taken	E1	E3	E5	C2	C4	C6	C8	R10	PPI
		(rank-abundance by station)								
27	226	1.5	3.5	7	6	8	9	5	1.5	3.5
4	37	3	6.5	9	3	6.5	6.5	3	6.5	1
11	504	1.5	1.5	6	5	7	9	8	4	3
18	115	3	5	8	9	2	4	1	6	7
25	25	3	4	6	5	9	7.5	7.5	1.5	1.5

$W_{5,9} = .405$ $.01 < p < .05$ $\chi^2_8 = 16.21$ $.025 < p < .05$

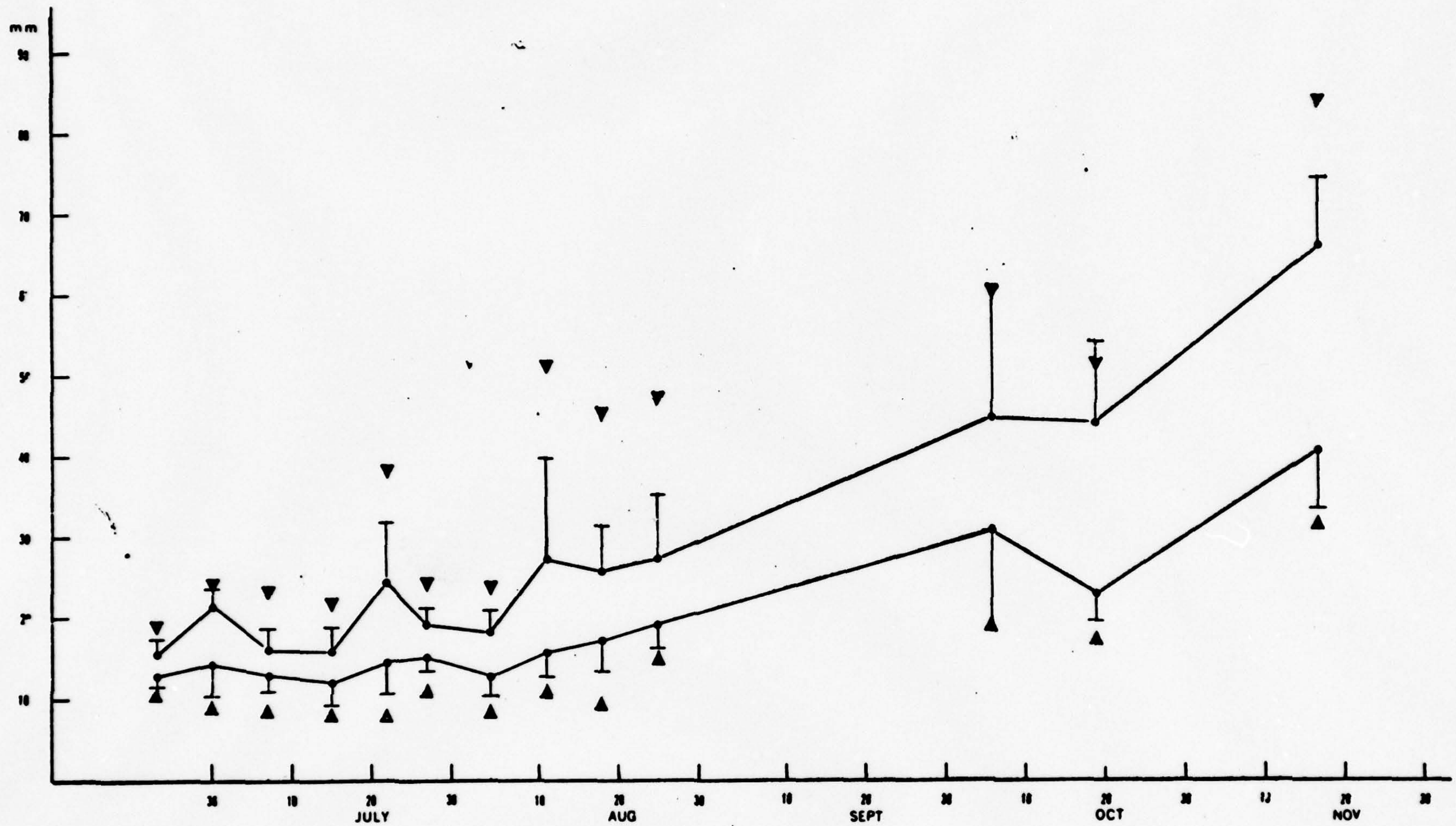


Fig. 11. Length-at-capture diagram, bay anchovy larvae, 1971. Explanation of symbols at base of Fig. 7.

encountered in the C&D area. (de Sylva et al 1962, Mansueti and Hardy 1967, Stevenson 1958).

Discussion

The euryhaline bay anchovy occurs in coastal, estuarine and fresh waters from the Gulf of Maine to Yucatan. The life history of this species in Chesapeake Bay was studied by Dovel (1971) and in Delaware Bay by Stevenson (1958). This species is an estuarine spawner with peak spawning taking place in waters of 13 - 15 ppt (Dovel 1971). No anchovy eggs were encountered in the C&D area. Spawning occurs from April to September and larvae and juveniles move upstream into low salinity areas. The maximum concentrations of larvae are not found in freshwater (cf menhaden) but in low salinity areas, 3 - 7 ppt, near the fresh-salt interface (Dovel 1971). Smith (1971) recorded first capture of young anchovies in June and last capture in November, exactly the pattern seen in the C&D data. The length-at-capture (Fig. 11) diagram constructed from C&D data closely agrees with growth information for this species provided by Stevenson (1958).

Smith (1971) reported that young anchovies were concentrated in the shore zone of the four tidal creeks of his study area, and it is possible that the stations in mid-channel of the C&D transect preclude adequate sampling of the degree of utilization of the C&D area by bay anchovy larvae.

It is interesting to note the succession, nearly without overlap, of _Alosa_ spp. larvae by bay anchovy larvae (Fig. 12). Larvae of both genera are morphologically somewhat similar and pelagic, being taken in greatest numbers near the surface, and it is at least interesting

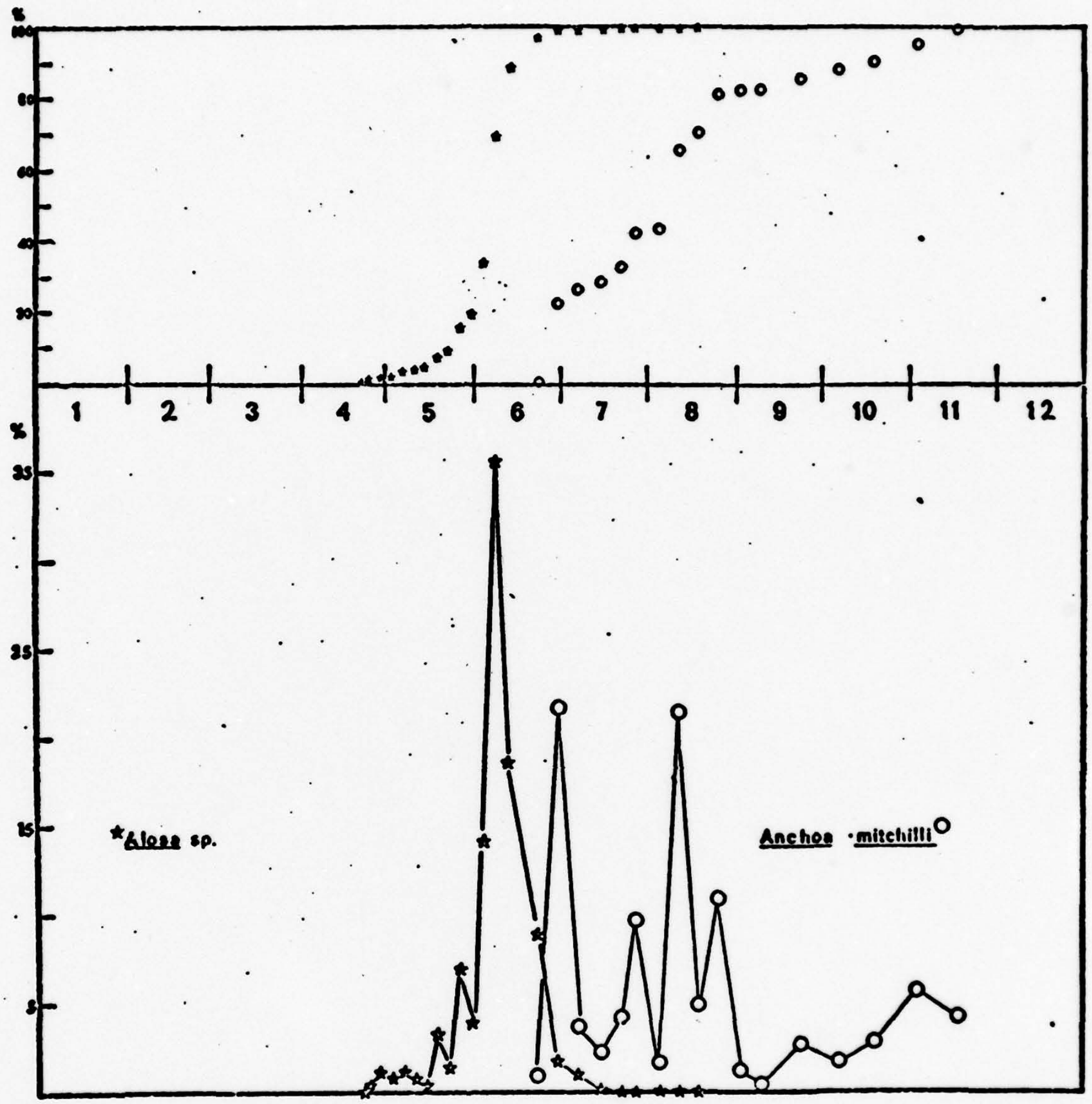


Figure 12. Bottom: Catch of Alosa sp. and Anchoa mitchilli expressed as percent of total catch for each species, plotted for entire sampling year.

Top: Catch of Alosa sp. and Anchoa mitchilli expressed as cumulative percent of total catch for each species, plotted for entire sampling year.

Abscissa: 1971 sampling year (January = 1; February = 2, etc.)

to note the avoidance of competition resulting from the utilization of the upper bay nursery areas at different time periods.

FAMILY ANGUILLIDAE

ANGUILLA ROSTRATA (LESUEUR) AMERICAN EEL

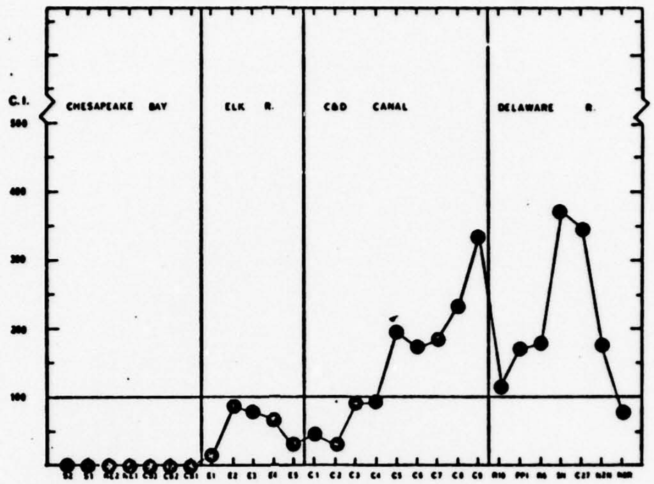
A total of 328 American eel elvers (69 in top nets = 21.04%; 259 in bottom nets = 78.96%) was taken in 1971. Raw data is given in Table A5. The effective time interval was March 31 to May 27. Seven consecutive sampling dates, April 6 - 21, accounted for 71.34% of the total catch. Water temperatures and salinities taken in 1971 are given in table B1.

Capture indices (Fig. 13) show peak captures in the Delaware River and Delaware portion of the C&D Canal. Rank-abundance data is given in Table 13. The capture data are highly concordant (p .005). The size-at-capture diagram (Fig. 14) shows that elvers recovered from C&D samples range from 48 to ca 70 mm TL.

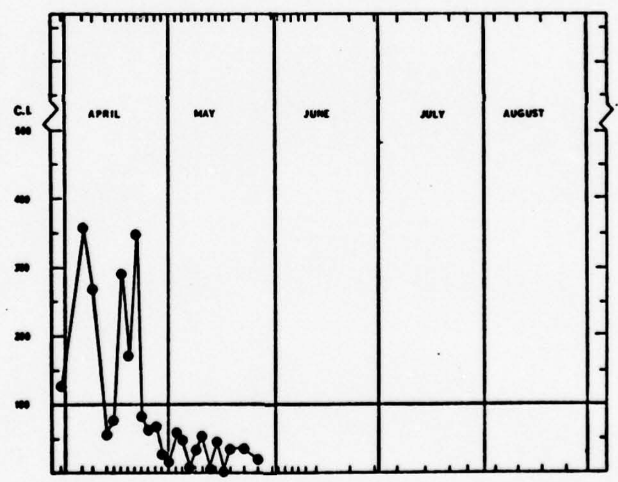
Discussion

The American eel is a catadromous species, spawning at sea, and returning to estuarine and freshwater habitats until reaching maturity. There is a large and growing literature on the reproduction of this species (for a fairly recent summary see Breder and Rosen 1966: 273 - 275).

Smith (1971) reported the first capture of elvers in the 4 tidal creeks of his Delaware River study area on March 17 (1969) and continued to take elvers throughout the spring months. De Sylva et. al. (1962) reported large captures of elvers in tributary and feeder streams throughout the Delaware system in February and March, and noted the apparent association of maximum captures with more turbid water conditions. Recovery of elvers from C&D samples agrees well with these results. In 1972 we took 7 (59 - 63 mm TL) elvers



A By station.



B By date.

Fig. 13. CI(i) for American eel elvers, 1971. Combined data, over ETI.

C = 328 E = 763 ETI = March 31 - May 27.

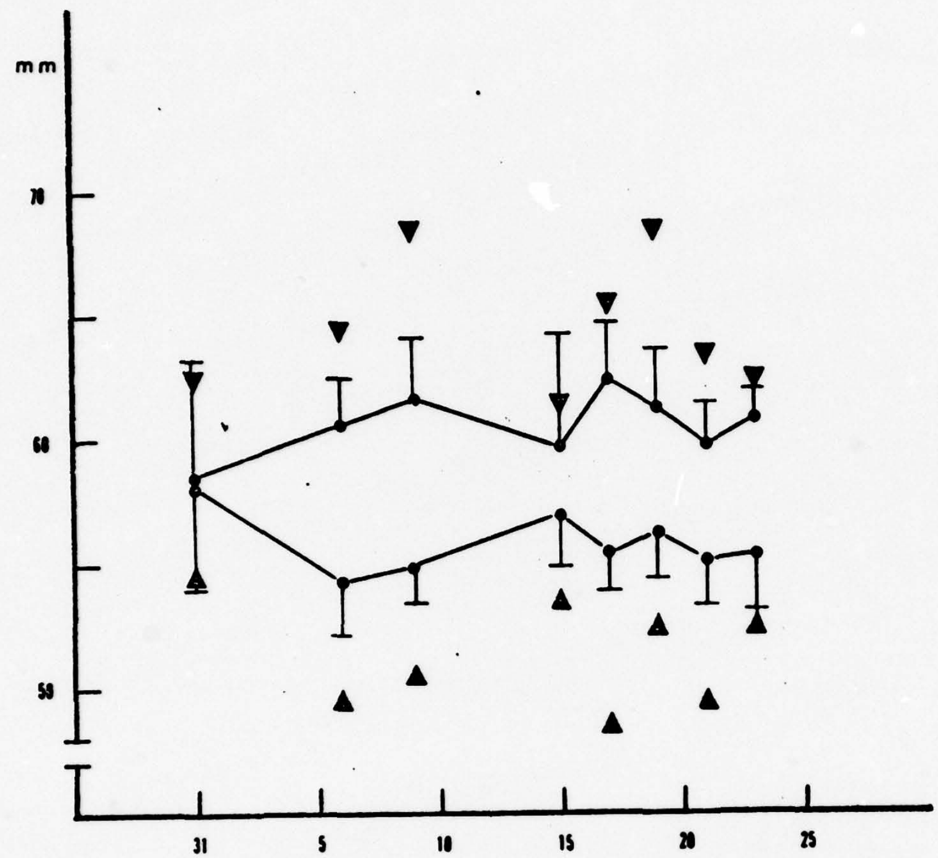


Fig. 14. Length-at-capture diagram, American eel elvers, 1971.
Explanation of symbols at base of Fig. 7.

Table 13. Rank-abundance by station of capture of American eel elvers, 1971. Capture data from Table A5. Effort data from Table 1. Pooled data for 6 sampling dates includes 52.44 % of total catch of American eel elvers. April 17 - 27; May 9 - 11. Zones as defined in Table 6.

Date	N	Chesapeake Bay	Elk River	C&D Canal	Delaware River
A. Raw data: given as capture(effort for each zone for each date.					
17	57	0(10	0(10	38(18	19(8
19	40	0(14	2(10	21(18	17(14
21	49	0(14	16(10	17(17	15(5
27	14	0(14	5(10	5(16	4(6
9	5	0(6	0(10	4(16	1(2
11	7	0(8	0(8	4(9	3(6
B. Ranks of resulting capture indices for each zone for each date.					
17		1.5	1.5	3	4
19		1	2	3	4
21		1	3	2	4
27		1	3	2	4
9		1.5	1.5	3	4
11		1.5	1.5	3	4

$W_{6,4} = .803$ $p < .01$ $\chi^2_3 = 14.45$ $p < .005$

at C8 (bottom haul) on January 27, and continued to catch elvers through May. American eels apparently use the C&D Canal as an access route to tributary streams and perhaps as a route to Chesapeake Bay. As in the case of Atlantic menhaden, it appears likely that elvers recovered from C&D samples had migrated up the Delaware River estuary.

FAMILY ATHERINIDAE

SILVERSIDES:

Membras martinica (Cuvier and Valenciennes)	Rough Silverside
Menidia beryllina (Cope)	Tidewater silverside
Menidia menidia (Linnaeus)	Atlantic silverside

A total of 89 silverside larvae, 4.0 - 14 .0 mm TL (68 in top nets = 76.40%; 21 in bottom nets = 23.60%) was taken in 1971. The effective time interval was June 13 to August 25. Capture data is presented in Table 14. Capture indices show peak captures in the Chesapeake Bay and Elk River stations. Kolba (1972) has recently summarized the problems involved in the identification of larval silversides, and reports (pers. comm.) that all silversides exceeding 8.0 mm S. L. in C&D samples examined by him were young Membras martinica.

Dovel (1971: 10) reports that young of all three species are common in low salinity areas and were present in his material from April to December. Smith (1971: 68 - 72) captured no Membras martinica less than 76 mm FL (fork length) in his study area of four tidal creeks tributary to the Delaware River. He found in the same area both eggs and larvae (9mm and larger TL) of Menidia beryllina from mid-May through August, and young (7 mm TL or larger) Menidia menidia were first taken in May and abundant in June. He noted that tidal creeks are important nursery areas for these species. Dovel (1971) reported the greatest captures of young of all 3 species in waters with salinities of 4 or more ppt. Our sampling design precludes a definite statement concerning the causality of the low captures of silverside larvae in the C&D area; the C&D area, a relatively freshwater area over the length of the transect, may be relatively unimportant as a nursery area for these three species, or our sampling design with stations in midchannel may have precluded adequate representation of silverside larvae in our samples.

Table 14. Capture of silverside larvae in 1971.

A. Capture by date. Combined data over ETI.

Date	Number of Samples	Number Taken	CI(i)
13 June	14	5	97.11
23	24	5	56.65
30	25	17	184.90
7 July	26	12	125.50
15	24	13	147.29
22	18	16	241.70
27	20	10	135.96
4 August	24	6	67.98
11	19	2	28.62
18	24	2	22.66
25 September	24	1	11.33
Total	242	89	

B. Capture by station. Combined data over ETI.

S2	14	4	77.69
NE1	21	14	181.27
CB2	16	14	237.92
E1	20	6	81.57
E3	22	19	234.83
E5	21	11	142.43
C2	22	8	98.88
C4	21	3	38.84
C6	19	6	85.87
C8	19	2	28.62
R10	18	2	30.21
PPI	19	0	0
C27	10	0	0
Total	242	89	

FAMILY BELONIDAE

STRONGLYURA MARINA (WALBAUM) ATLANTIC NEEDLEFISH

A total of 2 needlefish juveniles was taken in 1971: June 30, NE2 surface, 1 (32 mm TL); July 7, E5 surface, 1 (33.3). De Sylva et. al(1962: 23) reported captures of young Atlantic needlefish throughout the Delaware River estuary during the warmer months of the year. Smith (1971: 45) reported that the smallest specimens in his study area, 27 - 28 mm TL, were taken on June 4 and 9 respectively.

FAMILY HEMIRHAMPHIDAE

HEMIRHAMPHUS BRASILIENSIS (LINNAEUS) BALLYHOO

The remarkable capture of 1 (13.0 mm SL) juvenile of this species on May 7, 1971, at C5 (surface), will be documented in a paper by Johnson and Hardy, now in manuscript form.

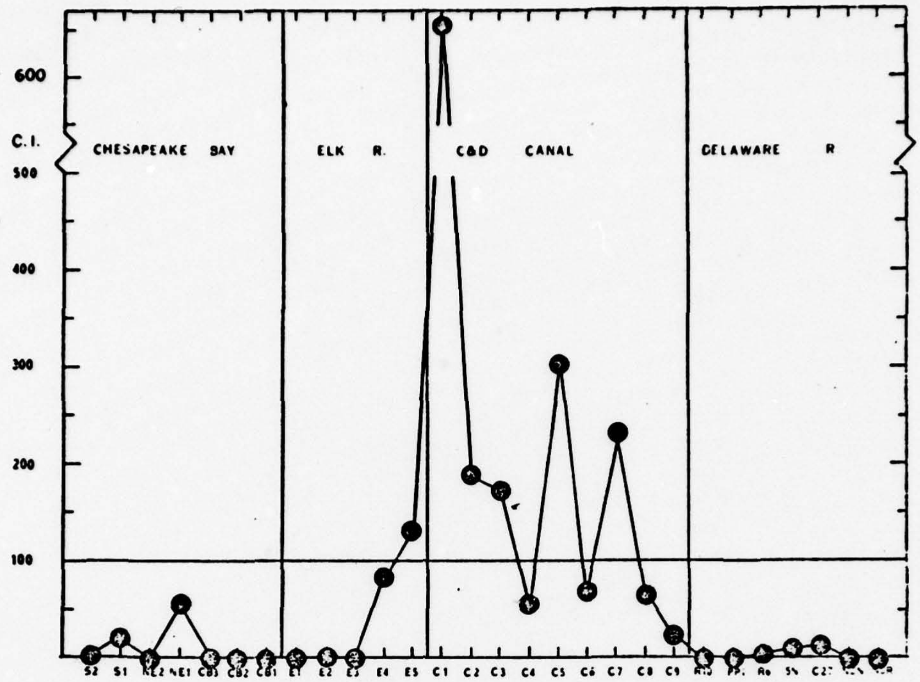
FAMILY PERCICHTHYIDAE

MORONE AMERICANA (GMELIN) WHITE PERCH

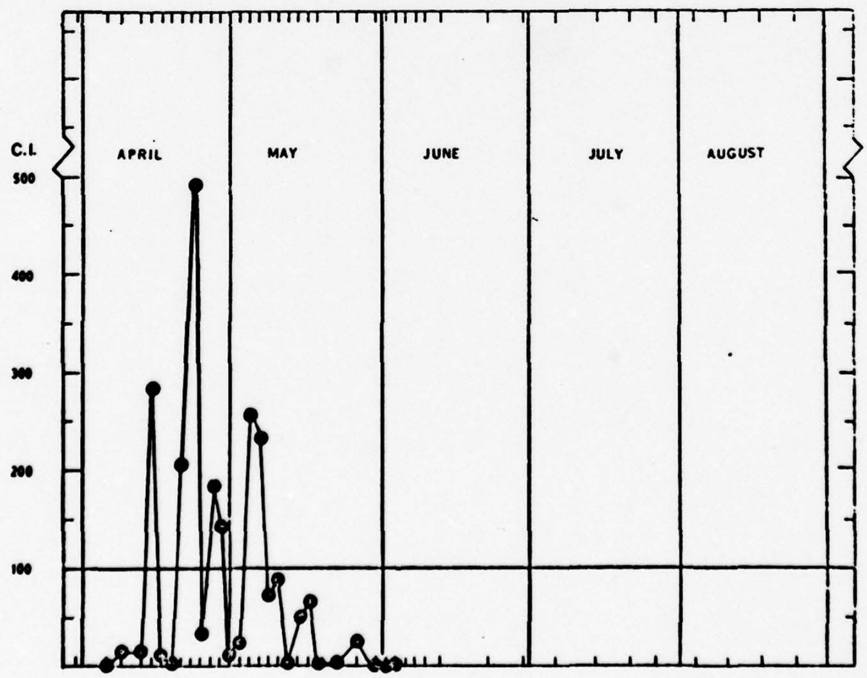
A total of 8121 white perch eggs (1020 in top nets = 12.56%; 7101 in bottom nets = 87.44%) was taken in 1971. Raw data is given in Table A6. Comparison of captures in top and bottom nets revealed highly significant ($p < .01$) agreement with respect to time and geography (Table 4). The effective time interval was April 6 to June 4. Five consecutive sampling days, April 21 - 29, accounted for 51.68% of the total catch of white perch eggs. Water temperatures and salinities taken in 1971 are given in Table B1.

Capture indices (Fig. 15) show peak captures in the C&D Canal and Elk River, with lesser peaks at Chesapeake Bay stations, especially NE1. Rank-abundance data for white perch eggs is presented in Table 15. The concordance value for the raw data (Table 15A) is highly significant ($.005 < p < .01$). Only 0.47 % of the total capture of white perch eggs was recovered from Delaware River stations. These were excluded from the analysis of the pooled raw data (Table 14B) and the data were analyzed in the same fashion as the data for Alosa spp. eggs (Table 9). The concordance value is significant ($.01 < p < .025$).

A total of 17545 white perch larvae (1953 in top nets = 11.13%; 15592 in bottom nets = 88.87%) was taken in 1971 (but see discussion of Morone spp. larvae under the account of striped bass captures) . Raw data is given in Table A7. Comparison of captures in top and bottom nets revealed significant ($p < .01$) agreement with respect to time but lack of agreement ($p > .20$) with respect to geography (Table 4). Thus data from top and bottom net hauls were analyzed independently.



A By station.



B By date.

Fig. 15. CI(i) for white perch eggs, 1971. Combined data over ETI.
C = 8121 E = 790 ETI = April 6 to June 4

Table 15. Part A. Rank-abundance by station of capture of white perch eggs, 1971. Ranks given in this table are based on raw data given in Table A6. Dates include April 9 - May 1. The 10 sampling dates accounted for 79.76 % of the total capture of white perch eggs and the 14 stations included accounted for 96.39% of the white perch eggs taken on these 10 dates.

Date	Number Taken	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9
		(rank-abundance by station)													
9	56	4.5	4.5	4.5	9.5	9.5	14	11	13	12	4.5	4.5	4.5	4.5	4.5
13	52	5.5	5.5	5.5	5.5	11.5	13	14	5.5	11.5	5.5	5.5	5.5	5.5	5.5
15	987	7.5	10	3.5	3.5	9	14	13	12	11	7.5	3.5	3.5	3.5	3.5
17	45	4.5	4.5	9.5	4.5	4.5	4.5	4.5	4.5	4.5	9.5	12	13	11	14
21	949	2.5	2.5	2.5	12	8	14	11	10	6	13	2.5	9	6	6
23	1727	4.5	4.5	4.5	4.5	9	4.5	4.5	4.5	4.5	14	12	13	11	10
25	103	3	7.5	7.5	7.5	10.5	14	12	10.5	7.5	3	3	3	3	13
27	917	3.5	3.5	3.5	3.5	9	14	11	3.5	10	12	7.5	13	3.5	7.5
29	500	1	4.4	2	9	13.5	12	10	6	11	4.5	7.5	7.5	13.5	3
1	57	5.5	5.5	5.5	5.5	5.5	13	5.5	5.5	5.5	5.5	5.5	11	14	12

$\chi^2_3 = 28.913$ $.005 < p < .01$

Table 15. Part B. Rank-abundance by station of capture of white perch eggs, 1971. Capture data from Table A6. Effort data from Table 1. Dates: April 13 - 29; May 1 - 15. Pooled raw data for the 15 included sampling dates accounts for 97.41 % of the white perch eggs taken in 1971. Zones as defined in Table 9.

Date	N	Chesapeake Bay	Elk River	Canal I	Canal II
A. Raw data: given as capture(effort for each zone for each date.					
13	52	2(6	1(10	49(8	0(10
15	987	147(6	13(10	826(8	1(10
17	45	2(10	1(10	0(8	41(10
21	949	0(14	100(10	729(8	119(10
23	1727	40(6	3(10	0(8	1684(10
25	103	8(2	6(10	84(8	5(10
27	917	4(14	24(10	717(8	154(9
29	500	2(4	138(10	348(8	150(8
1	57	0(8	0(10	12(8	41(10
3	72	0(2	0(10	0(7	72(8
5	753	0(6	121(8	630(9	2(8
7	1084	5(14	472(10	594(7	13(8
9	267	21(6	63(10	183(8	0(8
11	291	35(6	73(8	181(5	2(4
15	107	0(4	27(8	41(5	39(4
B. Ranks of resulting capture indices for each zone for each date.					
13		3	2	4	1
15		3	2	4	1
17		3	2	1	4
21		1	2	4	3
23		3	2	1	4
25		3	2	4	1
27		1	2	4	3
29		1	2	4	3
1		1.5	1.5	3	4
3		2	2	2	4
5		1	3	4	2
7		1	3	4	2
9		2	3	4	1
11		2	3	4	1
15		1	2	3	4

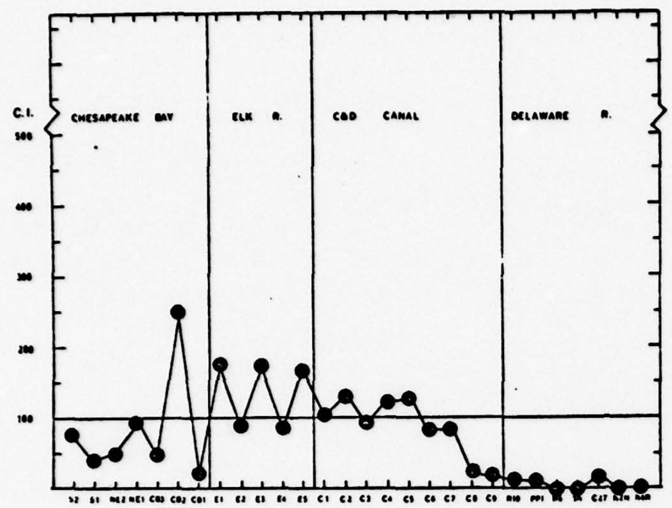
$W_{15,4} = .225$ $.01 < p < .05$ $\chi^2_3 = 10.14$ $.01 < p < .025$

The effective time interval was April 19 to July 27. Seven consecutive sampling days, May 23 to June 8, accounted for 46.76% of the total white perch larvae taken.

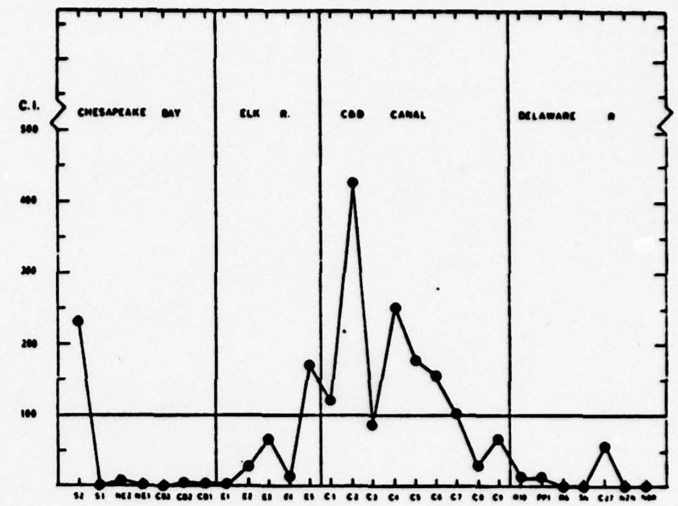
Capture indices (Fig. 16) reveal the lack of agreement between top and bottom net captures with respect to stations. Peak captures in top net hauls (Fig. 16C) were in the C&D Canal. The peak at station S2 resulted from the capture of 186 white perch larvae in a single surface net haul on June 23, representing 98.93 % of the total white perch larvae taken at this station. Peak captures resulting from bottom net hauls (Fig. 16D) are fairly evenly spread over the more freshwater portions of the C&D Transect, especially the Elk River stations and CB2. Rank-abundance data for top net captures (Table 16) and bottom net captures (Table 17) are in both cases highly concordant ($p < .005$).

The length-at-capture diagram (Fig. 17) shows that at first appearance in C&D samples in April, white perch larvae are 2.5 - 3.2 mm TL. Divergence of the two lines, ie divergence of the line connecting the upper means from that connecting the lower means, is probably related to growth (upper line) vs. continued input of small larvae (lower line) respectively. Length at capture data are included on this diagram for Morone spp. but will be discussed under the account of striped bass.

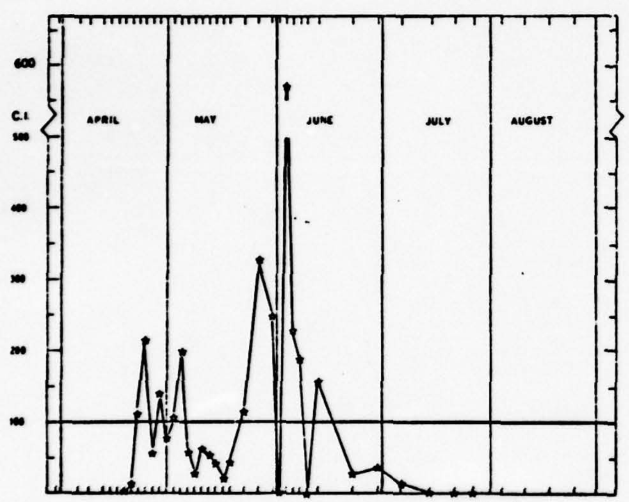
Identification of white perch eggs and larvae and of striped bass eggs and larvae was based almost entirely on information provided by Mansueti (1958, 1964). The problems involved in distinguishing ca 7 - 11 mm TL specimens of white perch from striped bass specimens of the same size is discussed under the latter species.



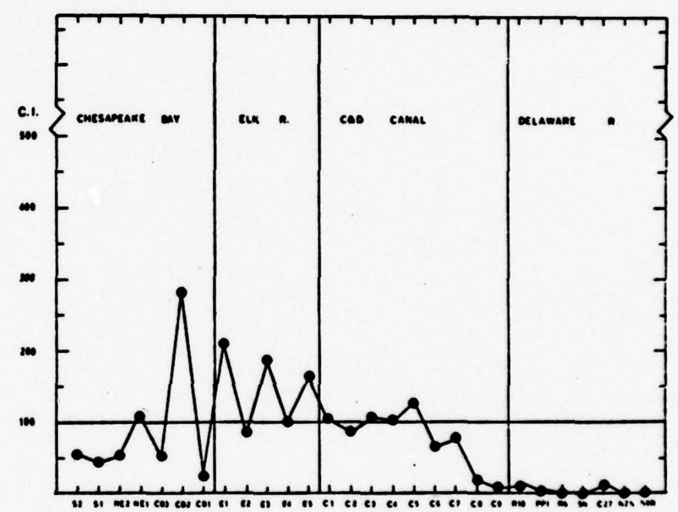
A By station. Combined data.
C = 17545 E = 805



C By station. Top net captures.
C = 1953 E = 404



B By date. Combined data.
C = 17545 E = 805



D By station. Bottom net captures.
C = 15592. E = 401.

Figure. 16. CI(i) for white perch larvae, 1971.
ETI = April 19 - July 27.

Table 16. Rank-abundance by station of capture of white perch larvae, 1971.
TOP NET captures only.
Capture data from Table A7. Effort data from Table 1.
Dates: April 21 - 27; May 1 - 31; June 4 - 30.
The 13 sampling dates included accounted for 69.99% of all white perch larvae taken in top net hauls in 1971.
Zones as defined in Table 6.

Date	N	Chesapeake Bay	Elk River	C&D Canal	Delaware River
A. Raw data: given as capture(effort for each zone for each date.					
21	6	0(7	0(5	6(8	4(2
27	58	0(7	4(5	53(9	1(4
29	163	0(2	0(5	126(9	37(2
1	71	0(4	39(5	30(9	2(2
7	121	1(7	0(5	108(8	12(3
9	16	0(3	4(5	12(8	0(1
11	17	1(4	2(4	13(5	1(3
23	190	186(3	0(3	3(4	1(2
27	512	0(3	153(3	353(3	6(3
31	40	5(3	29(3	5(4	1(3
4	78	0(3	3(4	71(5	4(3
8	85	0(1	0(3	84(5	1(2
30	10	0(3	0(3	10(3	0(3
B. Ranks of resulting capture indices for each zone for each date.					
21		2	2	4	2
27		1	3	4	2
29		1.5	1.5	3	4
1		1	4	3	2
7		2	1	4	2
9		1.5	3	4	1.5
11		1	3	4	2
23		4	1	3	2
27		1	3	4	2
31		3	4	2	1
4		1	2	4	3
8		1.5	1.5	4	3
30		2	2	4	2

$W_{13,4} = .380 \quad p < .01$ $\qquad X^2_3 = 14.84 \quad p < .005$

Table 17. Rank-abundance by station of capture of white perch larvae, 1971. BOTTOM NET captures only.
Dates: April 21 - 29; May 1 - 31; June 4 - 30; July 7 - 15.
The 17 sampling dates included accounted for 70.81% of the total white perch larvae taken. Zones as defined in Table 6.

Date	N	Chesapeake Bay	Elk River	C&D Canal	Delaware River
A. Raw data: given as capture(effort for each zone for each date.					
21	130	3(7	105(5	22(9	0(3
27	533	144(7	242(5	139(7	8(3
29	874	38(2	511(5	263(7	62(2
1	620	15(4	283(5	316(9	6(2
7	465	109(7	102(5	224(8	30(3
9	209	13(3	73(5	123(8	0(1
11	403	216(4	137(4	48(4	2(3
19	271	206(3	50(4	1(4	14(3
23	419	277(3	135(3	7(4	0(2
27	1125	770(3	153(3	189(3	13(2
31	1215	1034(3	180(2	0(2	1(3
4	3526	207(3	2848(4	428(5	43(2
8	825	96(1	621(3	101(5	7(2
23	141	50(3	56(2	35(4	0(3
30	189	52(3	73(3	46(4	18(3
7	91	45(3	8(3	38(4	0(3
15	5	1(3	0(3	3(4	1(3
B. Ranks of resulting capture indices for each zone for each date.					
21		2	4	3	1
27		3	4	2	1
29		1	4	3	2
1		2	4	3	1
7		2	3	4	1
9		2	3	4	1
11		4	3	2	1
19		4	3	1	2
23		4	3	2	1
27		4	2	3	1
31		4	3	1	2
4		2	4	3	1
8		3	4	2	1
23		3	4	2	1
30		3	4	2	1
7		4	2	3	1
15		2.5	1	4	2.5

$W_{17,4} = .449$ $p < .01$ $\chi^2_3 = 22.89$ $p << .005$

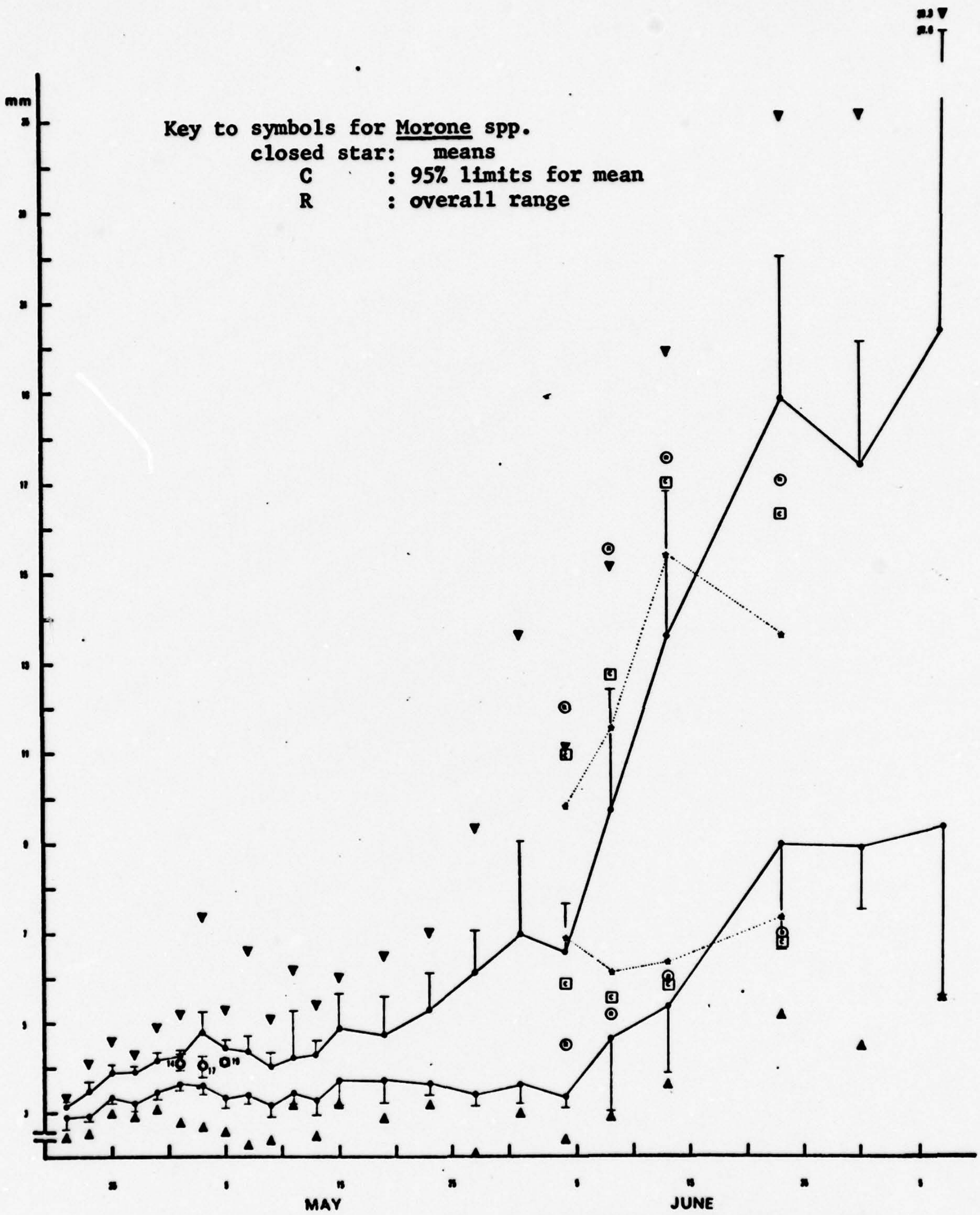


Fig. 17. Length at capture diagram for white perch larvae, 1971.
Explanation of symbols at base of Figure 7.
Solid line connects means of white perch larvae.
Dotted line (June only) connects means of Morone spp. larvae.

Discussion

Reproduction, growth, and ecology of white perch populations in Chesapeake Bay tributaries are discussed by Mansueti (1961, 1964). The white perch is euryhaline and found in estuarine and freshwater habitats from Nova Scotia to South Carolina. The largest concentrations of white perch are found in waters with salinities of 5 - 18 ppt. This species is semi-anadromous, ascending tributary streams, to spawn in tidal fresh or brackish water (Mansueti 1964). Smith (1971) found that white perch utilized all 4 tidal streams studied by him as spawning sites, and that spawning occured from early April to late May at temperatures of 11.0 - 19.0° C. This agrees closely with Mansueti's (1964) statement the spawning occurs from April to early June at 10 - 15° C. In the C&D samples white perch eggs were recovered from early April to early June. The eggs of the white perch are spherical (except for the attachment disk, when visible), markedly adhesive, of relatively high specific gravity, and demersal (Mansueti 1964). Dovel (1971) stated that white perch eggs recovered from his upper bay samples had been deposited upstream, and that only those dislodged and transported by stream flow were recovered. In the C&D material the ratio of striped bass eggs (semibuoyant, emersal) to white perch eggs (nonbuoyant, demersal) was 12.2: 1; whereas the ratio of striped bass larvae to white perch larvae was 1 to 4.2. There exists little doubt that the production of white perch eggs in the C&D area is not adequately reflected in their recovery from C&D samples.

White perch eggs hatch into tadpole like prolarvae in 44 - 50 h at 65° C. (Mansueti 1964). Dovel (1971) found the greatest numbers of white perch larvae in freshwater or waters of low salinity. This corresponds well with the results from the C&D study in which most of the white perch larvae were recovered from the Chesapeake Bay and Elk River stations. Dovel (1971:5) notes that while spawning occurs over a relatively short period of time, variations in hatching dates contribute to a large size range exhibited by individuals of the same year class during the first summer. This is markedly seen in the length-at-capture data illustrated in Fig. 17.

Smith (1971) noted the white perch as a year round resident in the Delaware River estuary and the dominant fish (in terms of numbers) in his study area. In view of the high probability (see Dovel 1971 and discussion under striped bass below) that most of the 7494 young fishes listed as Morone spp in this report are white perch, white perch larvae and juveniles dominated our catches.

MORONE SAXATILIS (WALBAUM) STRIPED BASS

Results of 1971 Sampling Year

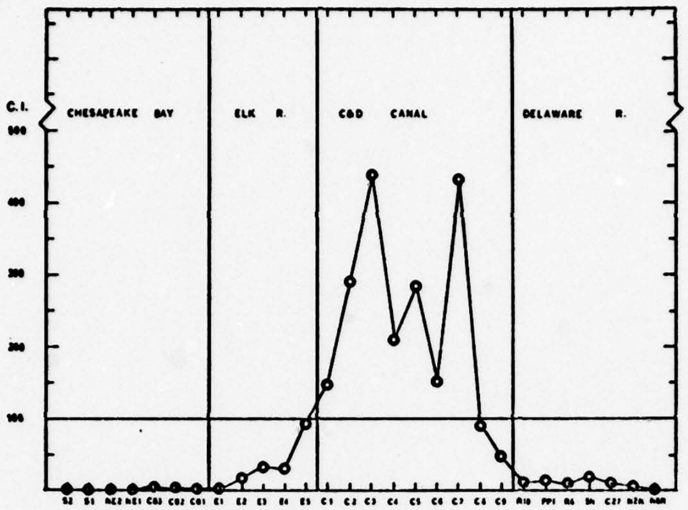
A total of 60,030 striped bass eggs (23,329 in top nets = 38.86%; 36701 in bottom nets = 61.14%) was taken in 1971. Raw data is given in Tables A8 and A9. Comparison of captures in top and bottom nets revealed highly significant ($p < .01$) agreement with respect to time and geography (Tables 2,3,4). The effective time interval was April 15 to June 13. Five consecutive sampling days, April 23 to May 1, accounted for 76.63% of the total catch of striped bass eggs. Water temperatures and salinities taken in 1971 are given in Table B1.

Capture indices (Fig. 18) show peak captures in the Chesapeake and Delaware Canal. Rank-abundance data for striped bass eggs is presented in Tables 5 and 6. The data sets, both raw and pooled, are highly concordant ($p < .005$).

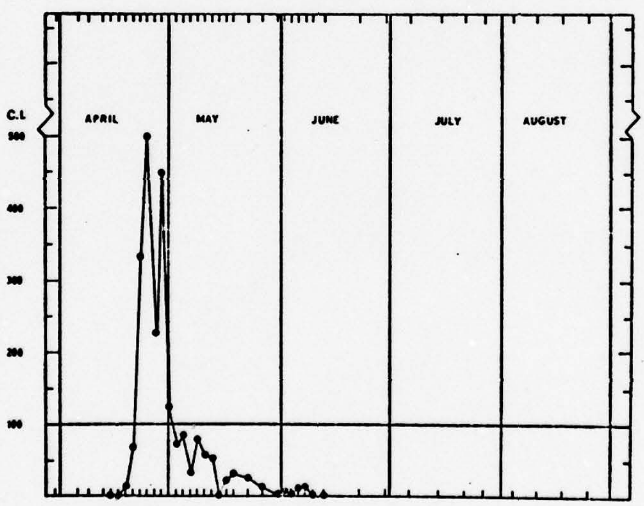
Concentrations of striped bass eggs (number/ m^3) are presented in Table 17. These concentrations, up to 36 eggs/m^3, are the highest for which I have been able to find records (note that estimates in Table 17 are based on non-replicated tows).

A total of 4196 striped bass larvae (587 in top nets = 13.99%; 3609 in bottom nets = 86.01%) was taken in 1971. Raw data is given in Tables A10 and A11. Comparison of captures in top and bottom nets revealed highly significant agreement ($p < .01$) with respect to time and geography (Table 4).

The effective time interval was April 21 to June 30. Five consecutive sampling dates, April 29 to May 7, accounted for 51.75% of the total catch.



A By station.



B By date.

Fig. 18. CI(i) for striped bass eggs, 1971. Combined data over ETI: April 15 to June 13.

C = 60030 E = 747

Table 17. Calculated concentrations of striped bass eggs during period of peak capture, April 23 - May 1, 1971. Expressed as number/ m^3. This period accounted for 76.63% of the total catch in 1971. Given as top and bottom results in that order for each sampling date.

F = no flowmeter reading available

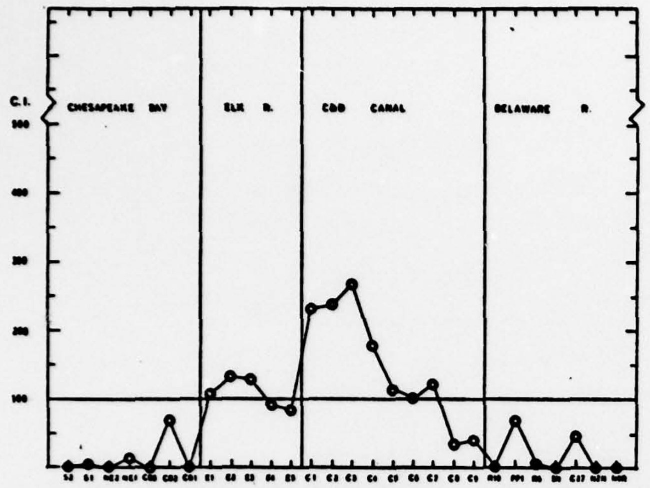
* = based on average value of 94 m^3 filtered/haul

Date	Number Taken	S2	S1	NE2	NE1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	R10	PP1	C27	N2N
April 23	3647	-	0	-	0	-	-	0	0	.009	0	.009	.009	0	.025	1.161	1.392	6.549	9.341	21.833	1.902	.532	-	-	-	-
	5489	-	0	-	0	-	-	.055	.048	.644	.353	.914	1.485	.245	.667	3.422	5.961	9.554	16.186	26.700	.256	.716	-	-	-	-
25	3496	-	-	-	-	-	-	0	0	0	0	F	0	F	.184	.838	1.915	8.361	4.890	13.163	10.547	2.584	-	-	-	-
	8546	-	-	-	-	-	-	.007	0	.010	.182	.298	.484	.609	.916*	1.474*	2.484*	14.789*	14.474*	36.253*	15.716*	2.290*	-	-	-	-
27	5344	0	0	0	0	0	0	0	0	.028	.029	0	.225	.226	26.511	15.077	8.940	2.753	2.416	1.716	.611	.461	.130	.264	.376	-
	3262	0	0	0	0	.071	F	0	.104	.010	.505	.048	.058	6.409	18.053	-	6.000	4.115	.268	2.290	-	.312	.084	.036	.676	-
29	5564	-	-	0	-	-	-	0	0	0	.085	.115	.755	1.919	15.531	16.845	11.277	4.017	2.065	1.319	.959	.426	-	-	.457	.118
	6663	-	-	.019	-	-	-	.118	.069	.120	1.794	1.628	5.505	11.650	17.112	17.200	18.299	-	-	1.180	1,324	.079	-	-	.598	0
May 1	1126	0	-	-	0	-	0	0	.009	.009	0	.010	1.196	1.045	3.345	4.475	.447	.350	.035	.059	.349	.083	-	F	.128	-
	2858	0	-	-	.013	-	.029	.010	.093	0	.426	F	1.733	11.676	5.011	5.079	1.933	.138	.310	.333	.135	.417	-	F	F	-

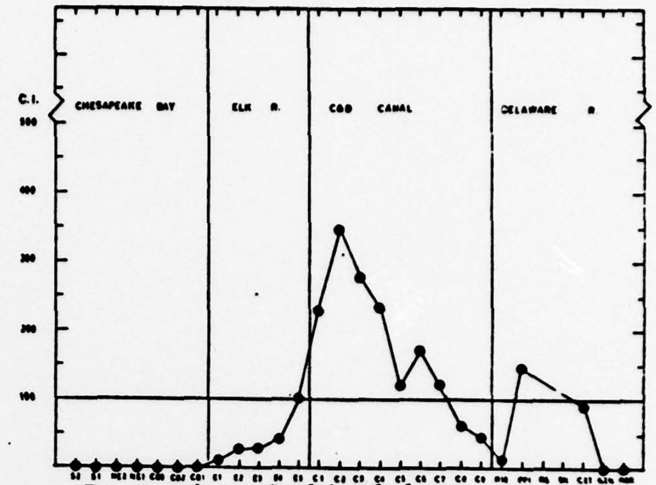
Capture indices (Fig. 19) reveal peak captures in the Elk River and C&D Canal. At first captures were highest in the C&D Canal but later were highest in the Elk River (Fig. 19D). It should be noted that the peak at station E2 is almost entirely the result of one net haul. Of three samples taken at this station from May 13 to June 4, 173/176 specimens were taken in one bottom net haul (Table A11). Rank-abundances (Table 18) for both raw (Table 18A: $p < .005$) and pooled (Table 18B: $.005 < p < .01$) data are highly concordant.

The length-at-capture diagram (Fig. 20) shows that at first appearance in C&D samples in April, striped bass larvae are usually 2.8 - 5.0 mmTL. Divergence of the line connecting the upper means from the line connecting the lower means is no doubt related to growth (upper line) vs continued input of small larvae (lower line).

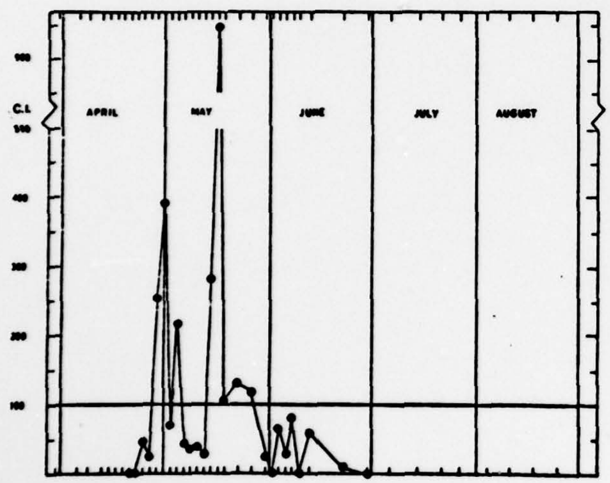
Identification of striped bass eggs and larvae was based almost entirely upon information provided by Mansueti (1958, 1964). Identification of striped bass eggs presented no problem. As Dovel (1971: 6) has pointed out, identification of striped bass and white perch larvae less than 6.0 mm TL is relatively easy. Juveniles of these two species exceeding ca 12.0 mm TL can be separated on the basis of anal fin counts, except for those individuals whose total anal fin elements equals 13. However, we were unable to separate most of the larvae of the two species within the 6.0 - 12.0 mm TL size range. Despite considerable effort toward providing reliable characters for identification of larvae within this size range, a total of 7511 larvae, taken between April 15 and July 7, could not positively be identified, and



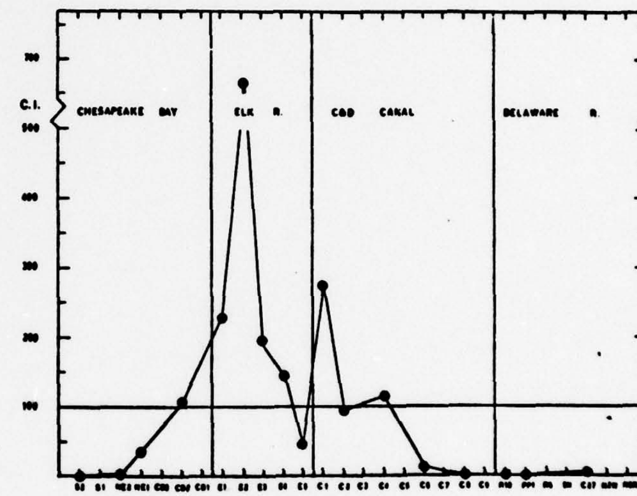
A By station. Combined data over ETI.
ETI: April 21 - June 30.
C = 4196 E = 661.



C By station. Combined data.
April 25 - May 11, 1971.
C = 2483 E = 318



B By date. Combined data over ETI.
ETI: April 21 - June 30.
C = 4196 E = 661.



D By station. Combined data.
May 13 - June 4, 1971.
C = 1498 E = 170.

Fig. 19. CI(i) for striped bass larvae, 1971.

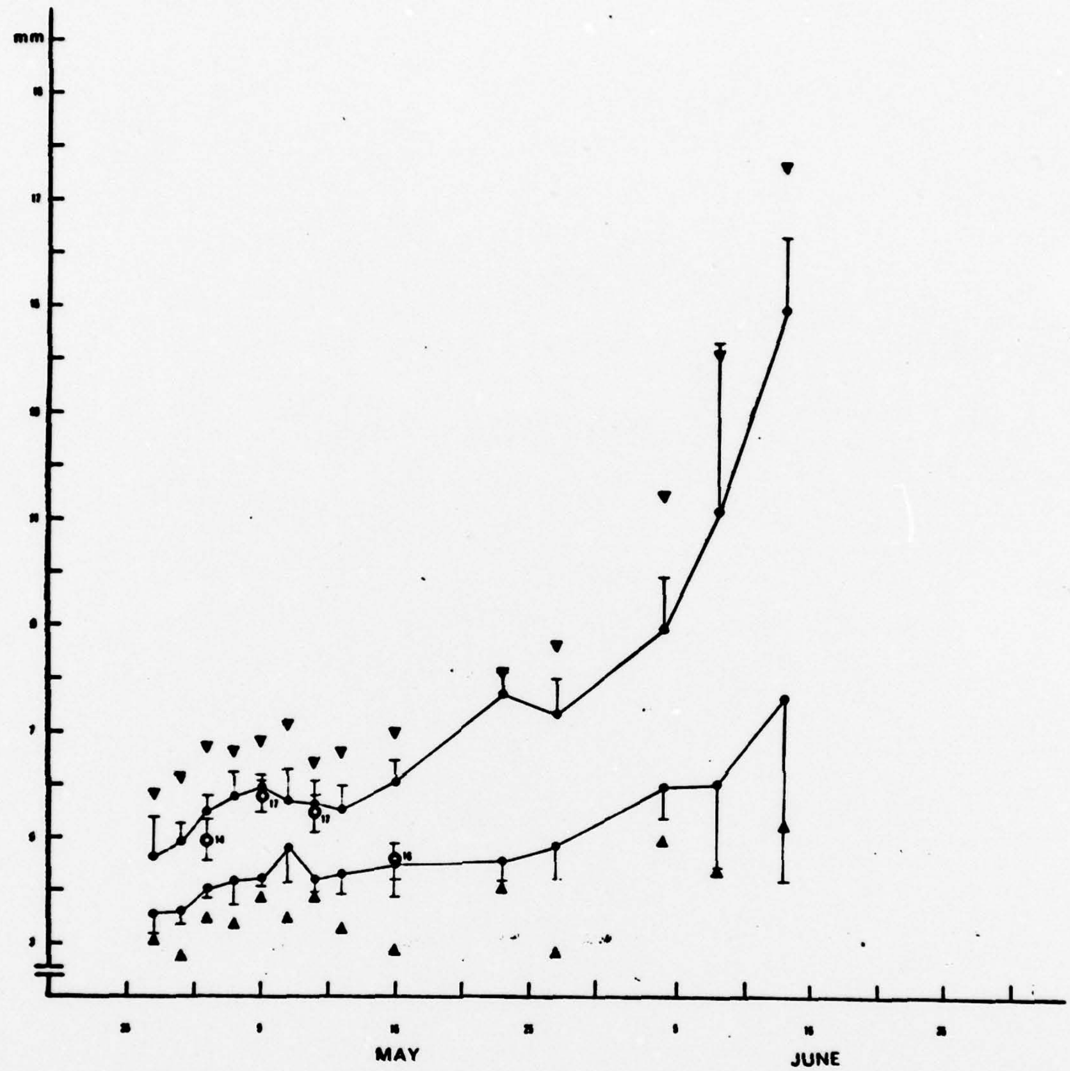


Fig. 20. Length-at-capture data for striped bass larvae, 1971. Explanation of symbols at base of Fig. 7.

Table 18. Part A. Rank-abundance by station of capture of striped bass larvae, 1971. Ranks given in this table are based on raw data given in Table A10. Dates include April 27 - June 13. These 15 sampling dates accounted for 84.75% of the total capture of striped bass larvae and the 8 stations included accounted for 55.91% of the striped bass larvae taken on these 15 dates.

Date	Number Taken	NE1	E1	E3	E5	C2	C4	C6	C8
		(rank-abundance by station)							
27	76	3	3	6	3	3	3	8	7
29	541	1	2	3	5	8	7	4	6
1	993	1	2	5	7	8	6	4	3
3	119	1.5	1.5	6	8	3	7	4.5	4.5
5	399	1.5	1.5	3	4	5	7	8	6
7	119	2.5	2.5	2.5	5	7	8	6	2.5
9	77	3	3	3	6	7	8	3	3
11	73	1.5	1.5	4.5	8	6.5	6.5	4.5	3
15	376	3	3	7	6	8	3	3	3
19	186	2.5	8	7	6	5	2.5	2.5	2.5
23	204	1	7	8	5	6	3	3	3
27	174	3	2	4	5	6	8	7	1
31	50	8	7	3.5	3.5	3.5	3.5	3.5	3.5
8	114	4	8	6	7	5	2	2	2
13	55	3	4	5	7	6	8	1.5	1.5

$W_{15,8} = .227$ $p < .01$ $\chi^2_7 = 23.85$ $p < .005$

Table 18. Part B. Rank-abundance by station of capture of striped bass larvae, 1971. Capture data from Table A10. Effort data from Table 1. Dates April 21 to June 23. Pooled raw data for the 14 sampling dates included accounts for 65.85% of the striped bass larvae taken in 1971. Zones as defined in Table 6.

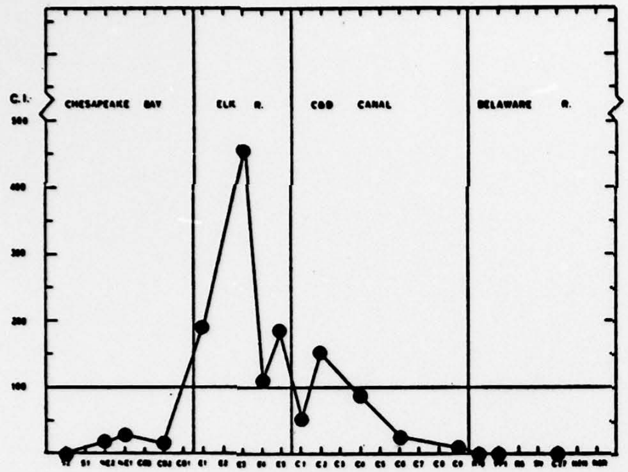
Date	N	Chesapeake Bay	Elk River	C&D Canal	Delaware River
A. Raw data: given as capture(effort for each zone for each date.					
21	14	4(14	6(10	3(17	1(5
27	76	0(14	4(10	66(16	6(8
29	541	0(4	25(10	460(16	56(4
1	993	0(8	157(10	648(18	88(4
7	119	0(14	3(10	83(15	33(6
9	77	0(6	3(10	74(16	0(2
11	73	2(8	39(8	31(9	0(6
19	186	33(6	150(8	1(8	2(6
23	204	53(6	123(6	28(8	0(4
27	174	15(6	24(6	130(6	5(5
31	50	47(6	3(5	0(6	0(6
4	123	3(6	108(8	12(10	0(5
8	114	1(2	80(6	33(10	0(4
23	19	2(6	6(5	11(7	0(6
B. Ranks of resulting capture indices for each zone for each date.					
21		3	4	1	2
27		1	2	4	3
29		1	2	4	3
1		1	2	4	3
7		1	2	4	3
9		1.5	3	4	1.5
11		2	4	3	1
19		3	4	1	2
23		3	4	2	1
27		2	3	4	1
31		4	3	1.5	1.5
4		2	4	3	1
8		2	4	3	1
23		2	3	4	1

$W_{14,4} = .285$ $p < .01$ $\chi^2_3 = 11.98$ $.005 < p < .01$

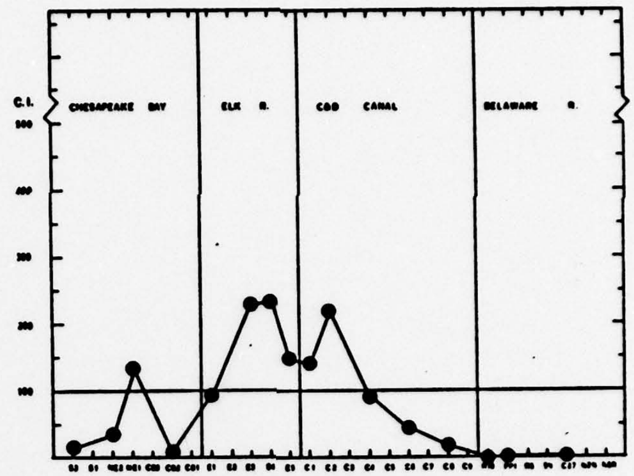
were termed *Morone* spp. Of these 7511 specimens, 15 (0.20%) were taken prior to June 4 and 2 (0.027%) after June 30, and subsequent analysis was based on fish recovered from samples taken from June 4 - 30 inclusive. During this time period totals of 7494 *Morone* spp. larvae (183 in top nets = 2.44%; 7311 in bottom nets = 97.56%), 5523 white perch larvae (248 in top nets = 4.49%; 5275 in bottom nets = 95.51%), and 320 striped bass larvae (16 in top nets = 5.00%; 304 in bottom nets = 95.00%) were taken. The ratio of identified white perch to identified striped bass larvae during this period of time, 17.26: 1, is close to Dovel's (1971:6) estimate of the capture ratio of white perch: striped bass larvae of comparable stages of development in the upper Chesapeake : 23: 1. This implies that ca 95% of the 7511 *Morone* spp larvae are in fact white perch larvae. Comparison of capture indices (Fig. 21) shows peak captures of all 3 categories of larvae in the Elk River and western portion of the C&D Canal during the time period, T = June 4 - 30. Calculation of concordance and tau values (Table 20) revealed highly significant agreement between captures of striped bass larvae, white perch larvae, and *Morone* spp. larvae during this time period, and thus the capture indices for combined data for all 3 categories (Fig. 21D) adequately illustrates the distribution of both white perch larvae and striped bass larvae in the C&D area during June, 1971.

Results of 1972 Sampling Year

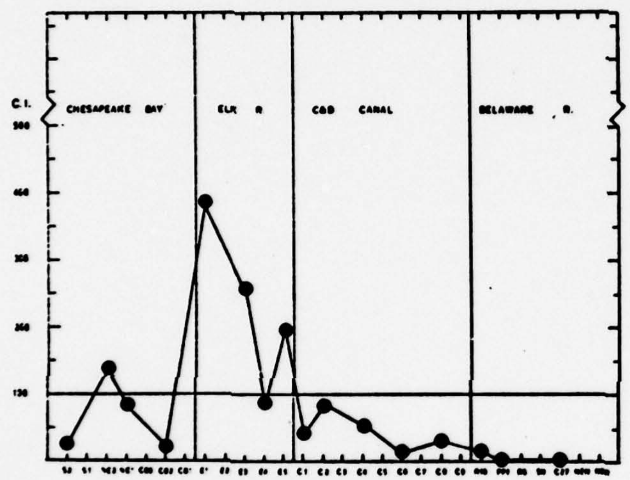
A total of 83918 striped bass eggs was taken in 1972 from a total of 445 samples. The effective time interval was April 10 to June 15. Samples taken on May 1-2 accounted for 54.94% of the



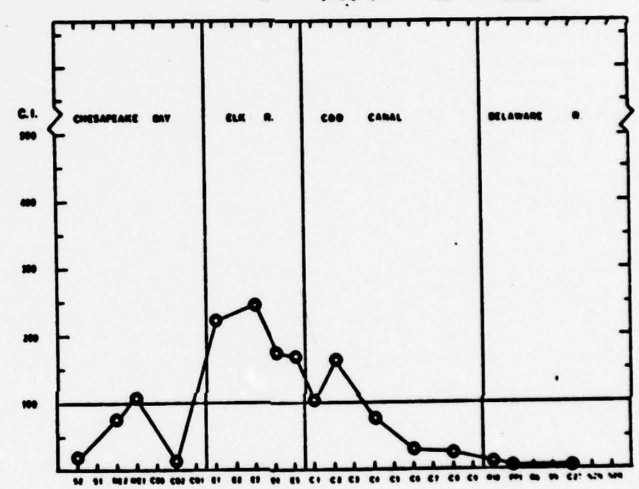
A Striped bass larvae.
C = 320 E = 122



C *Morone* spp. larvae.
C = 7494 E = 122



B White perch larvae.
C = 5523 E = 122



D Combined data, all 3 categories.
C = 13337 E = 122

Fig. 21. CI(i) for striped bass larvae, white perch larvae, and *Morone* spp. larvae, 1971. Combined data over T = June 4 - 30.

Species	Number Taken	S2	S1	NE2	NE1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	R10	PPI	R6	R5	C27	N2N	NBR
M. spp.	7494	54	-	43	670	-	44	-	537	-	1391	877	917	699	1339	-	586	-	226	-	95	-	0	2	-	-	14	-	-
W. P.	5523	77	-	128	293	-	65	-	1586	-	1161	251	895	170	376	-	260	-	48	-	140	-	51	16	-	-	6	-	-
S. B.	320	0	-	1	6	-	3	-	45	-	119	17	48	11	40	-	23	-	5	-	2	-	0	0	-	-	0	-	-
														Rank Abundance															
M. spp.		6	-	4	11	-	5	-	9	-	16	13	14	12	15	-	10	-	8	-	7	-	1	2	-	-	3	-	-
W. P.		6	-	7	12	-	5	-	16	-	15	10	14	9	13	-	11	-	3	-	8	-	4	2	-	-	1	-	-
S. B.		2.5	-	5	9	-	7	-	14	-	16	11	15	10	13	-	12	-	8	-	6	-	2.5	2.5	-	-	2.5	-	-
														Sum of Ranks															
		14.5	-	16	32	-	17	-	39	-	47	34	43	31	41	-	33	-	19	-	21	-	7.5	6.5	-	-	6.5	-	-

Concordance: W = .91

Chi-square, df = 15, = 40.941 $p < .001$

Tau values: W. P. cf. M. spp. $Tau_{16} = +.642$ $p < .01$

S. B. cf. M. spp. $Tau_{16} = +.750$ $p < .01$

S. B. cf. W. P. $Tau_{16} = +.750$ $p < .01$

M. spp. = Morone sp.
W. P. = M. *americana*, white perch
S. B. = M. *saxatilis*, striped bass

Table 20. Comparison of capture of striped bass larvae, white perch larvae, and Morone spp. larvae. Data pooled over T = June 4 - 30, 1971.

total number of striped bass eggs taken despite the expenditure of only 18.9% of the total effort on these two days. Temperature and salinity data taken in 1972 are presented in Table B2.

Major purposes of the sampling design established for 1972 included (1) estimation of the error associated with net hauls; and (2) determination of variability over short periods of time (6 hrs) of abundance at a given station with respect to other stations. Most hauls in 1972 were taken with the double net. Typical results for the 1972 sampling year are presented as Table 21, and they illustrate the extraordinary presumably systematic error seen in double net hauls. In almost all cases the outside (A) net captures were significantly higher than the inside(B) net captures, despite the fact that the nets were yoked together with only a 25 inch center-center separation. Flowmeter readings taken simultaneously in A and B nets were identical, and I am at a complete loss to explain the difference in catches. This error precluded making estimates of the error associated with a given net haul. Inclement weather, especially heavy rain and fog, as well as large amounts of floating debris in the canal, resulted in aborted efforts at night on a sufficient number of occasions, that blank values in the data plus the systematic net error precluded full accomplishment of our second major goal, ie analysis of short-term changes in abundance along the transect. The data presented in Table 21 is indicative of the information available to me on short-term changes in the C&D distribution of striped bass eggs. Finally the short period of time available for processing of samples forced us to limit our processing of 1972 samples for striped bass eggs only.

Table 21. Capture of striped bass eggs, May 1 - 2, 1971. Raw data.
Time is given in hours (24 h clock).
Key: A = A net capture B = B net capture
T = top net capture D = bottom net capture
RA = replicate (simultaneous) of A net haul
RB = replicate (simultaenous) of B net haul
Tide at Chesapeake City, Md. : F = flood E = ebb
FS = flood slack ES = ebb slack

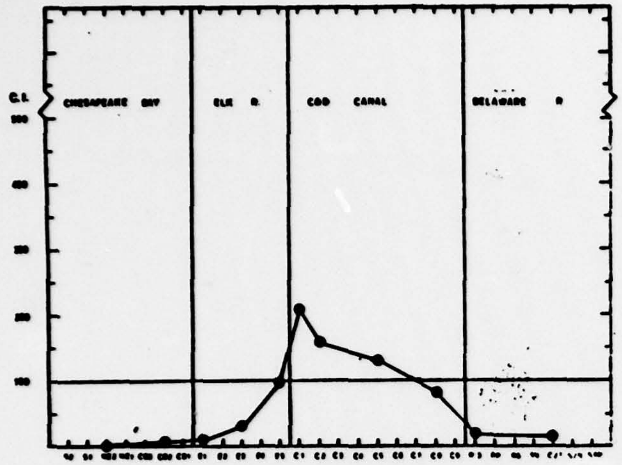
Time	NE2	CB2	E1	E3	E5	C1	C2	C5	C8	R10	C27
12-13FS	-	-	-	-	-	-	-	-	-	-	-
13-14E	-	-	-	-	-	-	1418A 522B	1773A 1454B	-	-	-
14-15E	-	-	-	-	-	-	-	-	961A 585B	24A 7B	14A -B
15-16E	-	-	-	-	-	-	-	-	-	-	-
16-17E	-	-	-	-	-	120A 76B	-	-	-	-	-
17-18E	-	-	-	-	-	-	-	-	-	-	-
18-19ES	-	-	-	-	-	-	-	-	-	-	-
19-20F	-	-	-	17A -B 217RA 328RB	979A 563B 1248RA 1811RB	777A 10B	-	-	-	-	-
20-21F	-	-	-	-	-	-	240A 10B 1422RA -RB	1304A 103B	-	-	-
21-22F	-	-	-	-	-	-	-	-	870A 227B	-	-
22-23F	-	-	-	-	765A 930B	1177A 1228B	-	-	-	-	-
23-24F	-	-	-	-	-	-	-	-	-	-	-
24-01FS	-	-	-	14A 8B	472A 376B 734RA 268RB	-	-	-	-	-	-
01-02E	-	-	-	-	-	600A 258B 1310RA 894RB	-	511A 411B	-	-	-
02-03E	-	-	-	-	-	-	1370A 1506B	-	1217A 704B	-	-
03-04E	-	-	-	-	-	-	-	-	-	-	-
04-05E	-	-	-	-	-	2327A 2050B	-	-	-	-	-
05-06E	-	-	-	-	-	-	-	-	-	-	-
06-07ES	-	-	-	-	-A 401B 1421RA -RB	944A 0B 1139RA 1084RB	-A 104B	-	-	-	-

Table 21. cont'd.

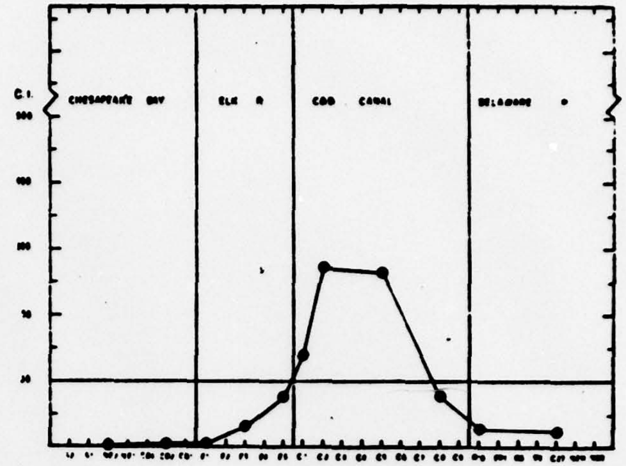
Time	NE2	CB2	E1	E3	E5	C1	C2	C5	C8	R10	C27
07-08F	-	-	-	-	-	-	-	1107A 11B	207A 101B	-	-
08-09F	-	-	-	-	-	-	-	-	-	187A 43B	15A 3B
09-10F	-	-	-	-	-	-	-	-	-	-	-
10-11F	-	-	-	-	-	-	-	-	-	-	-
11-12F	-	-	-	-	-	-	-	-	-	-	-
12-13FS	-	-	-	-	-	-	1130D 561T	1615D 547T	1223D 598T	-	-
13-14E	-	-	-	15D 2T	551D 1T	2264D 1275T	-	-	-	-	249D 65T
14-15E	0D 1T	-	4D 0T	-	-	-	-	-	-	400D 137T	-
15-16E	-	0D 0T	-	-	-	-	-	-	-	-	-

Analysis of catch data for 1972 recovery of striped bass eggs from C&D samples followed much the same lines as the analysis of 1971 catch data. Analysis of double-net captures was limited to material recovered from A (outside) net samples. Each half of the double net was identical to the bottom net used in 1971 and 1972 sampling efforts and was fished at the same depth. Therefore the A-net captures and bottom net captures for each station for each sampling day were combined yielding a pooled data estimate of abundance by station for a ca 30h period. A total of 59159 striped bass eggs (47790 from A-net hauls = 80.78% and 11369 from bottom net hauls = 19.22%) was taken in combined A+bottom net hauls. Top and bottom net captures in 1972 resulted in 15298 striped bass eggs (3929 in top net hauls = 25.68%; 11369 in bottom net hauls = 74.32%). Comparisons of captures revealed significant agreement with respect to time (top vs bottom, $tau_{10} = .933$, $p < .01$; top vs A+bottom, $tau_{10} = .844$, $p < .01$) and geography (top vs bottom, $tau_{11} = .782$, $p < .01$; top vs A+bottom, $tau_{11} = .709$, $p < .01$) for all hauls made in 1972. Subsequent analysis was restricted to A+bottom net captures.

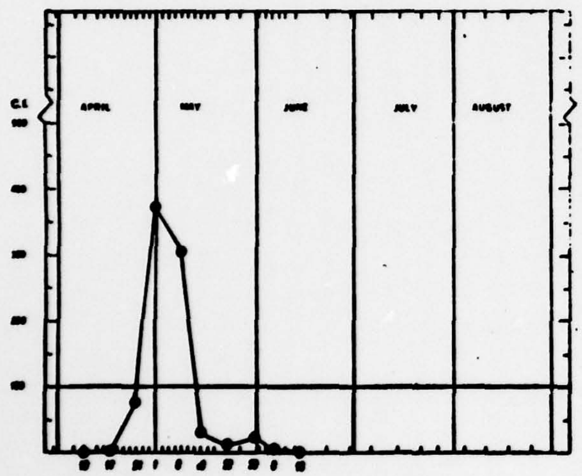
Capture indices (Fig. 22) revealed peak captures in the C&D Canal. Rank-abundance data is presented in Table 22 and is highly concordant ($p < .005$). There is striking agreement between 1971 and 1972 data with respect to catches over both time and geography. Catch data plotted as cumulative percent of total catch (for all 10 sampling dates in 1972 and for 10 sampling dates in 1971 nearest (in time) the sampling dates in 1972) are quite similar for the two years (Fig. 23). This similarity can also be seen in comparing capture indices with respect to time (Fig. 18B, 22B).



A By station, 1972.



C By station, 1971.



B By date, 1972.

Fig. 22. CI(i) for striped bass eggs, 1971 - 1972.

A,B: CI(i) for 1972 catch, over ETI = April 10 - June 15.
C = 59159 E = 288

C: CI(i) for part of 1971 catch (including those stations sampled in 1972) over ETI = April 15 - June 13.
C = 28062 E = 327

Table 22. Rank-abundance by station of capture of striped bass eggs, 1972. A+bottom net hauls. Data summed over ETI: April 10 - June 15 but calculation of concordance based on data from April 17 - June 7 inclusive. These 7 sampling dates accounted for 99.998% of the striped bass eggs taken in 1972 and the 8 stations included accounted for 99.78% of the striped bass eggs taken on these 7 dates.

Date	Number	NE2	CB2	E1	E3	E5	C1	C2	C5	C8	R10	C27
A. Raw data: given as capture(effort for each station for each date.												
10-11*	0(18	0(1	0(1	0(1	0(2	0(2	0(2	0(2	0(2	0(2	0(2	0(1
17-18	1(35	0(1	0(1	0(1	0(5	0(4	0(5	0(5	0(5	0(4	1(2	0(2
24-25	5675(36	-	-	7(1	278(5	1156(8	1208(6	1314(4	812(4	576(4	162(2	162(2
1-2	32011(42	0(1	0(1	4(1	46(3	5139(7	9579(9	5580(5	6310(5	4478(5	439(3	436(2
8-9	16911(27	-	-	89(1	1421(2	1673(4	6935(7	4712(7	1823(3	88(1	152(1	18(1
15-16	2328(35	0(1	9(1	11(1	156(4	290(4	671(4	828(4	218(4	76(4	55(4	14(4
22-23	867(36	-	-	0(1	251(6	237(6	139(5	115(5	107(5	2(4	5(2	11(2
30-31	1255(29	-	-	11(1	157(4	185(4	265(4	255(4	243(4	133(4	6(2	0(2
6	110(6	-	-	-	28(2	29(2	32(2	14(2	6(2	1(2	0(2	0(2
15	1(14	-	-	0(1	0(2	0(2	0(1	1(2	0(2	0(2	0(1	0(1
B. Ranks of resulting capture indices for selected stations for selected dates.												
24-25					1	4.5	6	8	7	4.5	2.5	2.5
1-2					1	4	6	7	8	5	2	3
8-9					7	4	8	6	5	2	3	1
15-16					3	6	7	8	5	4	2	1
22-23					8	7	6	5	4	1	2	3
30-31					4	5	8	7	6	3	2	1
6					6	7	8	5	4	3	1.5	1.5

$W_{7,8} = .635$ $p < .01$ $\chi^2_7 = 31.11$ $p < .005$

*the single striped bass egg taken on April 10 was taken in a B net haul.

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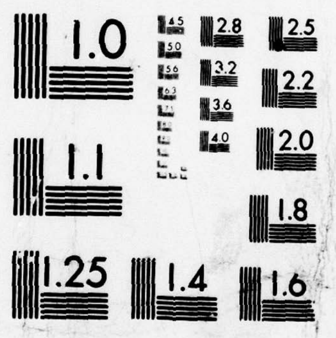


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

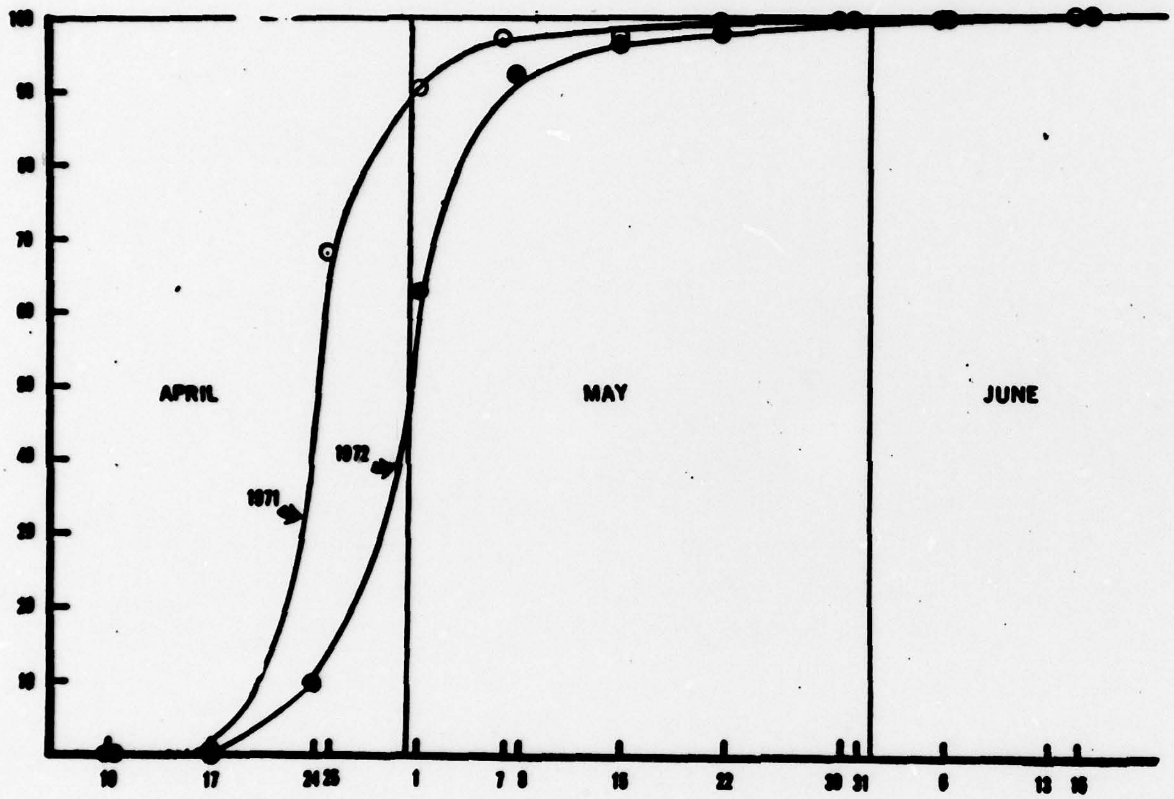


Fig. 23. Catch of striped bass eggs in 1971 (open symbols) and 1972 (closed symbols), plotted as cumulative percent of total catch by date.

Capture indices for 1971 and 1972 are compared in Table 23, and exhibit significant agreement with respect to time ($p = .02$) and striking agreement with respect to geography ($p < .01$).

Concentrations of striped bass eggs (Table 24) taken on May 1 - 2 were comparable with concentrations taken during peak captures in 1971 (Table 17).

Discussion

The striped bass is the most important commercial fish in Maryland. The annual commercial catch of this species along the Atlantic coast is nearly 9 million pounds with nearly 3.5 million pounds accounted for by Maryland alone. Maryland and Virginia together take two-thirds of the annual commercial catch of striped bass (Koo 1970: 80 - 92). These figures do not include the valuable sportfishery for this species. Chesapeake Bay is the primary spawning and nursery area for striped bass along the Atlantic coast and the production of striped bass in the bay exceeds that of the rest of North America combined.(Vladykov and Wallace 1952, Mansueti and Hollis 1963). Mansueti and Hollis (1963) listed known spawning grounds of striped bass in the Chesapeake Bay region (Fig. 24) and noted that the Potomac River and the head of the Chesapeake Bay together constituted 85% (by area) of the total spawning grounds available to striped bass in Maryland waters of the bay.

Dovel and Edmunds (1971) have documented the apparent change in striped bass spawning grounds in the upper bay from the lower reaches of the Susquehanna River to the Elk River and Chesapeake and Delaware Canal. They (p. 34) review available

Table 23. Part A. Comparison of captures of striped bass eggs in 1971 and 1972 by station. Data given are capture(effort by station summed over ETI (1971 data = combined top+ bottom; 1972 data = A+bottom).

Station	1971 Capture(Effort	Rank of CI(i)	1972 Capture(Effort	Rank of CI(i)
NE2	2(12	1	0(4	1
CB2	28(28	2	9(4	2
E1	96(47	3	122(9	3
E3	1180(46	6	2337(35	6
E5	3408(46	7	8709(43	8
C1	4721(40	9	18829(45	11
C2	9986(43	11	12819(40	10
C5	5185(23	10	9519(36	9
C8	2923(39	8	5354(32	7
R10	225(20	5	820(21	5
C27	308(29	4	641(19	4
Totals	28062(327		59159(288	

Tau$_{11}$ = .891 $p < .01$

Table 23. Part B. Comparison of striped bass egg captures in 1971 and 1972 by date. Data presented and collected as in part A. April 9 - June 15.(Dates in parentheses apply only to 1972)

Date	1971 Capture(Effort	Rank of CI(i)	1972 Capture(Effort	Rank of CI(i)
9	0(28	1		
10-11			0(18	1
17 (-18)	73(46	5	1(35	2
(24-) 25	12042(30	10	5675(36	8
1 (-2)	3984(40	9	32011(42	10
7	1121(45	8		
8-9			16911(27	9
15 (-16)	14(21	4	2328(35	7
(22-) 23	485(24	7	867(36	5
(30-) 31	2(23	3	1255(29	6
6	20(3	6	110(16	4
13	1(14	2		
15			1(14	3
Totals	17742(274		59159(288	

Tau$_{10}$ = .600 $p = .02$

Table 24. Calculated concentrations of striped bass eggs during period of peak capture, May 1 - 2, 1972. Expressed as number/ m^3. Data for A and bottom nets only.

Time	NE2	CB2	E1	E3	E5	C1	C2	C5	C8	R10	C27
1200-1800	-	-	-	-	-	1.14	13.77	18.66	9.15	0.27	0.16
1800-2400	-	-	-	0.17	10.41	7.93	2.40	13.43	8.70	-	-
2400-0600	-	-	-	0.15	5.06	6.06	14.89	5.49	13.23	-	-
0600-1200	-	-	-	-	13.41	8.99	-	9.80	2.07	1.48	0.18
1200-1800	-	-	0.04	0.15	5.80	22.42	14.18	19.94	15.68	4.76	2.90

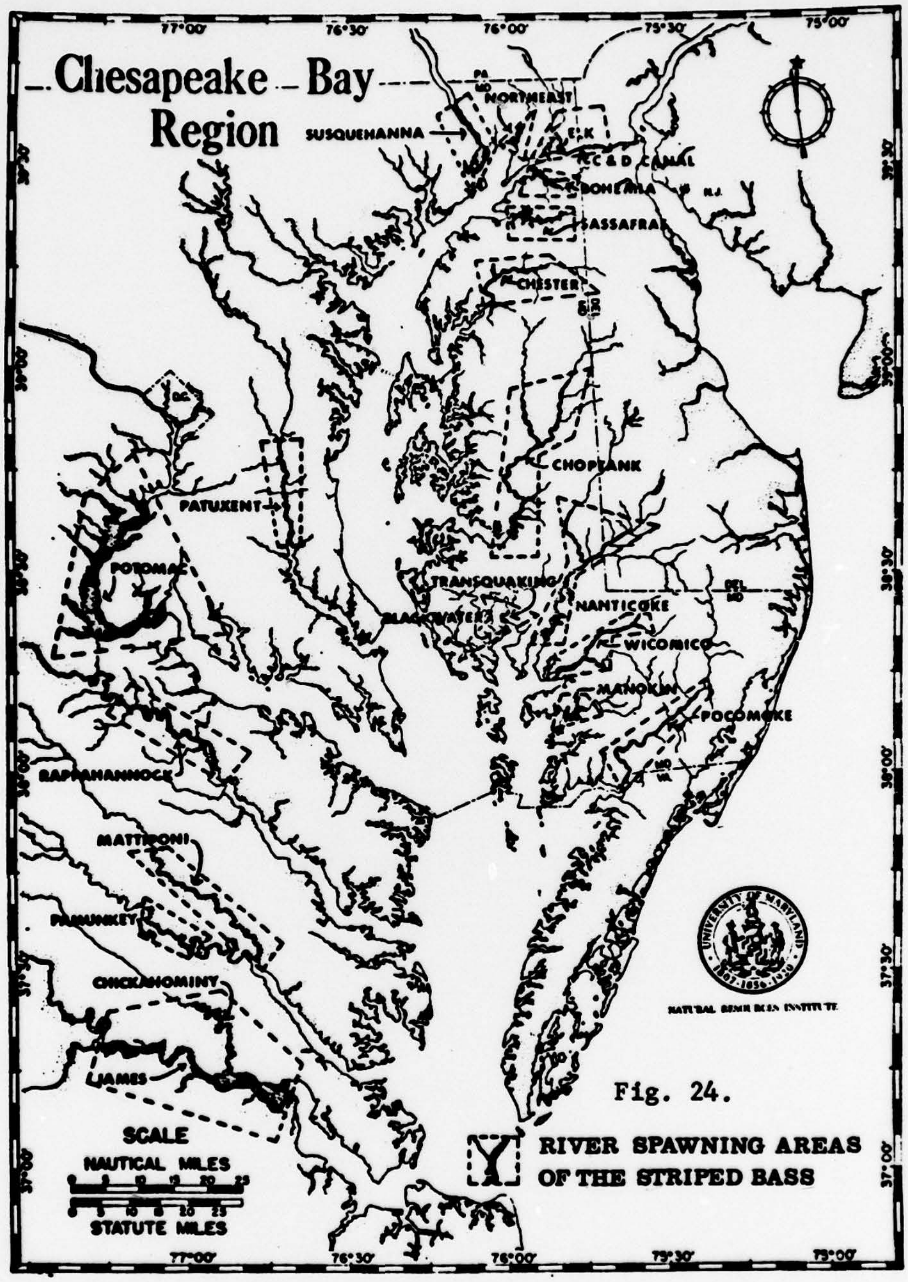

Chesapeake Bay
Region
77°00'
76°30'
76°00'
75°30'
75°00'
SUSQUEHANNA
NORTHEAST
ELK
C & D CANAL
SASSAFRA
CHESTER
CHOPTANK
PATUXENT
POTOMAC
TRANSQUAKING
NANTICOKE
WICOMICO
MANOKIN
POCOMOKE
RAPPAHANNOCK
PAMUNKEY
CHICKAHOMINY
JAMES
SCALE
NAUTICAL MILES
STATUTE MILES
RIVER SPAWNING AREAS
OF THE STRIPED BASS

Fig. 24.

historical information on striped bass spawning in the lower Susquehanna and conclude that the once probably important spawning grounds for this species were destroyed through the combined effects of hydroelectric dam construction (especially 4 dams built on the lower 54 miles of the river from 1904 - 1928) and pollution, especially pollution from coal mining activities. That the C&D canal, converted to a sealevel canal only in 1927, was an acceptable alternative to the destroyed spawning grounds in the Susquehanna is indicated by the high catches of striped bass eggs reported by Dovel and Edmunds (1971: 37) from the canal (a portion of their work is reproduced here as Fig. 25) and confirmed by the very high catches recorded in the present paper. That the lower Susquehanna is not important to the production of this species is indicated by Dovel and Edmund's data (Fig 25) and confirmed by C&D transect data (Figs 18, 22). In fact no striped bass eggs were taken at stations S2 and S1 on the Susquehanna flats in 1971. It can be shown that at these two stations where no striped bass eggs were taken in 40 hauls (with an average of 94 m^3 of water filtered/ haul) during the period of time that striped bass eggs were taken elsewhere along the transect, that the <u>maximum</u> concentration of striped bass eggs (95% limits) at these two stations was one egg/ 1253 m^3 or one egg/ 44,243 ft^3. Actual concentrations of eggs taken in the C&D Canal (Table 17) were as high as 36 eggs/ m^3 and were commonly found to be 10 - 20 eggs/ m^3 over miles of the canal (both top and bottom hauls during period of peak capture)

Dovel and Edmunds (1971) concluded that the canal was an acceptable alternative, indeed an apparently beneficial alternative,

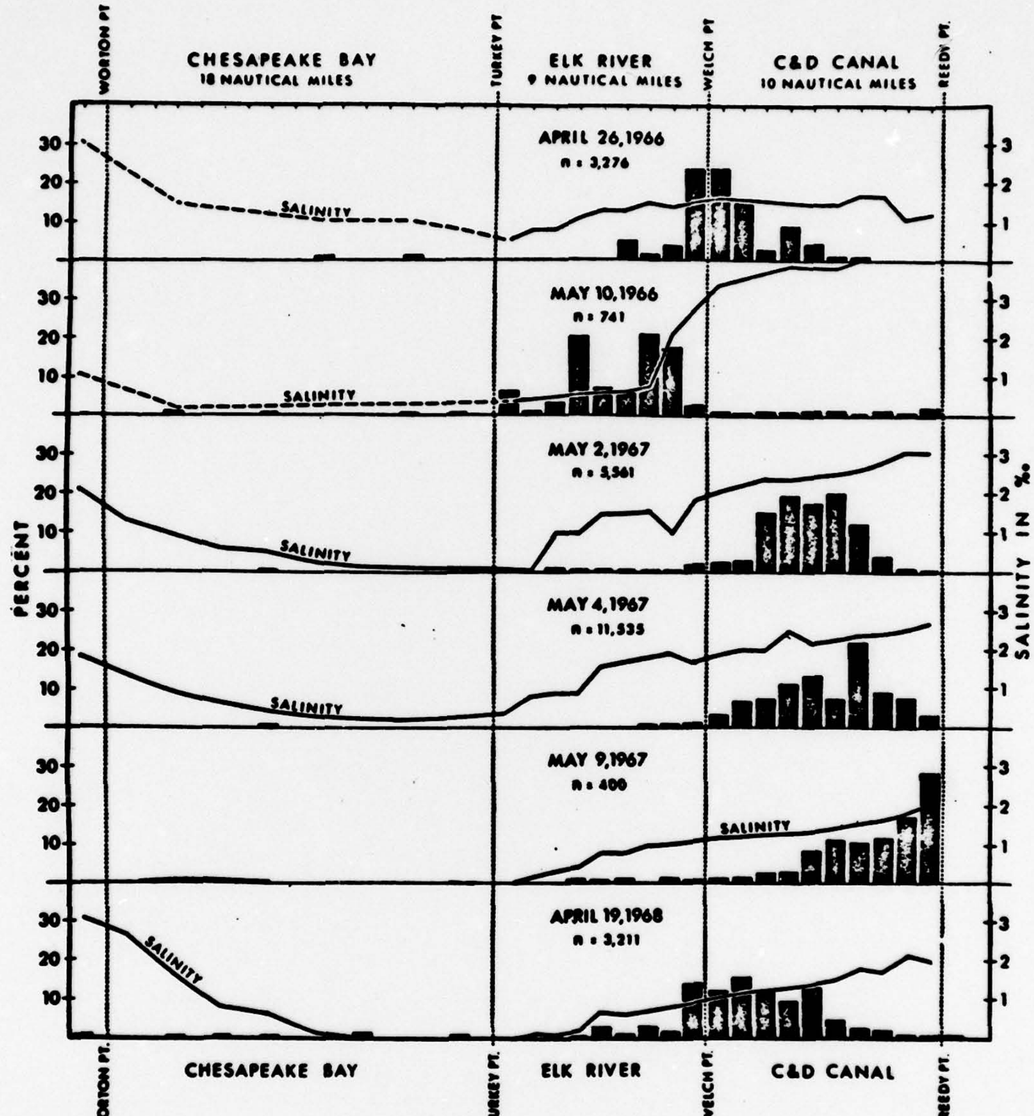


Fig. 25. Catch of striped bass eggs in C&D area, presented for each station as % of total catch on each sampling date (figure from Dovel and Edmunds 1971).

to the old upper bay spawning grounds of the striped bass because of a favorable distribution of salinity and water velocity.

The life history and environmental requirements for successful reproduction of striped bass have been discussed by an extensive number of authors (among them: Raney 1952, Mansueti 1958, Hollis and Mansueti 1963, Albrecht 1964, Talbot 1966, Dovel and Edmunds 1971). Striped bass are anadromous, spawning in fresh or virtually fresh water. Eggs are cast into the water, probably near the surface, are semibuoyant,and large (averaging 3.4 mm in diameter with a range of ca 2.4 - 3.9 after water hardening. Egg diameters are inversely correlated with salinity (Bason 1971). Hatching occurs 2 - 3 days (depending upon temperature) after fertilization (48 hrs at 18.3 C.) (Mansueti 1958, Mansueti and Hollis 1963). Albrecht (1964:10) discusses the importance of water currents in maintaining eggs in suspension, notes very low survival rates when eggs settle to the bottom, and states that the minimum current velocity required to maintain eggs in suspension is on the order of 1 foot/sec (= 30.48 cm/sec = .59 kt). Average current conditions in the C&D Canal (recorded as mean eastward tidal velocities) were reported to be 56.4 cm/sec in the 27 foot canal and 69.5 cm/sec in the 35 foot canal, with average maximum tidal velocities considerably larger (Pritchard and Cronin 1971). These velocities are more than sufficient to ensure maintainamce of striped bass eggs in the water column.

Albrecht (1964) has also shown that waters of low salinity may be advantageous to striped bass egg survival, and obtained highest hatches at salinities of 0.948 ppt (of chloride) with good hatches and survival in fresh water and in water with salinities to 4.595 - 4.740 ppt but found a marked decrease in survival in waters of higher salinity. Bottom salinities in the C&D area during the period of high river runoff were reported by Pritchard and Cronin (1971:13) to vary from 0.11 - 0.27 ppt in the Elk River, to 0.33 ppt at Summit Bridge near midcanal, to 1.45 ppt at Reedy Point, to 2.93 ppt in the channel of the Delaware River at a point five miles south of Reedy Point. Salinities observed by us during 1971 and 1972 (Tables B1, B2) agree well with Pritchard's data. All of these values are well within the range of tolerance reported by Albrecht (1964) for striped bass eggs and small larvae, and conditions in the canal approach optima.

Chittenden (1971) has discussed the destruction of the lower Delaware River spawning grounds of the striped bass and his work makes it seem not unlikely that the striped bass eggs and perhaps the small juveniles reported by Bason (1971: 14 -16; 59) and Smith (1971: 55) had their origin in the C&D Canal.

I have attempted a review of literature recording field concentrations of striped bass eggs. In many cases authors report the presence of striped bass eggs but provide no means of determining abundance in terms of numbers/ unit volume. In cases where such information is presented, the nets used were of difference shape, size, mesh size, making comparisons between efforts approximate at best. The greatest difficulty in comparing

C&D results with prior sampling efforts is the fact that most previous efforts have been in river systems and the nets were fixed in position, filtering the current of the river rather than being towed. Estimates are often presented in terms of numbers of eggs captured/ unit of time, which in the absence of adequate information on river velocities, makes any attempt at comparison nearly meaningless.

Tresselt (1950, 1952) reported on striped bass egg catches in 4 Virginia Rivers. He used three different net sizes which were fished fixed in the river current. His low catches for all rivers but the Mataponi are as likely a result of fishing before or after the peak period of spawning as reflecting actual differences in striped bass reproduction between the systems. His maximum catch (in 1.0 m nets?) was 5600 eggs/ 3 nets/ one hour of fishing at the surface, which is apparently considerably less than maximum numbers taken in C&D samples.

Rathjen and Miller (1957) reported on striped bass egg catches in the Hudson River. They used 0.5 m plankton nets as well as a small bottom trawl. Their report is based on a total of 71 striped bass eggs from which they calculated catch rates of 0.44 eggs/ h at the surface, 1.42 eggs/ h at middepth, and 0.61 eggs/ h at the bottom.

McCoy (1959) presents a most detailed analysis of the problems involved in samping design for estimation of striped bass egg numbers but gives no means of determing concentrations of eggs recovered from his samples in the Roanoke River.

Humphries (1966) sampled striped bass egg production in the Tar River, North Carolina. He used 15 inch plankton nets fished fixed in the current. His catches of up to 74.4 eggs/ min are at least 3 times less than maximum catches observed in the C&D area (when converted to equal mouth areas, equal times, and ca equal filtering rates).

Other reports of sampling efforts in river systems include Erkilla et al (1950) in the Sacremento - San Joaquin, Scruggs (1957) in the Santee-Cooper system, and May and Fuller (ca 1962) in the Congaree and Wateree Rivers. In all cases comparisons are very difficult to draw since there is no doubt of downstream advection of striped bass eggs in a river system, and the egg population may be dispersed over many miles of river, whereas there is mounting evidence (based on concordance values cited above) that in fact in the C&D system eggs and young larvae may remain where they are spawned and hatched, ie in the C&D Canal.

Murawski (1969) found striped bass eggs in the lower Delaware River from Oakwood, N. J. to Bridgeport, N. J.. He used fixed 0.5 m plankton nets and his reported captures are very low.

Finally Bason (1971) reported on a total of 103 striped bass eggs taken in 1970 from 5 stations in the C&D Canal and adjacent areas of the Delaware River. He used 0.5 m plankton nets towed at the surface for 5 minutes. Most (57%) were taken in the C&D Canal. His sampling dates were from April 28 - May 4. I am surprised at the low numbers of eggs reported by Bason, especially from the canal stations considering the much latger number of eggs recovered by our efforts from the canal during 1971 and 1972.

The concentrations of striped bass eggs observed by us in the C&D Canal remain the highest for which I have been able to find records.

FAMILY PERCIDAE

PERCA FLAVESCENS (MITCHILL) YELLOW PERCH

A total of 2125 yellow perch larvae (1185 in top nets = 55.76%; 940 in bottom nets = 44.24%) was taken in 1971. Raw data is given in Table A13. Comparison of captures in top and bottom nets revealed significant agreement with respect to both time ($p < .01$) and geography ($.02 < p < .05$) (Table 4). The effective time interval was April 19 to May 27. Five consecutive sampling dates, April 17 - 25, accounted for 67.11% of the total yellow perch larvae taken in 1971. Water temperature and salinity data taken in 1971 are presented in Table B1.

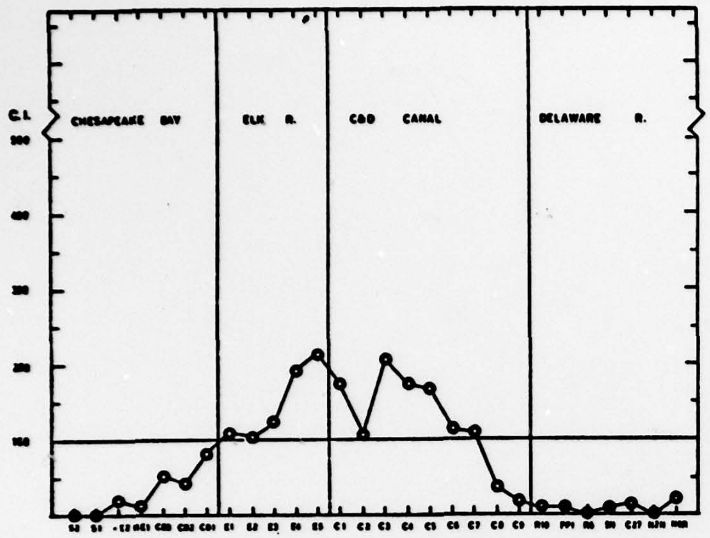
Capture indices (Fig. 26) reveal peak captures of yellow perch larvae in the Elk River and western portion of the C&D Canal. Rank-abundance data for yellow perch larvae is presented in Table 25 and was calculated for both raw and pooled data. In both cases the data sets are highly concordant ($p < .01$).

The length at capture diagram (Fig. 27) shows that at first appearance in C&D samples yellow perch larvae are between 4.3 and 7.3 mm TL.

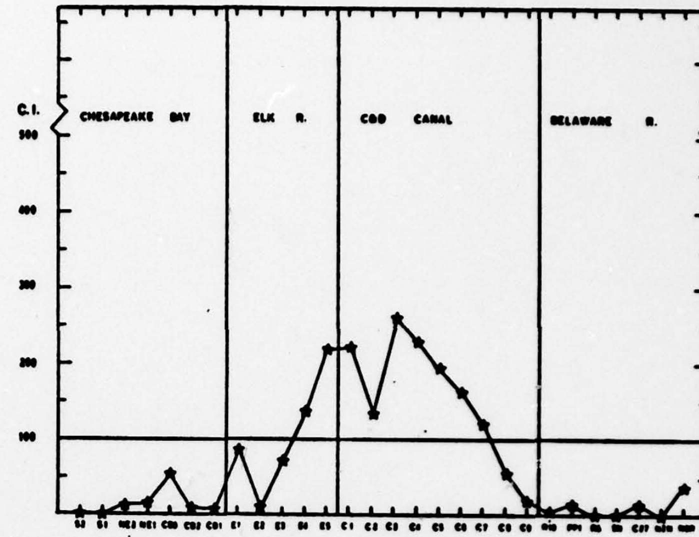
Yellow perch larvae were easily identified by characters provided by R. Mansueti (1964: 34 - 36) and A. J. Mansueti (1964: 46 - 66).

Discussion

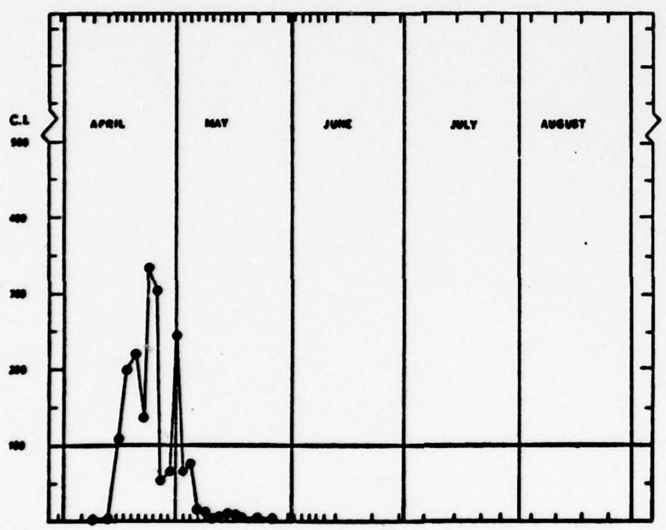
Various aspects of the life history of this species and especially its reproduction are discussed in Muncy (1962) and A. J. Mansueti (1964). Yellow perch spawn far upstream in



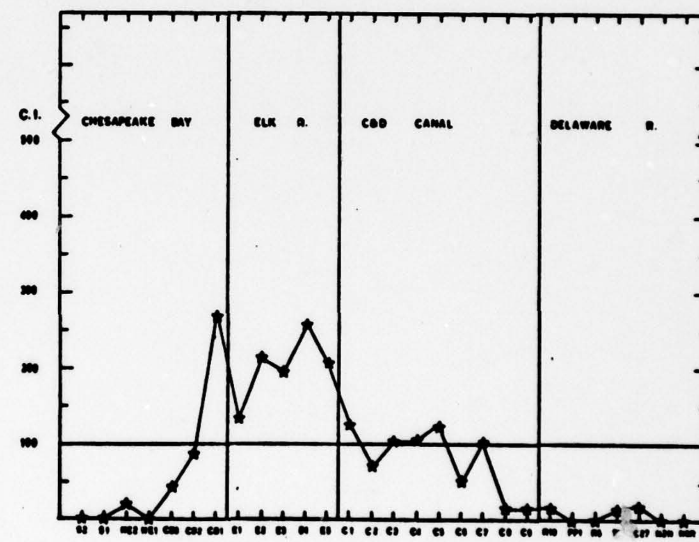
A By station. Combined data.
C = 2125 E = 711



C By station. Top net captures.
C = 1185 E = 356



B By date. Combined data.
C = 2125 E = 711



D By station. Bottom net captures.
C = 940 E = 355

Fig. 26. CI (i) for yellow perch larvae, 1971. ETI: April 19 - May 27.

Table 25. Part A. Rank-abundance by station of capture of yellow perch larvae, 1971. Ranks given in this table are based on raw data given in Table A13. Dates include April 15 to May 1. These 9 sampling dates accounted for 92.28% of the total capture of yellow perch larvae and the 15 stations included accounted for 95.82% of the yellow perch larvae taken on these 9 sampling dates.

Date	Number	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9
							(rank - abundance by station)									
15	111	2	15	7.5	14	13	7.5	12	10.5	7.5	5	7.5	4	10.5	2	2
17	269	8.5	14	15	13	12	11	6	7	8.5	10	4	5	2	2	2
19	363	10	12	9	13	15	11	14	8	7	4	5	2	2	2	6
21	188	12	8	9.5	14	13	15	9.5	11	6.5	2	6.5	2	4.5	4.5	2
23	336	7	2.5	1	7	7	9	10	2.5	11	15	13	14	12	4.5	4.5
25	270	2	2	4	2	5	6	8	9	12.5	11	15	10	12.5	14	7
27	73	1.5	14	3.5	7.5	7.5	10	12.5	12.5	10	15	10	5.5	3.5	5.5	1.5
29	62	8	4	9.5	4	13	11.5	14	15	4	9.5	4	11.5	4	4	4
1	289	8.5	5	5	7	10.5	14	15	10.5	14	12	8.5	2	5	2	2

$X^2_{14} = 32.48$ p .< .005

Table 25. Part B. Rank-abundance by station of capture of yellow perch larvae in 1971. Capture data from Table A13. Effort data from Table 1. Dates April 17 - May 9. Pooled raw data for these 8 sampling dates accounts for 60.09% of the yellow perch larvae taken in 1971. Zones as defined in Table 6.

Date	N	Chesapeake Bay	Elk River	C&D Canal	Delaware River
A. Raw data: given as capture(effort for each zone for each date.					
17	269	15(10	214(10	38(18	2(8
19	363	45(14	215(10	101(18	2(14
21	188	45(14	102(10	40(17	1(5
27	73	2(14	21(10	45(16	5(8
29	62	1(4	9(10	42(16	10(4
1	289	6(8	148(10	134(18	0(4
7	25	2(14	4(10	13(5	6(6
9	8	0(6	2(10	6(16	0(2
B. Ranks of resulting capture indices for each zone for each date.					
17		2	4	3	1
19		2	4	3	1
21		3	4	2	1
27		1	3	4	2
29		1	3	4	2
1		2	4	3	1
7		1	2	3	4
9		1.5	3	4	1.5

$W_{8,4} = .530 \quad p < .01$ $\qquad \chi^2_3 = 12.71 \quad .005 < p < .01$

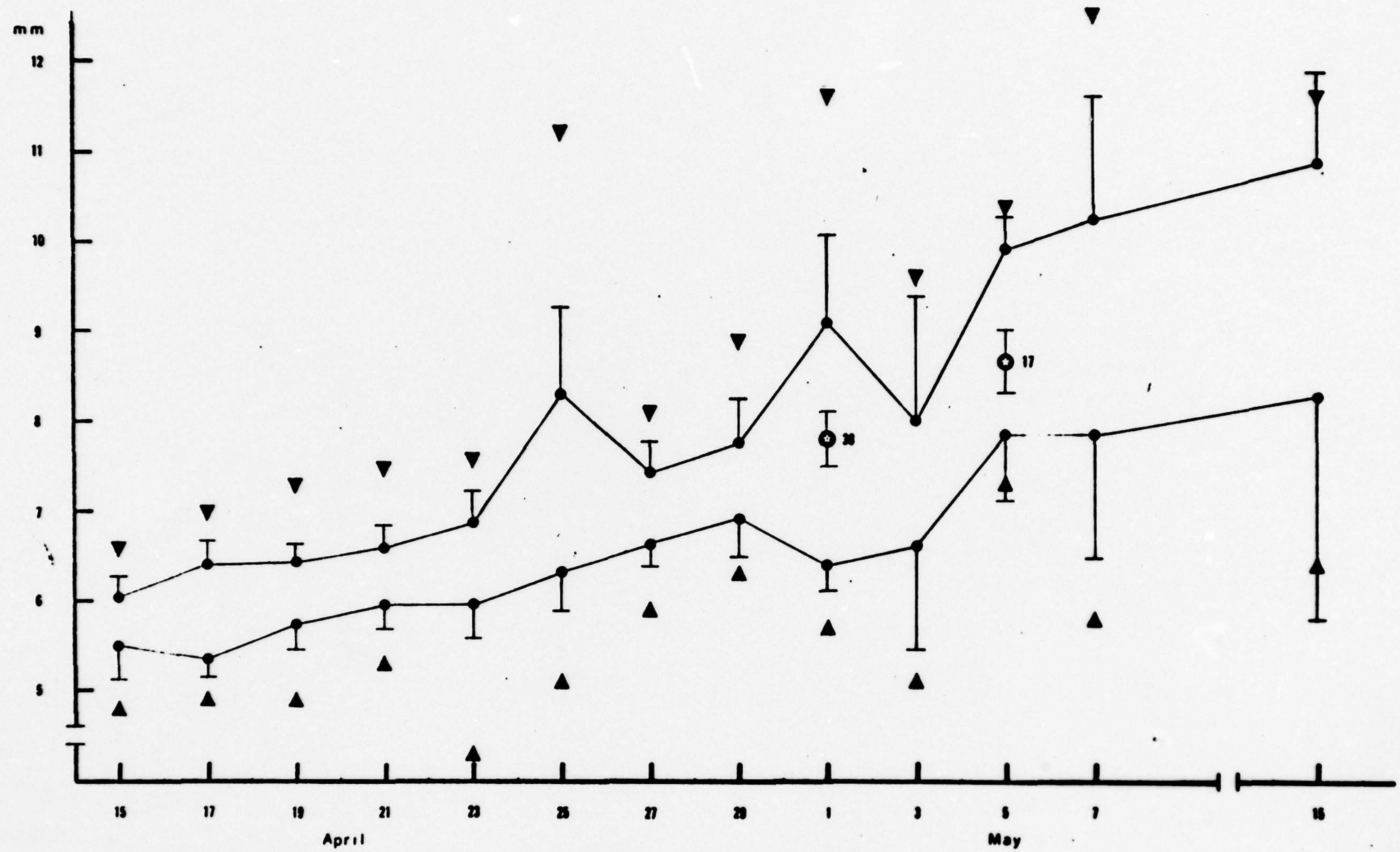


Fig. 27. Length-at-capture data for yellow perch larvae, 1971. Explanation of symbols at base of Fig. 7.

freshwater portions of Chesapeake tidal creeks and tributaries. Eggs are deposited on the bottom in waters 2 - 3 feet in depth in masses as accordion-foled strands (A. Mansueti 1964). Larvae move downstream and are abundant in low salinity nursery areas (Dovel 1971). Smith (1971) found spawning of this species in 4 tidal creeks tributary to the Delaware River to occur over clean-swept sand and gravel, in 1 - 4 feet of water, at temperatures of 6 - 12 C., and from early March through early April with peak activity during the last two weeks of March. The incubation period reported by A. Mansueti (1964) for laboratory cultured eggs at ambient (10 - 22 C.) was 25 - 27 days, with hatching lengths of 5.5 - 6.0 mm TL. These results correspond well with the appearance of yellow perch larvae in C&D samples and the size of the yellow perch larvae at first appearance. The size at capture diagram also corresponds well with length-frequency information provided by Dovel (1971: 59).

FAMILY SCIAENIDAE

CYNOSCION REGALIS (BLOCH AND SCHNEIDER) WEAKFISH

A total of 72 (7.0 - 85.0 mm TL) weakfish larvae and juveniles, nearly all from C6,C8,R10, and C27 (recoveries from these stations accounted for 83.34% of the total catch, the remaining larvae and juveniles were taken from E3, E5, C2, or C4) was taken in 1971. All were taken in bottom net hauls. The effective time interval was June 23 - October 19. An extensive study of the life history of this species in the Delaware River estuary can be found in Thomas (1971).

LEIOSTOMUS XANTHURUS LACEPEDE SPOT

Two (39.0 - 44.0) spot juveniles were taken at stations C6 and C8 on June 30, 1971, both in bottom net hauls. Their size agrees well with length-frequency and growth information presented by Thomas (1971: 193) who discusses the ecology of this species in the Delaware River estuary in detail.

MICROPOGON UNDULATUS (LINNAEUS) ATLANTIC CROAKER

A total of 27 (17.4 - 14.0 mm TL) Atlantic croaker larvae was taken in 1971. All but 7 came from bottom net hauls. All but one (1, 17 mm TL, E1 bottom, October 19) were taken from Canal or Delaware River stations. The effective time interval was October 19 to November 17. The limited data for recovery of this species from the C&D transect agrees very well with life history information for this species in the Delaware River estuary presented by Thomas (1971).

FAMILY SYNGNATHIDAE

SYNGNATHUS FUSCUS STORER NORTHERN PIPEFISH

Two northern pipefish juveniles (1, 45 mm TL, E3 bottom; 1, 65 mm TL, PPI bottom) were collected on July 22, 1971. Smith (1971: 86) reports capture of 6 (52 - 77 mm TL) individuals during July in tidal creeks tributary to the Delaware River.

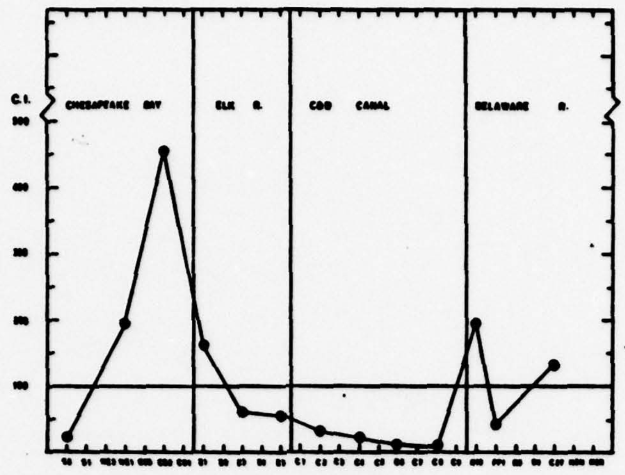
FAMILY GOBIIDAE

GOBIOSOMA BOSCI (LACEPEDE) NAKED GOBY

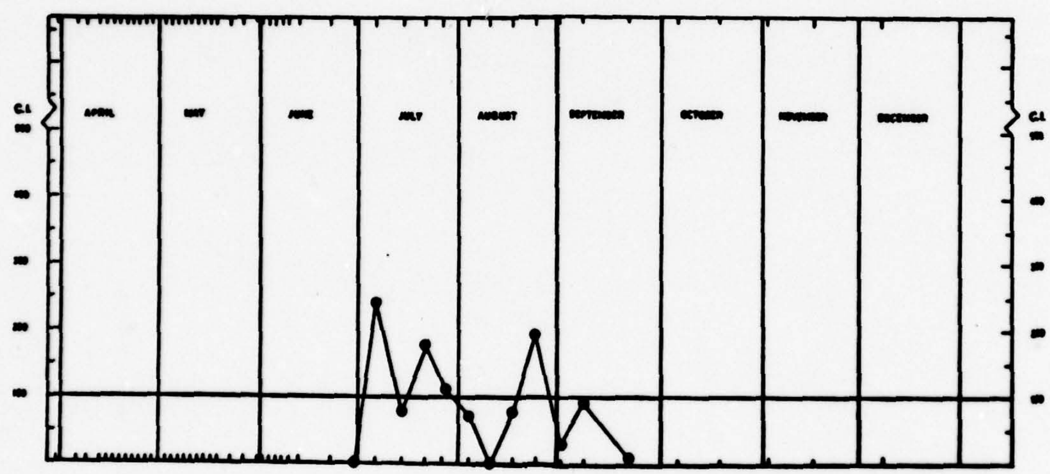
A total of 576 naked goby larvae (7 in top nets = 1.22%; 569 in bottom nets = 98.78%) was taken in 1971. Raw data is given in Table A14. The effective time interval was June 30 to September 23. Although captures of naked goby larvae were fairly even throughout the effective time interval, 57.64% of the total number of naked goby larvae taken were recovered from samples taken on the 4 sampling dates in July. Temperature and salinity data collected during 1971 are presented in Table B1.

Capture indices (Fig. 28) show peak captures in the Chesapeake Bay stations, especially CB2, and in the Delaware River. However of 119 specimens taken at the three Delaware River stations processed, 91 (76.5%) were taken in 3 bottom net hauls on July 7 (Table A14). Thus captures were consistently high (throughout the ETI) at only three stations: NE1,CB2, and E1. Rank-abundances of pooled data (Table 26) are concordant ($.01 < p < .025$).

The size-at-capture diagram (Fig. 29) reveals that naked goby larvae recovered from C&D samples are ca 4.3 - 15 mm TL throughout the effective time interval.



A By station.



B By date.

Fig. 28. CI(i) for naked goby larvae, 1971. Combined data over ETI.
C = 576 E = 243 ETI: June 30 to September 23.

Table 26. Rank-abundance by station of captures of naked goby larvae, 1971. Capture data from Table A14. Effort data from Table 1. Dates: July 7 - August 25. Pooled raw data for the 7 sampling dates included accounted for 92.18% of the naked goby larvae taken in 1971. Zones as defined in Table 6.

Date	N	Chesapeake Bay	Elk River	C&D Canal	Delaware River
A. Raw data: given as capture(effort for each zone for each date.					
7	151	37(6	14(6	9(8	91(6
15	46	9(6	12(6	10(8	15(6
22	79	28(4	32(6	8(8	11(2
27	56	23(2	33(6	0(8	0(4
4	42	20(6	11(6	11(8	0(6
18	46	31(6	14(6	1(8	0(4
25	111	96(6	12(6	3(8	0(4
B. Ranks of resulting capture indices for each zone for each date.					
7		3	2	1	4
15		2	3	1	4
22		4	2	1	3
27		4	3	1.5	1.5
4		4	3	2	1
18		4	3	2	1
25		4	3	2	1

$W_{7,4} = .455 \quad .01 < p < .05$ $\qquad \chi^2_3 = 9.56 \quad .01 < p < .025$

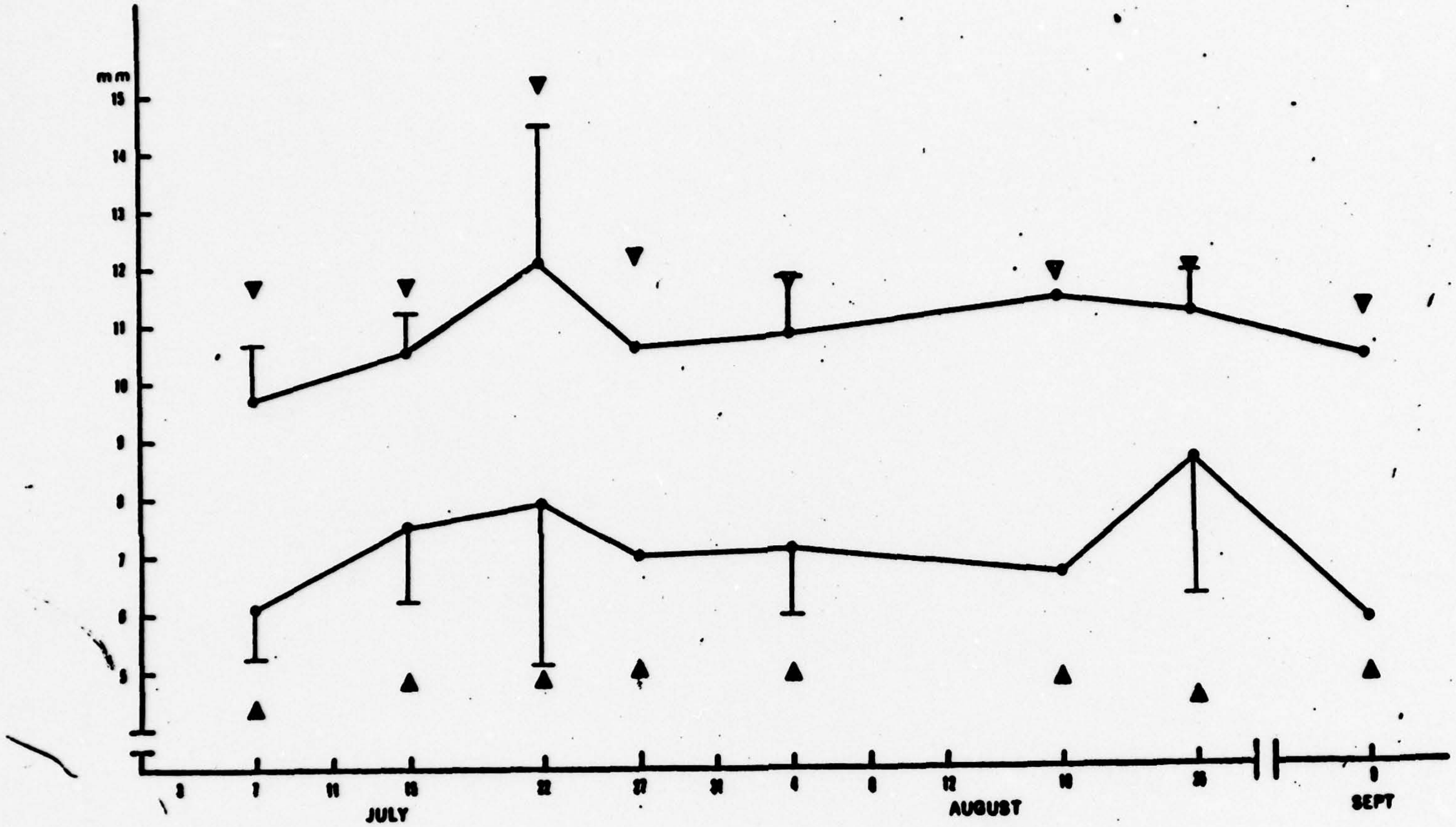


Fig. 29. Length-at-capture data for naked goby larvae, 1971. Explanation of symbols at base of Fig. 7.

Discussion

Aspects of the biology of *Gobiosoma bosci* are discussed by Hildebrand and Schroeder (1928: 323), Massmann, Norcross and Joseph (1963: 120 - 125), and Smith (1971: 86 - 88). This euryhaline species is an estuarine spawner, despositing attached eggs, usually found adherent to shells, spawning from June to October. The larvae hatch at ca 2 mm TL and undergo an upriver displacement into low salinity nursery areas (Massmann et. al. 1963). Larvae are most abundant in low salinity waters of 1 - 12 ppt and Dovel (1971) recovered the majority of naked goby larvae in his material from waters of 0 - 5 ppt. The size range, 6 - 11 mm TL, reported by Massmann et al (1963) as including the majority of naked goby larvae recovered from their samples corresponds well with the data on length-at-capture recovered from C&D material. Although Dovel (1971:10) reports that he captured large numbers of naked goby larvae in the C&D Canal, the results reported here (Table A14) show that only 8.33% of naked goby larvae recovered from C&D material was taken from the canal despite the expenditure of 36.21% of our total effort (1971) on the 4 canal stations (during the ETI for naked goby larvae). Naked goby larvae are found throughout warm water months. Dovel (1971) reported that 94% of the larvae recovered from his samples were taken from waters between 22 - 29° C.

CONCLUSIONS

The area of the Chesapeake and Delaware Canal fits well the concept of a common low salinity estuarine nursery for larval fishes discussed in detail by Dovel (1971: 12 - 18). Four basic advantages to fishes utilizing low salinity areas as nursery grounds have been noted and discussed by Thomas (1971): (1) reduction of competition in a low diversity community, i.e. what Thomas refers to as the availability of vacant niches, resulting from the low number of resident species; (2) abundance of food organisms; (3) occurrence of higher water temperatures than in downbay or coastal waters; (4) presence of fewer predators. Although the striped bass appears to be the only numerically important species in the C&D area spawning in the actual area covered by C&D transect stations, the larvae and juveniles of more than 20 species of fishes have been recovered from C&D samples. Although strong seasonality in the abundance of a given species is evident, as in all temperate estuaries, our data indicate that young fishes (of various species) are present in the C&D area throughout the year. The months of April, May, and June appear to be particularly important in this area as these three months effectively cover the peak periods of abundance of eggs, larvae, and juveniles of all numerically important species except the naked goby and bay anchovy (Table 8).

Important species spawning in freshwater found in the C&D area are the striped bass, white perch, alewife, and blueback herring. All but the striped bass spawn upstream in freshwater portions of tributaries and this is reflected in the far greater numbers of larvae taken than eggs of the latter 3 species (Table 8). No yellow perch eggs were taken (as might be expected), and the numbers of white perch and _Alosa_ spp. eggs taken no doubt reflect the fact that those eggs captured have been carried downstream from areas of spawning, and do not adequately represent production of eggs of these species in the upper bay area. An interesting parallel in captures exists between white perch eggs and _Alosa_ spp. eggs in that peak captures were consistly at station C1. This is the station in the canal nearest the upper Elk River and Herring Creek, a tributary of the Elk River. The source of these eggs is unknown but the consistent peak captures of both of these species at C1 does not suggest coincidence. The larvae of _Alosa_ spp. (Fig. 6), white perch (Fig. 16) and yellow perch (Fig. 26) show peak captures in the more freshwater portions of the C&D transect, ie the Chesapeake Bay, Elk River, and western Canal stations. Deferring consideration of the striped bass, it seems likely that the upstream spawning grounds of the freshwater spawners, the fact that the effects of canal enlargement on salinity distribution in the upper bay are expected to be minimal during the spring period of high freshwater runoff - ie during the period of peak occurrence of eggs and larvae of the freshwater spawners ; the fact that larvaeof these species are more abundant in the Chesapeake Bay and Elk River portions of the transect area than in the canal itself, the widespread occurrence of spawning grounds of these species within and outside of the Chesapeake Bay, and the apparently high production of these species, are sufficient indication that enlargement of the C&D Canal will effect no demonstrable changes in the populations of these species in the upper bay area.

Important species spawning in estuarine waters found in the C&D area include the bay anchovy, naked goby, and silversides.

Silverside and naked goby eggs are demersal and attached but anchovy eggs are an important component of the ichthyoplankton during warm water months in more saline portions of the Chesapeake Bay. No anchovy eggs were taken in the C&D samples. Our information on atherinid larvae is very meager due to the paucity of specimens recovered from our samples, but it is likely that the C&D samples, taken in midchannel, do not provide an adequate picture of the utilization of the C&D area as a nursery area for silverside larvae (cf Smith 1971). The presence of naked goby and bay anchovy larvae ideally represents the concept of a common low salinity nursery area geographically remote from the area of spawning. Dovel's(1971) data indicated maximum occurrences of bay anchovy larvae not in freshwater areas but in low salinity areas, 3 - 7 ppt, near the fresh/salt interface. His data might justify the speculation that enlargement of the C&D Canal might actually enhance production of this species in the upper bay by extending the area of low salinity (as opposed to fresh) water during the summer and fall months (Pritchard and Cronin 1971).

Important species spawning in marine waters whose larvae and juveniles are found in the C&D area include the American eel, Atlantic menhaden, and the three sciaenid species. Our catches of juvenile sciaenids are to meager to justify more than noting their occurrence. American eel elvers and Atlantic menhaden juveniles apparently utilize the C&D Canal primarily as an access to upriver areas, and perhaps as access to Chesapeake Bay. It seems unlikely that enlargement of the C&D Canal will effect demonstrable changes in upper bay populations of these two species.

This study was largely prompted by concern over the possible effects of canal enlargement upon the production of the striped bass in the upper bay. In the discussion that follows I have limited myself to a discussion concerned only with purely hydraulic effects of canal enlargement, and do not discuss the possibility that canal enlargement and subsequent expansion of canal use by ships will lead to pollution effects upon the production of striped bass. There seems to be little doubt that construction of the Chesapeake and Delaware Canal has benefitted the production of striped bass in Chesapeake Bay. The canal provided a favorable alternative to the historical and destroyed spawning grounds in the lower reaches of the Susquehanna River. The canal has been a sufficiently favorable alternative that this manmade area may be one of the more important spawning and nursery areas for this species. As a spawning and nursery ground the Chesapeake and Delaware Canal is highly atypical, perhaps unique, in that within the same circumscribed geographic area eggs are spawned, hatch, and the early growth of larvae occurs. Typically striped bass eggs are spawned upstream in a river. The eggs are carried downstream by the current and early growth of the larvae occurs in low salinity estuarine conditions at the mouth of the river.

The prime question prompting this study, ie whether or not canal enlargement will lead to significantly greater advection of striped bass eggs and larvae from the canal into the Delaware River estuary cannot be definitively answered until our knowledge of hydrographic conditions in the canal during the critical time period: ca the last week in April to early June, is improved. A number of factors: consistent peak captures of eggs, limited observations of presumed spawning activity, and limited information on the distribution of breeding adults in the canal area, strongly point to the conclusion that spawning occurs predominantly in the western portion of the canal itself (centered around C1 and C2). There is no doubt, based on the strong agreement (Table 23) between the results for 1971 and 1972, as well as the remarkable consistency of the data within each sampling year (Tables 5,6, 22), that by far the greatest coneentrations of striped bass eggs and young larvae are in the canal. The remarkable consistency of rank-abundance data for all numerically important species recovered from C&D samples, and particularly the very strong concordances exhibited by striped bass egg and larvae data, might justify the conclusion that the eggs and young larvae of the striped bass remain essentially where they are spawned and hatch - in the canal - and that the canal in essence is acting as a 14 mile long manmade nursery for this species, and that advection of eggs and larvae into the Delaware River estuary is not as important as feared (note that especially in 1972 hydraulic conditions in the canal closely approached those anticipated for the full 35 foot canal). The apparent shift in the distribution of larger striped bass larvae (Fig. 19, 21) from the canal into the Elk River might furthur support this conclusion (although it might also mean that those larvae in the canal were advected eastward).

Conflicting evidence provided by Mr. Thomas Hill of the Waterways Experimental Station at Vicksburg may be introduced at this time. In a series of dye injection experiments made in the hydraulic model of the 27 foot canal, Mr. Hill injected dye at Courthouse Point, in the Elk River beyond the westward entrance to the canal, and at Summit Bridge, in the central portion of thecanal. He used a simulated difference in elevation of 0.7 feet from the Chesapeake to the Delaware (Delaware lower), over twice the average difference of 0.3 feet reported by Pritchard and Cronin (1971). This difference in elevation resulted in a model net flow of 7000 ft^3/sec, seven times the average net flow for the 27 foot canal and more than twice the estimated net flow for the 35 foot canal (Pritchard and Cronin 1971). The dye injected at Courthouse Point was essentially flushed into the Delaware in 4 - 6 tidal cycles (ca 50 - 75 h in real time) while the dye injected at Summit Bridge was essemtially flushed into the Delaware in 1.5 - 2.0 tidal cycles (ca 19 - 25 h). While it could be argued that the head and net transport conditions were extreme, and the maintainance of a constant difference in elevation of the Chesapeake over the Delaware is unreal over any long time period, the question remains: how unreal? The critical period for striped bass production vis-a-vis hydraulic conditions in the C&D Canal would appear from data presented herein to be about April 20 to June 1, by which time most of the larvae (the eggs hatch in ca 48 h) would probably (our data on this is quite poor) be large enough to physically or behaviorally avoid advection. Are the conditions of the experiment run by Mr. Hill extreme and unreal for this time period. Factors that probably must be considered include (1) average discharge of the Susquehanna River during this period (2) average tidal conditions during this period, and (3) prevailing weather, especially wind, conditions during this period, and their interactions and effect on flows through the canal.

There exists nothing in the data presented in this report that would justify forestalling projected completion of the enlargement of the Chesapeake and Delaware Canal.

Suggestions for Furthur Study

(1) Recovery of 1972 Data

Time limitations precluded recovery of any eggs or larvae other than striped bass eggs for material taken in 1972 after April 17 - 18. Confirmation of the 1971 data for the eggs and larvae of other species found in the C&D area is obviously desirable, and could be effected most easily by processing of top and bottom net samples taken in 1972. This would allow direct comparison on a week by week basis with information from the 1971 sampling year. This work is already in progress.

(2) Dyed egg release

The release of dyed striped bass eggs, proposed in my report of January 1972, was not carried out this spring because of failures in the technique of dyeing eggs. Release of dyed eggs would allow an exact picture of the amount of tidal advection experienced by striped bass eggs over a short period of time, and might allow population estimates via mark-recapture models. I would think that one boat, using the top and bottom nets, running a transect limited to the canal, fishing over a 24h period, and run by several crews could efficiently accomplish the sampling required.

(3) Striped bass spawning, 1973.

The limitations imposed by time and manpower to process samples as well as the fact that the striped bass is the prime object of interest, suggest that any sampling efforts in 1973 should be limited to monitoring the 1973 production of striped bass eggs (? and larvae). The remarkable agreement between the data from 1971 and 1972 indicate that this could be accomplished with a minimum number of stations (say E5, C1 or C2, and C5 or C8) sampled over a restricted time period (mid-April to mid-May). At least some samples should be processed in the field shortly after they are collected in a determined effort to assess egg quality and the ratio of live to dead eggs present in the canal.

(4) Spawning Behavior

Very limited observations of presumed spawning behavior (rock-fights, splashing and activity of adult striped bass at the surface) in 1972 suggested that a more quantitative assessment of this activity, eg areas of peak occurrence, hours of peak occrrence, combined with efforts to demonstrate that the activity is in fact spawning, perhaps via sampling for non waterhardened eggs, would lead to additional evidence for the precise location of the prepondeaance of striped bass spawning within the C&D area.

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Table A1. Capture of *Alosa* spp. eggs in 1971: raw data (total: top and bottom captures combined)

Date	Number Taken	S2	S1	NE2	NE1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	R10	PP1	R6	SN	C27	N2N	NOR
April																													
9	30	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	30	0	0	0	0	-	-	-	-	-	-	-
13	4	-	-	-	0	-	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	-	-	-	-	-	-	-
15	243	-	-	-	5	-	0	0	0	7	0	0	3	80	92	47	9	0	0	0	0	0	-	-	-	-	-	-	-
17	15	0	-	-	0	11	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	-	-	0	0	-	0
19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0
21	39	0	0	0	0	0	0	0	0	0	0	0	0	35	3	0	0	1	0	0	0	0	-	-	0	0	0	-	-
23	378	-	323	-	5	-	-	0	0	0	0	0	0	0	0	0	0	35	0	15	0	0	-	-	-	-	-	-	-
25	7	-	-	-	-	-	-	3	1	0	0	0	1	0	2	0	0	0	0	0	0	0	-	-	-	-	-	-	-
27	538	0	22	0	0	0	0	0	0	0	0	0	18	372	50	0	16	24	0	36	0	0	0	0	-	-	0	-	0
29	160	-	-	-	0	-	-	0	0	1	0	3	17	41	9	12	11	4	6	30	26	0	-	-	-	-	0	0	-
May																													
1	6	0	-	-	0	-	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4	-	0	-	-	0	-	-
3	14	-	-	-	0	-	-	0	0	0	0	0	0	0	0	0	0	12	2	0	0	-	-	-	-	-	-	-	-
5	1499	0	-	0	0	-	-	-	1	0	1	-	53	567	333	541	3	0	0	0	0	0	-	-	-	-	-	-	-
7	972	0	6	0	0	0	0	0	0	0	0	109	203	615	4	11	18	4	2	0	0	-	0	0	-	-	0	-	-
9	93	1	-	-	0	-	-	0	0	0	0	1	1	78	12	0	0	-	0	0	0	0	-	-	-	-	0	-	-
11	59	0	15	-	1	-	0	-	3	0	0	-	19	-	8	13	0	-	0	-	0	-	0	0	-	-	0	-	-
13	626	-	-	-	0	-	-	-	0	0	0	0	0	626	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	128	-	-	-	0	-	0	-	0	-	0	14	7	35	27	-	1	-	44	-	0	-	-	-	-	-	-	-	-
17	43	-	-	-	-	-	-	-	0	0	0	0	-	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	0	0	-	-	0	-	0	-	0	-	0	0	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
23	2	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	2	-	0	0	-	-	0	-	-
27	70	0	-	-	0	-	0	-	0	-	0	-	6	-	64	-	0	-	0	-	-	-	0	0	-	-	0	-	-
Total	4927	1	366	0	11	11	0	3	5	8	1	127	328	2494	608	624	58	113	55	81	29	4	0	0	0	0	0	0	0
Top	334	0	6	0	0	11	0	0	3	0	1	8	12	128	77	35	14	5	6	25	3	0	0	0	0	0	0	0	0
Bottom	4593	1	360	0	11	0	0	3	2	8	0	119	316	2366	531	589	44	108	49	56	26	4	0	0	0	0	0	0	0

Table A2. Capture of Alosa larvae in 1971: raw data. Top and bottom captures (in that order) given for each sampling day.

Date	Number Taken	S2	S1	MR2	MR1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	E10	FP1	B6	B5	C27	M2B	MBR
April 25	5	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	3	0	0	1	0	1	-	-	-	-	-	-	-
	82	-	-	-	-	-	-	0	2	6	25	11	6	0	3	6	6	6	3	3	3	0	-	-	-	-	-	-	-
27	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	-	-	0	-	0
	73	1	20	9	3	6	1	4	8	3	3	2	0	5	0	-	0	0	0	0	-	0	0	0	-	-	0	-	0
29	8	-	-	-	0	-	-	0	0	0	0	0	0	0	5	0	0	0	0	0	3	0	-	-	-	-	0	0	-
	202	-	-	-	16	-	-	9	6	10	8	3	14	0	134	0	1	-	-	0	1	0	-	-	-	-	0	0	-
May 1	33	0	-	-	0	-	0	0	0	0	0	0	39	10	0	1	0	1	0	0	2	0	-	0	-	-	0	-	-
	112	0	-	-	3	-	7	0	6	6	8	6	20	25	11	14	6	0	0	0	0	0	-	0	-	-	0	-	-
3	39	-	-	-	0	-	-	-	0	1	11	6	26	15	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-
	48	-	-	-	0	-	-	-	0	5	7	7	12	8	0	-	7	0	2	0	0	-	-	-	-	-	-	-	-
5	150	5	-	10	0	-	-	-	0	3	19	-	2	69	0	0	-	6	43	1	-	-	-	-	-	-	-	-	-
	94	0	-	4	0	-	-	-	10	2	8	-	4	7	3	6	10	10	20	10	0	0	-	-	-	-	-	-	-
7	106	0	0	0	0	21	0	0	0	0	0	0	0	34	37	2	5	6	0	0	0	9	3	8	-	-	0	-	-
	220	140	36	15	0	0	0	2	4	3	1	1	3	7	0	-	4	1	0	0	0	-	0	1	-	-	2	-	-
9	87	0	-	-	5	-	-	0	17	27	6	7	0	7	0	12	2	-	0	0	2	2	-	-	-	-	0	-	-
	143	39	-	-	17	-	-	10	11	16	9	2	6	8	12	2	8	-	3	0	0	0	-	-	-	-	0	-	-
11	19	0	1	-	5	-	0	-	0	2	5	-	0	-	2	1	3	-	0	-	0	-	0	0	-	-	0	-	-
	127	3	2	-	8	-	12	-	17	4	7	-	31	-	7	-	28	-	8	-	0	-	0	0	-	-	0	-	-
13	36	-	-	-	0	-	-	-	0	0	0	0	36	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	0	-	-	-	0	1	1	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	19	-	-	-	0	-	0	-	0	-	1	0	4	0	10	-	4	-	0	-	0	-	-	-	-	-	-	-	-
	38	-	-	-	27	-	11	-	1	-	3	4	0	0	10	-	-	-	0	-	0	-	-	-	-	-	-	-	-
17	3	-	-	-	0	-	-	-	-	-	3	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	-	-	-	0	-	-	-	1	3	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	290	0	-	-	30	-	192	-	18	-	31	-	14	-	0	-	0	-	2	-	2	-	0	0	-	-	1	-	-
	265	34	-	-	27	-	127	-	20	-	7	28	19	-	0	-	12	-	0	-	0	-	1	0	-	-	0	-	-
23	62	0	-	-	3	-	0	-	0	-	1	-	4	-	18	-	30	-	5	-	0	-	1	0	-	-	-	-	-
	163	62	-	-	24	-	66	-	3	-	2	-	3	-	3	-	0	-	0	-	0	-	0	-	-	-	0	-	-
27	376	2	-	-	16	-	6	-	7	-	113	-	295	-	55	-	76	-	5	-	-	-	0	0	-	-	1	-	-
	377	379	-	-	64	-	35	-	16	-	11	-	17	-	18	-	14	-	3	-	-	-	0	-	-	-	0	-	-
31	236	3	-	-	30	-	110	-	0	-	5	-	23	-	18	-	23	-	6	-	0	-	6	2	-	-	8	-	-
	688	94	-	-	7	-	277	-	16	-	-	-	7	-	-	-	-	-	1	-	0	-	1	0	-	-	3	-	-
June 2	8	-	-	-	-	-	-	-	-	-	-	8	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	0	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1692	141	-	145	-	-	7	-	167	-	119	56	774	38	118	-	88	-	19	-	9	-	0	7	-	-	4	-	-
	736	57	-	511	-	-	30	-	30	-	44	0	11	3	24	-	6	-	1	-	0	-	3	-	-	-	0	-	-
6	134	-	-	-	-	-	-	-	-	-	-	154	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11	-	-	-	-	-	-	-	-	-	-	10	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	6089	-	-	-	940	-	-	-	60	-	624	-	3174	383	370	-	390	-	91	-	7	-	-	1	-	-	1	-	-
	218	-	-	-	108	-	-	-	4	-	11	-	8	1	19	-	51	-	7	-	4	-	-	0	-	-	0	-	-
10	880	-	-	-	-	-	-	-	-	-	-	792	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29	-	-	-	-	-	-	-	-	-	-	25	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	3806	-	-	-	845	-	-	-	917	-	726	-	277	-	175	-	19	-	18	-	59	-	-	-	-	-	-	-	-
	36	-	-	-	10	-	-	-	1	-	12	-	0	-	9	-	3	-	-	-	-	-	-	-	-	-	-	-	-
23	1618	107	-	-	363	-	91	-	396	-	410	-	21	-	1	-	6	-	0	-	-	-	5	15	-	-	4	-	-
	40	15	-	-	6	-	0	-	-	-	5	-	0	-	1	-	0	-	11	-	7	-	0	2	-	-	1	-	-
30	265	2	-	-	12	-	1	-	4	-	12	-	36	-	57	-	39	-	-	-	47	-	10	10	-	-	13	-	-
	16	1	-	-	0	-	0	-	0	-	C	-	0	-	6	-	1	-	2	-	0	-	4	2	-	-	0	-	-
July 7	150	14	-	-	28	-	0	-	4	-	5	-	51	-	8	-	10	-	23	-	5	-	0	2	-	-	0	-	-
	5	0	-	-	3	-	0	-	0	-	0	-	1	-	1	-	0	-	0	-	0	-	0	0	-	-	0	-	-
15	6	3	-	-	2	-	0	-	0	-	0	-	-	-	1	-	-	-	0	-	0	-	0	0	-	-	0	-	-
	12	0	-	-	0	-	0	-	0	-	11	-	0	-	1	-	0	-	0	-	0	-	0	0	-	-	0	-	-
22	1	-	-	-	0	-	0	-	0	-	1	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
	3	-	-	-	1	-	2	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
27	0	-	-	-	0	-	-	-	0	-	0	-	0	-	0	-	0	-	-	-	0	-	-	-	-	-	-	-	-
	0	-	-	-	0	-	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	0	-	-	-	-	-
August 4	5	0	-	-	0	-	0	-	0	-	0	-	1	-	0	-	0	-	0	-	0	-	0	0	-	-	4	-	-
	5	0	-	-	-	-	0	-	-	-	0	-	0	-	0	-	4	-	0	-	0	-	0	0	-	-	1	-	-
11	0	-	-	-	0	-	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	-	-	-
	0	-	-	-	0	-	-	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	0	-	-	-	-	-
18	1	0	-	-	0	-	0	-	1	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	-	-	-
	2	0	-	-	0	-	1	-	1	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	-	-	-
Total	19027	1092	67	694	2609	27	1024	25	1764	92	2275	1122	4939	633	1127	44	879	30	273	20	151	3	34	30	-	-	33	0	0
Top	15304	277	1	155	2279	21	407	0	1599	33	2092	1023	4774	564	865	16	718	13	212	2	136	3	25	43	-	-	38	0	0
Bottom	3723	815	66	539	330	6	617	25	165	59	183	99	165	69	262	28	161	17	61	18	15	0	9	5	-	-	15	0	0

Table A3. Capture of menhaden juveniles in 1971: raw data (total: top and bottom captures combined)

Date	Number Taken	S2	S1	NE2	NE1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	R10	PPI	R6	N5	C27	N2N	N8R
April																													
17	5	0	-	-	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	1	0	0	-	-	0	0	-	0
19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
21	10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0	1	1	0	0	0	-	-	0	0	1	-	-
23	1	-	0	-	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	-	-	-	-	-	-	-
25	1	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	-	-	-	-	-	-	-
27	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	-	-	4	-	0
29	4	-	-	-	0	-	-	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	-	-	-	-	0	2	-
May																													
1	4	0	-	-	0	-	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	-	0	-	-	0	-	-
3	3	-	-	-	0	-	-	-	0	0	0	0	0	0	0	0	0	3	0	0	0	-	-	-	-	-	-	-	-
5	8	0	-	0	0	-	-	-	0	0	1	-	0	0	0	3	0	0	2	2	0	0	-	-	-	-	-	-	-
7	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	2	2	1	-	2	29	-	-	0	-	-
9	8	0	-	-	0	-	-	0	0	0	0	0	2	0	0	0	1	-	1	0	1	1	-	-	-	-	2	-	-
11	15	0	0	-	0	-	0	-	0	0	0	-	0	-	1	3	1	-	3	-	1	-	4	1	-	-	1	-	-
13	0	-	-	-	0	-	-	-	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	9	-	-	-	0	-	0	-	0	-	0	1	0	0	0	-	1	-	3	-	4	-	-	-	-	-	-	-	-
17	0	-	-	-	-	-	-	-	0	0	0	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	129	0	-	-	0	-	0	-	0	-	0	0	0	-	0	-	26	-	30	-	57	-	0	0	-	-	16	-	-
23	62	0	-	-	0	-	0	-	0	-	0	-	1	-	0	-	13	-	12	-	13	-	4	18	-	-	1	-	-
27	3	0	-	-	0	-	0	-	0	-	0	-	0	-	1	-	0	-	0	-	-	-	1	0	-	-	1	-	-
31	5	0	-	-	0	-	0	-	0	-	0	-	1	-	0	-	0	-	0	-	1	-	0	0	-	-	3	-	-
June																													
2	1	-	-	-	-	-	-	-	-	-	-	0	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	3	0	-	0	-	-	0	-	0	-	0	0	0	0	0	-	0	-	0	-	0	-	2	0	-	-	1	-	-
6	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	1	-	-	-	0	-	-	-	0	-	0	-	0	0	0	-	0	-	0	-	0	-	-	1	-	-	0	-	-
10	1	-	-	-	-	-	-	-	-	-	-	1	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	0	-	-	-	0	-	-	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-
23	1	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	1	-	0	0	-	-	0	-	-
30	1	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	1	0	-	-	0	-	-
July																													
7	1	0	-	-	0	-	0	-	0	-	0	-	1	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
15	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
22	0	-	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	0	-	-	-	-	-
27	1	-	-	-	0	-	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	1	-	-	-	-	-
Total	325	0	0	0	0	0	0	0	0	0	2	2	6	1	4	17	43	8	36	8	80	1	15	30	0	0	30	2	0
Top	303	0	0	0	0	0	0	0	0	0	2	2	4	0	4	17	39	8	35	8	76	1	14	48	0	0	23	2	0
Bottom	22	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	4	0	1	0	4	0	1	2	0	0	7	0	0

Table A-4. Capture of anchovies in 1971: raw data (total: top and bottom captures combined)

Date	Number Taken	S2	NE1	CB2	E1	E3	E5	C2	C4	C6	C8	R10	PPI	C27
June														
23	21	0	0	0	0	0	0	0	0	0	3	6	4	8
30	512	0	0	0	1	0	0	0	68	0	426	3	1	13
July														
7	86	17	4	0	12	6	28	11	5	0	0	1	1	1
15	52	4	4	0	5	8	0	0	0	1	26	1	0	3
22	99	-	6	17	14	8	36	18	7	0	0	-	3	-
27	226	-	8	-	6	1	17	13	66	107	6	0	2	-
August														
4	37	0	0	2	1	3	14	2	3	4	1	3	0	4
11	504	-	8	-	0	0	25	16	37	268	145	4	1	-
18	115	0	0	5	4	14	24	27	3	6	0	13	[illegible]	-
25	257	0	0	9	2	2	33	9	42	118	42	0	0	-
September														
2	27	-	-	-	0	5	4	17	0	1	0	-	-	-
9	12	-	-	0	0	0	2	2	0	1	7	-	-	-
23	[illegible]	-	-	-	0	0	1	2	3	[illegible]	[illegible]	-	-	-
October														
6	41	-	-	-	0	0	0	0	11	0	0	4	[illegible]	[illegible]
9	66	-	-	-	0	0	18	15	2	15	[illegible]	-	-	-
November														
3	[illegible]	0	0	0	0	0	2	0	44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	99	0	0	0	0	0	0	3	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	2352	21	36	33	35	47	204	139	306	637	763	[illegible]	[illegible]	[illegible]
Top	2047	2	13	0	6	31	192	121	297	537	756	[illegible]	[illegible]	[illegible]
Bottom	305	19	17	33	29	16	12	18	9	100	7	[illegible]	[illegible]	[illegible]

Table A5. Capture of American eel elvers in 1971: raw data (total: top and bottom captures combined)

Date	Number Taken	S2	S1	ME2	ME1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1
March														
31	15	-	-	-	-	-	-	-	0	0	1	0	0	0
April														
6	37	-	-	-	-	-	-	-	-	-	2	2	0	2
9	32	-	-	-	-	-	-	-	0	0	4	2	3	0
13	8	-	-	-	0	-	0	0	0	0	0	0	0	0
15	11	-	-	-	0	-	0	0	0	0	2	0	0	0
17	57	0	-	-	0	0	0	0	0	0	0	0	0	0
19	40	0	0	0	0	0	0	0	0	1	1	0	0	0
21	49	0	0	0	0	0	0	0	1	6	4	3	2	4
23	12	-	0	-	0	-	-	0	0	1	0	0	1	0
25	8	-	-	-	-	-	-	0	0	0	1	0	0	0
27	14	0	0	0	0	0	0	0	1	3	0	1	0	2
29	4	-	-	-	0	-	-	0	1	1	0	0	0	0
May														
1	0		-	0	-	0	0	0	0	0	0	0	0	0
3	7	-	-	-	0	-	-	-	0	2	0	1	0	0
5	6	0	-	0	0	-	-	-	0	0	1	-	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	5	0	-	-	0	-	-	0	0	0	0	1	0	0
11	7	0	0	-	0	-	0	-	0	0	0	-	0	-
13	0	-	-	-	0	-	-	-	0	0	0	0	0	0
15	4	-	-	-	-	-	-	-	-	-	0	1	0	0
17	0	-	-	-	-	-	-	-	0	0	0	0	-	0
19	4	0	-	-	0	-	0	-	0	-	0	0	0	-
23	4	0	-	-	0	-	0	-	0	-	0	-	0	-
27	1	0	-	-	0	-	0	-	0	-	0	-	0	-
Total	328	0	0	0	0	0	0	0	3	14	16	11	6	8
Top	69	0	0	0	0	0	0	0	1	0	3	1	0	0
Bottom	259	0	0	0	0	0	0	0	2	14	13	10	6	8

Date	C2	C3	C4	C5	C6	C7	C8	C9	R10	PPI	R6	R5	C27	H28	H08
March															
31	0	1	2	1	1	3	3	3	-	-	-	-	-	-	-
April															
6	0	4	4	7	1	4	7	4	-	-	-	-	-	-	-
9	3	3	3	2	3	2	1	6	-	-	-	-	-	-	-
13	0	0	0	1	5	0	0	2	-	-	-	-	-	-	-
15	0	0	0	3	1	4	1	0	-	-	-	-	-	-	-
17	1	0	0	6	7	7	12	5	1	-	-	2	14	-	2
19	1	0	3	2	2	1	3	9	0	4	0	2	9	2	0
21	0	2	0	0	1	3	5	3	-	-	3	4	0	-	-
23	0	1	2	2	2	1	1	1	-	-	-	-	-	-	-
25	0	1	0	1	0	2	0	3	-	-	-	-	-	-	-
27	1	1	0	0	0	0	0	1	2	1	-	-	1	-	0
29	0	0	0	0	0	0	1	0	-	-	-	-	0	1	-
May															
1	0	0	0	1	1	0	1	0	-	0	-	-	0	-	-
3	0	0	1	0	0	0	3	-	-	-	-	-	-	-	-
5	0	0	0	0	0	0	2	3	-	-	-	-	-	-	-
7	0	0	0	0	0	0	0	-	0	0	-	-	0	-	-
9	0	0	0	-	1	0	0	2	-	-	-	-	1	-	-
11	0	0	0	-	4	-	0	-	1	2	-	-	0	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	0	-	2	-	1	-	0	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	0	-	0	-	0	-	0	-	1	2	-	-	1	-	-
23	0	-	0	-	1	-	0	-	2	1	-	-	0	-	-
27	0	-	0	-	1	-	-	-	0	0	-	-	0	-	-
Total	6	13	17	26	32	27	40	42	7	10	3	8	34	3	2
Top	0	2	5	5	2	4	9	13	1	1	0	0	20	1	1
Bottom	6	11	12	21	30	23	31	29	6	9	3	8	14	2	1

Table A6. Capture of white perch eggs in 1971: raw data (total: top and bottom captures combined)

Date	Number Taken	S2	S1	SR2	SR1	CR3	CR2	CR1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	R10	PP1	R6	R5	C27	SRP	SRR
April																													
8	2	-	-	-	-	-	-	-	-	-	0	0	0	1	1	0	0	0	0	0	0	0	-	-	-	-	-	-	-
9	36	-	-	-	-	-	-	-	0	0	0	2	2	23	5	10	6	0	0	0	0	0	-	-	-	-	-	-	-
13	32	-	-	-	2	-	0	0	0	0	0	0	1	9	39	0	1	0	0	0	0	0	-	-	-	-	-	-	-
15	907	-	-	-	143	-	0	2	1	10	0	0	2	209	250	243	44	1	0	0	0	0	-	-	-	-	-	-	-
17	45	0	-	-	0	0	2	0	0	0	1	0	0	0	0	0	0	1	3	13	3	19	0	-	-	0	1	-	0
19	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	3	0	0	0
21	949	0	0	0	0	0	0	0	0	0	0	30	2	631	42	33	1	114	0	3	1	1	-	-	1	0	0	-	-
23	1727	-	21	-	19	-	-	0	0	0	0	0	3	0	0	0	0	669	211	635	140	21	-	-	-	-	-	-	-
25	103	-	-	-	-	-	-	0	0	1	1	1	3	76	4	3	1	0	0	0	0	3	-	-	-	-	-	-	-
27	917	0	4	0	0	0	0	0	0	0	0	0	24	651	38	0	28	74	2	76	0	2	0	0	-	-	18	-	0
29	500	-	-	-	2	-	-	0	0	4	1	37	96	79	54	14	63	4	24	24	96	2	-	-	-	-	0	0	-
May																													
1	57	0	-	-	0	-	0	0	0	0	0	0	0	12	0	0	0	0	0	1	30	10	-	0	-	-	4	-	-
3	72	-	-	-	0	-	-	-	0	0	0	0	0	0	6	0	0	30	20	3	3	-	-	-	-	-	-	-	-
5	753	0	-	0	0	-	-	-	1	0	1	-	119	275	140	205	10	0	2	0	0	0	-	-	-	-	-	-	-
7	1084	4	0	0	0	0	0	1	0	0	4	154	314	453	32	12	77	4	0	0	1	-	0	0	-	-	0	-	-
9	267	0	-	-	21	-	-	0	0	0	1	31	11	173	0	0	0	-	0	0	0	0	-	-	-	-	0	-	-
11	291	1	0	-	34	-	0	-	0	0	0	-	73	-	170	3	0	-	2	-	0	-	0	0	-	-	0	-	-
13	6	-	-	-	0	-	-	-	0	0	0	0	0	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	107	-	-	-	0	-	0	-	12	-	1	0	0	13	23	-	3	-	39	-	0	-	-	-	-	-	-	-	-
17	43	-	-	-	-	-	-	-	0	1	0	0	-	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	3	0	-	-	0	-	0	-	2	-	0	1	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
23	11	3	-	-	7	-	0	-	0	-	0	-	9	-	0	-	0	-	0	-	1	-	0	0	-	-	0	-	-
27	73	1	-	-	3	-	0	-	0	-	0	-	4	-	65	-	0	-	0	-	-	-	0	0	-	-	0	-	-
31	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
June																													
2	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	1	0	-	0	-	-	1	-	0	-	0	0	0	0	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
Total	8121	9	25	0	220	0	3	11	16	16	10	330	662	2757	899	536	234	905	321	755	283	60	0	0	2	3	31	0	0
Top	1020	3	2	0	169	0	2	2	0	5	3	68	39	133	139	86	38	20	41	226	39	21	0	0	0	4	0	0	0
Bottom	7101	6	23	0	86	0	1	9	16	11	7	282	623	2624	760	450	196	885	280	529	244	39	0	0	2	1	31	0	0

Table A7. Capture of white perch larvae in 1971: raw data. Top and bottom captures (in that order) given for each sampling day.

Date	Number Taken	S2	S1	HB2	HB1	CB3	CB2	CB1	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5	C6	C7	C8	C9	A10	PPI	B6	H5	C27	HBW	HBR
April 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	-	0	2	0	0	0	-	-	0	-	0	-	-
	130	0	0	0	0	1	2	0	1	60	35	0	0	7	9	6	0	0	0	0	0	0	-	-	0	0	0	-	-
23	161	-	0	-	0	-	-	0	0	0	0	0	0	0	0	16	8	66	33	35	0	3	-	-	-	-	-	-	-
	660	-	37	-	23	-	-	7	32	21	17	34	64	17	9	83	149	34	40	53	4	5	-	-	-	-	-	-	-
25	106	-	-	-	-	-	-	0	0	0	0	0	0	3	4	10	42	3	19	7	0	16	-	-	-	-	-	-	-
	1296	-	-	-	-	-	-	33	14	20	142	60	67	58	134	102	139	217	70	183	15	32	-	-	-	-	-	-	-
27	30	0	0	0	0	0	0	0	0	1	0	0	3	0	21	0	0	0	23	8	1	0	0	1	-	-	0	-	0
	333	0	30	2	1	74	36	11	13	80	95	30	8	85	0	-	4	30	0	12	-	0	0	0	-	-	0	-	0
29	163	-	-	-	0	-	-	0	0	0	0	0	0	3	36	2	76	0	7	0	6	0	-	-	-	-	37	0	-
	876	-	-	-	0	-	-	30	61	86	80	49	226	8	179	6	59	-	-	0	11	0	-	-	-	-	62	0	-
May 1	71	0	-	-	0	-	0	0	1	3	2	0	33	25	0	2	1	1	0	0	1	0	-	0	-	-	2	-	-
	630	0	-	-	2	-	7	6	66	34	66	18	99	210	30	33	20	5	5	2	3	0	-	6	-	-	0	-	-
3	114	-	-	-	0	-	-	-	0	7	31	10	9	22	4	8	2	0	0	0	1	-	-	-	-	-	-	-	-
	306	-	-	-	0	-	-	-	0	62	68	78	48	53	43	-	53	12	61	12	16	-	-	-	-	-	-	-	-
5	115	1	-	2	0	-	-	-	0	4	9	-	5	30	0	0	-	8	48	0	-	-	-	-	-	-	-	-	-
	1124	0	-	0	0	-	-	-	41	20	34	-	45	30	50	107	162	134	308	81	14	2	-	-	-	-	-	-	-
7	121	0	0	0	0	0	0	1	0	0	0	0	0	10	4	11	56	9	10	4	4	-	5	6	-	-	1	-	-
	465	64	3	1	26	12	3	0	14	8	30	20	30	96	80	-	34	6	1	0	7	-	11	0	-	-	15	-	-
9	16	0	-	-	0	-	-	0	1	2	0	1	0	2	0	1	0	-	0	2	0	7	-	-	-	-	0	-	-
	300	3	-	-	4	-	-	6	5	16	4	1	47	45	23	16	25	-	11	2	1	0	-	-	-	-	0	-	-
11	17	1	0	-	0	-	0	-	0	1	1	-	0	-	10	1	1	-	0	-	1	-	1	0	-	-	0	-	-
	460	26	23	-	161	-	6	-	40	19	38	-	40	-	22	-	12	-	14	-	0	-	0	0	-	-	2	-	-
13	6	-	-	-	0	-	-	-	0	0	0	0	6	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	361	-	-	-	20	-	-	-	70	27	40	4	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	6	-	-	-	0	-	0	-	0	-	0	0	2	0	4	-	0	-	0	-	0	-	-	-	-	-	-	-	-
	177	-	-	-	0	-	132	-	0	-	17	9	1	0	10	-	-	-	0	-	0	-	-	-	-	-	-	-	-
17	7	-	-	-	0	-	-	-	-	-	7	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	20	-	-	-	0	-	-	-	17	3	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	4	0	-	-	0	-	0	-	1	-	0	-	0	-	0	-	1	-	1	-	0	-	1	0	-	-	-	-	-
	271	83	-	-	67	-	56	-	9	-	6	27	0	-	0	-	0	-	0	-	1	-	7	5	-	-	2	-	-
23	190	106	-	-	0	-	0	-	0	-	0	-	0	-	2	-	0	-	1	-	0	-	0	1	-	-	-	-	-
	419	0	-	-	198	-	79	-	53	-	67	-	15	-	4	-	2	-	1	-	0	-	0	-	-	-	0	-	-
27	312	0	-	-	0	-	0	-	0	-	6	-	167	-	266	-	74	-	13	-	-	-	1	2	-	-	3	-	-
	1125	54	-	-	125	-	591	-	36	-	21	-	96	-	91	-	54	-	44	-	-	-	1	-	-	-	12	-	-
31	36	0	-	-	0	-	5	-	0	-	17	-	6	-	4	-	1	-	0	-	0	-	1	0	-	-	0	-	-
	1215	36	-	-	122	-	876	-	192	-	-	-	21	-	-	-	-	-	0	-	0	-	0	1	-	-	0	-	-
June 2	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	0	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	78	0	-	0	-	-	0	-	0	-	0	0	3	0	36	-	7	-	7	-	1	-	0	2	-	-	2	-	-
	3526	30	-	128	-	-	49	-	1409	-	628	86	725	110	78	-	112	-	16	-	112	-	43	-	-	-	0	-	-
6	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	195	-	-	-	-	-	-	-	-	-	-	165	-	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	85	-	-	-	0	-	-	-	0	-	0	-	0	1	76	-	8	-	1	-	0	-	-	0	-	-	1	-	-
	825	-	-	-	96	-	-	-	102	-	432	-	87	29	19	-	49	-	1	-	3	-	-	7	-	-	0	-	-
10	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	75	-	-	-	1	-	-	-	1	-	0	-	0	-	33	-	0	-	12	-	8	-	-	-	-	-	-	-	-
	399	-	-	-	157	-	-	-	36	-	64	-	26	-	44	-	72	-	-	-	-	-	-	-	-	-	-	-	-
23	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	0	-	-	0	-	-
	141	20	-	-	17	-	5	-	-	-	13	-	43	-	22	-	2	-	8	-	3	-	0	0	-	-	0	-	-
30	10	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	10	-	0	0	-	-	0	-	-
	109	19	-	-	22	-	11	-	30	-	24	-	11	-	30	-	10	-	3	-	3	-	8	7	-	-	3	-	-
July 7	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
	91	39	-	-	6	-	0	-	0	-	1	-	7	-	23	-	1	-	3	-	11	-	0	0	-	-	0	-	-
15	0	0	-	-	0	-	0	-	0	-	0	-	-	-	0	-	-	-	0	-	0	-	0	0	-	-	0	-	-
	5	1	-	-	0	-	0	-	0	-	0	-	0	-	1	-	0	-	1	-	1	-	0	1	-	-	0	-	-
22	0	-	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	-	-	-	-	-	-	-	-
	2	-	-	-	0	-	0	-	0	-	0	-	2	-	0	-	0	-	0	-	0	-	-	0	-	-	-	-	-
27	0	-	-	-	0	-	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	-	-	-
	1	-	-	-	0	-	-	-	1	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	-	-	-
Total	17545	571	106	133	1064	87	1858	94	2221	507	2024	620	1930	890	1445	408	1236	533	844	401	236	65	79	43	0	0	150	0	0
Top	1953	188	0	2	1	0	5	1	4	18	93	11	214	104	536	55	277	87	177	56	31	26	9	12	0	0	46	0	0
Bottom	15592	383	106	131	1063	87	1853	93	2217	489	1931	609	1716	786	909	353	959	446	667	345	205	39	70	31	0	0	104	0	0

Table A8. Capture of striped bass eggs in 1971: raw data (total: top and bottom captures combined)

Date	No. Specimens	S2	S1	SH2	SH1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	R10	PPI	R6	3R	C27	H2F	HGR
April																													
15	15	-	-	-	0	-	0	0	0	0	0	0	9	0	2	2	0	0	0	0	0	2	-	-	-	-	-	-	-
17	73	0	-	-	0	0	0	0	0	6	0	7	1	0	2	0	0	1	10	1	1	0	26	-	-	15	2	-	1
19	727	0	0	0	0	0	0	0	2	3	8	39	138	144	72	11	6	8	1	5	1	2	73	94	30	64	9	16	1
21	2512	0	0	0	0	1	0	0	8	32	82	148	480	517	637	358	82	69	36	12	11	2	-	-	12	0	5	-	-
23	9136	-	0	-	0	-	-	6	5	68	36	97	154	27	48	416	750	1426	2262	3572	176	113	-	-	-	-	-	-	-
25	12062	-	-	-	-	-	-	1	0	1	18	32	44	63	101	202	393	2099	1732	4655	2284	417	-	-	-	-	-	-	-
27	8606	0	0	0	0	7	1	0	11	4	56	5	31	588	3758	1372	1366	614	230	311	55	65	22	27	-	-	83	-	0
29	12227	-	-	2	-	-	-	10	7	12	192	165	628	1145	3476	3010	2363	466	190	196	184	52	-	-	-	-	117	10	-
May																													
1	3984	0	-	-	1	-	3	1	11	1	43	23	310	1343	727	956	212	40	29	38	42	46	-	130	-	-	28	-	-
3	1571	-	-	-	0	-	-	-	0	87	197	111	324	248	131	26	215	79	77	38	38	-	-	-	-	-	-	-	-
5	1966	0	-	0	0	-	-	-	2	0	4	-	61	280	17	807	99	330	217	99	18	12	-	-	-	-	-	-	-
7	1121	0	0	0	0	24	11	6	9	8	125	4	90	29	206	68	413	33	22	15	22	-	5	12	-	-	19	-	-
9	2176	0	-	-	0	-	-	9	0	32	78	14	117	53	195	1164	219	-	95	59	24	117	-	-	-	-	0	-	-
11	1456	0	0	-	7	-	4	-	17	179	220	-	406	-	323	84	148	-	59	-	3	-	3	2	-	-	1	-	-
13	582	-	-	-	0	-	-	-	0	16	11	115	214	226	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	14	-	-	-	0	-	0	-	0	-	0	1	3	9	0	-	0	-	0	-	1	-	-	-	-	-	-	-	-
17	110	-	-	-	-	-	-	-	14	7	32	33	-	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	699	0	-	-	0	-	8	-	1	-	59	88	200	-	123	-	82	-	8	-	9	-	66	14	-	-	33	-	-
23	485	0	-	-	0	-	0	-	1	-	8	-	46	-	94	-	191	-	93	-	29	-	21	1	-	-	1	-	-
27	198	0	-	-	3	-	0	-	3	-	3	-	35	-	49	-	75	-	24	-	-	-	1	0	-	-	5	-	-
31	2	0	-	-	2	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
June																													
2	16	-	-	-	-	-	-	-	-	-	-	8	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	68	0	-	-	0	-	1	-	2	-	1	6	5	4	11	-	11	-	6	-	7	-	8	2	-	-	4	-	-
6	20	-	-	-	-	-	-	-	-	-	-	17	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	223	-	-	-	2	-	-	-	3	-	6	-	104	10	14	-	33	-	31	-	18	-	-	1	-	-	1	-	-
10	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	1	-	-	-	0	-	-	-	0	-	1	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-	-

Table A9. Capture of striped bass eggs in 1971: raw data. Top and bottom captures (in that order) given for each sampling day.

Date	No. Spec.	S2	S1	WE2	WE1	CD3	CD2	CD1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	R10	PP1	R6	SH	C27	H2N	MOR
April																													
15	4	-	-	-	0	-	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	-	-	-	-	-	-	-
	11	-	-	-	0	-	0	0	0	0	0	0	9	0	0	2	0	0	0	0	0	0	-	-	-	-	-	-	-
17	17	0	-	-	0	0	0	0	0	1	0	5	0	0	0	0	0	1	0	0	0	0	6	-	-	4	0	-	0
	36	0	-	-	0	0	0	0	0	5	0	2	1	0	2	0	0	0	10	1	1	0	30	-	-	11	2	-	1
19	253	0	0	0	0	0	0	0	0	2	0	6	32	49	40	10	6	8	0	4	1	2	9	39	0	27	0	10	0
	474	0	0	0	0	0	0	0	2	1	8	33	106	95	32	1	0	0	1	1	0	0	64	55	30	37	1	6	1
21	921	0	0	0	0	0	0	0	0	1	1	1	91	119	377	227	-	47	30	10	9	0	9	9	4	-	4	-	-
	1301	0	0	0	0	1	0	0	8	51	81	147	309	398	260	131	82	22	6	2	2	2	-	-	8	0	1	-	-
23	3647	-	0	-	0	-	-	0	0	1	0	1	1	0	2	108	142	633	850	1703	136	30	-	-	-	-	-	-	-
	3409	-	0	-	0	-	-	6	3	67	36	96	153	27	46	308	608	793	1392	1869	20	63	-	-	-	-	-	-	-
25	3496	-	-	-	-	-	-	0	0	0	0	1	0	10	16	62	157	696	357	1211	791	199	-	-	-	-	-	-	-
	8346	-	-	-	-	-	-	1	0	1	10	31	46	53	87	140	236	1405	1375	3444	1493	218	-	-	-	-	-	-	-
27	5344	0	0	0	0	0	0	0	0	3	3	0	25	26	2306	1372	742	256	215	151	55	41	12	26	-	-	35	-	0
	3262	0	0	0	0	7	1	0	11	1	53	5	6	364	1372	-	626	358	15	160	-	26	10	3	-	-	48	-	0
29	5964	-	-	0	-	-	-	0	0	0	9	12	83	213	1491	1634	1139	446	190	126	96	46	-	-	-	-	53	10	-
	6663	-	-	2	-	-	-	10	7	12	183	153	545	932	1985	1376	1226	-	-	72	90	6	-	-	-	-	64	0	-
May																													
1	1126	0	-	-	0	-	0	0	1	1	0	1	128	117	281	443	38	28	3	5	29	6	-	33	-	-	12	-	-
	2030	0	-	-	1	-	3	1	10	0	43	22	182	1226	446	513	176	12	26	33	13	40	-	97	-	-	16	-	-
3	206	-	-	-	0	-	-	-	0	3	46	13	25	52	0	26	30	2	3	3	3	-	-	-	-	-	-	-	-
	1365	-	-	-	0	-	-	-	0	84	151	90	299	196	131	-	185	77	74	35	35	-	-	-	-	-	-	-	-
5	290	0	-	0	0	-	-	-	2	0	4	-	10	117	0	96	-	0	42	21	-	-	-	-	-	-	-	-	-
	1676	0	-	0	0	-	-	-	0	0	0	-	31	163	17	713	99	350	175	78	18	12	-	-	-	-	-	-	-
7	473	0	0	0	0	0	0	0	1	0	0	0	0	0	26	60	279	32	22	11	6	-	2	6	-	-	6	-	-
	646	0	0	0	0	26	11	6	8	8	125	4	82	21	182	-	136	1	0	4	16	-	3	6	-	-	13	-	-
9	706	0	-	-	0	-	-	2	0	3	5	5	19	20	19	303	61	-	19	37	20	115	-	-	-	-	0	-	-
	1446	0	-	-	0	-	-	7	6	29	73	9	98	33	176	781	158	-	76	22	4	2	-	-	-	-	0	-	-
11	316	0	0	-	0	-	0	-	0	3	4	-	5	-	160	84	17	-	30	-	1	-	3	1	-	-	0	-	-
	1140	0	0	-	7	-	4	-	17	176	216	-	401	-	155	-	131	-	29	-	2	-	0	1	-	-	1	-	-
13	303	-	-	-	0	-	-	-	0	0	0	0	129	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	379	-	-	-	0	-	-	-	0	16	11	107	85	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	5	-	-	-	0	-	0	-	0	-	0	1	3	0	0	-	0	-	0	-	1	-	-	-	-	-	-	-	-
	9	-	-	-	0	-	0	-	0	-	0	0	0	9	0	-	-	-	0	-	0	-	-	-	-	-	-	-	-
17	43	-	-	-	-	-	-	-	-	-	32	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	67	-	-	-	-	-	-	-	14	7	-	22	-	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	233	0	-	-	0	-	0	-	0	-	11	-	90	-	73	-	33	-	0	-	5	-	0	0	-	-	5	-	-
	446	0	-	-	0	-	0	-	1	-	48	80	118	-	30	-	29	-	0	-	4	-	30	14	-	-	28	-	-
23	107	0	-	-	0	-	0	-	0	-	0	-	13	-	22	-	99	-	26	-	20	-	6	1	-	-	-	-	-
	290	0	-	-	0	-	0	-	1	-	6	-	33	-	72	-	92	-	67	-	9	-	15	-	-	-	1	-	-
27	33	0	-	-	1	-	0	-	0	-	0	-	16	-	2	-	16	-	0	-	-	-	0	0	-	-	0	-	-
	165	0	-	-	2	-	0	-	3	-	3	-	19	-	47	-	61	-	34	-	-	-	1	-	-	-	5	-	-
31	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
	2	0	-	-	2	-	0	-	0	-	-	-	0	-	-	-	-	-	0	-	0	-	0	0	-	-	0	-	-
June																													
2	13	-	-	-	-	-	-	-	-	-	-	0	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	25	0	-	-	0	-	0	-	1	-	0	0	1	4	2	-	4	-	1	-	2	-	3	2	-	-	3	-	-
	43	0	-	-	0	-	1	-	1	-	1	4	4	0	9	0	7	-	5	-	3	-	3	-	-	-	1	-	-
6	14	-	-	-	-	-	-	-	-	-	-	11	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	107	-	-	-	0	-	-	-	2	-	0	-	90	6	7	-	25	-	31	-	10	-	-	0	-	-	0	-	-
	26	-	-	-	2	-	-	-	1	-	6	-	6	4	7	-	0	-	0	-	0	-	-	1	-	-	1	-	-
10	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	1	-	-	-	0	-	-	-	0	-	1	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-	-
	0	-	-	-	0	-	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-	-
Totals:																													
Top	23329	0	0	0	1	0	0	2	5	18	116	84	777	813	4912	4311	2806	2167	1827	3200	1211	461	31	108	4	31	126	20	0
Bot	36701	0	0	2	14	32	28	31	91	450	1064	629	3631	3900	3074	3963	3034	3018	3275	5721	1712	367	176	177	30	40	102	6	2

Table A10. Capture of striped bass larvae in 1971: raw data (total: top and bottom captures combined)

Date	Number Taken	S2	S1	MR2	MR1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	E10	PPI	B6	B5	C27	[illegible]	[illegible]
April																													
21	14	0	3	0	1	0	0	0	0	0	0	6	0	0	0	0	0	1	1	1	0	0	-	-	1	0	0	-	-
23	4	-	0	-	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	-	-	-	-	-	-	-
25	86	-	-	-	-	-	-	0	0	0	0	0	0	0	1	2	4	8	5	27	17	22	-	-	-	-	-	-	-
27	76	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	15	15	30	2	4	0	0	-	-	6	-	0
29	341	-	-	-	0	-	-	0	1	4	2	5	13	7	211	108	97	0	7	0	30	0	-	-	-	-	36	0	-
May																													
1	993	0	-	-	0	-	0	0	11	12	23	26	85	213	237	66	63	23	15	19	12	0	-	79	-	-	9	-	-
3	119	-	-	-	0	-	-	-	0	10	4	14	13	19	1	3	5	18	3	26	3	-	-	-	-	-	-	-	-
5	399	0	-	0	0	-	-	-	0	2	3	-	5	11	6	18	63	58	169	43	12	9	-	-	-	-	-	-	-
7	119	0	0	0	0	0	0	0	0	0	0	0	3	29	18	0	21	2	7	6	0	-	6	14	-	-	13	-	-
9	77	0	-	-	0	-	-	0	0	0	1	0	2	8	4	9	45	-	0	3	0	5	-	-	-	-	0	-	-
11	73	2	0	-	0	-	0	-	0	9	8	-	23	-	11	0	11	-	8	-	1	-	0	0	-	-	0	-	-
13	26	-	-	-	0	-	-	-	0	3	9	11	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	376	-	-	-	0	-	0	-	0	-	19	90	4	210	53	-	0	-	0	-	0	-	-	-	-	-	-	-	-
17	361	-	-	-	-	-	-	-	102	173	82	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	186	0	-	-	0	-	33	-	118	-	13	15	4	-	1	-	0	-	0	-	0	-	0	0	-	-	2	-	-
23	204	0	-	-	0	-	33	-	36	-	67	-	20	-	25	-	1	-	1	-	1	-	0	0	-	-	0	-	-
27	176	0	-	-	9	-	6	-	3	-	10	-	11	-	13	-	100	-	17	-	-	-	0	0	-	-	5	-	-
31	30	0	-	-	27	-	20	-	3	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
June																													
2	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	123	0	-	1	-	-	2	-	38	-	44	10	16	6	1	-	2	-	1	-	2	-	0	0	-	-	0	-	-
6	8	-	-	-	-	-	-	-	-	-	-	7	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	114	-	-	-	1	-	-	-	0	-	64	-	16	4	22	-	7	-	0	-	0	-	-	0	-	-	0	-	-
10	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	35	-	-	-	3	-	-	-	7	-	8	-	13	-	10	-	14	-	0	-	0	-	-	-	-	-	-	-	-
23	19	0	-	-	1	-	1	-	0	-	3	-	3	-	7	-	0	-	4	-	0	-	0	0	-	-	0	-	-
30	1	0	-	-	1	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
Total	4196	2	3	1	43	0	113	0	319	215	361	107	232	510	621	306	433	125	253	157	81	41	6	93	1	0	91	0	0
Top	587	2	0	0	0	0	1	0	0	0	86	3	26	20	74	99	92	16	47	17	32	8	0	20	1	0	43	0	0
Bottom	3609	0	3	1	43	0	114	0	319	215	275	104	206	490	547	207	341	109	206	140	49	33	6	73	0	0	48	0	0

Table A11. Capture of striped bass larvae in 1971: raw data. Top and bottom captures (in that order) given for each sampling day.

Date	Number Taken	S2	S1	NE2	NE1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	B10	FF1	B6	B5	C27	[illegible]	[illegible]
April 21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	-	-	1	-	0	-	-
	13	0	3	0	1	0	0	0	0	0	0	6	0	0	0	0	0	1	1	1	0	0	-	-	0	0	0	-	-
23	2	-	0	-	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	-	-	-	-	-	-	-
	2	-	0	-	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	-	-	-	-	-	-	-
25	17	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	1	2	0	1	10	3	-	-	-	-	-	-	-
	60	-	-	-	-	-	-	0	0	0	0	0	0	0	1	2	3	6	5	26	7	19	-	-	-	-	-	-	-
27	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	15	14	2	0	0	0	-	-	0	-	-
	44	0	0	0	0	0	0	0	0	2	1	1	0	0	0	-	0	14	0	16	-	6	0	0	-	-	6	-	-
29	229	-	-	-	0	-	-	0	0	0	0	0	0	1	60	84	42	0	7	0	11	0	-	-	-	-	36	0	-
	312	-	-	-	0	-	-	0	1	4	2	5	13	6	151	24	55	-	-	0	19	0	-	-	-	-	32	0	-
May 1	87	0	-	-	0	-	0	0	0	0	0	0	13	12	0	12	2	13	2	0	0	0	-	10	-	-	7	-	-
	900	0	-	-	0	-	0	0	11	12	23	26	72	201	237	154	61	10	13	19	4	0	-	61	-	-	2	-	-
3	13	-	-	-	0	-	-	-	0	0	2	3	1	4	0	3	0	0	0	0	0	-	-	-	-	-	-	-	-
	206	-	-	-	0	-	-	-	0	10	2	11	12	15	1	-	5	10	3	26	3	-	-	-	-	-	-	-	-
5	20	0	-	0	0	-	-	-	0	0	0	-	0	3	0	0	-	0	17	0	-	-	-	-	-	-	-	-	-
	379	0	-	0	0	-	-	-	0	2	3	-	5	0	6	18	63	38	152	43	12	9	-	-	-	-	-	-	-
7	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	5	0	0	-	0	2	-	-	12	-	-
	84	0	0	0	0	0	0	0	0	0	0	0	3	29	18	-	5	2	2	6	0	-	6	12	-	-	1	-	-
9	5	0	-	-	0	-	-	0	0	0	0	0	0	0	0	0	0	-	0	0	0	5	-	-	-	-	0	-	-
	72	0	-	-	0	-	-	0	0	0	1	0	2	0	4	9	45	-	0	3	0	0	-	-	-	-	0	-	-
11	9	2	0	-	0	-	0	-	0	0	0	-	0	-	5	0	1	-	0	-	1	-	0	0	-	-	0	-	-
	64	0	0	-	0	-	0	-	0	9	8	-	23	-	6	-	10	-	8	-	0	-	0	0	-	-	0	-	-
13	0	-	-	-	0	-	-	-	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	26	-	-	-	0	-	-	-	0	3	9	11	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	3	-	-	-	0	-	0	-	0	-	0	0	0	0	3	-	0	-	0	-	0	-	-	-	-	-	-	-	-
	373	-	-	-	0	-	0	-	0	-	19	90	4	210	30	-	-	-	0	-	0	-	-	-	-	-	-	-	-
17	82	-	-	-	0	-	-	-	-	-	82	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	279	-	-	-	0	-	-	-	102	173	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
	186	0	-	-	0	-	33	-	118	-	13	15	4	-	1	-	0	-	0	-	0	-	0	0	-	-	2	-	-
23	1	0	-	-	0	-	0	-	0	-	1	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	-	-	-
	200	0	-	-	0	-	33	-	36	-	66	-	20	-	25	-	1	-	1	-	1	-	0	-	-	-	0	-	-
27	34	0	-	-	0	-	0	-	0	-	1	-	0	-	2	-	30	-	1	-	-	-	0	0	-	-	0	-	-
	140	0	-	-	9	-	6	-	3	-	9	-	11	-	11	-	70	-	16	-	-	-	0	-	-	-	5	-	-
31	1	0	-	-	0	-	1	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
	40	0	-	-	27	-	19	-	3	-	-	-	0	-	-	-	-	-	0	-	0	-	0	0	-	-	0	-	-
June 2	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	2	0	-	0	-	-	0	-	0	-	0	0	2	0	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
	121	0	-	1	-	-	2	-	30	-	44	10	14	6	1	-	2	-	1	-	2	-	0	-	-	-	0	-	-
6	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	0	-	-	-	-	-	-	-	-	-	-	7	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	9	-	-	-	0	-	-	-	0	-	0	-	9	0	0	-	0	-	0	-	0	-	-	0	-	-	0	-	-
	100	-	-	-	1	-	-	-	0	-	64	-	7	4	22	-	7	-	0	-	0	-	-	0	-	-	0	-	-
10	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	4	-	-	-	0	-	-	-	0	-	0	-	0	-	4	-	0	-	0	-	0	-	-	-	-	-	-	-	-
	38	-	-	-	3	-	-	-	7	-	0	-	13	-	6	-	14	-	-	-	-	-	-	-	-	-	-	-	-
25	1	0	-	-	0	-	0	-	0	-	0	-	1	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
	16	0	-	-	1	-	1	-	-	-	3	-	2	-	7	-	0	-	4	-	0	-	0	0	-	-	0	-	-
30	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-	0	0	-	-	0	-	-
	1	0	-	-	1	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
Total	4096	2	3	1	43	0	115	0	319	215	361	107	232	510	621	306	433	123	253	157	81	41	6	93	1	0	91	0	0
Top	387	2	0	0	0	0	1	0	0	0	86	3	26	20	74	99	92	16	47	17	32	8	0	20	1	0	43	0	0
Bottom	3640	0	3	1	43	0	114	0	319	215	275	104	206	490	547	207	341	109	206	140	40	33	6	73	0	0	48	0	0

Table A12. Capture of Morone spp. larvae in 1971: raw data (total: top and bottom captures combined)

Date	Number Taken	S2	S1	NE2	NE1	C30	C32	C31	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	E10	FF1	E6	E5	C27	[illegible]	[illegible]
May 15	0	-	-	-	0	-	0	-	0	-	0	0	0	0	0	-	0	-	0	-	0	-	-	-	-	-	-	-	-
	1	-	-	-	0	-	0	-	0	-	0	1	0	0	0	-	-	-	0	-	0	-	-	-	-	-	-	-	-
17	0	-	-	-	0	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	-	-	-	0	-	-	-	1	0	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
	0	0	-	-	0	-	0	-	0	-	0	0	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
23	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	-	-	-
	1	0	-	-	0	-	1	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	-	-
27	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	0	-	-	0	-	-
	2	0	-	-	0	-	1	-	1	-	0	-	0	-	0	-	0	-	0	-	-	-	0	-	-	-	0	-	-
31	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
	0	0	-	-	0	-	0	-	0	-	-	-	0	-	-	-	-	-	0	-	0	-	0	0	-	-	0	-	-
June 2	10	-	-	-	-	-	-	-	-	-	-	10	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	0	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	3	0	-	0	-	-	0	-	0	-	0	0	0	0	0	-	0	-	0	-	3	-	0	0	-	-	0	-	-
	1047	0	-	43	-	-	17	-	39	-	10	246	33	220	334	-	5	-	49	-	0	-	0	-	-	-	13	-	-
6	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	587	-	-	-	-	-	-	-	-	-	-	453	-	134	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	66	-	-	-	0	-	-	-	0	-	0	-	24	0	24	-	17	-	0	-	0	-	-	0	-	-	1	-	-
	2883	-	-	-	100	-	-	-	0	-	1120	-	627	213	330	-	320	-	62	-	81	-	-	2	-	-	0	-	-
10	0	-	-	-	-	-	-	-	-	-	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	302	-	-	-	-	-	-	-	-	-	-	178	-	124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	107	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	103	-	4	-	-	-	-	-	-	-	-
	1929	0	-	-	410	-	0	-	490	-	107	-	179	-	499	-	236	-	-	-	-	-	-	-	-	-	-	-	-
23	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	0	-	-	0	-	-
	551	33	-	-	157	-	20	-	0	-	146	-	51	-	104	-	0	-	12	-	0	-	0	0	-	-	0	-	-
30	7	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	7	-	0	0	-	-	0	-	-
	12	1	-	-	3	-	7	-	0	-	0	-	1	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
Total	7311	34	-	43	670	-	46	-	539	-	1391	888	919	699	1339	-	306	-	226	-	95	-	0	2	-	-	14	-	-
Top	193	0	-	0	0	-	0	-	0	-	0	10	24	0	24	-	17	-	103	-	14	-	0	0	-	-	1	-	-
Bottom	7318	34	-	43	670	-	46	-	539	-	1391	878	895	699	1315	-	369	-	123	-	81	-	0	2	-	-	13	-	-

Table A13. Capture of yellow perch larvae in 1971: raw data (total: top and bottom captures combined)

Date	Number Taken	S2	S1	NE2	NE1	CB3	CB2	CB1	E1	E2	E3	E4	E5	C1	C2	C3	C4	C5	C6	C7	C8	C9	R10	FP1	P6	M5	C27	[illegible]	[illegible]
April 9	0	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	1	0	0	-	-	-	-	-	-	-
13	1	-	-	-	0	-	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	-	-	-	-	-	-	-
	2	-	-	-	0	-	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	-	-	-	-	-	-	-
15	9	-	-	-	0	-	0	0	0	0	0	1	0	1	2	2	0	0	0	3	0	0	-	-	-	-	-	-	-
	102	-	-	-	0	-	1	0	36	3	26	19	3	4	2	1	2	3	1	1	0	0	-	-	-	-	-	-	-
17	95	0	-	-	0	0	0	0	39	2	28	0	0	0	7	2	11	1	3	0	0	0	0	-	-	0	0	-	2
	176	0	-	-	0	4	2	9	13	60	20	27	25	5	0	7	2	0	0	0	0	0	0	-	-	0	0	-	0
19	196	0	0	0	11	0	0	1	7	1	19	65	2	72	7	5	1	1	0	0	0	2	0	0	0	0	0	0	2
	167	0	0	1	3	0	9	20	22	19	21	38	21	11	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
21	44	0	0	0	0	9	2	0	2	1	0	3	12	0	7	4	-	3	0	1	0	0	-	-	0	-	0	-	-
	144	0	0	1	0	1	14	18	4	11	23	19	27	12	9	1	0	2	0	0	1	0	-	-	0	1	0	-	-
23	215	-	0	-	0	-	-	0	0	0	0	0	0	0	0	15	84	38	47	28	1	2	-	-	-	-	-	-	-
	121	-	1	-	0	-	-	4	2	1	4	4	5	6	2	12	17	17	18	25	2	1	-	-	-	-	-	-	-
25	192	-	-	-	-	-	-	0	0	0	0	1	0	13	14	26	21	35	25	21	31	5	-	-	-	-	-	-	-
	78	-	-	-	-	-	-	0	0	1	0	1	5	2	11	7	11	16	5	12	3	4	-	-	-	-	-	-	-
27	42	0	0	0	0	0	0	0	10	0	3	0	1	2	6	4	8	2	2	1	2	0	0	0	-	-	1	-	0
	31	0	0	1	0	1	0	0	0	1	0	3	3	4	0	-	12	2	0	0	-	0	4	0	-	-	0	-	0
29	34	-	-	-	0	-	-	0	0	0	0	3	0	0	24	0	0	0	3	0	0	0	-	-	-	-	4	0	-
	28	-	-	-	0	-	-	1	0	2	0	1	3	6	7	0	2	-	-	0	0	0	-	-	-	-	6	0	-
May 1	241	0	-	-	0	-	0	2	0	0	0	0	117	26	7	75	10	4	0	0	0	0	-	0	-	-	0	-	-
	40	0	-	-	0	-	2	2	1	1	3	0	10	5	1	3	3	0	0	1	0	0	-	0	-	-	0	-	-
3	31	-	-	-	0	-	-	-	0	1	1	5	19	2	0	3	0	0	0	0	0	-	-	-	-	-	-	-	-
	21	-	-	-	0	-	-	-	0	0	9	0	2	3	1	-	4	1	0	0	1	-	-	-	-	-	-	-	-
5	61	0	-	3	1	-	-	-	1	0	1	-	0	6	14	1	-	4	24	6	-	-	-	-	-	-	-	-	-
	2	0	-	0	0	-	-	-	0	0	0	-	1	0	0	0	0	0	1	0	0	-	-	-	-	-	-	-	-
7	16	0	0	0	0	0	0	0	0	0	0	0	0	3	1	2	0	2	1	0	1	-	1	4	-	-	1	-	-
	9	0	0	0	0	0	1	1	1	1	2	0	0	0	1	-	0	1	0	0	1	-	0	0	-	-	0	-	-
9	3	0	-	-	0	-	-	0	0	0	0	0	0	0	0	0	0	-	3	0	0	0	-	-	-	-	0	-	-
	5	0	-	-	0	-	-	0	0	0	0	1	1	0	1	2	0	-	0	0	0	0	-	-	-	-	0	-	-
11	2	0	0	-	0	-	0	-	0	0	0	-	0	-	0	0	2	-	0	-	0	-	0	0	-	-	0	-	-
	0	0	0	-	0	-	0	-	0	0	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
13	0	-	-	-	0	-	-	-	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	0	-	-	-	1	1	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	2	-	-	-	0	-	0	-	0	-	0	1	0	0	1	-	0	-	0	-	0	-	-	-	-	-	-	-	-
	3	-	-	-	0	-	0	-	0	-	0	1	0	0	2	-	-	-	0	-	0	-	-	-	-	-	-	-	-
17	1	-	-	-	0	-	-	-	-	-	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	0	-	-	-	0	-	-	-	0	0	-	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
	0	0	-	-	0	-	0	-	0	-	0	0	0	-	0	-	0	-	0	-	0	-	0	0	-	-	0	-	-
23	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	-	-	-	-
	1	0	-	-	0	-	1	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	-	-
27	0	0	-	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	0	0	-	-	0	-	-
	1	0	-	-	0	-	0	-	0	-	0	-	1	-	0	-	0	-	0	-	-	-	0	-	-	-	0	-	-
Total	2125	0	1	6	15	15	32	38	139	106	161	201	266	184	127	172	190	134	134	100	43	15	5	4	0	1	12	0	4
Top	1185	0	0	3	12	9	2	3	39	5	53	79	131	125	90	139	137	91	108	60	35	9	1	4	0	0	6	0	4
Bottom	940	0	1	3	3	6	30	35	80	101	108	122	115	59	37	33	53	43	26	40	8	6	4	0	0	1	6	0	0

Table A14. Capture of naked goby larvae in 1971: raw data (total: top and bottom captures combined)

Date	Number Taken	S2	NE1	CB2	E1	E3	E5	C2	C4	C6	C8	R10	PPI	C27
June														
30	3	0	0	0	0	0	0	1	0	0	0	0	0	2
July														
7	151	0	16	21	4	3	7	5	1	2	1	74	7	10
15	46	1	6	2	4	5	3	5	4	0	1	1	0	14
22	79	-	10	18	25	1	6	1	3	0	4	-	11	-
27	56	-	23	-	31	2	0	0	0	0	0	0	0	-
August														
4	42	0	0	20	0	9	2	2	3	6	0	0	0	0
11	2	-	0	-	0	0	0	2	0	0	0	0	0	-
18	46	0	0	31	10	4	0	1	0	0	0	0	0	-
25	111	6	24	66	10	1	1	2	1	0	0	0	0	-
September														
2	9	-	-	-	0	5	2	0	1	1	0	-	-	-
9	27	-	-	14	0	3	9	0	1	0	0	-	-	-
23	4	-	-	-	0	2	2	0	0	0	0	-	-	-
Total	576	7	79	172	84	35	32	19	14	9	6	75	18	26
Top	7	0	0	0	5	0	0	0	1	0	1	0	0	0
Bottom	569	7	79	172	79	35	32	19	13	9	5	75	18	26

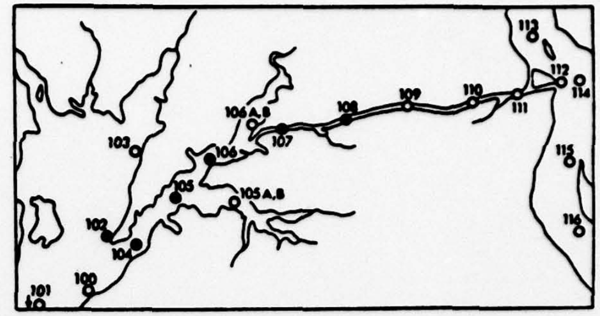

Table B1. Temperature (°C.) and salinity (ppt) data collected in 1971. Station positions shown in figure at right. Values for surface and bottom, in that order, given for each station.

Date	Temperature						Salinity					
	102	104	105	106	107	108	102	104	105	106	107	108
March 2	4.9	-	-	4.8	-	-	-	-	-	-	-	-
	4.8	-	-	4.9	-	-	-	-	-	-	-	-
April 1	7.6	8.9	-	-	-	6.6	0.5	0.5	-	-	-	1.4
	7.4	8.2	-	-	-	6.5	0.5	0.4	-	-	-	1.6
May 1	-	-	20.5	19.9	21.9	18.5	-	-	0.5	0.9	1.5	2.1
	-	-	18.8	18.3	20.2	17.5	-	-	0.4	1.4	1.6	2.1
June 22	-	-	29.3	30.2	27.0	26.3	0.9	0.9	1.2	1.7	1.7	2.1
	-	-	28.1	28.0	26.3	25.5	1.0	1.1	1.1	1.7	1.8	2.1
July 12-14	-	-	27.2	27.6	28.0	27.5	-	-	1.1	2.1	2.2	5.7
	-	-	27.0	27.2	27.5	27.5	-	-	1.0	3.9	4.4	5.4
Aug. 30-31	-	-	-	-	28.2	24.8	0.9	1.1	-	-	1.2	1.2
	-	-	-	-	26.9	24.6	1.1	1.4	-	-	1.3	1.3
Sept. 20-22	-	-	-	27.2	-	25.3	-	-	-	-	-	-
	-	-	-	27.1	-	26.4	-	-	-	-	-	-
Oct. 26-27	17.7	17.9	17.8	17.5	18.0	17.9	1.9	3.3	3.1	2.9	2.2	2.6
	18.0	18.2	17.9	17.8	17.8	18.0	4.7	6.8	5.6	3.3	4.4	2.7
Dec. 6 -7	2.3	3.4	4.5	3.8	4.6	4.6	0.3	1.1	1.4	1.1	1.1	1.2
	2.8	3.9	4.5	4.0	4.3	4.8	0.6	2.4	1.3	1.0	1.3	1.2

Table B2. Temperature (°C.) and salinity (in conductivity, millimhos/cm) data collected in 1972. Station positions shown in Figs. 1 and 2. Values given for 1 and 20' depths in that order.

Date	Temperature						Conductivity					
	NE2	E1	E5	C1	C5	C27	NE2	E1	E5	C1	C5	C27
March 27	-	6.1	6.2	-	6.1	6.5	-	0.6	0.6	-	0.7	0.9
	-	5.8	6.0	-	6.0	5.5	-	0.6	0.6	-	0.7	0.9
April 3	7.1	7.0	7.6	7.9	7.1	7.0	0.6	0.8	0.7	0.7	0.8	1.2
	-	7.0	7.5	7.2	7.5	7.0	-	0.7	0.7	0.7	0.8	1.2
April 10	6.9	5.9	7.0	7.0	7.5	7.0	0.6	0.6	0.8	0.8	0.8	2.3
	6.7	5.9	7.0	7.0	7.1	7.5	0.6	0.6	0.8	0.8	0.9	4.4
April 17	-	11.8	10.9	11.8	11.8	11.1	-	0.6	1.4	1.6	2.6	2.2
	-	10.0	10.9	10.5	9.5	10.5	-	0.6	1.4	1.7	2.7	2.1
April 24	11.8	12.0	12.6	12.0	12.2	12.0	0.6	0.6	0.8	0.8	1.0	0.6
	11.8	11.8	12.9	12.5	12.7	12.2	0.6	0.6	0.8	0.8	1.0	0.7
May 1	-	15.2	15.8	16.0	-	-	-	0.5	0.7	0.7	-	-
	-	14.0	15.0	15.0	-	-	-	0.5	0.7	0.7	-	-
May 8	18.0	17.9	18.4	17.9	17.5	17.0	0.6	0.6	0.6	0.6	0.6	0.7
	17.1	17.0	17.4	18.0	17.0	16.5	0.6	0.6	0.6	0.6	0.6	0.7
May 15	16.0	16.2	18.0	17.5	17.0	17.0	0.6	0.6	0.6	0.6	0.8	0.8
	15.5	15.5	18.0	17.0	17.0	17.0	0.6	0.6	0.6	0.6	0.6	0.8
May 22	19.2	18.5	19.0	19.0	-	-	0.6	0.6	0.7	0.7	-	-
	18.2	18.2	18.5	18.5	-	-	0.6	0.6	0.7	0.7	-	-
May 30	21.5	20.0	20.0	21.0	20.0	19.0	0.6	0.8	1.2	1.4	1.6	2.2
	21.0	20.0	20.0	20.0	19.0	19.0	0.6	0.8	1.2	1.2	1.6	3.2

Table B2. cont'd.

Date	Temperature						Conductivity					
	NE2	E1	E5	C1	C5	C27	NE2	E1	E5	C1	C5	C27
June 6	22.5	22.0	21.5	21.0	21.0	21.5	0.6	0.6	0.8	0.8	0.8	0.6
	23.0	22.0	22.0	22.0	21.0	22.0	0.6	0.6	0.8	0.9	0.8	0.6
June 15	-	21.0	22.0	22.0	22.0	22.5	-	0.6	0.6	0.6	0.6	1.2
	-	21.0	22.0	22.0	22.0	21.5	-	0.6	0.6	0.6	0.6	1.2
June 28	-	-	18.0	19.0	20.0	20.8	-	-	0.5	0.6	0.6	0.6
	-	-	17.9	18.6	19.0	19.9	-	-	0.6	0.6	0.6	0.6