1978

Planktonic fish eggs and larvae of the lower Chesapeake Bay

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PLANKTONIC FISH EGGS AND LARVAE
OF THE LOWER CHESAPEAKE BAY

A Thesis

Presented to

The Faculty of the School of Marine Science

The College of William and Mary in Virginia

In Partial Fulfillment

of the Requirements for the Degree of

Master of Arts

By

John Edward Olney

1978

APPROVAL SHEET

This thesis is submitted in partial fulfillment of

the requirements for the degree of

Master of Arts

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ACKNOWLEDGMENTS

Dr. George Grant initiated and directed the sampling program on which this study is based. I am sincerely grateful to him for the guidance, support and suggestions offered during the course of this study and for his review of the manuscript. My thanks are extended to Dr. John V. Merriner for his careful review of the manuscript and to Dr. John A. Musick for his comments and encouragement.

I wish to thank W. G. Smith, P. L. Berrien and Dr. A. W. Kendall, National Marine Fisheries Service, Dr. S. L. Richardson, Gulf Coast Research Laboratory and A. J. Lippson, Martin Marietta Corporation, for their assistance in my initial attempts at identification of Chesapeake Bay ichthyoplankton. I have benefited from discussions with my former colleagues Drs. B. B. Bryan and F. Jacobs and thank them for many enjoyable days in the field. My compliments and thanks are extended to Captain Jack Lewis and the crew of the R/V Pathfinder.

Finally, I offer sincere thanks to Martha, who typed an original draft, sorted plankton as a willing volunteer, maintained home fires during frequent cruises, and constantly offered her friendship, companionship, encouragement and patience.

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ABSTRACT

The species composition, seasonal abundance, and spatial distribution of planktonic fish eggs and larvae in the lower Chesapeake Bay was determined from plankton collections during the period 1971-1976. Eggs and/or larvae of 32 species representing 22 families of marine and estuarine fishes were taken. Peak spawning activity began in May and continued through August of each year but eggs, larvae and/or juvenile stages were taken in the plankton year-round.

Eggs and larvae of the bay anchovy, *Anchoa mitchilli*, dominated the ichthyoplankton, making up 96% of the total eggs and 88% of all larvae taken. A comparison of egg and larval densities from the lower Chesapeake Bay to existing data from other east coast estuaries suggests that Chesapeake Bay is the center of spawning activity for this species.

Eggs and larvae of several sciaenid species, especially the weakfish, *Cynoscion regalis*, ranked second in numerical abundance after *Anchoa mitchilli*. Additional important species represented by eggs and/or larvae were *Hypsoblennius hentzi*, *Gobiosoma ginsburgi*, *Trinectes maculatus*, *Symphurus plagiusa*, *Paralichthys dentatus* and atherinids, with the remaining species occurring infrequently.

The lower Chesapeake Bay ichthyoplankton assemblage was divided into five ecological categories: a) eggs and larvae of resident spawners, b) eggs and larvae of shelf spawners passively transported into the Bay, c) postlarvae of shelf and oceanic spawners which utilize the Bay as a nursery site, d) postlarvae of subtropical species infrequently intruding into lower Chesapeake Bay waters, and e) larvae of oligo- and mesohaline species occasionally occurring in higher salinities.

Although lower Chesapeake Bay ichthyoplankton exhibits marked year to year density fluctuations, species composition and general distributional patterns remain consistent on a yearly basis and apparently have not significantly changed over a 47 year period.

PLANKTONIC FISH EGGS AND

LARVAE OF THE LOWER CHESAPEAKE BAY

INTRODUCTION

Information on the ichthyoplankton of the lower Chesapeake Bay is scattered and generally lacking. With the exception of an early, much cited study by Pearson (1941), there have been no extensive ichthyoplankton surveys of lower Bay waters even though several species of commercial and recreational importance are known to spawn within the Bay. Although Pearson (1941) supplied valuable information on species occurrence, seasonality, and development, his study was limited to daylight collections at a few stations near the Bay entrance. His results excluded information on pelagic eggs, estimates of abundance of eggs and larvae, and measurements of physical parameters which affect ichthyoplankton distribution.

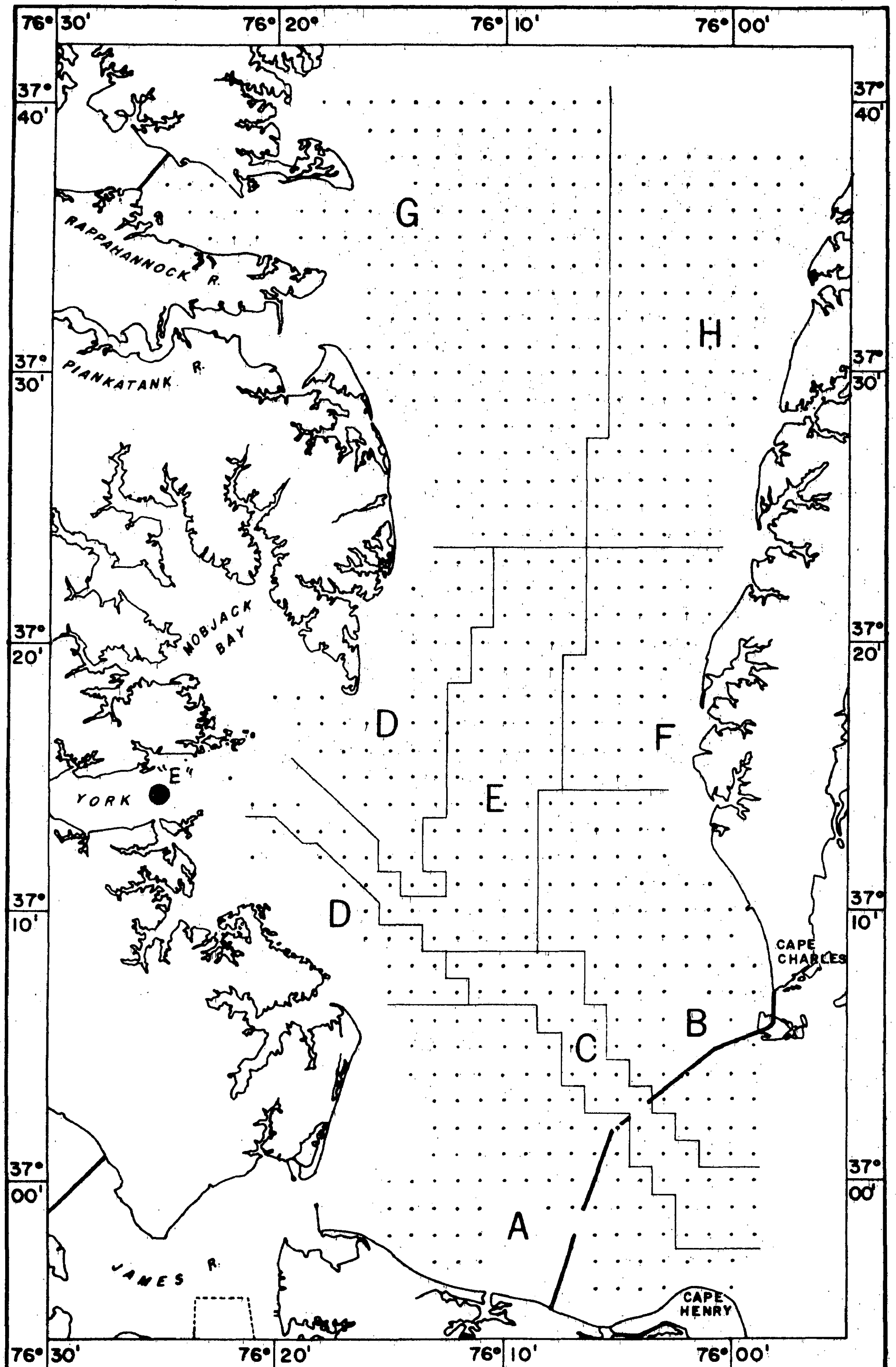
Several studies have presented data on fish eggs and larvae from locations within or near the present study area. Massmann et al. (1961, 1962) reported on fish larvae taken at three stations within the Bay and 22 stations off the Virginia coast. Dovel (1967, 1971) examined ichthyoplankton north of the Patuxent River. Schauss (1977) has presented data on the larvae and juveniles of fishes taken in Lynnhaven Inlet. In addition, many authors have provided specific information on the early life history and ecology of fishes spawning within the lower reaches of the Bay (Hildebrand and Schroeder 1928; Wallace 1940; Massmann et al. 1954; Runyan 1961; Norcross et al. 1961; Massmann et al. 1963; Dovel 1963; Joseph et al. 1964; Mansueti and Hardy 1967; Dovel et al. 1969; Richardson and Joseph 1973, 1975; Hardy and Johnson 1974; and Olney and Grant 1976).

During the period 1971-1976 the Planktology Department of the Virginia Institute of Marine Science conducted a survey of lower Chesapeake Bay plankton. Although the survey's major emphasis was on the invertebrate zooplanktonic assemblage (Bryan 1977; Grant 1977; and Jacobs 1978), a large number of fish eggs and larvae was taken. This report describes the species composition, seasonal abundance, and spatial distribution of lower Chesapeake Bay ichthyoplankton based on these collections.

METHODS AND MATERIALS

Fish eggs and larvae from plankton collections made during a monthly zooplankton survey August 1971-August 1973; two neuston surveys, August 1975 and March 1976; and a 24 hr. station during August 1973 were utilized. The study area (Fig. 1) included approximately 700 km^2 of the lower Chesapeake Bay from 37°40'N to the mouth of the Bay. This area was gridded into one-square- mile stations and divided into eight subareas on the basis of bathymetry

FIGURE 1. Sampling area in the lower Chesapeake Bay



76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK
"E"
JAMES R.
CAPE CHARLES
CAPE HENRY
A
B
C
D
D
E
F
G
H

and a priori knowledge of Bay hydrography. Daylight collections were made monthly through August 1973 at 20-30 randomly selected stations using 18.5 cm bongo frames with metered nets constructed of 202μm mesh Nitex. The bongos were towed in a stepped-oblique fashion in 2 m/min steps from depth to the surface. Prior to each zooplankton collection, standard hydrographic techniques were utilized to measure temperature, dissolved oxygen, and salinity at each 2 m interval from depth.

In August 1973 a 24 hr. zooplankton station was occupied near the mouth of the York River at station "E" (Fig. 1). Oblique bongo tows were made at 2 hr. intervals from a depth of 10 m to the surface. In August 1975 and March 1976 neuston surveys were conducted incorporating the use of a 50 x 60 cm neuston net (202μm mesh) towed for 5-15 minutes at the surface with a concurrent oblique bongo tow. As with the 25 month survey, standard techniques were utilized to measure physical parameters during the additional sampling periods. A total of 36 stations were occupied during these two neuston surveys with equal numbers of day and night collections. Sampling dates, number of stations, location of stations by subarea, and gear used during each cruise are summarized in Table 1.

Plankton collections were preserved in five percent seawater formalin and returned to the laboratory for sorting. Fish eggs and larvae were removed from the samples with the aid of a stereoscope. The most abundant eggs and larvae were removed from sample aliquots

TABLE 1

MONTHLY SAMPLING SUMMARY OF LOWER CHESAPEAKE BAY PLANKTON, 1971-76, INDICATING THE TOTAL NUMBER OF STATIONS OCCUPIED IN EACH SUBAREA.

Months	Gear*	Total	Subareas								
			A	B	C	D	E	F	G	H	"E"
1971											
Aug.	B	30	3	5	3	3	3	3	5	5	
Sept.	B	30	3	4	3	3	4	3	5	5	
Oct.	B	30	3	5	3	3	3	3	5	5	
Nov.	B	17	3	3	2	1	3	3		2	
Dec.	B	8				3	2		2	1	
1972											
Jan.	B	27	3	5	3	3	3	3	3	4	
Feb.	B	26	3	4	3	3	3	3	4	3	
March	B	26	3	5	3	3	3	3	3	3	
Apr.	B	22	3	3	3	3	3	1	3	3	
May	B	24	3	3	3	3	3	3	3	3	
June	B	29	6	6	5	4	3	5			
July	B	49	8	6	6	7	6	7	3	3	3
Aug.	B	23	2	3	3	3	3	3	3	3	
Sept.	B	24	3	3	3	3	3	3	3	3	
Oct.	B	19	3		2	3	3	1	3	3	1
Nov.	B	19	3	3	3	3	3	3			1
Dec.	B	22	3	3	3	2	3	3	1	3	1
1973											
Jan.	B	23	3	3	2	3	3	3	3	3	
Feb.	B	25	3	3	3	3	3	3	3	3	1
March	B	21	3	3	3	3	3	3		2	1
Apr.	B	25	3	3	3	3	3	3	3	3	1
May	B	25	3	3	3	3	3	3	3	3	1
June	B	25	3	3	3	3	3	3	3	3	1
July	B	22	3	3	3	3	3	2	2	2	1
Aug.	B	29	3	3	3	3	3	2			12
1975											
Aug.	B,N	17	2	2	2		2	3	3	3	
1976											
March	B,N	19	3	2	2	3	1	1	4	3	
TOTALS		656	84	89	78	80	81	76	70	74	24

*B = 18.5 cm bongo
N = 50 x 60 cm neuston net

(1/4 - 1/128) but infrequent types were sorted from whole samples or one-half splits. All specimens were retained in formalin. Measurements were made with an ocular micrometer or dial calipers and are reported in mm. Preflexion larvae were measured from the tip of the snout to the notochord tip (notochord length = NL) and flexion or postflexion larvae were measured to the base of the caudal-fin rays (standard length = SL) following Ahlstrom et al. (1976). Abundance estimates for fish eggs are reported as total eggs/10^3 and for larvae as total larvae/$100m^3$. Mean monthly abundances are computed by dividing the total eggs or larvae counted at all stations by the total water filtered during each month. Hydrographic measurements are reported as mean water column values unless otherwise indicated.

Identification of eggs and larvae was based on known spawning times, previously reported descriptions, and reference collections. References most often used in identification were Hildebrand and Schroeder (1928), Bigelow and Schroeder (1953), Mansueti and Hardy (1967), Colton and Marak (1969), Pearson (1941), and Lippson and Moran (1974). To further aid in identification, several specimens were cleared and stained following the methods of Mook and Wilcox (1974).

RESULTS

Hydrography

Mean monthly salinities in the lower Chesapeake Bay study area fluctuated between spring lows of 16.4 ppt to summer-fall highs of 23.2 ppt (Figure 2A). Mean salinity peaks in June and November 1972 probably resulted from decreased sampling effort in those months since weather conditions did not permit collections in the upper, less saline portion of the Bay. Generally, salinities varied from 15 ppt in the upper study area to about 28 ppt at the Bay entrance. The lowest salinity found was 6.3 ppt in surface waters in July 1972 and the highest reading was 31.9 ppt in August 1973. Massive freshwater runoff in June and July 1972 due to the passage of Tropical Storm Agnes accounted for the lowest salinity values observed during the study.

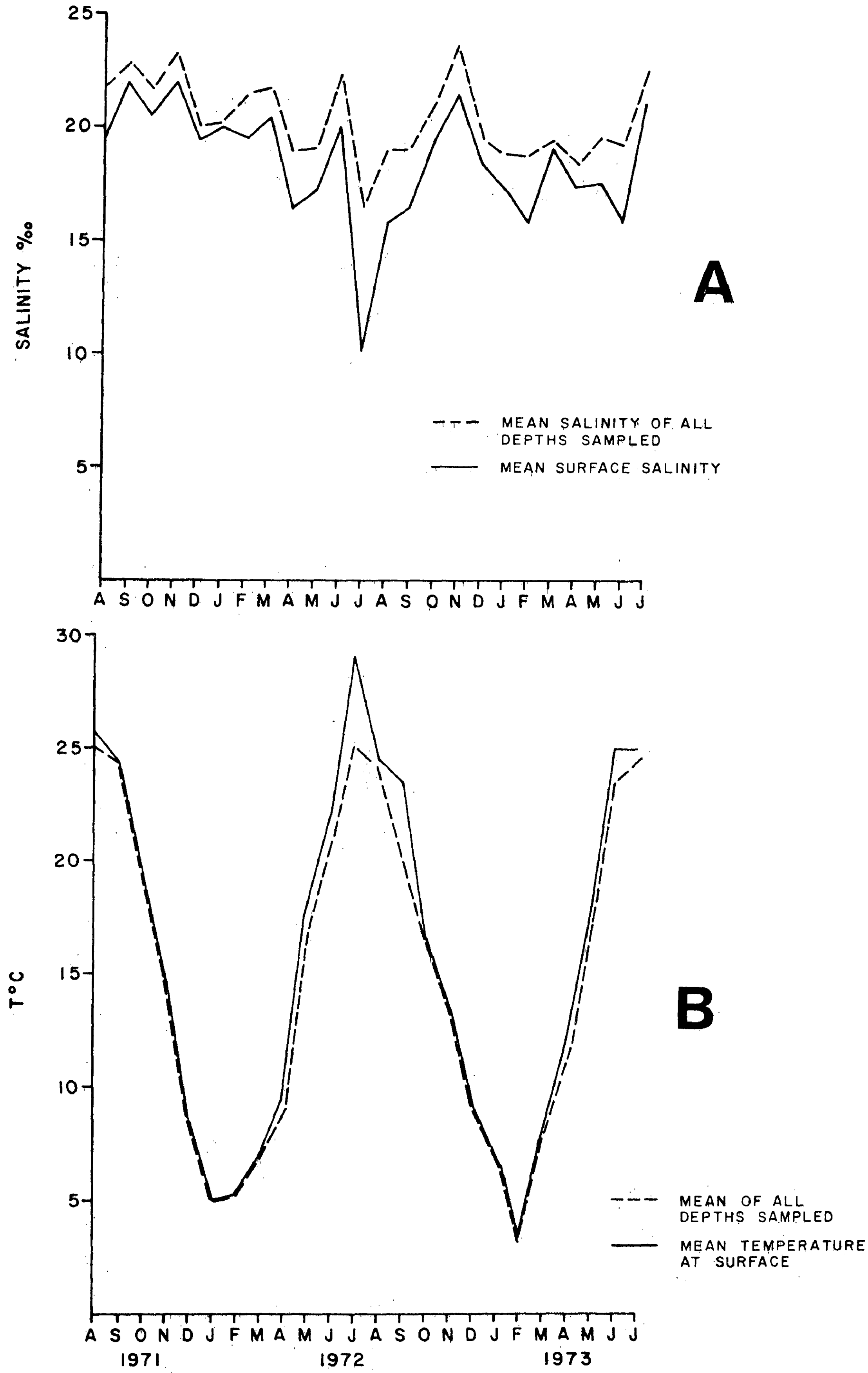
Mean monthly temperatures are depicted in Figure 2B. Temperatures varied from a high of 25.6°C to 3.0°C. Mean surface temperatures peaked in July 1972 reflecting surface heating of freshwater Agnes runoff.

Specific hydrographic ranges and their relationships to the occurrence and distribution of lower Bay ichthyoplankton are discussed in the following sections. For a more complete presentation of hydrographic data from the lower Chesapeake Bay zooplankton survey, see Bryan (1977) and Jacobs (1978). An extensive assessment of the effects of Tropical Storm Agnes on the Chesapeake Bay estuarine system is given by Davis (1974).

General Composition of the Ichthyoplankton

A total of 678 separate plankton collections were made at 656

FIGURE 2. A) Mean monthly salinity and B) Mean monthly temperature in the lower Chesapeake Bay, 1971 - 1973.



25
20
15
10
5
SALINITY ‰
A
MEAN SALINITY OF ALL DEPTHS SAMPLED
MEAN SURFACE SALINITY
A S O N D J F M A M J J A S O N D J F M A M J J
30
25
20
15
10
5
T°C
B
MEAN OF ALL DEPTHS SAMPLED
MEAN TEMPERATURE AT SURFACE
A S O N D J F M A M J J A S O N D J F M A M J J
1971
1972
1973

stations occupied during the period August 1971-March 1976. Fish eggs and/or larvae were present at over half (55.3%) of the total stations. Samples (n=389) yielded 29,400 specimens, 69% of which were fish eggs.

Thirty-two species representing 22 families of fishes were identified (Table 2). Eggs and larvae of the anchovies, Anchoa mitchilli and A. hepsetus, dominated the collections making up 96% of the eggs and 88% of the total larvae taken. The impossibility of reliable separation of A. mitchilli and A. hepsetus larvae at sizes under 10.0 mm SL forced the lumping of all anchovy larvae as Anchoa spp. Since no identifiable A. hepsetus postlarvae were taken and A. mitchilli eggs outnumbered those of its congener by a ratio of 340:1, the bay anchovy, Anchoa mitchilli, was considered to be the dominant fish in both egg and larval stages in the lower Chesapeake Bay.

Figure 3 depicts the familial constituents of the lower Chesapeake Bay ichthyoplankton excluding Anchoa mitchilli. Five families made up 77% of the total non-Anchoa larvae taken (n=2231). These were the Sciaenidae (three species), the Blenniidae (one species), the Soleidae (one species) and the Cynoglossidae (one species). Bothids, atherinids, clupeids and syngnathids made up 11% with the remaining 12 families occurring infrequently. Fish eggs other than those of Anchoa mitchilli were divided into 8 categories, four of which (Anchoa hepsetus, Trinectes maculatus, sciaenid eggs and cynoglossid eggs) made up almost 98% of the total (Fig. 3B). The identification of these latter two egg categories are discussed in a

TABLE 2

SPECIES, TOTAL NUMBER, AND MONTHS OF OCCURRENCE OF FISH EGGS AND LARVAE IN THE LOWER CHESAPEAKE BAY

Species	Number		Occurrence	
	Eggs	Larvae	Eggs	Larvae
Conger oceanicus		1		May
Brevoortia tyrannus	10	28	July-August	February, April-May, August
Anchoa mitchilli	18,121	49	May-August	All months
Anchoa hepsetus	53		May-August	
Anchoa spp.		6834		May-September
Gobiesox strumosus		10		June-September
Lophius americanus		1		May
Urophycis regius		9		March
Rissola marginata		3		August-September
Membras martinica		47		March, August
Atherinid larvae		132		May, August
Syngnathus fuscus		50		All seasons
Hippocampus erectus		7		March, July-August
Prionotus spp.	1	14	August	August
Cynoscion regalis		555		June-September
Menticirrhus spp.		39		June-August
Leiostomus xanthurus		12		March

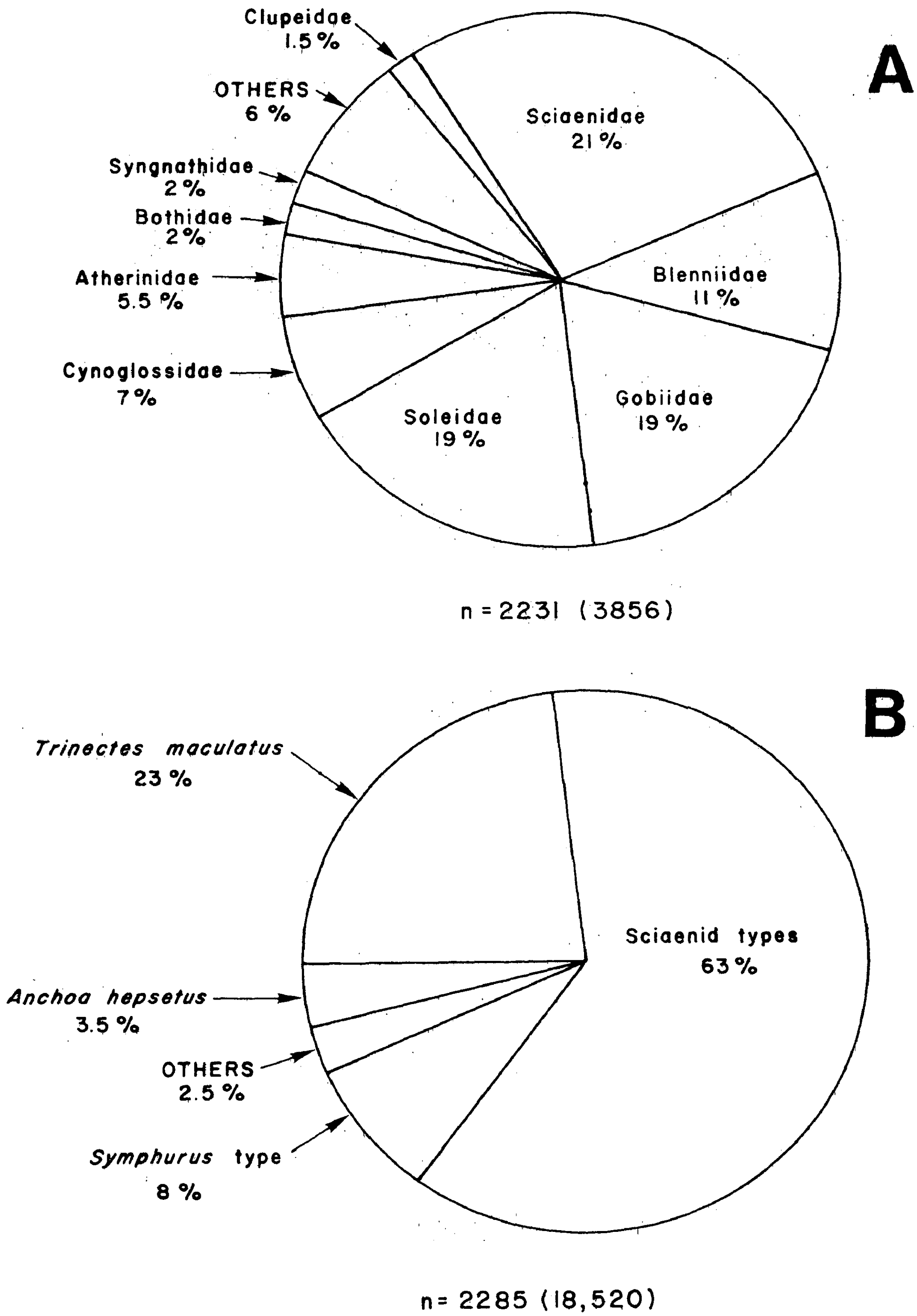
TABLE 2 (continued)

Species	Number		Occurrence	
	Eggs	Larvae	Eggs	Larvae
Unidentified sciaenids	1248		May-August	
Tautoga onitis	10		May	
Hypsoblennius hentzi		181		June-September
Ammodytes sp.		4		January-March
Gobiosoma ginsburgi		358		June-September
Gobiosoma bosci		5		June-August
Microgobius thalassinus		9		June-August
Gobiidae, 6-spined		1		August
Gobiidae, 7-spined		46		June-September
Scomber scombrus		3		May
Peprilus triacanthus		1		July
Peprilus paru		13		August
Paralichthys dentatus		52		March
Etropus microstomus		1		August
Scophthalmus aquosus		10		May
Pseudopleuronectes americanus		3		March-April
Trinectes maculatus	682	425	June-September	June-September

TABLE 2 (concluded)

Species	Number		Occurrence	
	Eggs	Larvae	Eggs	Larvae
Symphurus plagiusa		152		July-August
Symphurus-type	192		June-August	
Sphoeroides maculatus		5		May, July, August
Unknowns	89	53	Oct.-Nov., Mar.-Apr.	July-August
Totals	20,406	9114		

FIGURE 3. Familial constituents of lower Chesapeake Bay ichthyoplankton excluding Anchoa mitchilli, 1971 - 1973. A) planktonic fish, B) planktonic eggs.


A
Clupeidae 1.5 %
OTHERS 6 %
Syngnathidae 2 %
Bothidae 2 %
Atherinidae 5.5 %
Cynoglossidae 7 %
Sciaenidae 21 %
Blenniidae 11 %
Gobiidae 19 %
Soleidae 19 %
n = 2231 (3856)
B
Trinectes maculatus 23 %
Anchoa hepsetus 3.5 %
OTHERS 2.5 %
Symphurus type 8 %
Sciaenid types 63 %
n= 2285 (18,520)

following section.

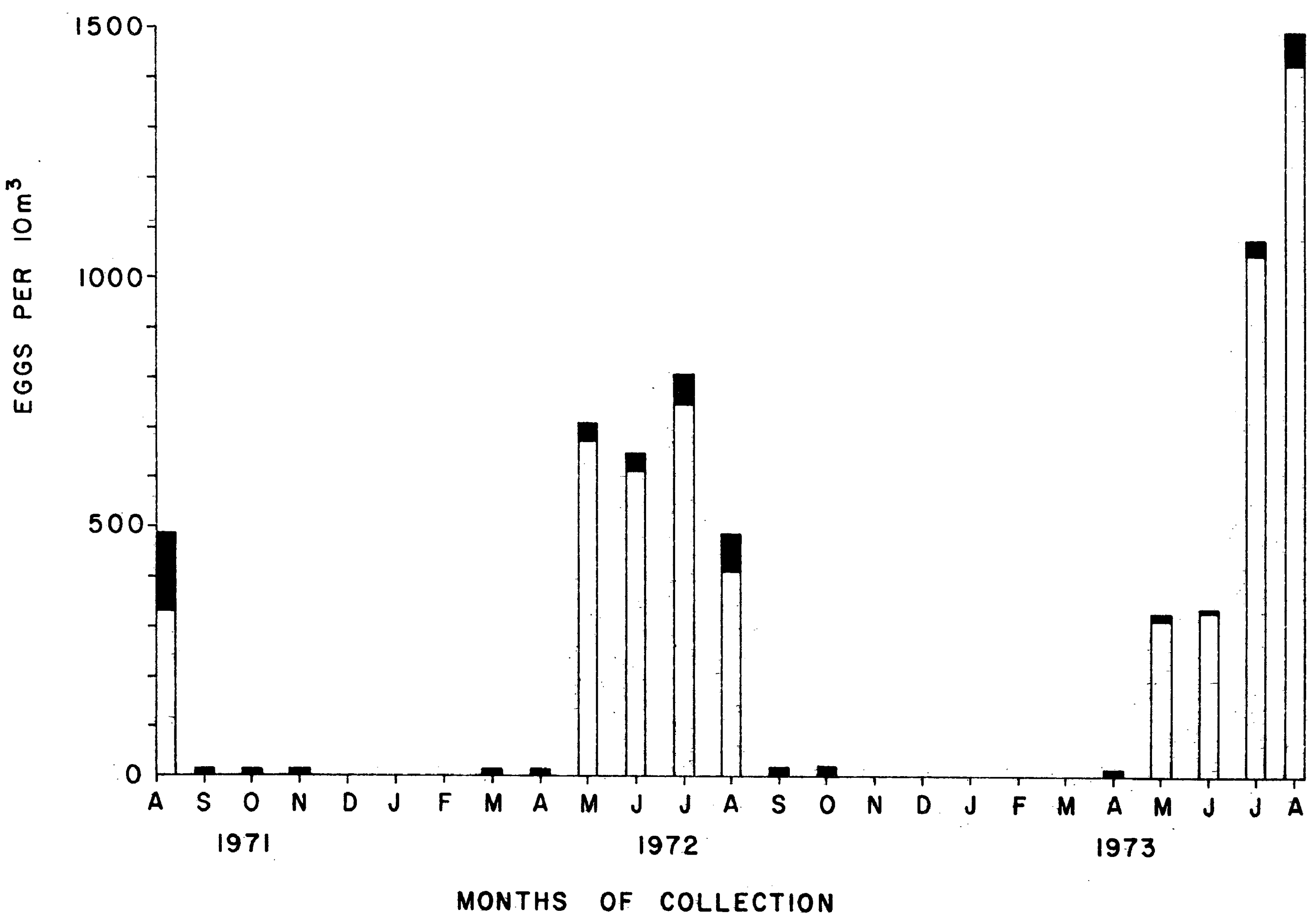
Seasonal Occurrence and Abundance of the Ichthyoplankton

Fish eggs were present in Bay plankton during August-November 1971, March-October 1972, April-August 1973, August 1975 and March 1976 (Fig. 4). Peak spawning activity, mainly by *A. mitchilli*, was consistent during May-August in each year. The greatest mean monthly abundance of *A. mitchilli* eggs occurred in August 1973 and of eggs of other species in August 1971. Peaks of larval fish abundance in the lower Chesapeake Bay (Fig. 5) generally followed those of pelagic eggs. During the two full spawning seasons sampled (1972, 1973), larval fishes were in low abundance until July, two months after the first appearance of high egg densities. Collections included fishes during all months sampled except October 1971, October, December 1972 and January, April 1973. Larval anchovy abundances were consistently higher than those of any other species in summer months. Although the greatest monthly abundance was recorded during the flood conditions of 1972, summer anchovy densities were consistent throughout the sampling period. Fishes other than *Anchoa* sp. peaked in abundance in August 1971 (Fig. 5).

Systematic Analysis

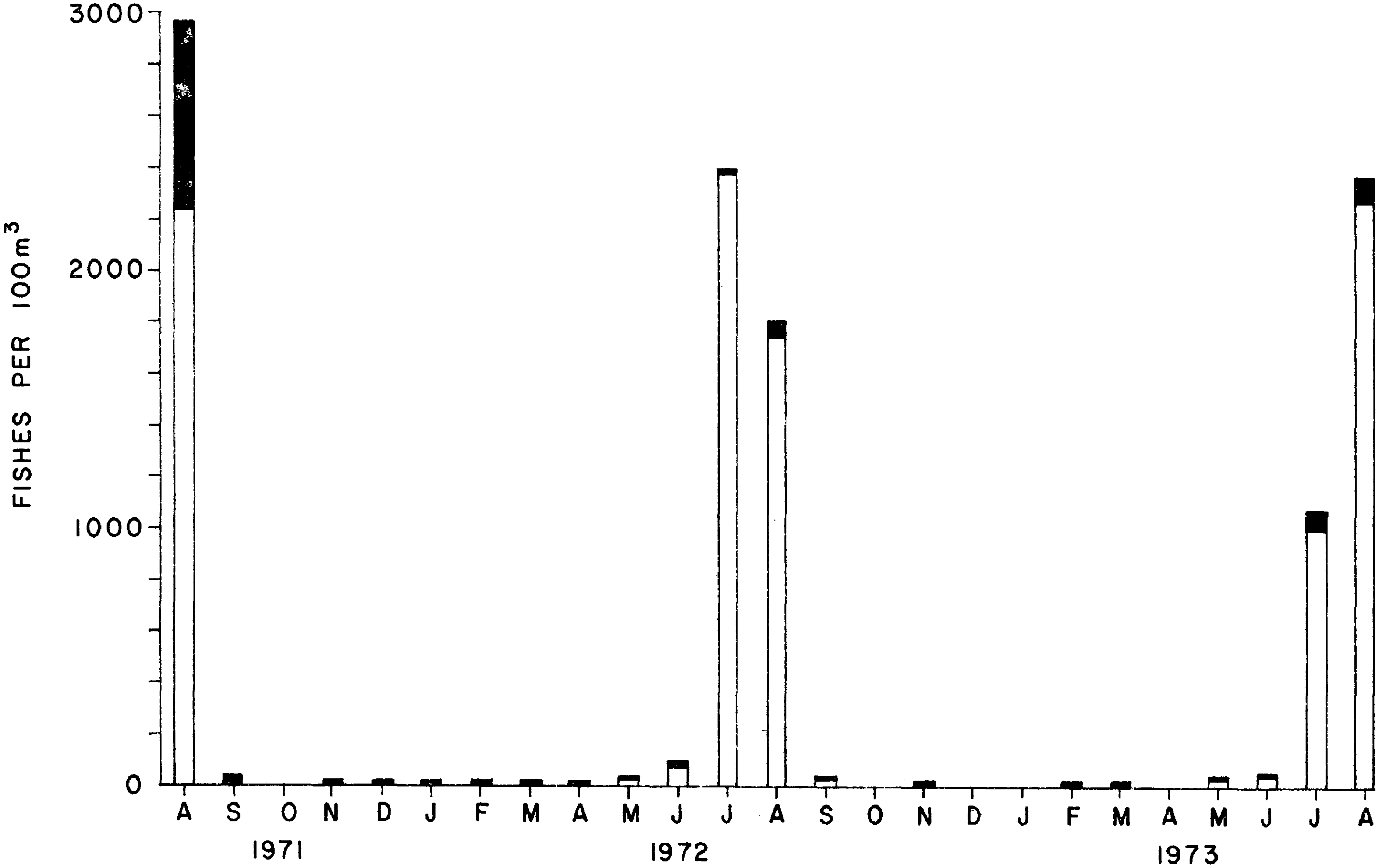
The following systematic accounting of the planktonic fish eggs and larvae taken in the lower Chesapeake Bay folllows the phyletic relationships espoused by Greenwood et al. (1966). Information on identification, distribution, ecology, and life history is included

FIGURE 4. Seasonal abundance of planktonic fish eggs in the lower Chesapeake Bay, 1971 - 1973. Unshaded portions depict densities of *Anchoa mitchilli*.



EGGS PER $10m^3$
1500
1000
500
0
A S O N D J F M A M J J A S O N D J F M A M J J A
1971
1972
1973
MONTHS OF COLLECTION

FIGURE 5. Seasonal abundance of planktonic fishes, 1971 - 1973. Unshaded portions depict densities of *Anchoa mitchilli*.


FISHES PER 100m3
3000
2000
1000
0
A S O N D J F M A M J J A S O N D J F M A M J J A
1971
1972
1973

where applicable.

Teleostei

Anguilliformes

Congridae

Conger oceanicus (Mitchill)

A single, transforming leptocephalus larva of the conger eel was taken at a mid-channel station near the Bay entrance on 15 May 1972. Temperature and salinity at the time of capture were 16.2°C and 19.9 ppt. The larva was 103.2 mm SL and had 37 predorsal, 59 preanal, about 79 postanal, and about 138 total myomeres. The only other leptocephalus known from Chesapeake Bay waters having similar total myomere counts is the speckled worm eel, *Myrophis punctatus*. This species is distinguished from *C. oceanicus* by the presence of pigmented gut swellings (Lippson and Moran 1974).

Spawning of *C. oceanicus* occurs at sea and larvae generally arrive in middle Atlantic estuaries as juveniles or elvers (Lippson and Moran 1974). Only a few instances of estuarine occurrence of *C. oceanicus* leptocephali are recorded: Long Island Sound (Perlmutter 1939); Raritan Bay (Lippson and Moran 1974); Chesapeake Bay (Pearson 1941 and the present record).

Clupeiformes

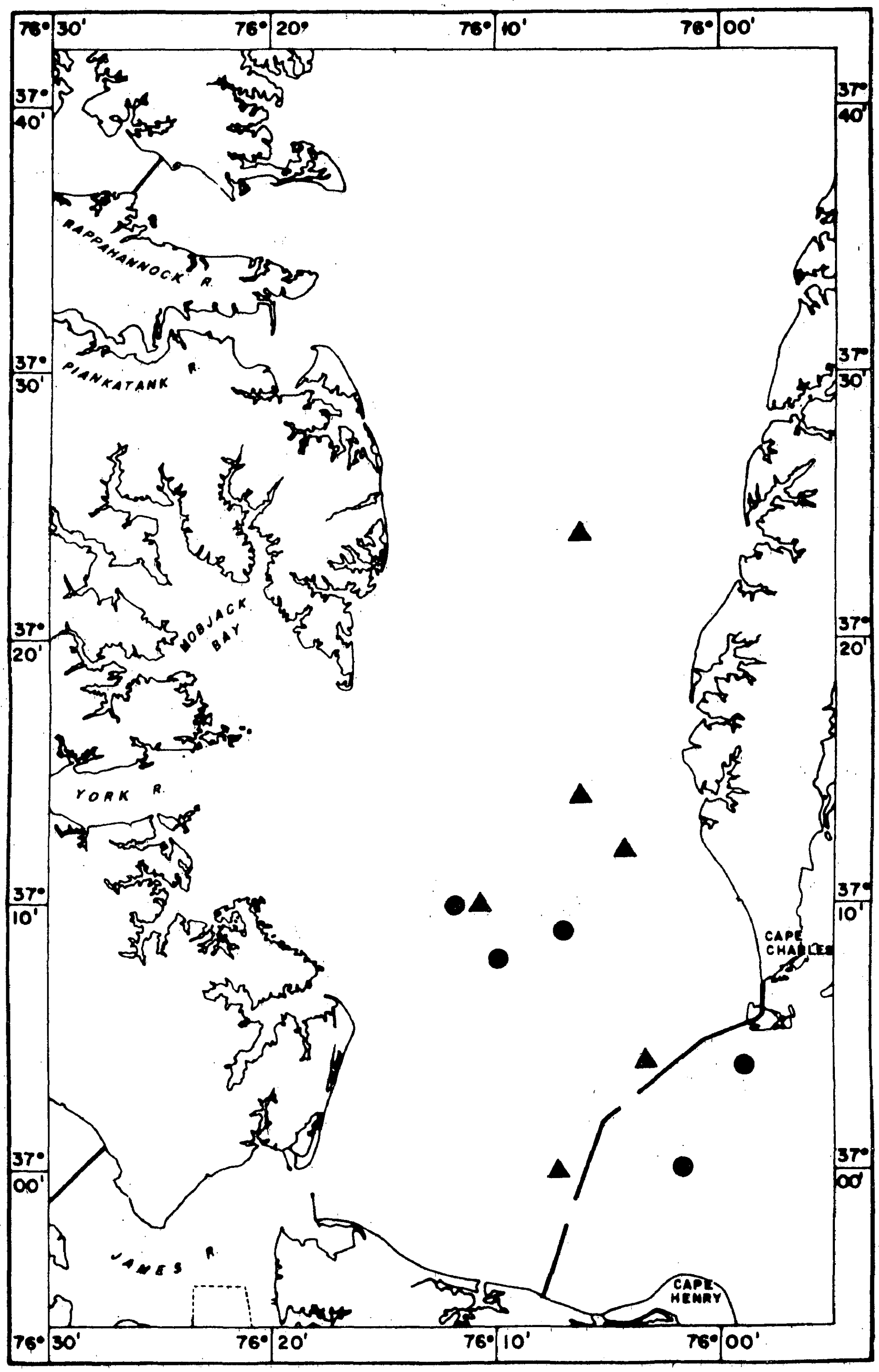
Clupeidae

Brevoortia tyrannus (Latrobe)

Eggs and preflexion larvae of the Atlantic menhaden appeared infrequently in lower Chesapeake Bay plankton collections. Only 10 menhaden eggs were taken; August 1971, n=8; July, August 1972, n=2. Eggs were captured in mid-channel areas near the Bay entrance (Fig. 6) where temperature and salinity ranges were 22.1-25.2°C and 22.2-25.3 ppt. Preflexion menhaden larvae were limited to collections in August 1971 and 1972 while postlarvae were taken during winter and spring (Table 3). Larvae (n=28) ranged in size from 3.0 mm NL to 28.0 mm SL. As with menhaden eggs, preflexion larvae were distributed within the higher salinity, mid-channel portions of the estuary (Fig 6). Mid-winter and spring captures of postlarval menhaden were widely distributed within the study area, occurring at stations in all eight subareas.

The sparce occurrence of menhaden eggs and preflexion larvae in the present collections supports the view of Pearson (1941) and Massman et al. (1962) that spawning in the Chesapeake Bay is very limited. Spawning occurs chiefly at sea (Bigelow and Schroeder 1953; Massmann et al. 1962; Mansueti and Hardy 1967; and others) with subsequent inshore movement of postlarvae and later utilization of the estuary as a nursery ground by postlarvae and juveniles (Massmann et al. 1954, Henry 1971). The relatively low number of postlarvae taken in this study is probably attributable to gear avoidance and the predominance of daylight collections since menhaden larvae are taken in greater abundance in evening hours (Lewis and Wilkins 1971).

FIGURE 6. Locations of capture of eggs and preflexion larvae of *Brevoortia tyrannus*.



● eggs

▲ preflexion larvae

TABLE 3

MONTHLY DATA SUMMARY OF MENHADEN LARVAE IN CHESAPEAKE BAY PLANKTON COLLECTIONS, 1971-1976

Date	Number Taken	Length Range (mm)	Temperature Range (°C)	Salinity Range (ppt)
1971				
August	9	3.0-13.0	24.1-25.6	17.8-26.2
1972				
February	4	22.0-26.0	5.6-5.9	20.7-22.0
April	1	18.0	8.8	15.3
May	1	-	15.4	24.6
1973				
August	1	3.9	22.6	24.8
February	1	24.0	3.6	17.1
1976				
March	11	22.0-28.0	11.0-11.9	15.9-28.6

Engraulidae

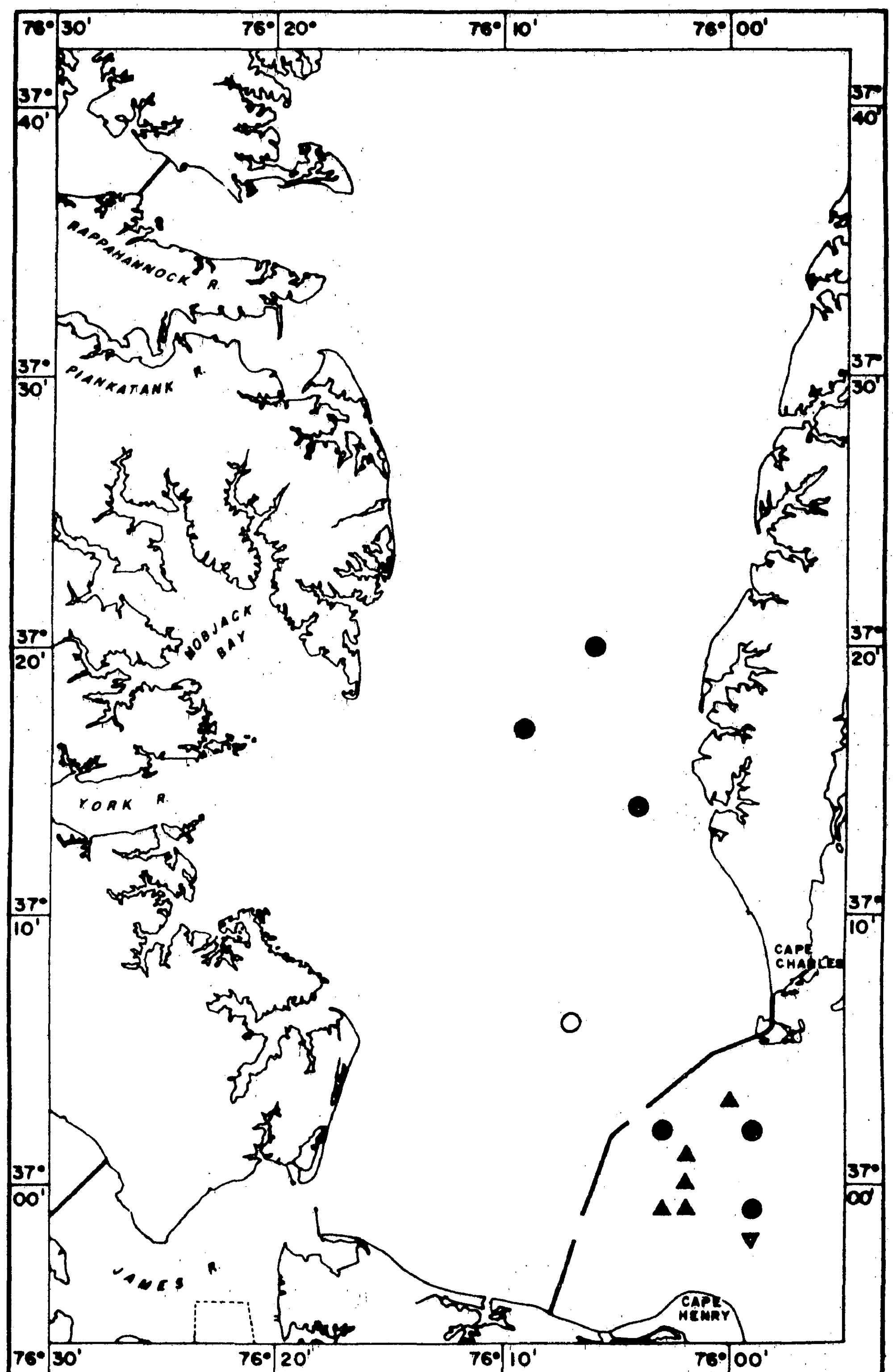
Anchoa hepsetus (Linnaeus)

Eggs of the striped anchovy (n=53) made up 3.5% of all eggs other than those of *Anchoa mitchilli* taken in lower Bay plankton collections. Months of occurrence, total positive stations, number of specimens and range of estimated densities (eggs/10 m^3) were: August 1971, 1, 1, 2.4; May 1972, 4, 23, 5.4-78.9; June 1972, 2, 2, 3.6-7.2; July 1972, 1, 1, 3.6; July 1973, 1, 1, 22.0; August 1973, 4, 13, 2.1-12.2; August 1975, 1, 12, 25.5.

As in the case of the eggs and early larvae of the Atlantic menhaden, *A. hepsetus* eggs were collected in the saline, mid-channel portions of the Bay near its mouth (Fig. 7). Temperature and salinity ranges were 14.7-27.8°C and 19.1-31.5 ppt except in June 1972 when Tropical Storm Agnes surface runoff water depressed mean salinities at positive stations to below 13.0 ppt. Peak abundance of *Anchoa hepsetus* eggs was observed at three stations in the Bay entrance in May 1972. Tidal conditions at the time of capture during this period ranged from maximum flood to slack before ebb indicating that the eggs were probably spawned over the inner shelf off Virginia and transported into the Bay in the salt wedge.

Due to the impossibility of reliably separating larval *Anchoa* spp. under 10 mm, no larval *A. hepsetus* were identified from lower Bay plankton collections. On the basis of the presence of eggs, however, it is probable that preflexion larvae of this species are present in

FIGURE 7. Locations of capture of eggs of *Anchoa hepsetus*, 1971 - 1975.



○ 1971 ▲ 1973
● 1972 ▼ 1975

lower Chesapeake Bay waters.

Postlarval Anchoa hepsetus were conspicuously absent from these collections, as they were from previous collections in the Bay (Pearson 1941; Massmann et al. 1961, 1962). Massmann et al. (1961, 1962) provide the only reports of postlarvae north of Cape Hatteras, North Carolina; one 19 mm SL specimen taken in the Atlantic Ocean off the Bay entrance and one 23 mm SL postlarva from the Pamunkey River, Virginia. South of Hatteras, Fahay (1975) has taken postlarvae in meter net collections from the South Atlantic Bight and Lewis and Mann (1971) took A. hepsetus larvae in Onslow Bay. Hildebrand and Cable (1930) collected large numbers of larvae less than 12.0 mm near Beaufort, N. C., however larger fish were uncommon. Apparently, the postlarvae of A. hepsetus occur in areas that have received low sampling intensity such as estuarine shallows and grassy areas (Hildebrand and Cable 1930) and offshore along the outer continental shelf (Mansueti and Hardy 1967).

Anchoa mitchilli (Valenciennes)

The eggs of the bay anchovy (n=18,121) outnumbered those of sciaenids, soles, cynoglossids, and striped anchovies by 15:1, 27:1, 94:1, and 342:1, respectively. Mean monthly abundances of bay anchovy eggs never dipped below 320 eggs/10 m^3 during periods of anchovy spawning (Fig. 4) and reached highs of 1000-1400/10 m^3 in July and August 1973. Mean densities of eggs of other species never reached abundance values higher than 160/10 m^3 in peak spawning periods.

Maximum density of bay anchovy eggs was observed in August 1975 (Table 4) when abundances of eggs in surface waters reached over 8000/10 m^3.

Monthly abundances of A. mitchilli eggs (Fig. 4) reveal clearly defined May-August peaks. Bay anchovy eggs occurred in August 1971, May-August in 1972 and 1973, and August 1975. Bay anchovy spawning in the lower Chesapeake Bay commenced in May when mean water column temperatures approached 17°C (Fig. 2B) and abruptly ceased after August. Dovel (1971) found similar spawning patterns in the upper portions of the Bay; between 1963-1965 most anchovy eggs appeared in May-August, although some eggs were present as early as 22 April (1963) and as late as 27 September (1965).

Eggs of A. mitchilli were taken at all stations during August 1971 and May-August 1972-1973 and presented a continuous distribution throughout the study area during these months. During 1972 and 1973 eggs appeared abundantly in the most saline portions of the Bay (the Bay mouth and the eastern Bay margin) when the spawning season commenced in May and June (Figs. 8 and 9). By July and August of 1972 and 1973, anchovy spawning encompassed the entire study area.

Larvae of the bay anchovy dominated the collections of larval fishes during the months of peak anchovy abundance (Fig. 5). Larval and postlarval A. mitchilli (n=6883) made up 88% of the total fish larvae and were taken in August 1971, May-September 1972 and May-August 1973. Larvae were also present in August 1975 and juveniles were taken in March 1976. This pattern was consistent with

FIGURE 8. Abundance and distribution of *Anchoa mitchilli* eggs, 1972.

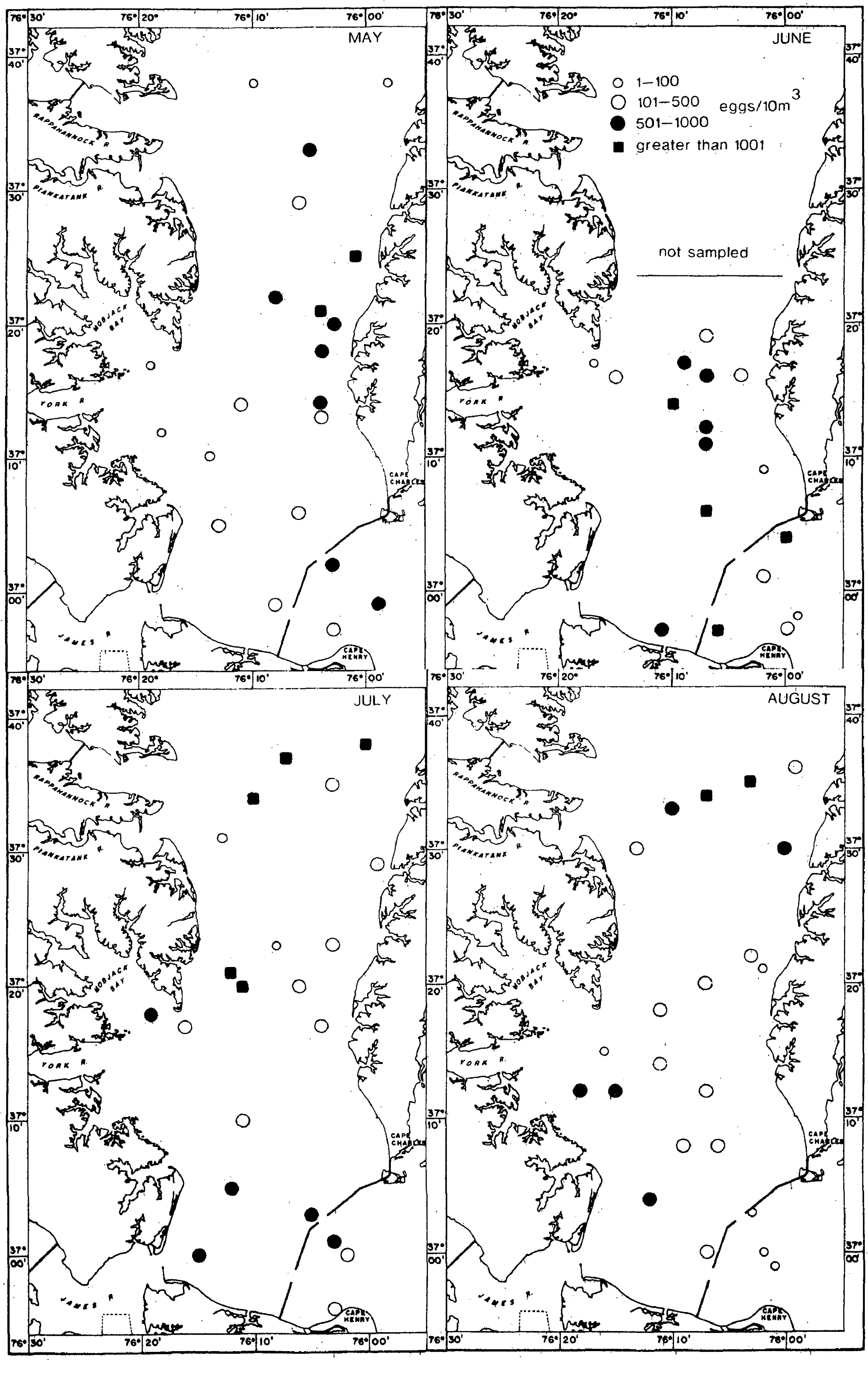
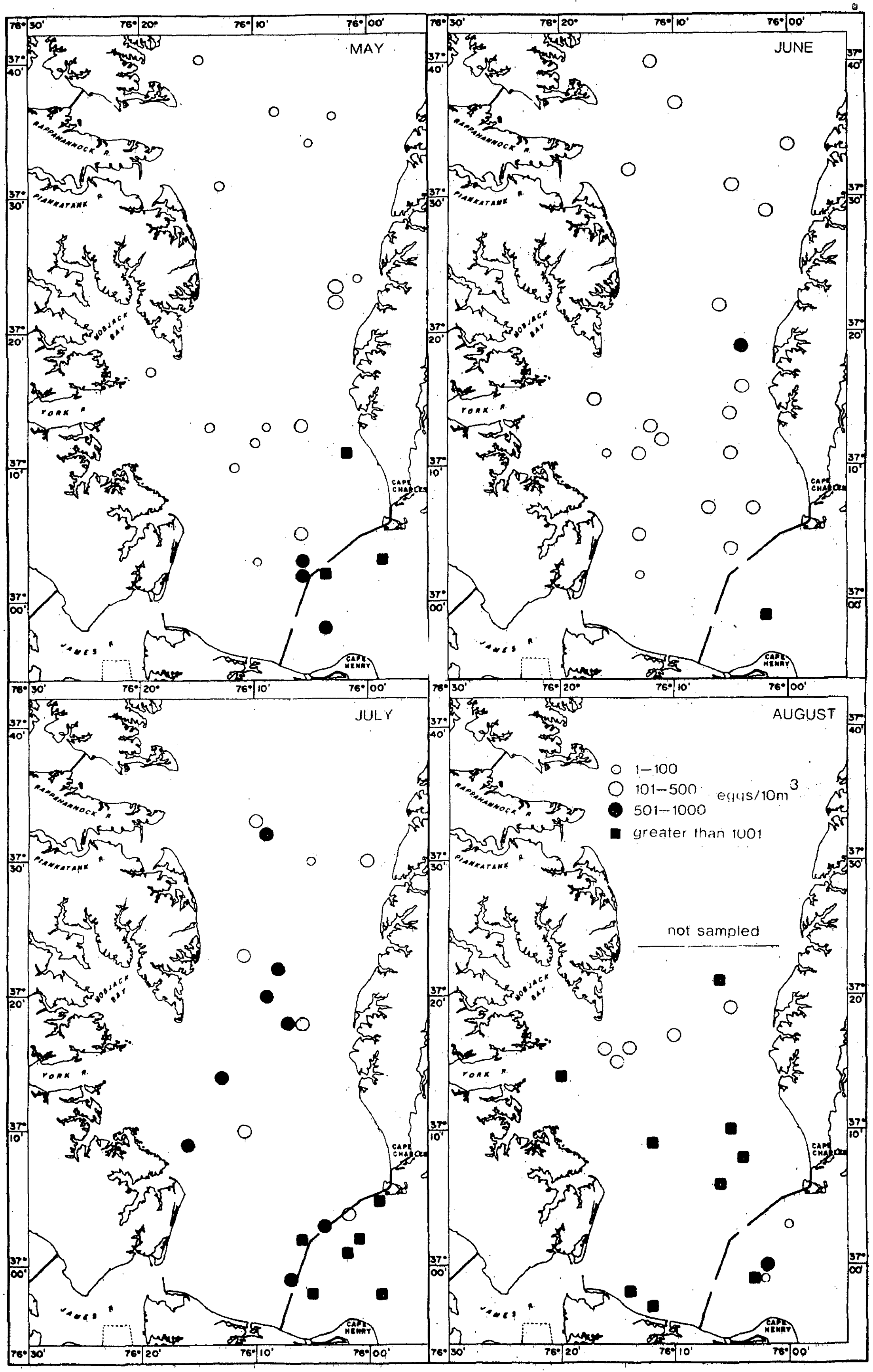

MAY
JUNE
JULY
AUGUST
1–100
101–500
eggs/10m^3
501–1000
greater than 1001
not sampled
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK R.
JAMES R.
CAPE CHARLES
CAPE HENRY
76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'

FIGURE 9. Abundance and distribution of *Anchoa mitchilli* eggs, 1973.


MAY
JUNE
JULY
AUGUST
1–100
101–500
501–1000
greater than 1001
eggs/10m3
not sampled
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK R.
JAMES R.
CAPE CHARLES
CAPE HENRY
76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'

the presence of eggs (Fig. 4) and with previous records of larval occurrence (Dovel 1971). Densities of larvae lagged temporally behind eggs, low numbers of larvae in May-June and peaks in July and August. The greatest mean monthly larval abundance was recorded in July 1972, although all late summer mean densities were high, ranging from 1098-2403 larvae/100 m^3 (Fig 4). The highest observed density (10,362/100 m^3) was recorded in August 1972 (Fig. 10). The distribution of larval anchovies during the 1972-1973 spawning seasons (Figs. 10 and 11) paralleled the egg pattern. Larval anchovies appeared first at stations near the Bay mouth and in the mid-channel areas, gradually increasing in numbers to peak abundances and widest distributions in August (taken at all stations in August 1971, July and August 1972,1973). Length frequency data (Fig. 12) indicated slight changes in size composition as the spawning season progressed. In June, July 1972 and 1973, anchovies in the 1-3 mm NL size groups made up 83-95% of the total catch. In August 1971 and 1973, this group made up 61-65% of the total catch as percentages of larger size groups increased. Although juvenile <u>A. mitchilli</u> as large as 35 mm SL were taken on occasion (March 1976), the vast majority of specimens were between 2.0 mm NL and 10.0 mm SL with collections conspicuously skewed towards smaller size classes. The largest postlarval <u>A. mitchilli</u> (11.0-18.0 mm SL) were taken during night surface tows of the 50 x 60 cm neuston net (Fig. 13).

Data from simultaneous collections of bongo and neuston nets in August 1975 are presented in Table 4. Comparison of paired values

FIGURE 10. Abundance and distribution of larval *Anchoa mitchilli*, 1972.

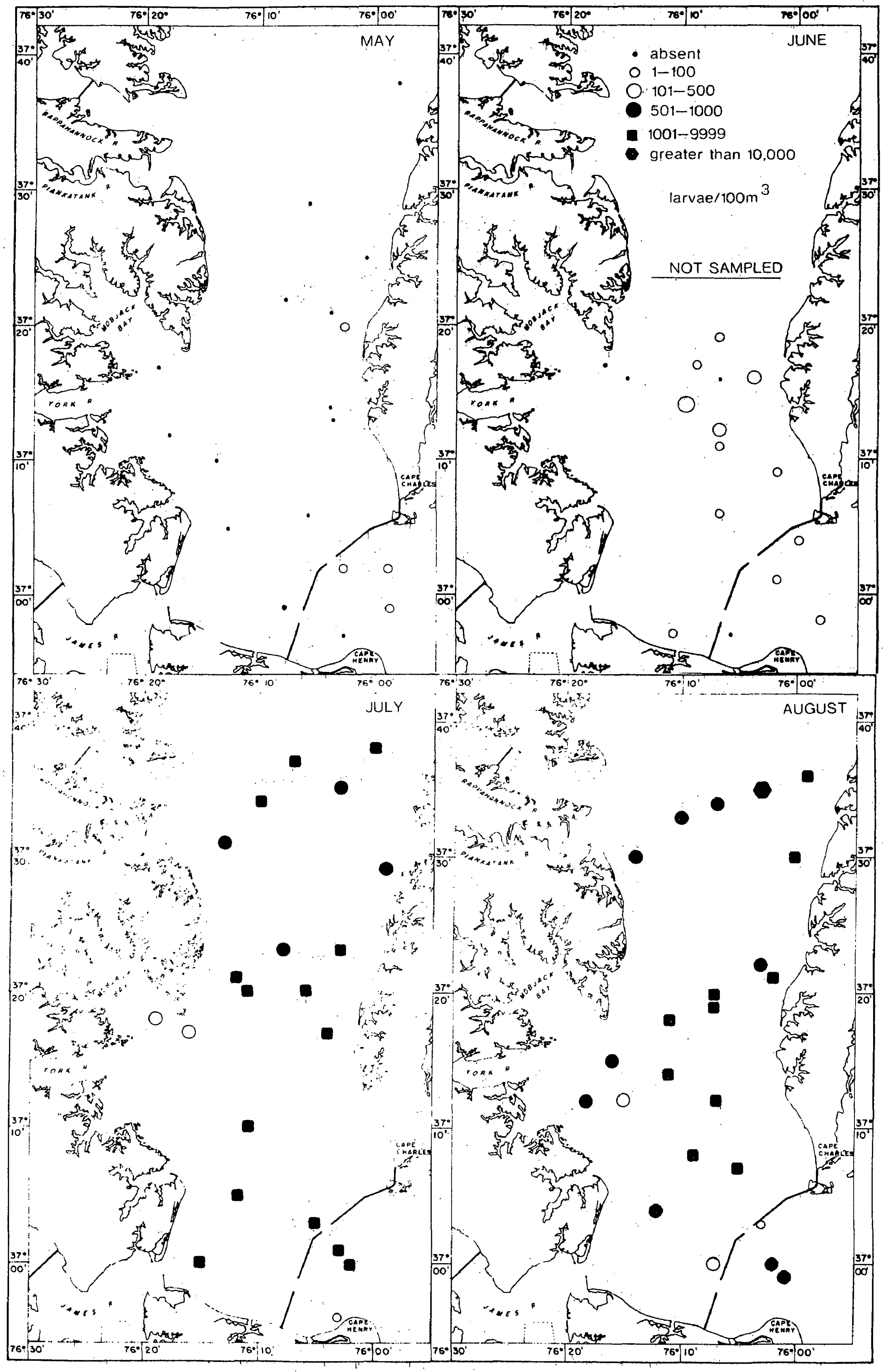

MAY
JUNE
JULY
AUGUST
absent
1–100
101–500
501–1000
1001–9999
greater than 10,000
larvae/100m^3
NOT SAMPLED
76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'
RAPPAHANNOCK R
PIANKATANK R
MOBJACK BAY
YORK R
JAMES R
CAPE CHARLES
CAPE HENRY

FIGURE 11. Abundance and distribution of larval *Anchoa mitchilli*, 1973.

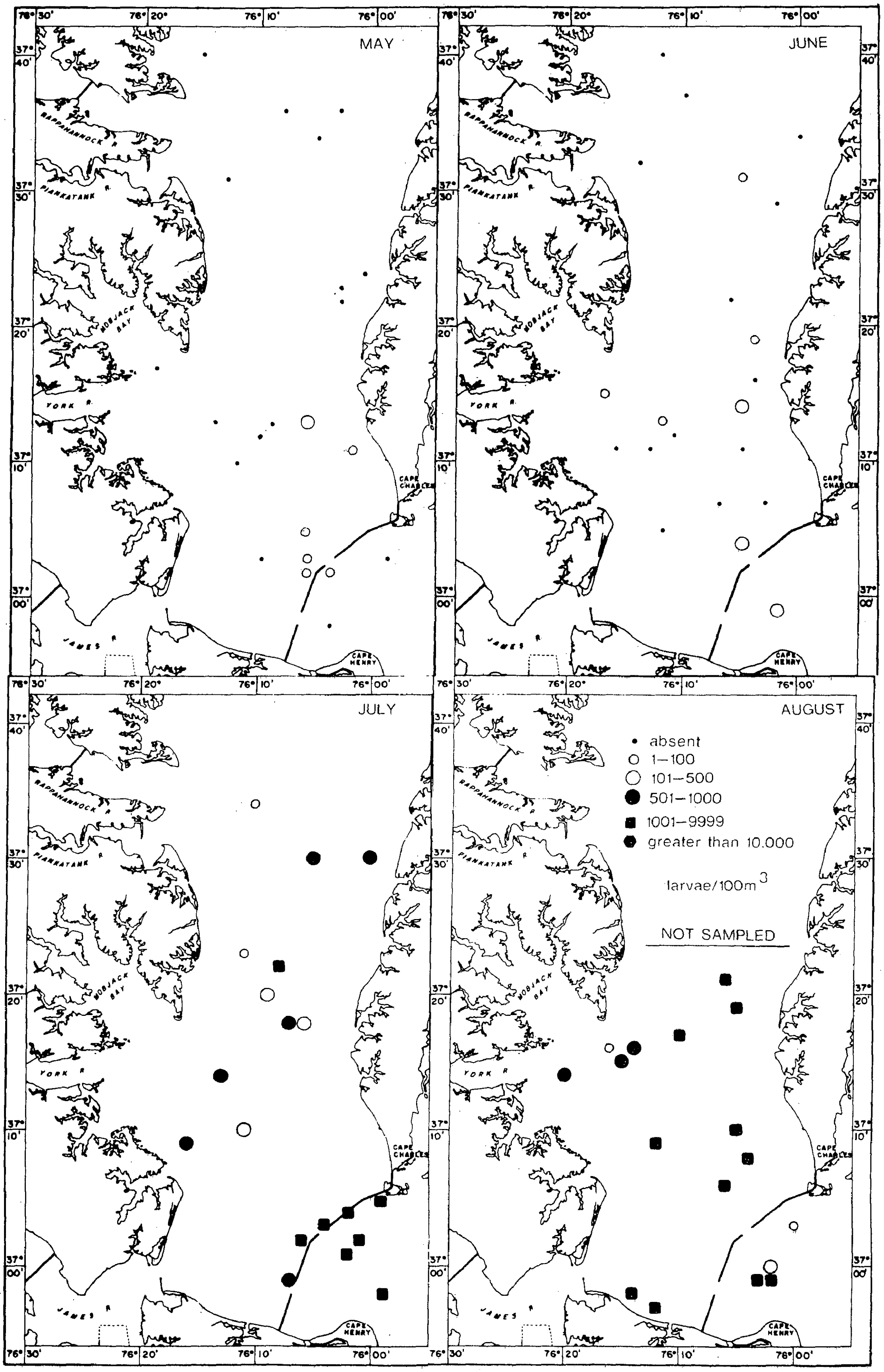
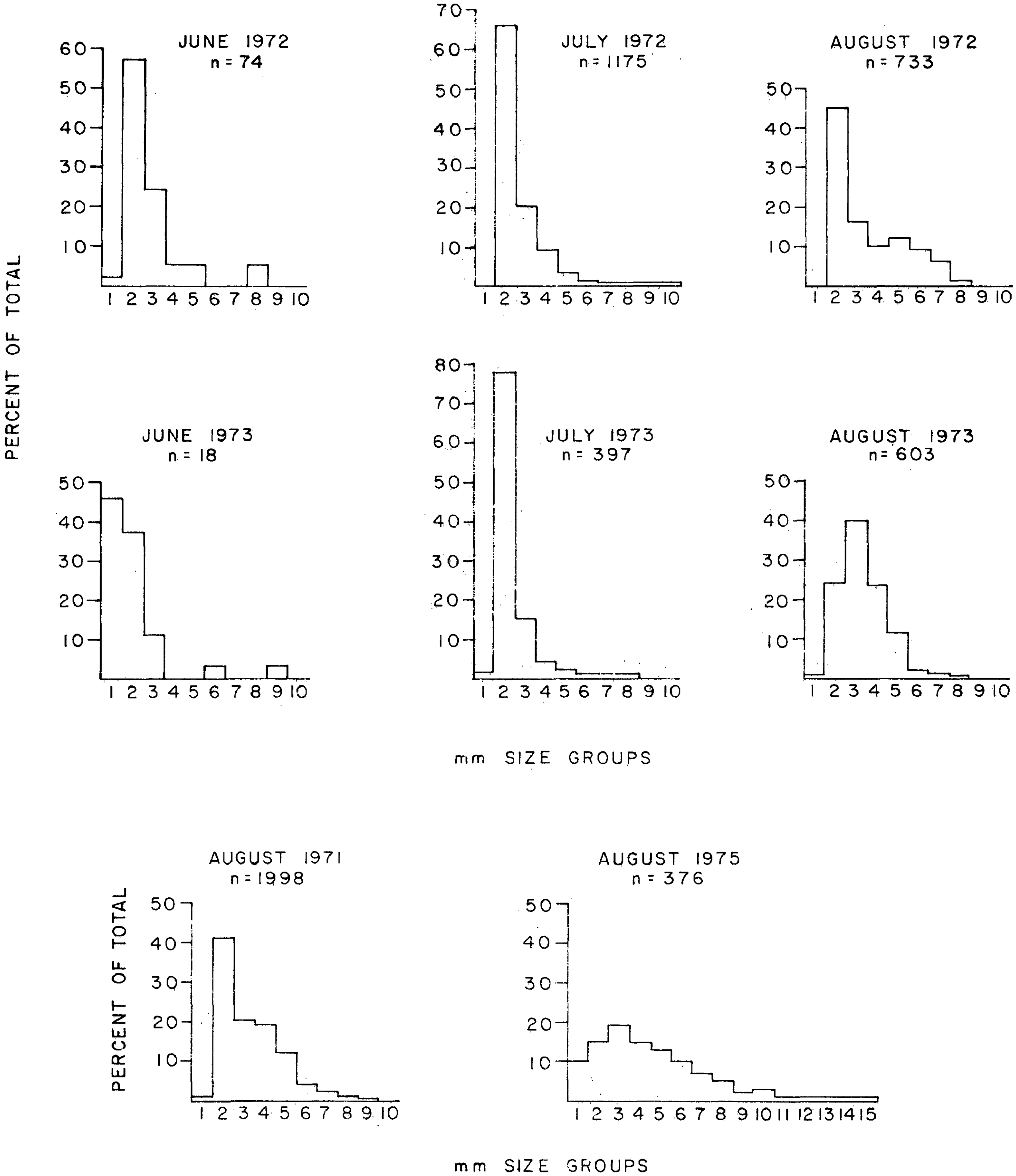
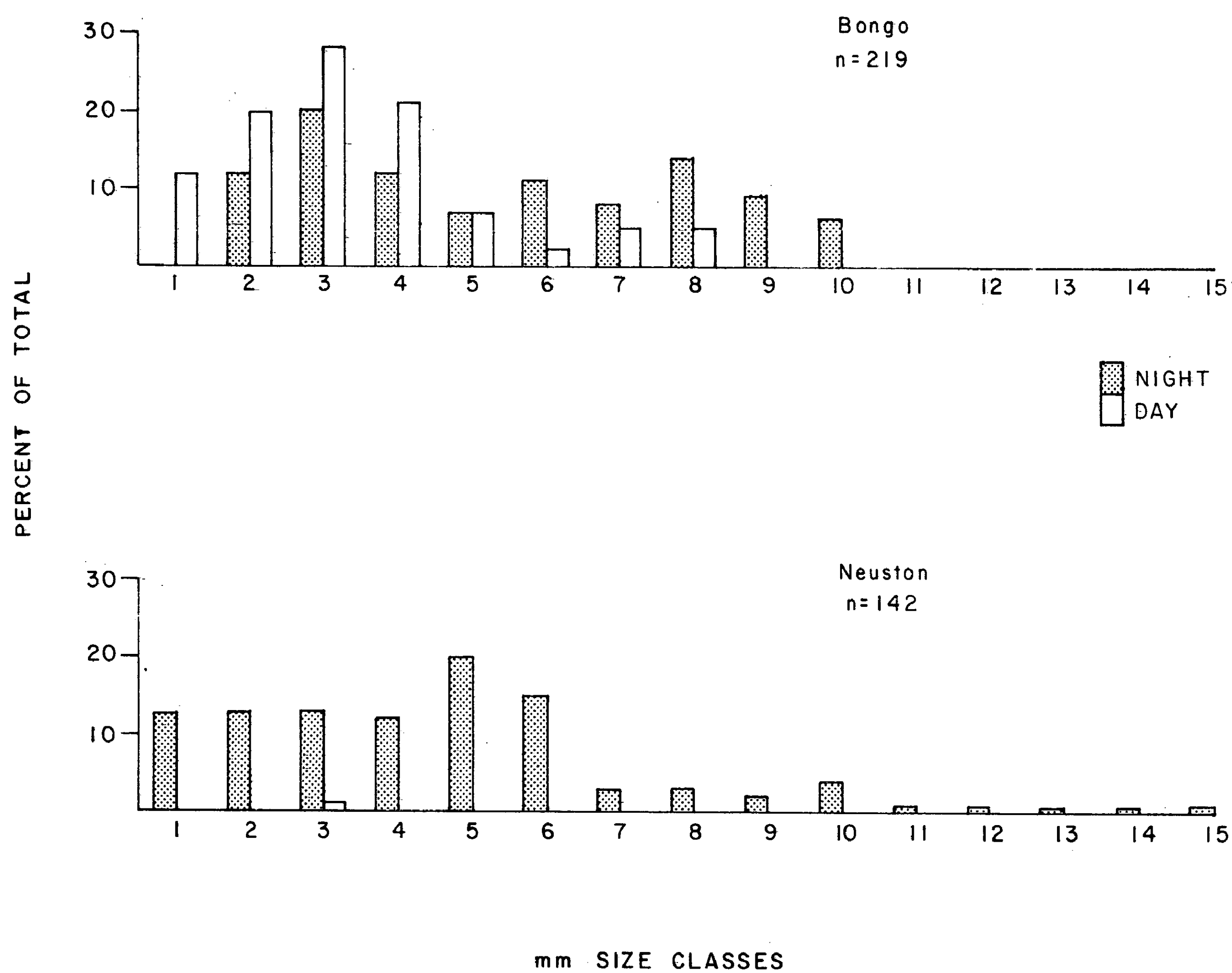

MAY
JUNE
JULY
AUGUST
76°30'
76°20'
76°10'
76°00'
37°40'
37°30'
37°20'
37°10'
37°00'
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK R.
JAMES R.
CAPE CHARLES
CAPE HENRY
absent
1–100
101–500
501–1000
1001–9999
greater than 10.000
larvae/100m3
NOT SAMPLED

FIGURE 12. Percent frequency of size classes among larvae of _Anchoa mitchilli_, 1971 - 1975.



PERCENT OF TOTAL
JUNE 1972
n = 74
JULY 1972
n = 1175
AUGUST 1972
n = 733
JUNE 1973
n = 18
JULY 1973
n = 397
AUGUST 1973
n = 603
mm SIZE GROUPS
AUGUST 1971
n = 1998
AUGUST 1975
n = 376
PERCENT OF TOTAL
mm SIZE GROUPS

FIGURE 13. Comparison of percent frequency of *Anchoa mitchilli* size classes in surface and subsurface collections, August 1975.



PERCENT OF TOTAL
Bongo
n=219
NIGHT
DAY
Neuston
n=142
mm SIZE CLASSES

TABLE 4

ABUNDANCES OF EGGS AND LARVAE OF *ANCHOA MITCHILLI* IN 16 CONCURRENT SURFACE AND SUBSURFACE COLLECTIONS, AUGUST 1975

Water Filtered (m^3)		Day (D) or Night (N)	Eggs (No./10 m^3)		Larvae (No./100 m^3)	
Bongo	Neuston		Subsurface	Surface	Subsurface	Surface
9.836	183.07	D	2667.8	2422.7	244.0	0
6.33	205.05	D	3854.7	8080.8	347.6	0
7.39	156.82	D	1991.9	1280.5	676.6	10.2
14.12	93.55	D	733.7	358.3	1076.5	0
8.47	139.37	D	651.7	266.6	0	0
10.48	210.05	D	282.4	31.6	267.2	0
9.31	104.04	N	0	3.56	10.7	2.9
5.24	54.15	N	0	1.48	19.1	1.8
11.25	78.23	N	10.7	4.1	124.4	40.9
9.03	111.27	N	1275.7	1135.9	144.0	88.1
7.91	112.39	N	3074.6	5184.8	101.1	7.1
12.39	91.34	N	0	32.3	16.1	39.4
9.89	84.45	N	4.0	0.2	80.9	65.1
13.40	136.20	N	59.7	193.8	179.1	184.3
11.52	119.21	N	38.2	46.9	34.7	15.1
8.15	128.51	D	382.8	175.6	184.0	0

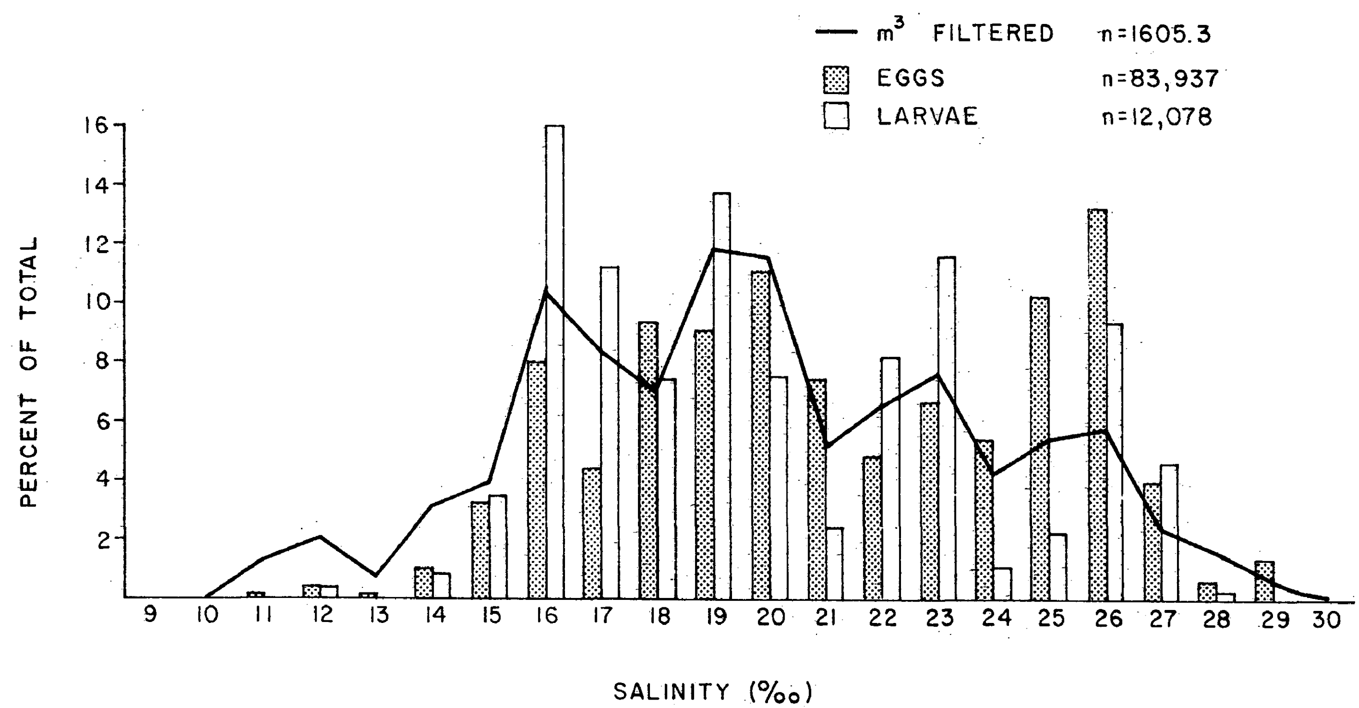
using the t-statistic (Snedecor and Cochran 1967) provided no evidence of differences (df=15, t=0.86) between surface and subsurface density estimates of A. mitchilli eggs, but did support the conclusion (df=15, t=2.56) that larval A. mitchilli <8.0 mm NL were most available to subsurface nets, especially during daylight hours when avoidance of the surface layer by larvae was readily apparent.

The data indicate that anchovy eggs and larvae (under 8 mm NL) are available to 18.5 cm bongos, but larger size classes of larvae can avoid the net, especially in daylight conditions. This conclusion is based on the collection of anchovy larvae up to 18.0 mm SL by the larger neuston gear in August 1975 (neuston to bongo mouth opening ratio, 7:1) and the absence of larvae greater than 11.0 mm SL in daylight bongo collections prior to August 1975. Despite this sampling bias, observed day-night differences in surface catches (size frequency and density) in the lower Bay indicate that A. mitchilli larvae greater than 10 mm SL migrate to the surface layers at night. This behavior appears similar to that of the Northern anchovy, Engraulis mordax, which fill their swim bladders in an energy-saving diel cycle (Hunter and Sanchez 1976). Future sampling to assess Bay anchovy larval size composition must include evening neuston sampling and subsurface collections with larger bongos (Ahlstrom and Stevens 1976).

Dovel (1971) found a disjunct salinity distribution of A. mitchilli eggs and larvae in the upper Chesapeake Bay, with larvae in greater concentrations in lower salinity waters. A similar analysis of the lower Chesapeake Bay data (Fig. 14) failed to strongly support Dovel's observations. Both egg and larval stages appeared evenly distributed throughout the observed salinity range, although eggs peaked in abundance at 26 ppt and larvae at 16 ppt. The absence of discrete sampling in the present study prevented examination of variations in abundance due to vertical salinty stratification and stepped, oblique tows obscured trends in horizontal abundance related to salinity. The possibility that spawning behavior of adults and movements of larvae in the higher salinities of the lower Bay are not similar to those in the low salinities of upper Bay waters, however, cannot be discounted.

The dominance of *Anchoa mitchilli* egg and larval stages in lower Chesapeake Bay ichthyoplankton samples is not considered to be an artifact of sampling. Bay anchovy eggs and larvae were recorded as dominant in the Magothy River (Dovel 1967), the upper Chesapeake Bay (Dovel 1971), Lynnhaven Bay (Schauss 1977) and Long Island Sound (Perlmutter 1939, Wheatland 1956). In addition, Pearson (1941) listed larval and postlarval *Anchoa mitchilli* as the most numerous of all species in lower Chesapeake Bay plankton, although estimates of density were not provided. The present abundance estimates for the lower Bay (2-7671 eggs/10 m^3) during periods of peak spawning are comparable to records of maximum abundance for the upper Bay by Dovel (1971) of 141,440 eggs/330 m^3 water (=4286/10 m^3) and to Wheatland's (1956) estimates of 58-1230 eggs/10 m^3 during months of peak abundance

FIGURE 14. Distribution of *Anchoa mitchilli* eggs and larvae by salinity.


m3 FILTERED n=1605.3
EGGS n=83,937
LARVAE n=12,078
PERCENT OF TOTAL
16
14
12
10
8
6
4
2
9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
SALINITY (‰)

in 1952 in Long Island Sound. The surface maximum density of over 8000 eggs/10 m^3 (August 1975) is unique and indicative of the importance of Bay surface waters to the spawning success of *A. mitchilli*. Similar surface maxima of fish eggs (*Urophycis* spp.) have recently been recorded along the continental shelf off New Jersey (pers. observ.).

There are few published estimates of *Anchoa mitchilli* larval abundance. The present mean density estimates during peak periods (1098-2403 larvae/100 m^3) are considerably higher than Wheatland's (1956) estimated range in 1952-53 of 15-594 larvae/100 m^3, as is the August 1972 larval maximum of over 10,000 larvae/100 m^3. This latter extreme, however, may be a result of larval transport from upper Bay waters during 1972 flood conditions. Hildebrand (1963) lists *A. mitchilli* as common in New York waters but as exceedingly abundant from New Jersey south to Cape Hatteras, North Carolina, thus the lower Chesapeake Bay may be the center of spawning activity for this species.

Gobiesociformes

Gobiesocidae

Gobiesox strumosus (Cope)

Larval skilletfish (n=9) ranging in size from 2.2 mm NL - 11.5 mm SL were taken in lower Bay ichthyoplankton samples in August-September 1971, June-July 1972 and July-August 1973. Salinity and temperature ranges for these collections were 12.9 - 23.9 ppt and 23.8 - 26.5°C.

Skilletfish larvae were widely distributed within the study area (Fig. 15) but never occurred at stations in the Bay mouth or along its eastern edge. The largest specimen had completed metamorphosis and represented the most northerly capture.

Abundances of G. strumosus larvae ranged from 2.9 - 15.2 larvae/100 m^3 at positive stations. These may be underestimates of the abundance of larvae of this species since Musick (1972) lists G. strumosus as common to abundant in the lower Bay. Pearson (1941) took 87 larval skilletfish from 2 - 4.5 mm TL with the largest collections appearing in May. Although no abundance estimates were recorded by Pearson, the larger number of specimens taken in Pearson's meter net collections suggests that larval skilletfish avoid smaller sampling gear in daylight hours.

The early life history stages of Gobiesox strumosus have been described by Runyan (1961) and Dovel (1963). Dovel (1967, 1971) and Schauss (1977) provide additional records of skilletfish in plankton collections in middle Atlantic estuaries.

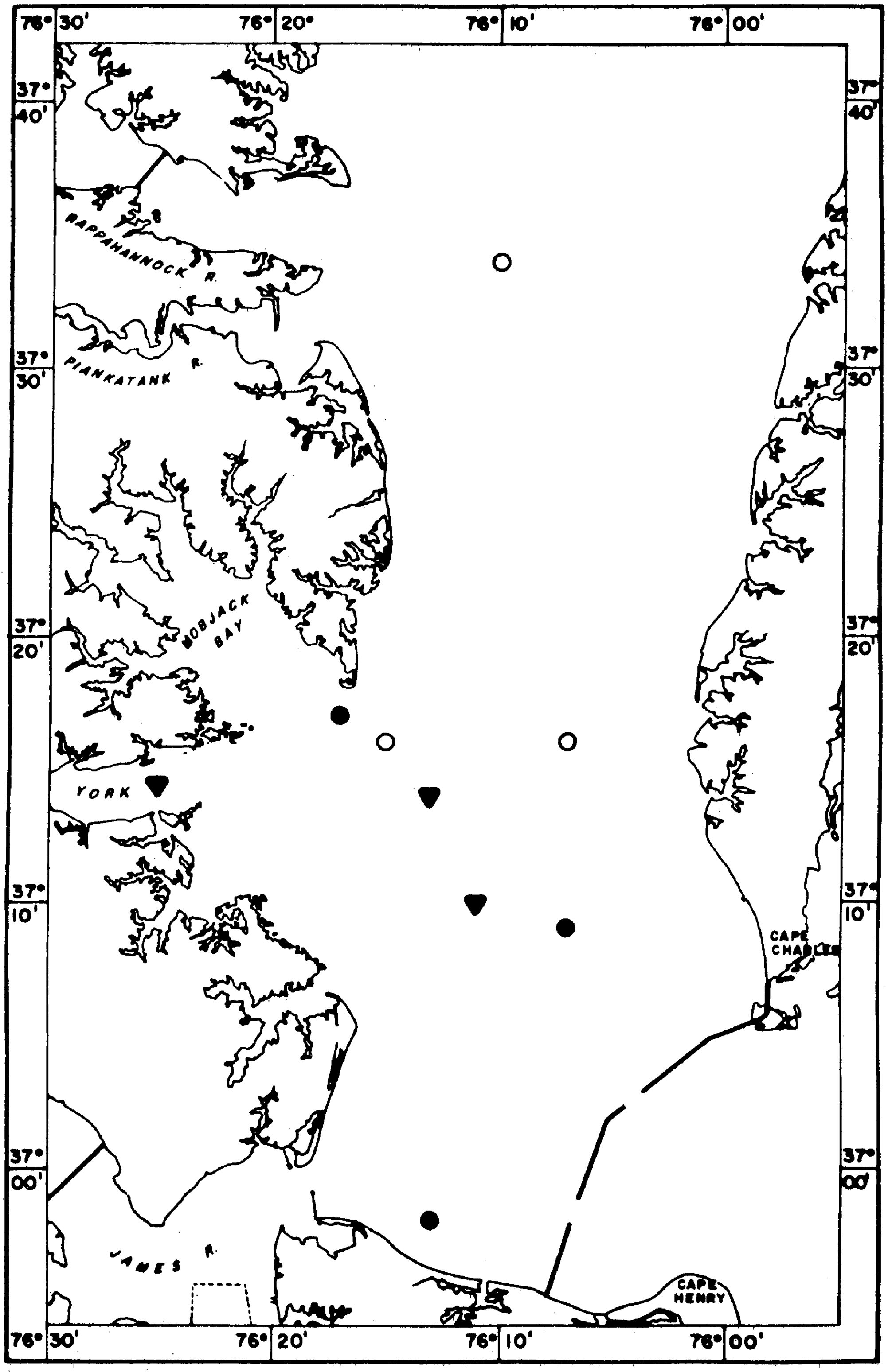
Lophiiformes

Lophiidae

Lophius americanus (Valenciennes)

A single, damaged goosefish larva was taken on 15 May 1973 at a Bay mouth station (29.2 ppt and 16.6°C). The specimen (4.7 mm NL) lacked the elongate dorsal rays characteristic of the genus, but was identified by pigmentation, precocious pelvic development, and the

FIGURE 15. Locations of capture of larval skilletfish, *Gobiesox strumosus* in the lower Chesapeake Bay, 1971 - 1973.



● 1971 ○ 1972 ▼ 1973

voluminous finfold characteristic of the early larva (Bigelow and Schroeder 1953).

The conclusion that larval goosefish occur only rarely in lower Chesapeake Bay waters is supported by Pearson (1941), and Hildebrand and Schroeder (1928). Although adults and juveniles are occasionally taken by trawls in the lower Bay (Musick 1972), and both shoal and deep water spawning have been recorded (Bigelow and Schroeder 1953), spawning probably occurs in deeper waters of the central and outer shelf off Virginia. It appears that larval *Lophius* are indictors of shelf water intrusion into the Chesapeake Bay system.

Gadiformes

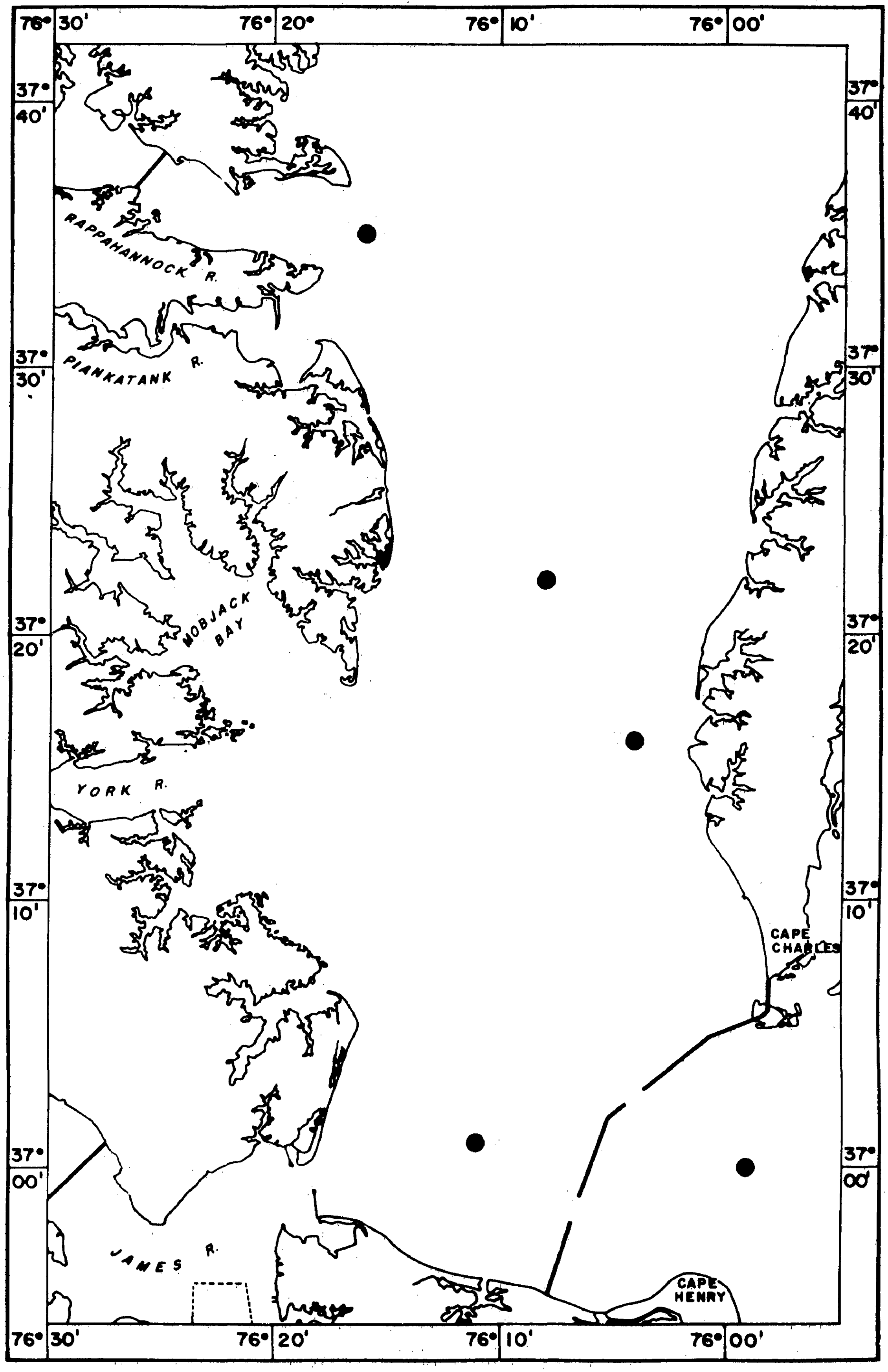
Gadidae

Urophycis regius (Walbaum)

In March 1976, nine juvenile spotted hake were taken in evening neuston collections at five stations widely scattered throughout the lower Bay (Fig. 16). Temperature, salinity and size ranges were 11.0-11.9°C, 13.7-27.8 ppt, and 41-52 mm SL.

There are no previous records of the pelagic young of *Urophycis regius* occurring in Chesapeake Bay waters, however, the present collection is not considered unusual. Barans (1972) documented a small, resident population of young-of-the-year spotted hakes in the York River and lower Chesapeake Bay during March-June 1966-68. The present data and the overwhelming dominance of *Urophycis* spp. (*regius* and *chuss*) in midshelf ichthyoneuston collections (Olney and Grant,

FIGURE 16. Locations of capture of the pelagic young of _Urophycis regius_, March 1976.



76° 30'
76° 20°
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK R.
JAMES R.
CAPE CHARLES
CAPE HENRY
76° 30'
76° 20'
76° 10'
76° 00'

unpubl. data) support Barans' conclusion that the spring movement of hake into the estuary is not a directed migration but the result of a general shoreward movement of shelf populations.

The absence of *U. regius* in spring collections in 1972 and 1973 reflects the absence of night neuston sampling. In March 1976 hakes avoided the 18.5 cm bongo sampler and were absent in daylight neuston tows. Their occurrence at the surface in evening hours probably represents feeding excursions of juveniles which have not completed the transition to the benthic habitat. Examination of the gut contents of several individuals (41 mm SL, 47 mm SL) revealed strictly planktonic diets. The gut of the largest individual contained over 100 copepods.

In the middle Atlantic Bight, *U. regius* spawns from late September through February and *U. chuss* from May-September (Barans and Barans 1972). The late stage eggs of *Urophycis* spp. are easily recognized (Barans and Barans 1972; Hildebrand and Cable 1938; Colton and Marak 1969), but eggs in an early state of development might be confused with those of stromatiid and sciaenid fishes. Early stage eggs of *Urophycis* spp. (*regius* or *chuss*) may be overlooked in estuarine and nearshore collections, however the known spawning distributions of these fishes and the absence of mature specimens in the Bay preclude this possibility.

Gadiformes

Ophidiidae

Rissola marginata (DeKay)

Three larval ophidiids, tentatively assigned to *Rissola marginata*, were taken at statons (n=3) near the Bay entrance. The three specimens (2.9 mm NL, 16 August 1971; 3.7 mm NL, 21 September 1971; 11.2 mm SL, 17 August 1972) were taken in salinity and temperature ranges of 23.9 - 24.8 ppt and 22.6 - 24.6°C.

Meristic counts recorded for the largest specimen were: dorsal-fin rays, 136+; anal-fin rays, 112; total myomeres, 67. These data agree with unpublished meristic counts for larvae of *R. marginata* (Dr. A. W. Kendall, pers. commun.), and approach counts of adult *R. marginata* (Miller and Jorgenson 1973). The two smallest specimens lacked dorsal or anal rays and myomeres were difficult to distinguish.

Musick (1972) lists only *R. marginata* as occurring in the lower Chesapeake Bay, yet unpublished VIMS and NMFS data (person. obs. and Kendall, pers. commun.) indicate that at least four larval ophidiid types sometimes occur in large abundances in middle Atlantic Bight ichthyoplankton collections. These types probably represent larvae of *R. marginata*, *Lepophidium cervinum*, *Otophidium omostigmum* and *Ophidion beani*. The possibility that larvae of these species sometimes occur in lower Bay waters cannot be discounted. As a result, the identity of the smallest specimens in the present collection remains in doubt. Pearson (1941) recorded 12 *R. marginata* larvae from the lower Bay ranging from 2-7 mm TL but did not substantiate the identifications.

Atheriniformes

Atherinidae

Membras martinica (Valenciennes)

Although a large number of young atherinids (n=179) were taken during the lower Bay survey, less than half (n=51) could be identified to species on the basis of scale morphology (Lippson and Moran 1974). These were all juveniles of the rough silverside, Membras martinica. The remainder of the specimens could not be assigned to genus or species and are treated in the following section.

Juvenile M. martinica, ranging in size from 17-94 mm SL, were collected in Bay plankton samples in August 1973 and 1975, and March 1976 in surface salinity and temperature ranges of 13.7-24.8 ppt and 11.5-28.5°C. Excluding five specimens taken in oblique bongo collections during a 24 hr station at the York River mouth, all M. martinica occurred in evening neuston samples. The York River specimens were probably taken in surface waters during oblique collections.

Membras martinica juveniles were taken at scattered stations near the Bay mouth and the York, Rappahannock River entrances and are probably common surface fishes in evening hours in the lower Chesapeake Bay (Musick 1972; Dovel 1971; Hildebrand and Schroeder 1928). Their disjunct distribution and relative paucity in the present collections (0.6-20.8 fish/100 m^3) reflect the lack of intensive evening neuston sampling and the inability to identify individuals smaller than 15 mm SL. The largest specimen taken (94 mm SL) was also the single cold water occurrence but its appearance off the Rappahannock River mouth does not resolve the question of winter habitat for this species (Musick 1972).

Atherinidae

The identification of larval atherinids (Menidia and Membras) below 15 mm SL is a problem which has been encountered by many investigators (Dovel 1967, 1971; Schauss 1977; Scotton et al. 1973; Lippson and Moran 1974). Egg and larval stages of the various species have been described; Menidia menidia (Kuntz and Radcliffe 1917; Scotton et al. 1973; Lippson and Moran 1974); Menidia beryllina (Hildebrand 1922; Lippson and Moran 1974); and Membras martinica (Kuntz 1916; Lippson and Moran 1974) however larval characters separating co-occurring species are inadequate. Lippson and Moran (1974) have attempted species separation based on the number, orientation and relative size of cephalic melanophores but this method has yet to be fully substantiated. Chesapeake Bay collections contained a large number of specimens with overlapping pigment characters, thus silverside larvae were not assigned to genus or species.

Silverside larvae (n=128) were collected in May 1973 and August of 1972, 1973 and 1975 (Table 5) at stations scattered evenly over the study area. Larval atherinids were more frequent in surface collections, only four percent (n=5) taken oblique bongo tows.

TABLE 5

COLLECTION DATA FOR LARVAL SILVERSIDES
(ATHERINIDAE) IN THE LOWER CHESAPEAKE BAY

Date	Gear*	Number of Specimens	Abundance (#/100 m^3)	Length Range (mm)	Mean Length (mm)	Salinity (ppt)	Temperature (°C)
August 1972	B	1	17.9	12.0	-	15.2	24.6
May 1973	B	1	11.5	5.6	-	16.3	18.8
August 1973	B	1	3.2	2.7	-	32.5	18.1
	B	2	11.6	8.6-9.4	9.0	26.2	18.9
August 1975	N	2	1.1	3.8-4.3	4.1	19.1	27.4
	N	16	7.8	4.5-7.6	6.3	18.7	27.8
	N	2	2.6	-	-	17.5	27.5
	N	38	18.1	4.1-7.1	5.6	15.7	29.4
	N	1	0.9	7.0	-	14.4	27.7
	N	1	1.8	8.6	-	13.9	28.5
	N	2	2.2	7.3-11.0	9.2	20.3	28.5
	N	13	31.6	4.3-12.0	9.8	18.4	28.1
	N	42	35.2	4.5-12.6	6.1	20.6	27.6
	N	6	7.7	7.8-10.5	9.4	14.5	28.1

* B = 18.5 cm bongo
N = 50 x 60 cm neuston

Abundances ranged from 0.9-35.2 larvae/100 m^3 at positive stations. Atherinids were most abundant in surface waters during August 1975; more larvae were taken in daylight (n=100) than in evening (n=27) tows. A diel pattern in surface occurrence was not substantiated, however, since evening bongo tows yielded no larvae.

The data indicate that larval silversides are good avoiders of small bongo samplers. The almost complete absence of larvae in May-July samples can only be explained by this feature as well as the lack of surface sampling during these months. Future assessments of abundance and distribution of atherinids in the lower Bay must include neuston collections (Lindsay et al. 1978) and will depend on improvements in identification techniques.

Gasterosteiformes

Syngnathidae

Syngnathus fuscus (Storer)

A total of 50 specimens of the northern pipefish ranging from 8.0-115.0 mm SL were taken in 1971-1976. Most specimens (n=35) were under 20 mm SL and were taken in August, September 1971; June, July, and September 1972; May-August 1973; and August 1975. Larger fishes (20-115 mm SL) were taken only in winter months, November-March (Table 6). Pipefish occurred throughout the lower Bay (Fig. 17) with the greatest abundances recorded at stations in the middle and upper portions of the study area. There were relatively few occurrences at the Bay mouth. Salinity and temperature ranges were 10.8-25.9 ppt and

TABLE 6

MONTHLY DATA SUMMARY FOR NORTHERN PIPEFISH,

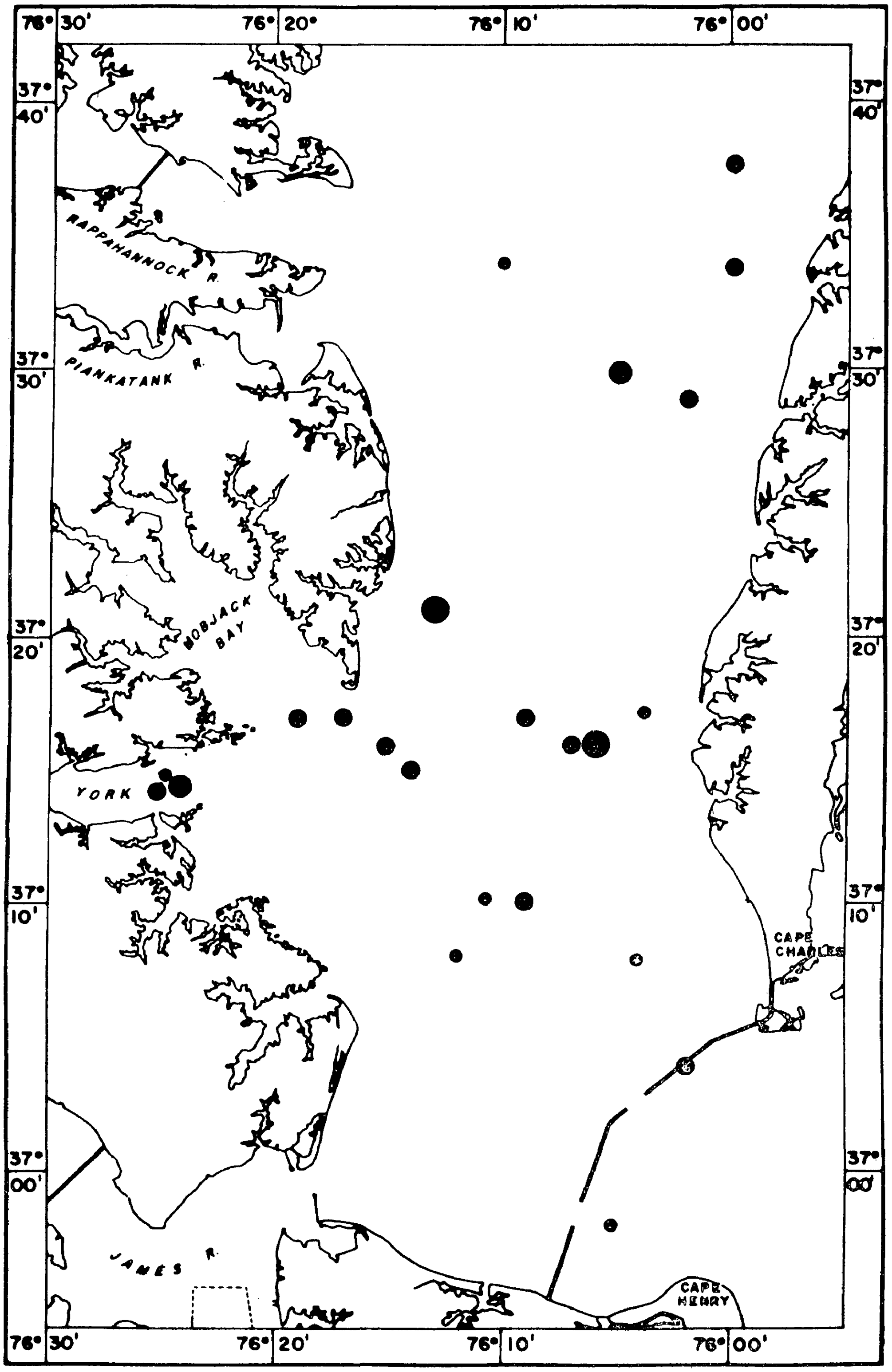
SYNGNATHUS FUSCUS, 1971-1976.

Month	Percent Occurrence	Number of Specimens	Average Abundance (No./100 m^3)	Range of Abundance (No./100 m^3)	Length Range (mm)	Temperature Range (°C)	Salinity Range (ppt)
1971							
August	3.3	1	0.4	15.2	12.0	26.2	18.9
September	3.3	2	2.1	60.8	9.3-10.3	24.6	20.4
1972							
January	3.7	1	0.3	8.8	36.0	4.8	21.3
June	13.8	6	4.4	7.7-71.8	11.0-16.0	20.9-22.1	13.4-20.0
July	8.2	4	0.8	8.9-10.7	9.8-70.0	22.6-26.5	10.8-17.5
September	4.2	1	0.8	17.9	18.5	23.1	21.4
November	5.3	1	0.5	10.7	31.0	13.2	21.7
1973							
February	4.0	1	0.4	10.7	52.0	3.1	15.7
May	8.0	2	0.8	22.9	11.5-16.0	18.8	16.3
June	8.0	2	1.6	11.9-14.3	9.5-13.0	23.2-23.4	19.4-20.3

TABLE 6 (concluded)

Month	Percent Occurrence	Number of Specimens	Average Abundance (No./100 m^3)	Range of Abundance (No./100 m^3)	Length Range (mm)	Temperature Range (^oC)	Salinity Range (ppt)
July	13.6	4	2.3	4.9-25.2	15.0-21.0	21.5-25.4	18.3-25.9
August	20.7	16	4.3	7.6-47.4	11.8-22.0	24.8-26.5	19.0-24.8
1975 August	11.8	3	0.1	0.6- 2.4	8.0-33.0	27.4-28.3	19.1-21.7
1976 March	15.8	6	---	0.5- 1.4	98.0-115.0	11.1-11.4	15.7-16.7

FIGURE 17. Distribution and abundance of Syngnathus fuscus larvae, 1971 - 1973.



• 1–10 ● 26–50
● 11–25 ● greater than 51

larvae/100m^3

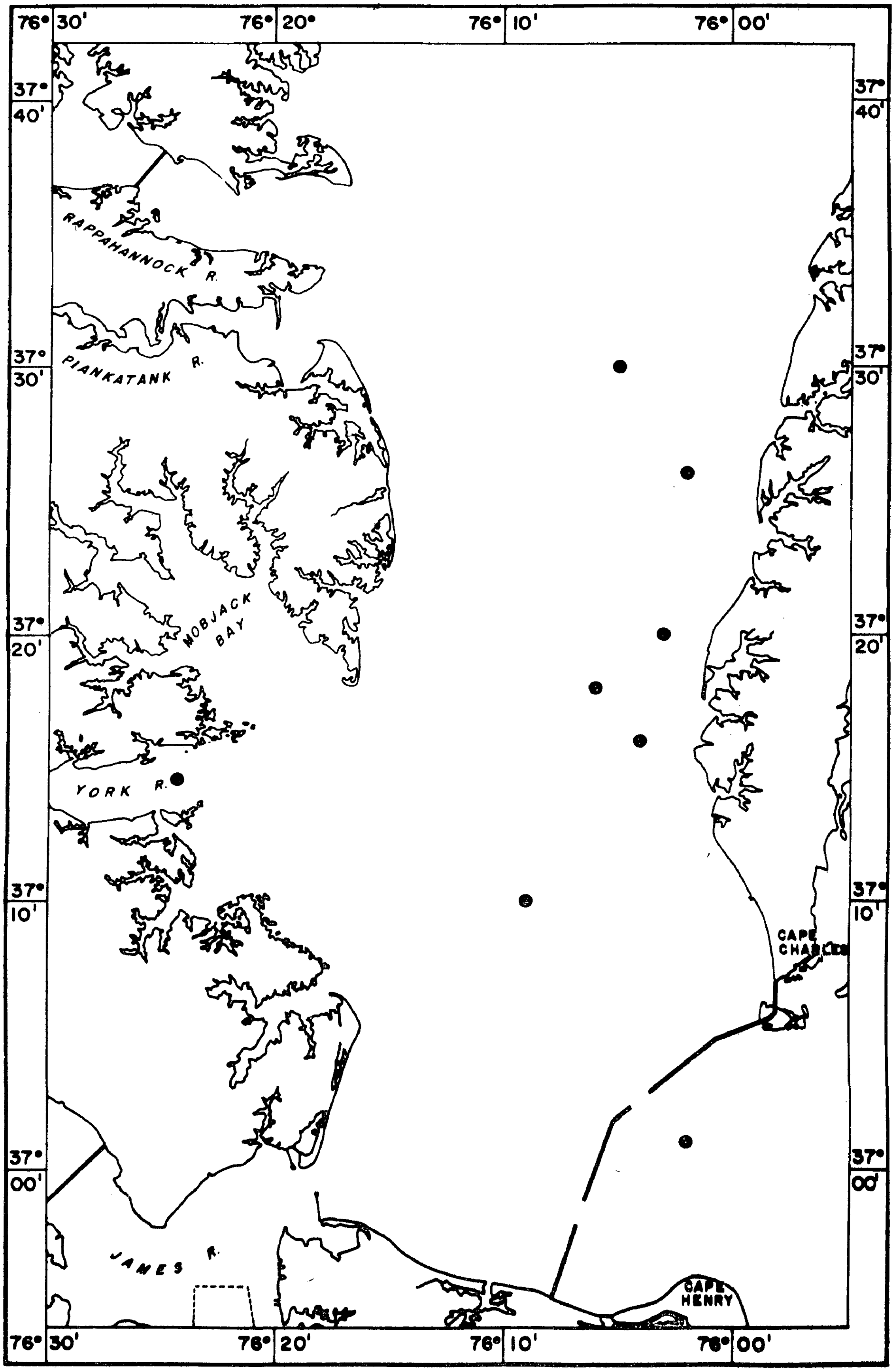
3.1-28.3°C with the majority of the specimens (n=37) occurring in salinities less than 20 ppt. These distributional and hydrographic data agree well with Mercer's (1973) findings that S. fuscus was more abundant than S. floridae in shallow waters between 13 and 20 ppt. Mercer found S. fuscus juveniles present at seine stations from June-October with peak spawning in May and early June.

The absence of Syngnathus floridae in these collections is puzzling. Mercer (1973) found both species in equal abundance in the York River with S. floridae preferring higher salinities and deeper waters than S. fuscus. Males of both species were found with eggs and larvae in pouch. Pearson (1941) found S. floridae in Bay mouth plankon collections but S. fuscus was most abundant. Schauss (1977) took no S. floridae in Lynnhaven Bay but did report a single juvenile specimen of S. louisianae.

Hippocampus erectus (Perry)

Seahorses are occasional to common inhabitants of the Chesapeake Bay (Musick 1972) and have been recorded in Bay plankton collections by Pearson (1941) and Dovel (1971). Captures of 8 young seahorses, ranging in length (as defined by Ginsburg 1937) from 7.0-57.0 mm, occurred in July and August and were largely restricted to the eastern half of the Bay (Fig. 18) in a salinity range of 18.3-23.6 ppt. These data indicate that H. erectus larvae are either transported into the Bay from seaside spawning areas or originate from bayside Eastern Shore habitats.

FIGURE 18. Locations of capture of *Hippocampus erectus*, 1971 - 1976.



76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK R.
JAMES R.
CAPE CHARLES
CAPE HENRY

Scorpaeniformes

Triglidae

Prionotus sp.

Larval searobins (n=14) were taken in August 1971 at eight stations near the Chesapeake Bay entrance and along its eastern margin. In addition, a single *Prionotus* sp. egg in a middle stage of development was taken at the Bay mouth in August 1972. Temperature, salinity, length and abundance ranges for larvae were 22.9-24.5°C, 22.7-28.1 ppt, 1.8-3.8 mm NL and 24.2-96.6 larvae/ 100 m^3. Absence of *Prionotus* spp. from all other summer collections and the paucity of eggs in the plankton indicates that spawning in the lower Bay is very limited. The appearance of larval *Prionotus* sp. in the Bay apparently coincides with intrusions of high salinity shelf water. Pearson (1941) found large numbers of searobin larvae, 1.5-11 mm TL, in Bay mouth plankton collections in June-July 1929. The absence of larvae larger than 3.8 mm NL in the present collections strongly suggests that gear avoidance biased abundance estimates.

Perciformes

Sciaenidae

Leiostomus xanthurus (Lacepede)

Postlarval spot (n=13), ranging in size from 10.8-20.0 mm SL, were taken in lower Bay plankton collections in February 1972 and March 1976. Temperature and salinity ranges were 4.5-11.5°C and 15.7-18.7 ppt. The majority of the specimens occurred in subsurface collections after dark in the mid-portions of the study area off New

Point Comfort. Abundance estimates ranged from 2.0 to 24.1 larvae/100 m^3. The paucity of postlarvae in late winter and spring collections in 1972 and 1973 in the present study as well as in collections made by Pearson (1941) probably reflect the lack of evening sampling. Young spot have been taken in large numbers during evening hours in several previous studies (Fahay 1975; Powles and Stender 1976), and are probably good avoiders of small collecting gear. The presence of postlarval *L. xanthurus* in February-March and the absence of smaller larvae in the lower Chesapeake Bay agrees well with available data on spawning and early life history in this species (Lippsom and Moran 1974; Chao and Musick 1978; Hildebrand and Schroeder 1928).

Menticirrhus spp.

Larval kingfish, ranging in size from 1.5 mm NL - 4.7 mm SL (n=40), occurred in lower Bay plankton collections in August 1971 and 1973. Although larvae of *M. saxatilis* and *M. americanus* greater than 8 mm SL can be separated on the basis of differential pigmentation, especially in pelvic and dorsal fins (Lippsom and Moran 1974), the present specimens could not be assigned to species since these characters were undeveloped. In this regard, identifications of *M. americanus* larvae in the lower Bay (Pearson 1941) were not substantiated and must be considered tentative. Both species are occasional to common residents in the lower Bay and its adjacent estuaries (Musick 1972; Chao and Musick 1977; Hildebrand and Schroeder 1928) and spawning of both species may occur in the Chesapeake Bay. *Menticirrhus littoralis*, the Gulf kingfish, is only rarely taken in the Bay (Musick 1972) and is thus removed from consideration.

Menticirrhus sp. larvae were taken at stations throughout the study area in August 1971 (Fig. 19) with the greatest densities occurring at midchannel stations near the Bay mouth. Larval densities ranged from 12.1-193.7 larvae/100 m^3 in August 1971 ($\bar{X}$=52.3) but were considerably less in August 1973 (4.5-16.6, $\bar{X}$=2.1 larvae/100 m^3). In 1973, *Menticirrhus* larvae appeared at only 3 stations along the eastern Bay. No larval kingfish were taken in the flood conditions of 1972. Mean salinity and temperature ranges at positive stations were 17.5-28.1 ppt and 23.1-25.6°C.

The data indicate that spawning of *Menticirrhus* sp. occurs within the lower Chesapeake Bay and may be adversely affected by unusual hydrographic conditions as in summer 1972 (Tropical Storm Agnes). The absence of larvae greater than 5 mm SL suggests sampling bias due to gear avoidance of larger larvae during daylight hours. Further collections of larger size classes will serve to better delimit the extent to which *M. americanus* and *M. saxatilis* utilize the estuary as a spawning habitat and nursery ground.

Cynoscion regalis (Block and Schneider)

Larvae of the weakfish ranked second in numerical abundance after *A. mitchilli*. Of the 608 sciaenid larvae, 91% (n=555) were larval weakfish ranging from 1.3 mm NL-8.0 mm SL (Table 7). Larvae were consistently taken in summer of each year at mean water column temperatures of 18-22°C. *Cynoscion regalis* larvae peaked in abundance

FIGURE 19. Abundance and distribution of larval kingfish, *Menticirrhus* spp., in August 1971,1973.

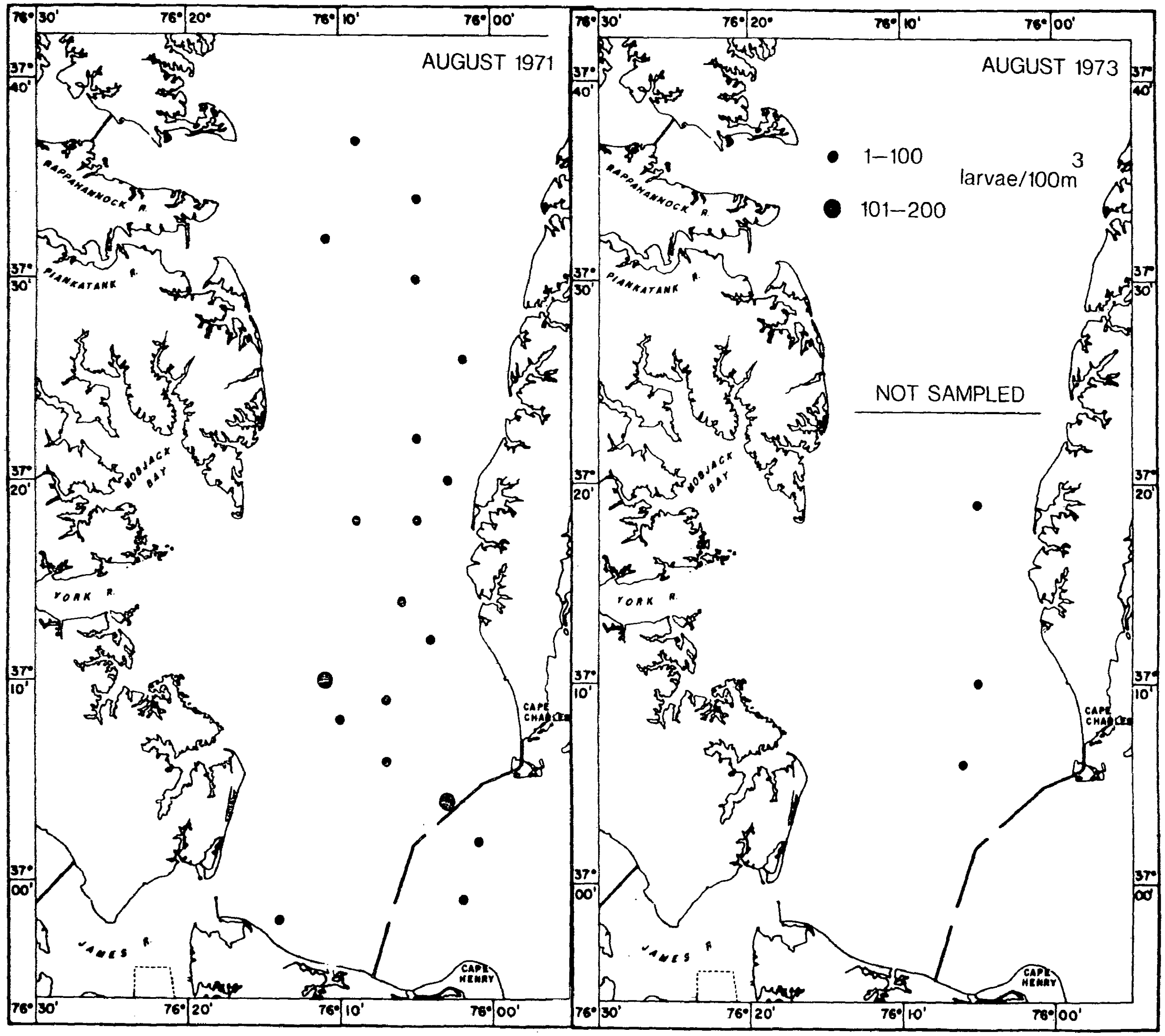

AUGUST 1971
AUGUST 1973
1–100
101–200
larvae/100m3
NOT SAMPLED
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK R.
JAMES R.
CAPE CHARLES
CAPE HENRY
76°30'
76°20'
76°10'
76°00'
37°40'
37°30'
37°20'
37°10'
37°00'

TABLE 7

MONTHLY DATA SUMMARY FOR LARVAL WEAKFISH, CYNOSCION REGALIS, 1971-1975

Month	Percent Occurrence	Total Specimens	Length Range (mm)	Abundance Range (No./100m^3)	Average Monthly Abundance (No./100m^3)	Temperature Range (°C)	Salinity Range (ppt)
1971							
August	100	453	1.5-8.0	15.2-966.2	302.6	22.8-25.8	16.1-28.1
September	7	2	3.6-3.9	10.0-12.1	1.1	23.2-24.9	23.2-27.9
1972							
June	3	1	2.5	17.9	0.7	22.0	12.9
July	10	13	1.3-2.6	17.6-639.3	15.9	22.2-28.1	11.2-24.0
August	9	4	2.0-2.4	42.9-46.3	4.6	22.7-23.6	17.8-25.3
1973							
July	55	39	1.5-3.6	4.9-281.4	22.6	21.5-24.3	22.1-27.7
August	56	38	1.9-3.6	3.2-93.5	17.4	18.1-25.8	21.5-31.5
1975							
August	18	5	1.6-5.2	3.8-21.2	4.8	26.1-27.3	21.3-29.6

and percent occurrence in August 1971 when 82% of all C. regalis larvae were taken. Smaller average abundance peaks occurred in July 1972 and July, August 1973.

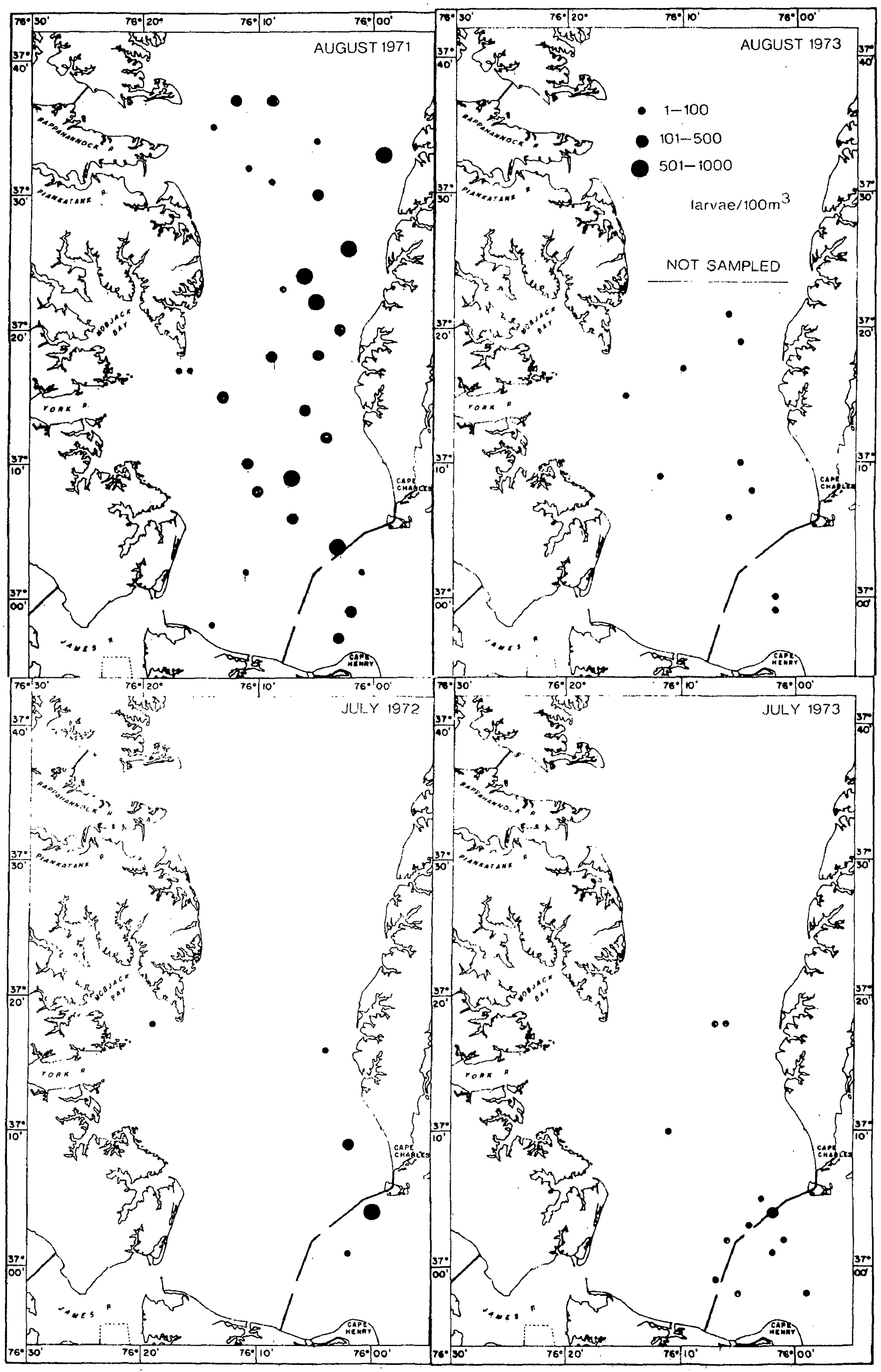
In August 1971 larvae were distributed throughout the sampling area with the highest densities appearing at midchannel stations near the Bay mouth and along the eastern Bay margin (Fig. 20). During 1972 and 1973, larvae were concentrated in the lower half of the study area and never reached the wide distribution seen in 1971. In 1973, larval distribution indicated spawning at the Bay mouth in July with larvae gradually dispersing into the more northerly Bay areas by August.

Density estimates of C. regalis larvae in summer months ranged from 3.2-966.2 larvae/100 m^3. The low densities of August 1972 may reflect effects of Tropical Storm Agnes. Peak spawning probably preceeded the August 1975 cruise as temperatures were above 25°C.

The small size range observed in larval C. regalis (Table 7) indicate that larvae greater than 5 mm SL were generally unavailable to the 18.5 cm bongo. As a result, length frequency analysis by month provided little insight into growth or distribution patterns. As expected, however, the largest larvae appeared in August collections of each year.

The present data are in general agreement with Pearson's (1941) observations on the spawning of C. regalis in the lower Bay. Pearson (1941) found larval weakfish to dominate the non-Anchoa

FIGURE 20. Abundance and distribution of larval *Cynoscion regalis* during selected months, 1971 - 1973.


AUGUST 1971
AUGUST 1973
JULY 1972
JULY 1973
1–100
101–500
501–1000
larvae/100m^3
NOT SAMPLED
RAPPAHANNOCK R
PIANKATANK R
MOBJACK BAY
YORK R
JAMES R
CAPE CHARLES
CAPE HENRY
76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'

ichthyoplankton component with the greatest abundances occurring at the Bay mouth. In contrast to the present study, Pearson found planktonic larvae in May-August with peak concentrations in June. Larvae were almost entirely absent in August 1929 and 1930. Apparently, lower Bay spawning of C. regalis varies from year to year in temporal and spatial extent, but peak concentrations of larvae regularly occur in June, July or August.

Chao and Musick (1977) have summarized available information on the distribution and early life history of C. regalis along the eastern seaboard and have questioned whether the lower Bay and nearshore waters are a major spawning ground for weakfish. Previous surveys indicated that inshore waters of the middle Atlantic Bight are not major spawning grounds for C. regalis (Joseph 1972; Massman et al. 1961, 1962), but Pearson's (1941) survey and the present data confirm that C. regalis does utilize the lower Bay as a spawning site.

Sciaenidae eggs

Familial identification of sciaenid eggs in lower Bay plankton collections was based on a previous study of sciaenid spawning in the Chesapeake Bay (Joseph et al. 1964). Sciaenid eggs are pelagic and relatively small (0.66-1.3 mm egg diameter), generally with highly pigmented late stage embryos, and usually with multiple oil globules which coalesce with development (Joseph et al. 1964; Lippsom and Moran 1974). Hildebrand and Cable (1934), Merriman and Sclar (1952), and Richards (1959) have pointed out the difficulty of separating sciaenid eggs from those of several families including the Pomadasyidae, Scombridae, Sparidae and Stromateidae. The possibility that some misidentification of non-sciaenid eggs (especially those of the stromateid *Peprilus paru*) has occurred due to overlapping characters cannot be discounted (Wheatland 1956; Richards 1959).

Eggs of sciaenid fishes dominated the catch of eggs other than those of *Anchoa mitchilli* and were taken in August and September 1971; May-August 1972; May-August 1973; and August 1975 (Table 8). Data for June and July 1972 represents pooled data from five separate cruises conducted after the passage of Tropical Storm Agnes.

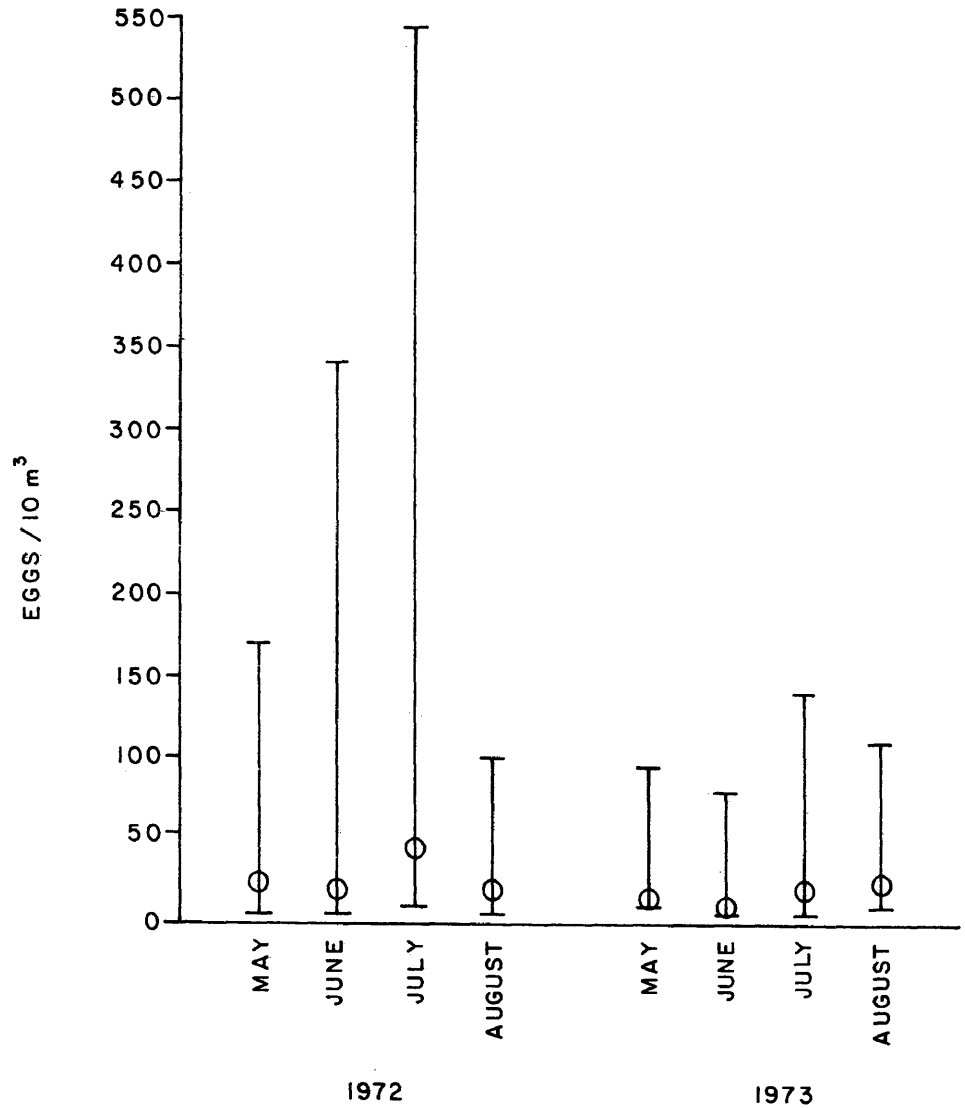
Sciaenid egg densities ranged from 0.3-676.3 eggs/10 m^3 with the highest density estimate occurring in August 1971. During the 1972 and 1973 May-August sciaenid spawning seasons in the lower Bay, egg abundances ranged from 3.6-548.8 eggs/10 m^3 with peaks in July of each year (Fig. 21). Mean monthly abundances (Table 8) ranged from 0.6-81.9 eggs/10 m^3 with peaks occurring in August 1971 and July 1972. Maximum observed abundance, percent occurrence, and to a lesser extent mean monthly abundance in May-July 1972 greatly exceeded those values recorded for May-July 1973. August values in each year were considerably less than values observed in August 1971. The discrepancies in average monthly abundance, percent occurrence and maximum observed densities between the 1972 and 1973 spawning seasons is opposite to that expected. The extreme salinity and temperature fluctuations observed after the passage of Tropical Storm Agnes (Davis 1974)

TABLE 8

MONTHLY DATA SUMMARY FOR SCIAENID EGGS, 1971-1975

Month	Percent Occurrence	Total Eggs	Salinity Range (ppt)	Temperature Range (°C)	Mean Monthly Abundance (No./10 m^3)	Abundance Range (No./10 m^3)
1971						
August	87	405	17.1-28.1	22.8-25.8	81.9	6.1-676.3
September	10	12	20.9-27.7	24.1-24.2	0.6	2.4-9.7
1972						
May	75	74	15.9-25.5	15.4-17.2	25.1	4.3-170.5
June	45	65	12.9-28.9	16.8-23.2	21.7	5.3-340.9
July	59	144	10.9-24.0	19.8-28.6	44.7	7.2-548.8
August	65	134	12.7-26.7	22.4-25.6	23.6	3.6-102.9
1973						
May	19	11	16.5-26.5	15.9-17.4	7.7	7.8-97.5
June	20	32	19.9-25.8	21.1-24.7	6.2	6.2-77.1
July	45	50	19.9-27.7	21.5-26.7	18.0	3.1-140.9
August	48	110	21.5-31.5	18.3-25.8	24.9	7.0-108.9
1975						
August	71	219	20.4-29.7	23.6-27.6	16.9	0.3-250.8

FIGURE 21. Ranges of abundances of sciaenid eggs taken in lower Chesapeake Bay during the 1972, 1973 spawning seasons. Mean monthly abundances are indicated by the circle.


EGGS / 10 m³
550
500
450
400
350
300
250
200
150
100
50
0
MAY
JUNE
JULY
AUGUST
MAY
JUNE
JULY
AUGUST
1972
1973

apparently had little effect on the ongoing 1972 sciaenid spawning season.

During 1972, eggs were evenly distributed throughout the study area (Fig. 22) with greatest concentrations occurring at stations in the Bay mouth or along the Bay's eastern margin. Although 1973 abundances were considerably lower, a similar distribution pattern was noted (Fig. 23). Occurrence of sciaenid eggs by salinity regime in 1973 (Fig. 24) revealed a distinct polyhaline distribution. Although sampling effort was relatively uniform throughout the observed salinities (11.0-31.0 ppt), almost 84% of all sciaenid eggs were taken at stations with mean salinities greater than 26 ppt.

Of the 14 species of sciaenid fishes reported from the Chesapeake Bay (Musick 1972), 10 species occur within the area as young-of-the-year (Chao and Musick 1977) and 7 species are known (or suspected) to spawn within the lower Bay or its contiguous waters (Lippsom and Moran 1974) during spring or summer months. These species and their egg diameter ranges (if known) are recorded below. Unless otherwise noted, egg diameter data are those of Lippsom and Moran 1974. The species are: C. regalis, 0.80-1.30 mm; C. nebulosus, 0.70-0.85 mm (Fable et al. 1978); Bairdiella chrysoura, 0.66-0.88 mm; Menticirrhus saxatilis, 0.75-0.92 mm; M. americanus, eggs unknown; Pogonias cromis, 0.81-1.08 mm; and Sciaenops ocellata, eggs unknown. The overlapping characteristics of these eggs and the probability that 2 or more species spawn concurrently within the lower Chesapeake Bay did not

FIGURE 22. Distribution and abundance of sciaenid eggs during the 1972 spawning season.

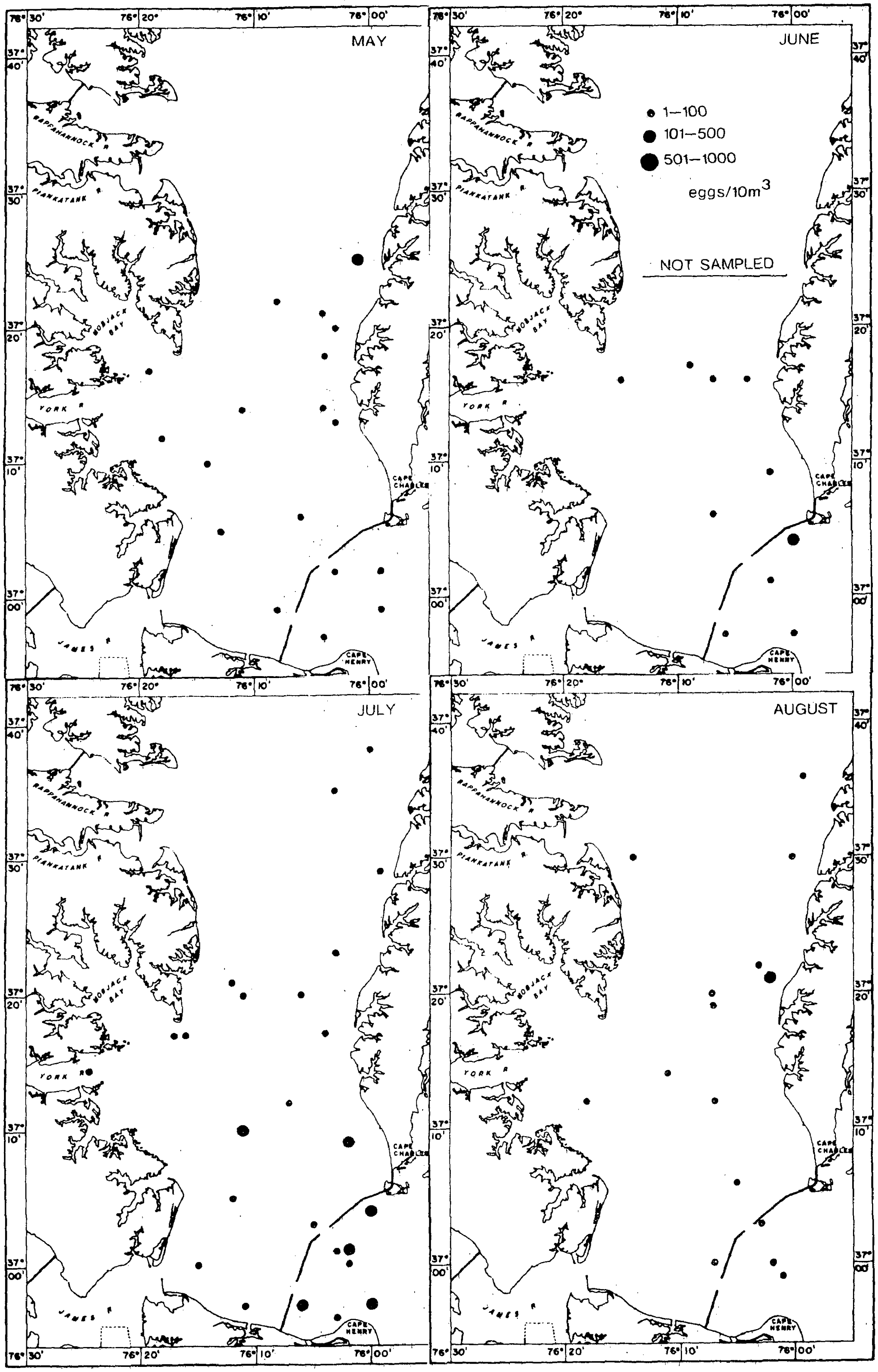

MAY
JUNE
JULY
AUGUST
1–100
101–500
501–1000
eggs/10m3
NOT SAMPLED
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK R.
JAMES R.
CAPE CHARLES
CAPE HENRY
76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'

FIGURE 23. Distribution and abundance of sciaenid eggs during the 1973 spawning season.

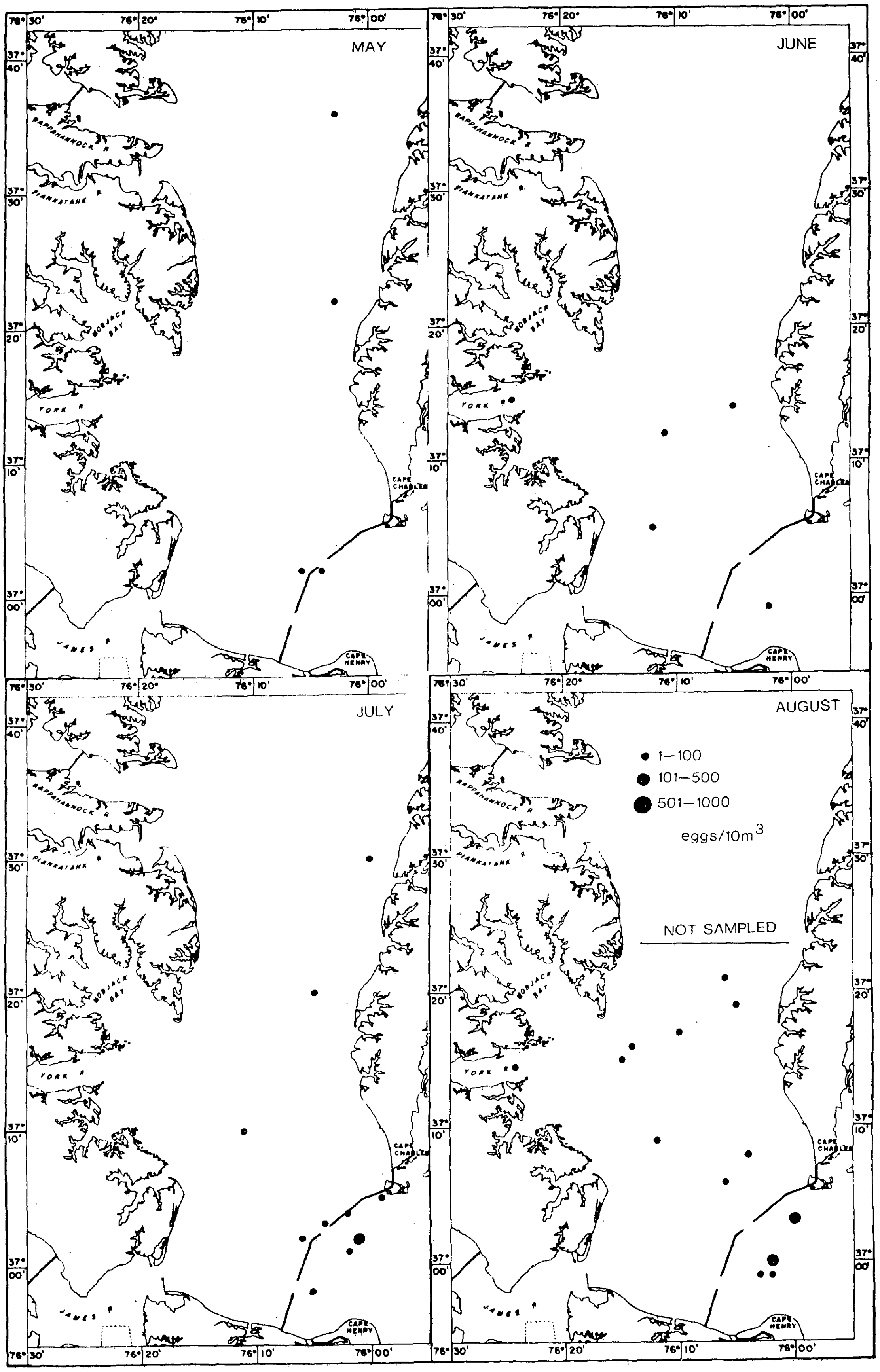
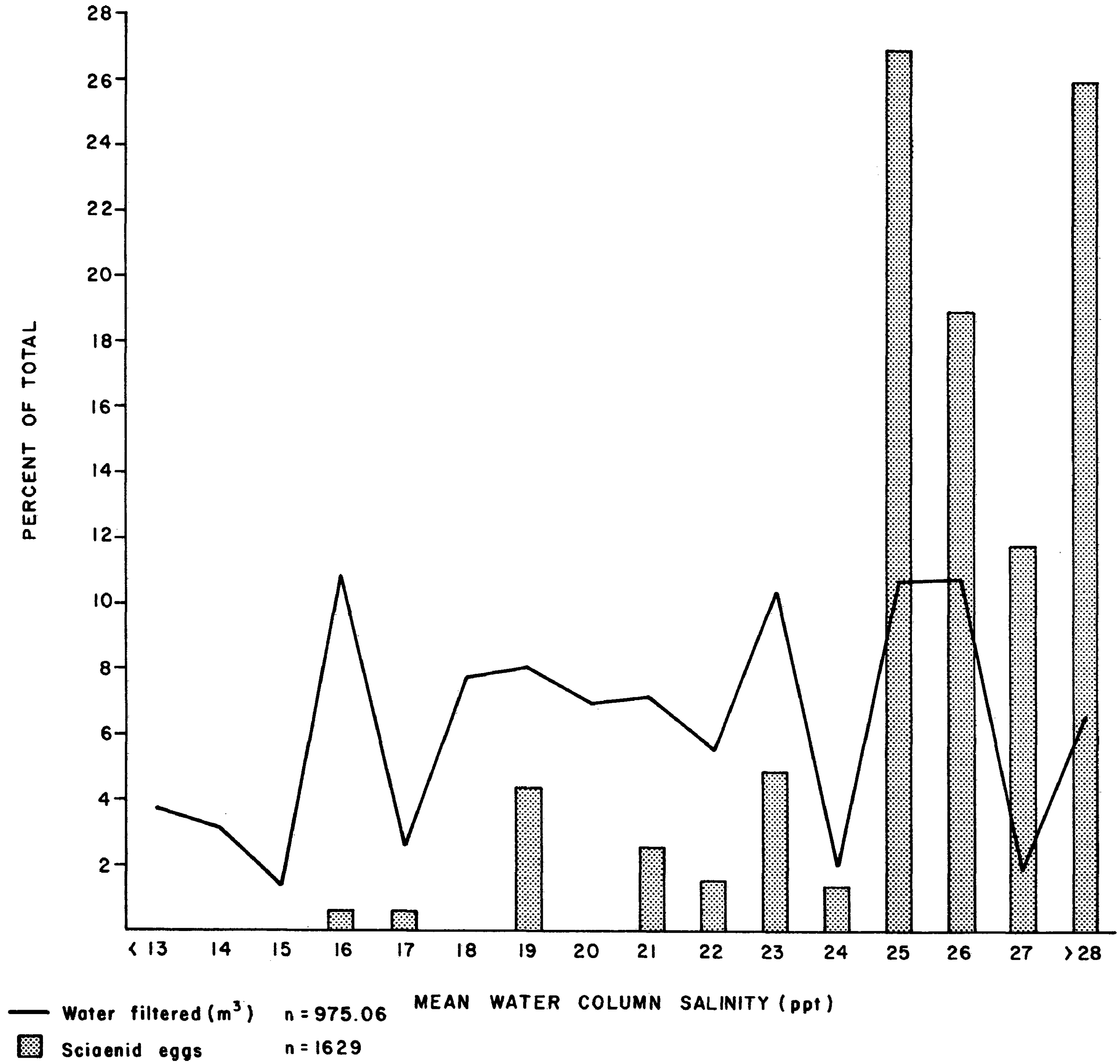

MAY
JUNE
JULY
AUGUST
1–100
101–500
501–1000
eggs/10m3
NOT SAMPLED
RAPPAHANNOCK R
PIANKATANK R
MOBJACK BAY
YORK R
JAMES R
CAPE CHARLES
CAPE HENRY
76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'

FIGURE 24. Distribution of sciaenid eggs by salinity regime during 1973 spawning season.


PERCENT OF TOTAL
28
26
24
22
20
18
16
14
12
10
8
6
4
2
< 13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
> 28
MEAN WATER COLUMN SALINITY (ppt)
Water filtered (m³) n = 975.06
Sciaenid eggs n = 1629

permit separation of the present collection to the species level. Detailed analysis of egg diameter distribution (Fig. 25) and oil globule diameter versus egg diameter (Fig. 26) in sciaenid eggs taken in August 1971 illustrate the overlapping nature of these characters. Eggs of species group A (Figs. 25 and 26) ranged from 0.58-0.72 mm egg diameter with small oil globules (0.067-0.116 mm) and were separable from those of species group B, C, and D (0.74-1.10 mm). Species group A appears similar to eggs designated "Type 1" by Joseph et al. (1964) and may be eggs of *Bairdiella chrysoura*. Eggs of species groups B, C, and D are not easily separated by egg diameter (Fig. 25) or oil globule diameter (Fig. 26) but the wide size range observed and the polymodal distribution suggests that several species are present. The data suggests that lower Bay collections contain eggs of several sciaenid species as did those of Joseph et al. (1964). Based on larval occurrence (the present data, Pearson 1941; Joseph et al. 1964), eggs of *Cynoscion regalis*, *Menticirrhus* spp., *Bairdiella chrysoura*, and *Pogonias cromis* are included. The absence of larval *C. nebulosus* and *Sciaenops ocellata* and the paucity of spawning records north of Cape Hatteras suggests that eggs of these species are not present.

Perciformes

Labridae

Tautoga onitis (Linnaeus)

Eggs of the tautog (n=10) appeared in July 1972 and May 1973 at four stations adjacent to the Chesapeake Bay bridge tunnel. The eggs

FIGURE 25. Size frequency distribution of sciaenid egg diameters, August 1971.

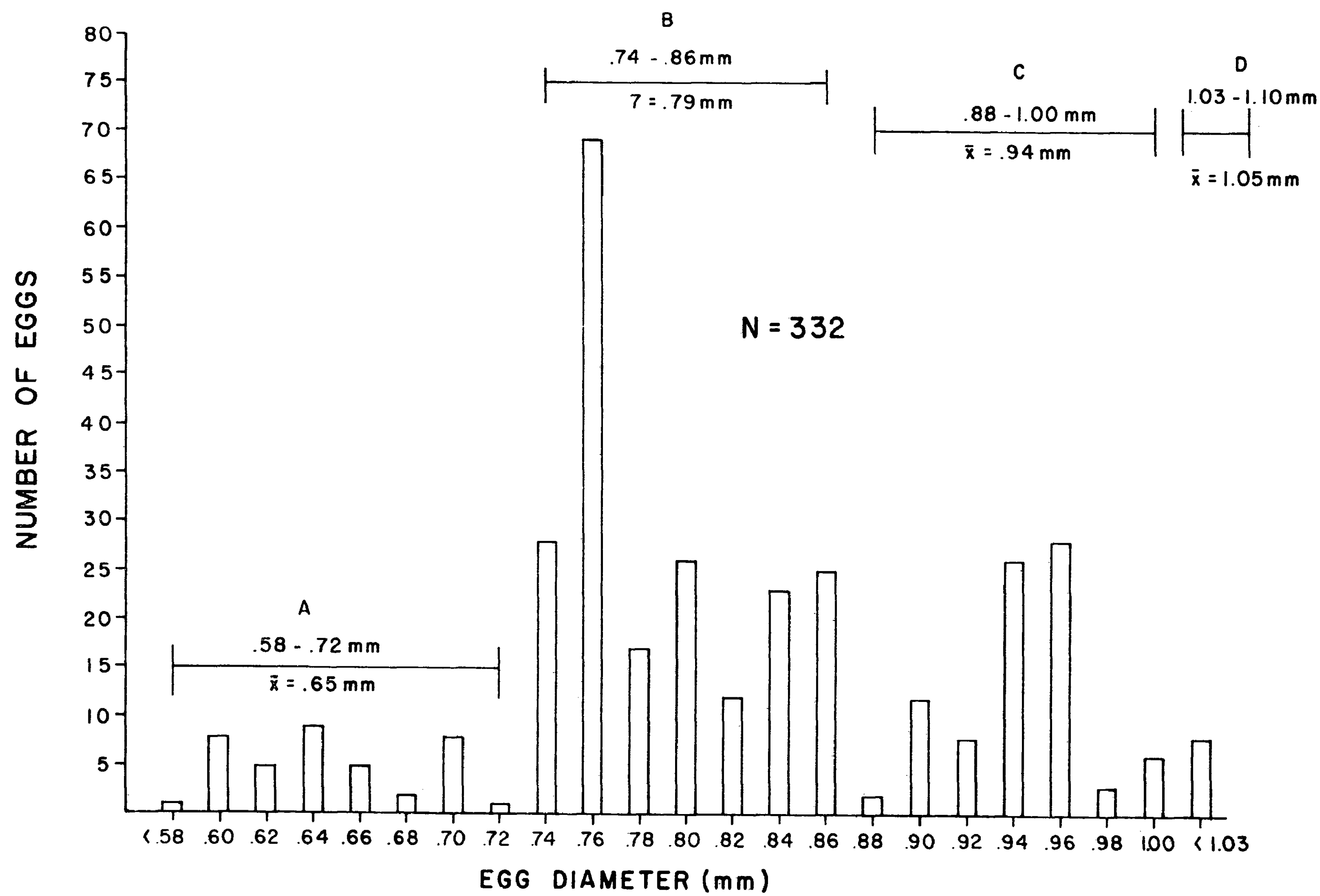
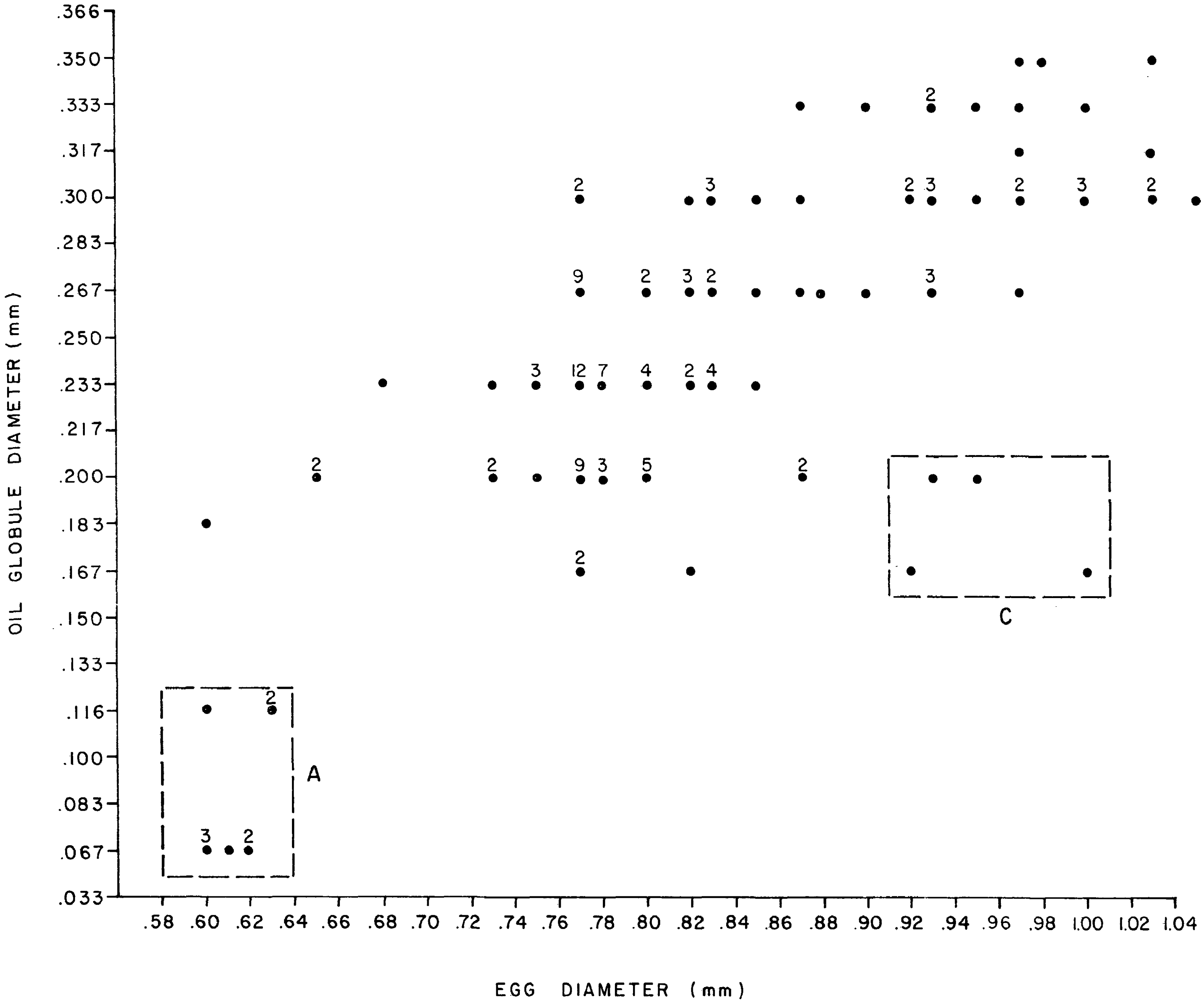

NUMBER OF EGGS
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
A
.58 - .72 mm
x̄ = .65 mm
B
.74 - .86 mm
7 = .79 mm
C
.88 - 1.00 mm
x̄ = .94 mm
D
1.03 - 1.10 mm
x̄ = 1.05 mm
N = 332
< .58
.60
.62
.64
.66
.68
.70
.72
.74
.76
.78
.80
.82
.84
.86
.88
.90
.92
.94
.96
.98
1.00
< 1.03
EGG DIAMETER (mm)

FIGURE 26. Scatter diagram of oil globule diameters versus egg diameters of 134 sciaenid eggs, August 1971.


OIL GLOBULE DIAMETER (mm)
.366
.350
.333
.317
.300
.283
.267
.250
.233
.217
.200
.183
.167
.150
.133
.116
.100
.083
.067
.033
.58 .60 .62 .64 .66 .68 .70 .72 .74 .76 .78 .80 .82 .84 .86 .88 .90 .92 .94 .96 .98 1.00 1.02 1.04
EGG DIAMETER (mm)
A
C

ranged in diameter from 0.93-1.07 mm and were all in either early stages of development or ruptured. Mean temperature and salinity ranges at stations where *T. onitis* eggs were present in July 1972 were 21.7-21.8°C and 22.8-23.8 ppt; and in May 1973, 15.4-16.4°C and 23.6-25.3 ppt.

Williams (1967), Wheatland (1959), and Perlmutter (1939) have reported protracted spawning seasons for *T. onitis* (May-October) with egg diameter decreasing with increasing water temperatures. The present collections agree with these observations. Eggs ranged from 1.05-1.07 mm in diameter in May and from 0.93-1.00 mm in July.

Tautoga onitis ranges along the Atlantic coast from Nova Scotia to South Carolina with peak abundances between Cape Cod and the Delaware Capes (Bigelow and Schroeder 1953). The species is a common spring, fall and winter resident in the lower Bay (Musick 1972). The present spawning record and the collection of 10 *T. onitis* larvae by Pearson (1941) are the only records of tautog spawning in the lower Bay. Judging from the sparcity of eggs and larvae, the lower Chesapeake Bay probably represents the southern limit of tautog spawning activity.

Perciformes

Blenniidae

Hypsoblennius hentzi (Lesueur)

Identification of larval blennies in plankton collections in the lower Chesapeake Bay was based on descriptions by Hildebrand and Cable

(1938) and Lippsom and Moran (1974). All larvae (n=180) were assigned to *Hypsoblennius hentzi* on the basis of the possession of one or more of the following characters: no more than 25 postanal myomeres, melanophores visible under the auditory vesicle, opercular spines of unequal length.

Larvae of the feather blenny were taken in August, September 1971; June-September 1972; June-August 1973; and August 1975. Collection data including abundance estimates and length ranges of larvae are summarized in Tables 9 and 10. Larvae greater than 6.0 mm SL were taken only in evening collections during August 1975 (Table 10). All other *H. hentzi* ranged between 1.9 and 4.8 mm NL indicating that larger larvae avoided the 18.5 cm bongos during daylight hours.

Larval *H. hentzi* were moderately abundant in lower Bay collections, ranking fifth in numerical abundance after anchovies, weakfish, hogchokers and gobies. Abundance estimates ranged from 0.9-204.5 larvae/100 m^3 and peaked in August 1971 and 1973 (Table 9). During all months of *H. hentzi* occurrence, larvae were taken at stations widely scattered throughout the study area.

Musick (1972) reports two blenniid species, *H. hentzi* and *Chasmodes bosquianus*, common to abundant residents of the lower Chesapeake Bay yet larvae of *C. bosquianus* were absent. This discrepancy may be related to salinity preference since a comparison of the distribution of blenny larvae in the Chesapeake Bay by salinity and temperature (Table 11) reveals clear salinity partitioning.

TABLE 9

MONTHLY DATA SUMMARY FOR LARVAE OF THE FEATHER BLENNY, *HYPSOBLENNIUS HENTZI*, 1971-1973

Month	Percent Occurrence	Specimens	Length Range* (mm)	Temperature Range (°C)	Salinity Range (ppt)	Mean Monthly Abundance (larvae/100m^3)	Abundance Range
1971							
August	40	30	2.0-4.6	22.9-26.2	18.2-27.9	23.1	12.1-204.5
September	27	10	2.4-4.1	23.2-24.9	19.6-27.8	8.4	12.1-30.4
1972							
June	17	5	2.5-4.3	19.3-21.9	19.1-24.7	4.4	10.7-42.9
July		4	2.8-3.9	21.7-25.4	15.5-18.2	2.9	17.9-35.9
August	22	5	2.3-3.6	22.4-25.3	17.4-26.7	6.4	15.4-42.9
September	21	5	2.7-4.8	23.1-23.8	14.6-17.6	3.3	2.7-4.8
1973							
June	12	3	2.7-4.7	22.4-25.2	16.6-23.3	2.4	21.5-31.0
July	27	11	2.2-3.4	20.4-24.3	20.5-22.1	5.3	4.8-29.9
August	39	15	1.9-4.0	23.1-25.8	21.5-26.9	9.3	4.8-117.8

* Flexion complete by 5.0 mm.

TABLE 10

COMPARISON OF 15 CONCURRENT SURFACE AND SUBSURFACE COLLECTIONS OF *HYPSOBLENNIUS HENTZI* IN AUGUST 1975.

		SURFACE			SUBSURFACE		
Tow	Time (Day or Night)	No.	Abundance (No./100 m^3)	Length Range (mm)	No.	Abundance (No./100 m^3)	Length Range (mm)
1	D	14	7.7	2.2-3.6	2	20.3	3.8-3.9
2	D	22	26.8	2.3-3.3	3	47.4	2.3-3.5
3	D	0			1	27.1	2.5
4	D	0			4	28.3	2.5-3.5
5	D	0			1	23.6	3.3
6	D	0			1	12.3	2.8
7	N	1	0.9	3.1	1	10.7	3.2
8	N	2	3.7	2.4-2.5	0		
9	N	0			2	16.3	2.9-3.2
10	N	3	2.7	2.2-9.9	3	33.2	2.5-6.0
11	N	10	8.9	2.6-4.7	1	12.6	3.4
12	N	7	7.7	2.9-4.4	0		
13	N	6	15.4	3.0-3.8	1	10.1	2.7
14	N	4	46.9	2.3-2.9	0		
15	N	3	40.3	2.2-3.0	0		
Summary		72		2.2-9.9	20		2.3-6.0
Average abundance			10.1			13.2	

TABLE 11

DISTRIBUTION OF BLENNY LARVAE BY SALINITY AND TEMPERATURE IN THE CHESAPEAKE BAY. C=*CHASMODES BOSQUIANUS* (ADAPTED FROM DOVEL 1971); H=*HYSOBLENNIUS HENTZI* (PRESENT SURVEY)

Temperature °C	C %	H %	Salinity ppt	C %	H %
18	<1		5	1.6	
19	<1	<1	6		
20	9.8	<1	7		
21	5.3	5.0	8	<1	
22	12.6	2.5	9	1.7	
23		11.8	10	6.36	
24	20.5	11.1	11	17.9	
25	13.8	10.6	12	33.3	
26	24.7	33.2	13	12.5	
27	5.9	25.1	14	18.8	<1
28	<1		15	2.9	1.2
29	1.1		16	4.4	1.9
30	<1		17		3.5
31	<1		18		2.2
			19		3.7
			20		1.5
			21		35.5
			22		8.2
			23		17.6
			24		<1
			25		4.2
			26		2.9
			27		1.9
			28		2.5
			29		11.9
Totals	1209	398		991	403

Salinity ranges for larval *C. bosquianus* were 5-16 ppt with peak abundances occurring between 10 and 14 ppt (Dovel 1971). In lower Bay collections *H. hentzi* larvae appeared in a salinity range of 14-29 ppt, with peaks in abundance between 21 and 23 ppt. Temperature data (Table 11) and information on spawning (Dovel 1971; Lippsom and Moran 1974) indicate seasonal overlap and Saksena and Joseph (1972) reported *C. bosquianus* eggs in the York River near Gloucester Point. Further sampling in a wider salinity range and over shoaler areas where *C. bosquianus* appears more abundant (Musick 1972) is necessary to further delimit the factors controlling spatial distribution of larvae of these species.

Perciformes

Ammodytidae

Ammodytes sp.

Although larval sand lances of the genus *Ammodytes* appear in great abundance in waters overlying the continental shelf off Virginia (Norcross et al. 1961) and other estuaries (Richards and Kendall 1973), collections of larvae within the Chesapeake Bay were sparse. Only two larvae (4.9 mm NL, 19 January 1972; 7.5 mm NL, 14 February 1973) and one postlarva (34 mm SL, 29 March 1976) were taken in temperature and salinity ranges of 3.3-11.9°C and 18.4-22.5 ppt. Meristic counts of the 1976 postlarva (D 61, A 31, total vertebrae, 71) were in agreement with data of Richards and Kendall (1973) and Winters (1970). The specimen is provisionally assigned to *A. hexapterus*.

Existing data on *Ammodytes* sp. larvae in Chesapeake Bay (Pearson 1941; Norcross et al. 1961; and the present collections) may be biased by daylight sampling since Richards and Kendall (1973) recorded a greater subsurface catch rate in night tows. In addition, *Ammodytes* sp. larvae are probably effective avoiders of 18.5 cm bongos.

Perciformes

Gobiidae

Identification Notes

Although several familial characters (slender body shape, gut length approximately 50% SL, conspicuous gas bladder, oblique mouth, precocious fin development) serve well to distinguish larvae of the Gobiidae from larvae of most other marine teleostean families, characters useful at lower taxonomic levels are poorly known. Larvae have been described for less than 25% of the 170+ gobiid genera including the American genera *Microgobius*, *Gobiosuma* and *Coryphopterus* (see Miller 1973 and Smith and Richardson 1977 for synopses of additional, overseas genera). This hiatus is surprising considering the periodic abundance peaks of goby larvae often observed in estuarine habitats as well as the natural division of gobiid genera into at least three distinct meristic groupings: 6,7 and 7+ dorsal spines; 26 or 27 total vertebrae (Dawson 1969). At the specific level, habitat preference (including depth-, sediment- or salinity-restricted distribution) and pigmentation appear to be the only basis (thus far, at least) on which goby species can be separated (Richardson and Joseph 1975). The former criterion is especially tenuous in an estuarine situation where tidal effects tend to obscure environmental regimes. Pigmentation, on the other hand, can be a useful identification tool but must be used with caution considering effects of individual variation, time of capture and preservation (Berry and Richards 1968).

Of the seven goby species known to occur within the present study area (Musick 1972), three are resident spawners (Migrogobius thalassinus, Gobiosoma bosci, and G. ginsburgi) and the remainder are probably tropical strays. Richardson and Joseph (1975) have distinguished between larvae of M. thalassinus and G. bosci and Massman et al. (1963) briefly discussed characters separating Gobiosoma spp. In the latter case, the presence or absence of a single postanal, vertically expanded melanophore was the prime character used to separate G. bosci from G. ginsburgi. Unfortunately, this character was not illustrated or the identifications substantiated. To further complicate identifications of Chesapeake Bay goby larvae, preflexion stages less than 4.0 mm NL of all three species are extremely difficult to separate (S. L. Richardson, pers. commun.).

In the present collections, larval gobies fell into five categories. These are larvae of G. ginsburgi, G. bosci, M. thalassinus, unidentified Gobiidae (mostly preflexion larvae and probably a mixture of the aforementioned species) and unidentified 6-spined goby larvae. Identificatons of all larvae must be considered tentative until a definitive study distinguishing Chesapeake Bay larvae, especially Gobiosoma spp., at all stages of development appears.

Microgobius thalassinus (Jordan and Gilbert)

Larvae of the green goby ranging in size from 3.8 mm NL - 5.2 mm SL (n=9), were taken in August 1971, June 1973, and August 1975. Abundance estimates, salinity and temperature ranges in the lower Bay were 0.73-30.3 larvae/100 m^3; 17.7-23.6 ppt; and 23.3-27.2°C. The greatest abundances and most frequent occurrence (36%) were recorded on 29-30 August 1973 during a special 24 hr sampling period in the mouth of the York River. Larvae (n=5) occurred in 4 of 11 tows during this period yet were conspicuously absent at 18 lower Bay stations during the same period.

Richardson and Joseph (1975) reported M. thalassinus larvae as most abundant in the mid-saline portions of the York River and postulated a salinity-restricted distribution. The rare and scattered occurrence of green goby larvae in the lower Chesapeake Bay during the present survey, and especially the distribution record observed in August 1973, support Richardson and Joseph's (1975) distributinal scheme.

Gobiosoma bosci (Lacepede)

A single larva of this goby species was taken in August 1973 at the York River mouth (19.0 ppt; 26.1°C). The specimen, 7.1 mm SL, had a vertically expanded postanal melanophore (Massamann et al. 1963) and agreed well with reference specimens of G. bosci from lower salinity waters (James River at Surry, Va.). The larva co-occurred with larvae of *G. ginsburgi* and *M. thalassinus*.

Gobiosoma ginsburgi (Hildebrand and Schroeder)

Pelagic young of the seaboard goby (n=358) dominated the collections of larval gobies, ranking fourth in numerical abundance after *A. mitchilli*, *C. regalis* and *Trinectes maculatus* larvae. Occurrences of seaboard goby larvae in the plankton indicated a consistent summer spawning pattern. Adult *G. ginsburgi* spawn demersal eggs attached to oyster shells in May-October (Hildebrand and Schroeder 1928, Dahlberg and Conyers 1973) and pelagic young were taken in August, September 1971; June-September 1972; June-August 1973 and in August 1975 with peak abundances in August 1971 and June and August 1972 (Table 12). Abundances ranged from 0.55 to 479.4 larvae/100 m^3 in salinity and temperature ranges of 12.3-27.9 ppt and 19.3-27.4°C.

Gobiosoma ginsburgi is considered a polyhaline species (Musick 1972) and larval distribution may be salinity-restricted (Massmann et al. 1963; Richardson and Joseph 1975, and the present data). Occurrences at stations with average water column salinities less than 16 ppt were infrequent (7/67=10.4%) and might be explained by tidal excursion, misidentification and, in 1972, lowered average salinity due to storm runoff.

Surface and subsurface collections in August 1975 (Table 13) indicate greater availability of larvae to subsurface daylight tows.

TABLE 12

MONTHLY DATA SUMMARY FOR LARVAE OF <u>GOBIOSOMA GINSBURGI</u> IN THE LOWER CHESAPEAKE BAY

Month	Percent Occurrence	Total Specimens	Length Range (mm)	Salinity Range (ppt)	Temperature Range (°C)	Mean Monthly Abundance (No./100 m^3)	Range of Observed Abundance (No./100 m^3)
1971							
August	66.7	124	2.0-5.3	17.1-27.9	22.8-26.2	66.1	12.1-368.1
September	13.3	16	2.3-5.1	18.0-23.2	24.1-24.9	9.5	24.2-110.3
1972							
June	34.5	33	2.4-5.6	13.3-24.7	19.3-22.9	25.6	17.9-479.4
July	26.5	21	2.5-6.3	12.3-21.6	21.6-26.1	17.2	8.9-171.5
August	43.5	19	2.2-5.0	15.2-26.7	22.4-25.6	28.4	17.9-128.6
September	16.7	5	2.2-5.7	16.7-25.1	22.9-23.3	4.9	13.5-53.3
1973							
June	32.0	11	2.6-5.4	12.5-20.5	23.0-25.2	8.7	12.5-20.5
July	45.5	33	2.0-4.1	18.3-26.7	21.5-25.6	18.1	12.6-100.8
August	55.2	29	1.9-5.9	18.8-25.9	23.1-27.4	14.4	8.5-73.6

TABLE 13

COMPARISON OF 12 SURFACE AND SUBSURFACE COLLECTIONS OF GOBIOSOMA GINSBURGI, AUGUST 1975

	Time	SURFACE			SUBSURFACE		
Collection	(Day or Night	Number	Abundance (#/100m^3)	Length Range (mm)*	Number	Abundance (#/100m^3)	Length (mm)
1	D	1	.55	damaged	4	40.7	2.4-3.3
2	D	-	---	---	4	63.2	2.2-2.7
3	D	-	---	---	7	189.4	2.2-4.0
4	D	-	---	---	13	99.2	2.2-4.2
5	D	-	---	---	4	38.2	3.4-4.0
6	D	-	---	---	13	159.5	2.1-4.1
7	N	1	1.3	5.6	1	8.9	5.5
8	N	-	---	---	3	33.2	2.9-3.5
9	N	1	.90	2.3	--	---	---
10	N	-	---	---	8	64.5	2.2-4.5
11	N	6	4.40	4.8-6.6	--	---	---
12	N	1	13.4	3.3	--	---	---

*Flexion complete by 5.0 mm.

The majority (73%) of all G. ginsburgi larvae occurred in bongo samples.

Larval G. ginsburgi has widely scattered distribution throughout the study area but greatest abundances were consistently recorded in the mid-portions of the lower Bay (Figs. 27 and 28). Intrusion of larvae of this species from shelf waters is quite limited since larvae were never found in high densities (>300/100 m^3) at stations seaward of the Chesapeake Bay Bridge tunnel.

Gobiidae, Seven-spined

Some goby larvae (n=46) were identified only to the level of family and probably represent a mixture of the three resident gobies (M. thalassinus, Gobiosoma spp.). The specimens were not assigned to species due to their small size, state of preservation (faded melanophores) or mutilation at time of capture. The distribution and seasonal occurrence of these specimens coincides with that of the previously discussed species.

Gobiidae, Six-spined

One postflexion, premetamorphic larva of a six-spined goby was taken in an evening surface collection at the Bay mouth in August 1975. The specimen was 8.2 mm SL and lacked pigment execpt for an internal black sheath surrounding the posterior portion of the gas bladder. The specimen was cleared and stained following Dingerkus and Uhler (1977). All fins and vertebral elements were ossified and the following counts were recorded: D VI, 11; A 12; P_1 17; P_2 I, 5;

FIGURE 27. Abundance and distribution of larval *Gobiosoma ginsburgi*, 1971 - 1972.

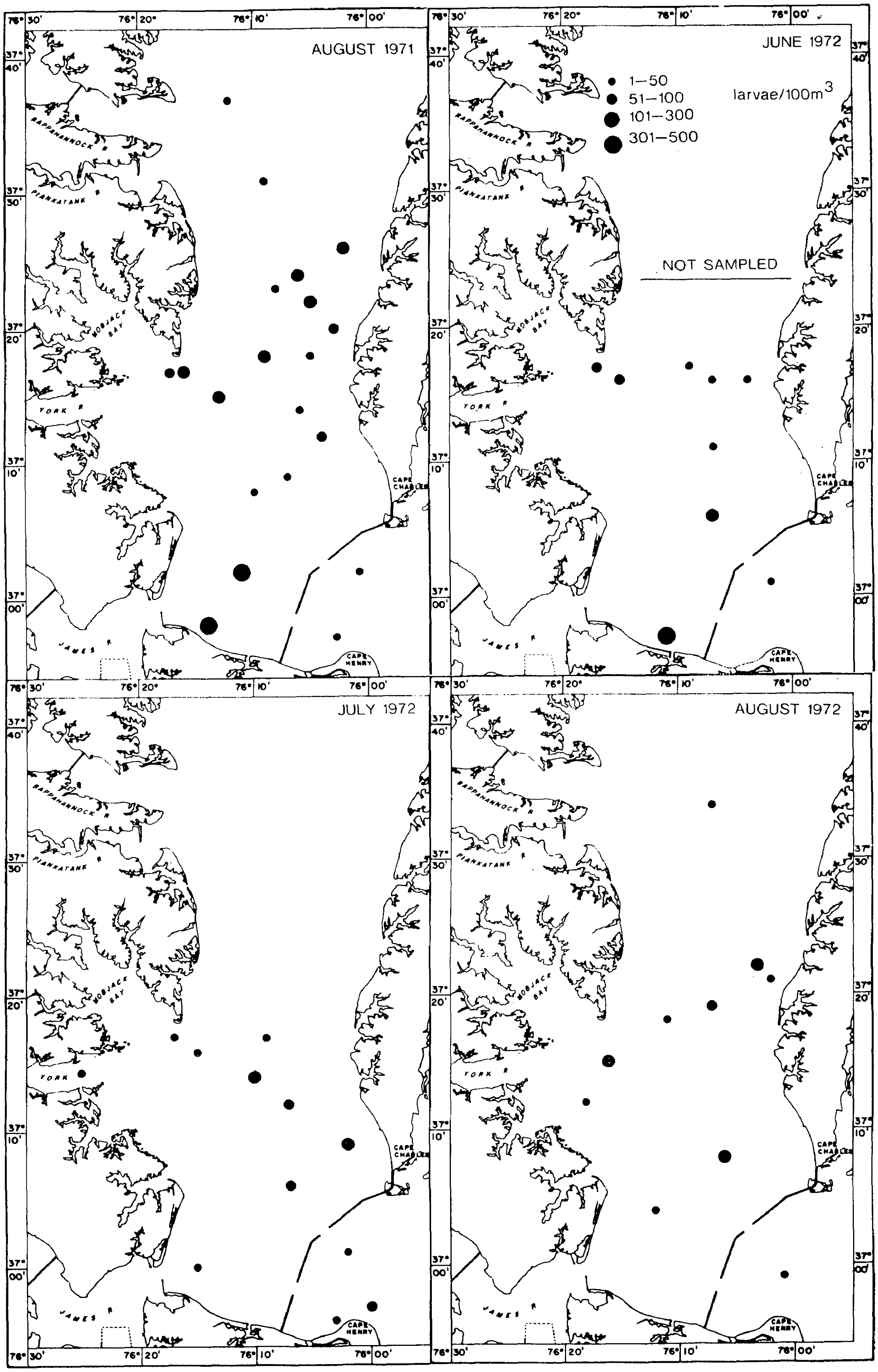
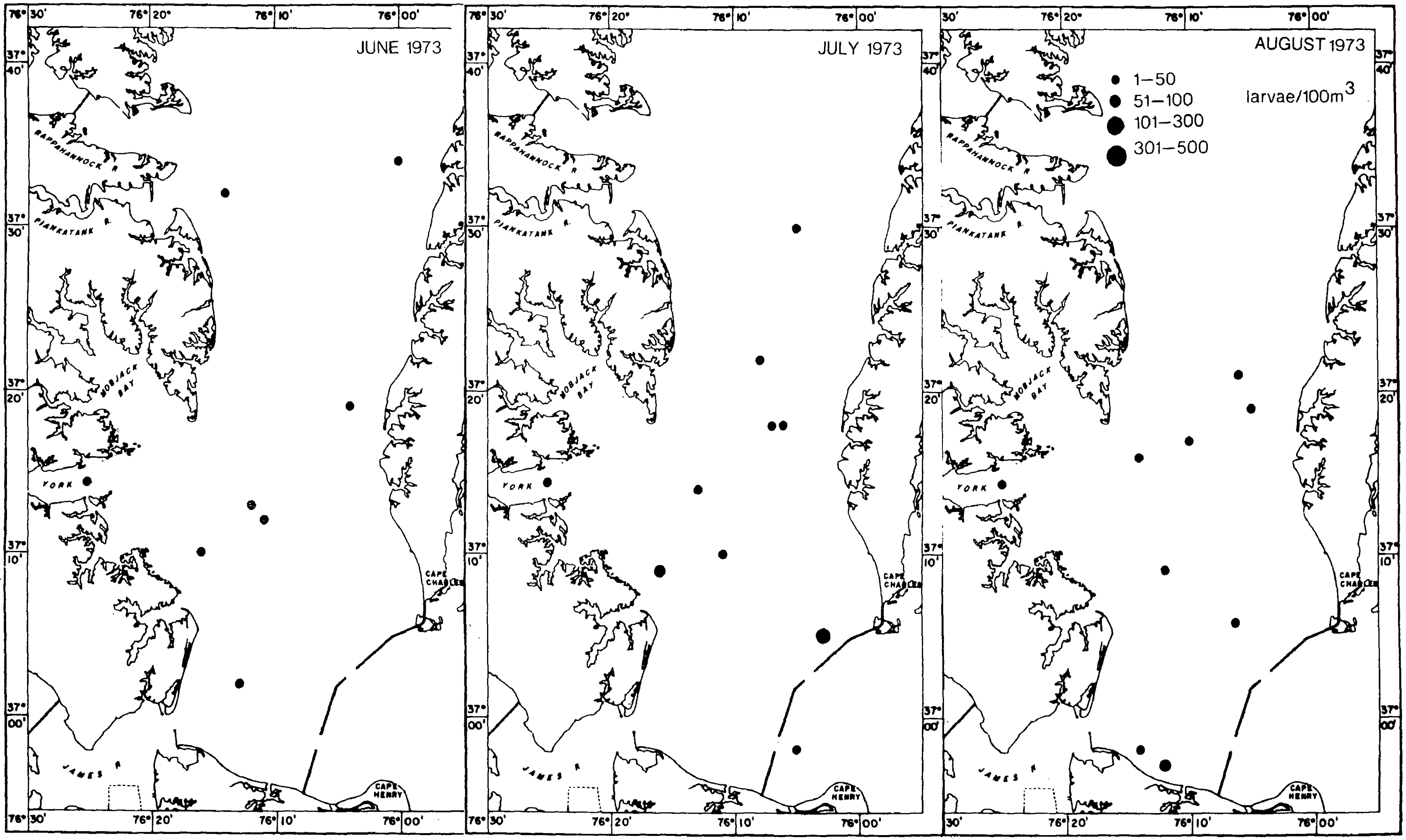

AUGUST 1971
JUNE 1972
1–50
51–100
101–300
301–500
larvae/100m³
NOT SAMPLED
JULY 1972
AUGUST 1972
RAPPAHANNOCK R
PIANKATANK R
MOBJACK BAY
YORK R
JAMES R
CAPE CHARLES
CAPE HENRY
76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'

FIGURE 28. Abundance and distribution of larval *Gobiosoma ginsburgi*, 1973.


JUNE 1973
JULY 1973
AUGUST 1973
1–50
51–100
101–300
301–500
larvae/100m3
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK
JAMES R.
CAPE CHARLES
CAPE HENRY

thoracic vertebrae, 10; caudal vertebrae, 16; total vertebrae, 26. The last soft ray of the anal and dorsal fins was split to the base but only counted as one ray.

Two subtropical six-spined goby species, Gobionellus boleosoma and Evorthodus lyricus, have been recorded as rare adult occurrences in the lower Chesapeake Bay (Musick 1972). Although these species are easily separated as adults using differential characters of dentition, position of the mouth and pigmentation (Dawson 1969), their meristic characters overlap precluding identification of the present specimen.

Three additional postflexion larvae of six-spined gobies available for comparison were collected by meter net in the James River estuary near Surry in November 1975 and vary in length from 9.5-12.3 mm SL. Two types are evident, one represented by the smallest metamorphic specimen (9.5 mm SL: D VI, 11; A 12) and the second represented by two larger but premetamorphic individuals (11.6, 12.3 mm SL; D VI, 14; A 15; P_1 17; P_2 I, 5). All specimens are similar in pigment characters to the unidentified Chesapeake Bay specimen with the exception of the 11.6 mm SL specimen which had a highly pigmented (? discolored) sagitta. This character may be a result of preservation since the largest specimen lacks sagittal coloration. The smallest James River specimen is most similar to the present Chesapeake Bay larva and may be a later developmental stage of the same species. The largest James River larvae have higher dorsal and anal counts and may represent larvae of Gobionellus hastatus, a subtropical species not previously recorded from the lower Bay (Dawson 1969). Clearly descriptive information on six-spined goby larvae is needed before identification of these specimens can be confirmed. It appears, however, that meristic data, pigmentation and length at metamorphosis may be useful characters.

The rare occurrence of postflexion six-spined goby larvae in the Chesapeake Bay and James River in late summer and fall collections fits a distributional pattern found for metamorphic larvae of *Elops saurus* in the James River (Govoni and Merriner, in press) and for larvae of *Echiodon* sp. on the inner shelf off Virginia (Olney and Markle, in press). Pelagic larval stages of subtropical species are regularly dispersed north of Cape Hatteras into the middle Atlantic Bight via warm core Gulf Stream eddies. Since summer and fall hydrographic conditions in middle Atlantic estuaries match those conditions normally encountered by subtropical species, these Gulf Stream intruders may be able to survive for short periods of time north of their normal range but apparently cannot withstand harsh winter conditions.

Perciformes

Scombridae

Scomber scombrus (Linnaeus)

Three larval Atlantic mackerel were collected at the mouth of the Chesapeake Bay in May 1973 (average salinity and temperature, 29.2 ppt and 16.6°C). The larvae (9.4, 7.7, 6.5 mm SL) co-occurred with a single specimen of the goosefish, *Lophius americanus*. Both species are polyhaline and occasionally taken as adults in the lower Chesapeake Bay (Musick 1972). Berrien (1978) reported significant spawning activity by *S. scombrus* in inshore waters off Virginia early in the spawning season (May) and took large numbers of mackerel larvae (2.5-8.1 mm SL) between Chesapeake Bay and Oregon Inlet in May 1966. The present records of larval *S. scombrus* undoubtedly represent intrusion of shelf water into the lower Bay. The absence of *S. scombrus* eggs in the present collections and the lack of previous records of mackerel eggs and larvae in the Bay indicate that Atlantic mackerel do not utilize Chesapeake Bay as a spawning or nursery site.

Perciformes

Stromateidae

Peprilus triacanthus (Peck)

A single postlarval butterfish (12.6 mm SL) was taken in July 1972 at the Chesapeake Bay entrance (19.9 ppt; 21.6°C). The specimen was cleared and stained for meristic examination and the following counts were recorded: D III, 46; A III, 41; total vertebrae, 32. These are within the ranges given for *P. triacanthus* (Haedrich and Horn 1972).

Butterfish are abundant spring-fall residents of the lower Chesapeake Bay (Musick 1972) and juveniles coincide seasonally with the presence of certain coelenterate species with which they associate (Mansueti 1963). The absence of larger numbers of postlarval and juvenile *P. triacanthus* in the present collections is undoubtedly due to gear avoidance since mid-summer peaks of scyphozoan hosts were consistently observed (pers. obs.) and many young-of-the-year fishes often occur in lower Bay and York River pound net catches (Hildebrand and Schroeder 1928; DuPaul and McEachran 1973).

Peprilus triacanthus probably does not utilize the lower Chesapeake Bay as a spawning site. Although, Hildebrand and Schroeder (1928) observed ripe fish in the lower Bay in May, larvae were not taken. Pearson (1941) collected larvae (1.8-57 mm in length, n=232) at the Bay mouth in May-September, but the majority of the specimens were most likely postlarvae. *Peprilus triacanthus* eggs may have been confused with those of various sciaenid species within the Bay (see Sciaenidae Eggs), however, no larvae were present and the early larval stages are distinctive (Colton and Honey 1963; Lippsom and Moran 1974). Bigelow and Schroeder (1953) consider *P. triacanthus* to spawn principally at sea and Wheatland (1956) found eggs but no larvae in Long Island Sound collections and concluded that *P. triacanthus* spawned more heavily in offshore areas than within enclosed Bays.

Stromateidae

Peprilus paru (Linnaeus)

Preflexion larvae of the harvestfish, *Peprilus paru*, were taken in bongo collections in August 1971, 1972, and 1973. The larvae (n=13) ranged from 1.8 to 3.1 mm NL and were identified on the basis of the distinctive lateral pigmentation described by Pearson (1941).

Salinity, temperature, and abundance ranges were 16.1-26.7 ppt; 22.4-25.9°C; and 8.3-71.7 larvae/100 m^3.

Larval harvestfish occurred at stations scattered throughout the study area but most specimens were taken at stations well inside the Bay mouth. The distribution, the small size of the larvae, and the consistent August captures supports the conclusion that this species spawns within the Chesapeake Bay in late summer. Although eggs of *P. paru* are undescribed, they most likely resemble those of its congener *P. triacanthus* and thus may have been lumped with eggs of various sciaenid species.

Pleuronectiformes

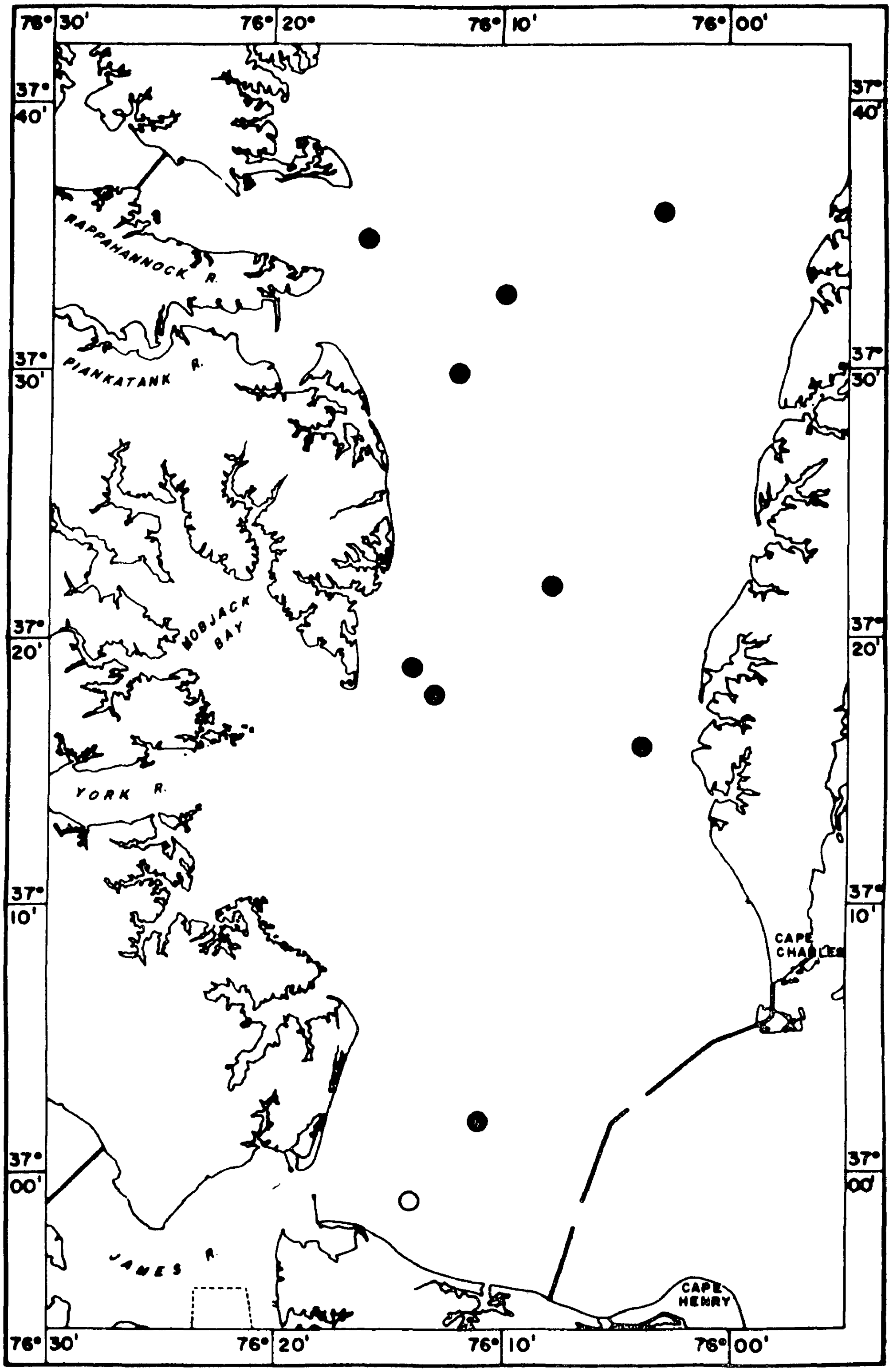
Bothidae

Paralichthys dentatus (Linnaeus)

A total of 52 postlarvae of the summer flounder, *Paralichthys dentatus*, were taken in March 1976 and ranged from 10.5 to 14.2 mm SL. Temperature and salinity ranges were 11.0-12.2°C and 13.7-19.7 ppt. Identification was based on dorsal fin ray pigmentation (Deubler 1958) and meristic analysis (Woolcott et al. 1968). All cleared and stained specimens (n=15) had 68-73 anal rays and 41-42 total vertebrae.

The majority of the specimens (n=29) were collected during night tows at stations scattered throughout the study area (Fig. 29). With the exception of one specimen taken in a dawn bongo collection, all *P. dentatus* occurred in surface neuston tows and many had guts filled with oppossum shrimp, *Neomysis americana*. These data support the

FIGURE 29. Locations of capture of summer flounder postlarvae in surface waters, March 1976.


76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK R.
JAMES R.
CAPE CHARLES
CAPE HENRY

● NIGHT

○ DAY

conclusion that diel catch differences in postlarval flounder reflect periods of high and low activity rather than gear avoidance (Smith 1973). Summer flounder postlarval absence during late winter/early spring collections in 1971-1973 is probably related to this diel activity rhythm since night sampling was not conducted during that period. Larvae may spend daylight hours on or close to the bottom and are therefore unavailable to oblique bongo tows.

Larval P. dentatus were never taken in high densities (1.1-4.9 larvae/100 m^3), and ranked eighth in overall numerical abundance. The postlarvae dominated the collections in March 1976, however, outnumbering juvenile A. mitchilli.

Etropus microstomus (Gill)

A single, flexion larva (6.2 mm NL/6.0 mm SL) of the smallmouth flounder was taken in August 1972 in the Chesapeake Bay mouth (25.3 ppt; 22.7^{o}C). The specimen was identified following Richardson and Joseph (1973).

Richardson and Joseph (1973) did not report E. microstomus larvae from the Chesapeake Bay, but did refer to waters less than 37 m in the Chesapeake Bight. Pearson (1941) collected 108 specimens of Etropus sp. (2.5-13 mm) in July 1929 and it is likely that those larvae were E. microstomus. The discrepancy between Pearsons data and the present single occurrence is probably due to gear avoidance.

Scopthalmidae

Scopthalmus aquosus (Mitchill)

Windowpane larvae (n=10, 2.8 mm NL to 7.0 mm SL, $\bar{X}$=4.9 mm) were taken during May 1972 and 1973 at stations scattered along the eastern, high salinity edge of the lower Bay. Salinity, temperature and density ranges were 16.4-25.3 ppt, 15.4-17.2°C, and 8.9-71.7 larvae/100 m^3. Larvae exhibited a progressive increase in length with increasing distance from the Bay entrance (Table 14). These data and the lack of identifiable *S. aquosus* eggs support the conclusion that spawning of this species is very limited or nonexistent within the Bay.

Juvenile and adult windowpanes are common to abundant year-round residents in the Bay (Musick 1972) and larvae may enter the Bay to utilize an estuarine nursery as do larvae of many species including *P. dentatus*, *L. xanthurus*, *P. triacanthus*, and *B. tyrannus*. Smith et al. (1975), however, consistently found mid- and inner-shelf concentrations of larvae >5.0 mm in 1965-1966 and no evidence of estuarine dependence. Whether larvae are passively intruded or actively migrate into the estuary is still a question since absence of evening sampling and use of small gear bias these data. Additional sampling is clearly needed to evaluate estuarine dependence in this species.

TABLE 14

LENGTH (mm) OF *SCOPTHALMUS AQUOSUS* LARVAE VERSUS APPROXIMATE DISTANCE FROM THE CHESAPEAKE BAY ENTRANCE

Mile	Length
0	2.8, 4.4, 4.6
12	3.9, 5.7
19	5.8, 3.4
23	5.3
27	6.1
31	7.0

Pleuronectidae

<u>Pseudopleuronectes</u> <u>americanus</u> (Walbaum)

Larval winter flounder (n=3) were taken in April 1972 (7.5 mm SL), March 1973 (3.0 mm NL) and March 1976 (7.5 mm SL). Salinity and temperature ranges for these occurrences were 11.9-18.4 ppt and 7.6-11.9°C. The presence of a recently hatched individual in the lower Bay samples and Dovel's (1971) collections of many yolksac larvae north of the present study area indicate that spawning of this species occurs throughout the entire Chesapeake Bay estuary.

Soleidae

<u>Trinectes</u> <u>maculatus</u> (Bloch and Schneider)

Eggs and larvae of the hogchoker, <u>Trinectes</u> <u>maculatus</u> were major summer components of the lower Chesapeake Bay ichthyoplankton and ranked third in numerical abundance after eggs and larvae of <u>A.</u> <u>mitchilli</u> and sciaenid species. Spawning of <u>T.</u> <u>maculatus</u> commenced in June (ca. 18-22°C) and continued through September 1972, the only full spawning season sampled (Table 15). Egg abundances peaked in August 1971, 1972 and 1973 with estimated densities ranging from 0.6 to 340 eggs/10 m^3. Temperature and salinity ranges were 18.8-28.6°C, and 10.9-28.1 ppt.

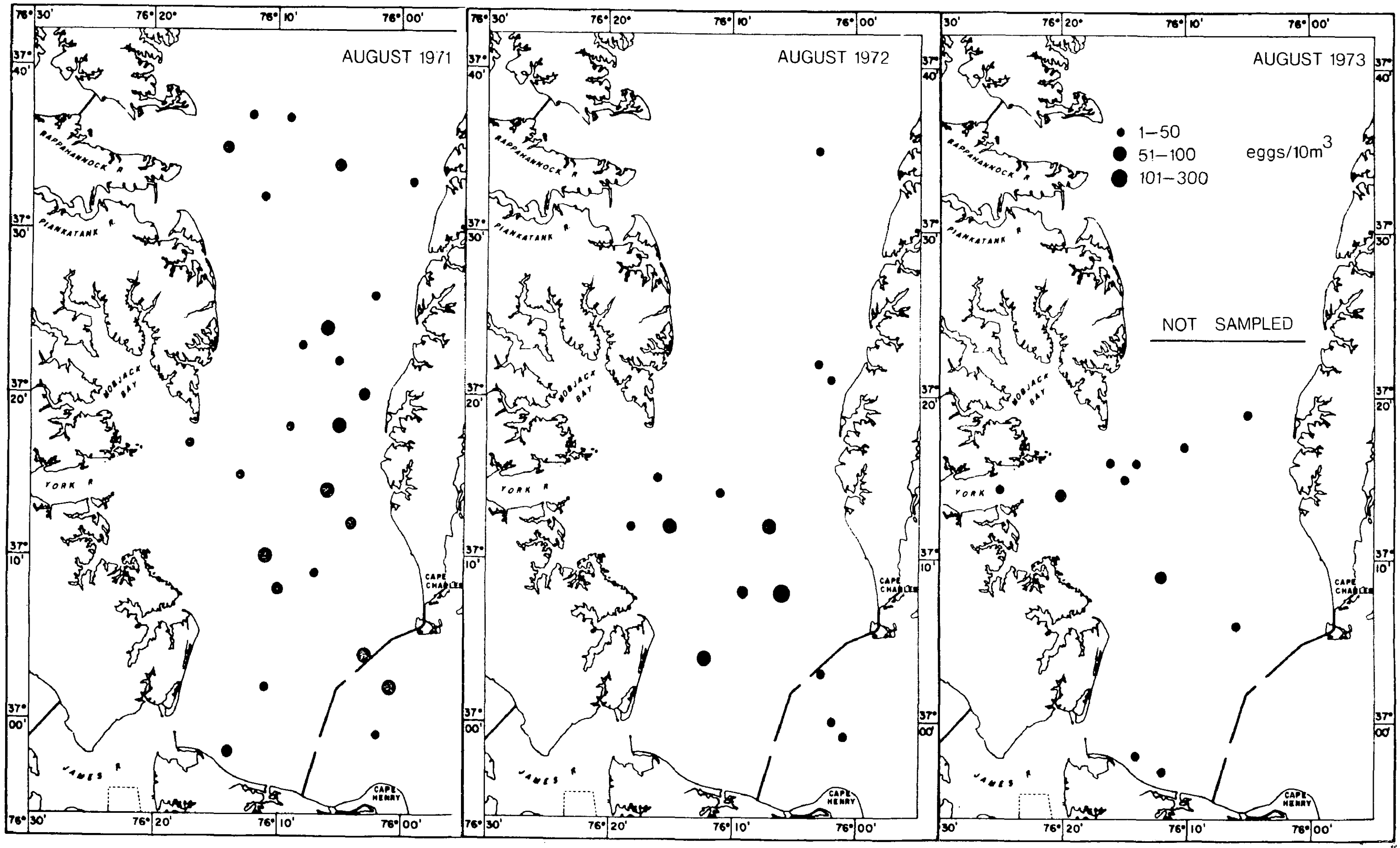
During months of peak densities (Fig. 30), eggs of <u>T.</u> <u>maculatus</u> were evely distributed throughout the study area with a slight trend towards greater abundance in mid-channel areas. Spawning may not be restricted to Bay waters. Eggs appeared occasionally in large numbers

TABLE 15

MONTHLY DATA SUMMARY FOR EGGS OF *TRINECTES MACULATUS*

	Percent Occurrence	Number of Eggs	Abundance Range ($1/10m^3$)	Mean Monthly Abundance ($1/10m^3$)	Slinity Range (ppt)	Temperature Range (°c)
1971						
August	83.3	353	3.0-195.7	59.2	16.1-28.1	23.2-26.2
1972						
June	17.2	13	8.6-37.3	2.9	14.6-24.6	18.8-23.4
July	36.7	65	3.6-157.8	13.0	10.9-24.0	21.6-28.6
August	60.8	104	2.1-340.9	38.1	15.6-25.3	22.6-25.7
September	4.2	2	3.6	0.2	16.7	23.7
1973						
June	20	17	7.4-94.3	6.0	16.9-21.4	22.7-25.1
July	27.3	30	1.5-53.9	4.9	20.4-26.7	23.5-26.7
August	55.2	93	3.9-96.1	20.3	19.0-25.9	25.8-27.4
1975						
August	17.6	5	0.6-2.8	0.1	21.8-21.9	26.9-27.3

FIGURE 30. Abundance and distribution of *Trinectes maculatus* eggs during selected months.


AUGUST 1971
AUGUST 1972
AUGUST 1973
1–50
51–100
101–300
eggs/10m3
NOT SAMPLED
RAPPAHANNOCK R
PIANKATANK R
MOBJACK BAY
YORK R
JAMES R
CAPE CHARLES
CAPE HENRY
76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'

at stations in the Bay mouth, and Massmann et al. (1961,1962) reported hogchoker larvae at Atlantic Ocean stations during June 1960 and July 1961.

Larval hogchokers (n=425) were taken in August 1971, June-September 1972, July, August 1973, and August 1975. Density estimates ranged from 5.2 to 724.6 larvae/100 m^3 reaching a maximum in August 1971 (Table 16, Fig. 31). Survival or hatching success may have been reduced for this species during lowered salinity conditions imposed by Tropical Storm Agnes in 1972. Fewer hogchoker larvae were taken in all of 1972 than in any one month of the 1971 or 1973 spawning seasons, despite the fact that total spawning (egg abundances) was not noticably reduced during or after the passage of the storm.

Larval hogchokers ranged from 1.2 to 3.2 mm NL, indicating either gear avoidance or assumption of a demersal habitat at a very small size, or both. Since Dovel et al. (1969) observed low larval abundances in meter net collections, the latter possibility seems more plausible. Upriver migrations of young of this species (Dovel et al. 1969) may also contribute to the absence of larger specimens.

Cynoglossidae

Symphurus plagiusa (Linnaeus)

Olney and Grant (1976) provide an account of some aspects of the early life history of the blackcheek tonguefish, *S. plagiusa*, in the lower Chesapeake Bay based in part on data from the present study. The abstract of that paper is presented here.

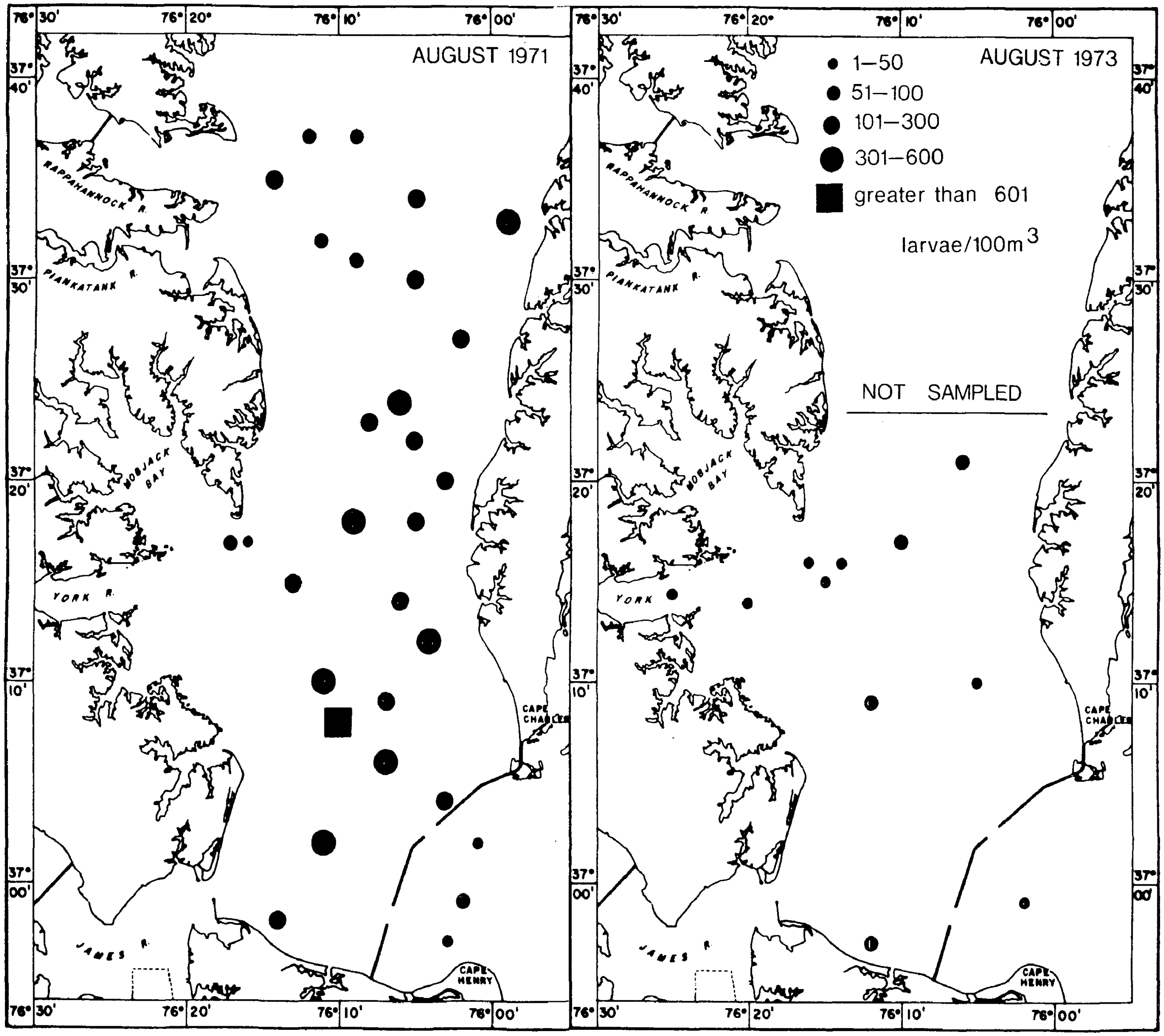
TABLE 16

MONTHLY DATA SUMMARY FOR LARVAE OF TRINECTES MACULATUS

Month	Percent Occurrence	Total Specimens	Length Range (mm)	Salinity Range (ppt)	Temperature Range (^oC)	Abundance Range (No./100m^3)	Mean Monthly Abundance (No./100m^3)
	100	344	1.5-3.2	16.1-28.1	23.2-26.2	15.2-724.6	143.9
1972							
June	3.4	2	1.9-2.4	---*	---*	15.4	0.7
July	10.2	6	1.3-2.0	19.9-22.9	19.8-22.5	8.9-85.8	5.2
August	8.7	2	1.2-1.8	24.8-26.7	22.4-22.6	35.9-42.9	3.7
September	16.7	4	1.8-2.9	15.5-20.2	23.0-23.8	10.7-54.1	6.2
1973							
July	40.9	16	1.5-3.2	18.8-27.7	23.3-26.7	5.2-41.9	9.4
August	44.8	48	1.2-2.4	19.0-31.5	18.3-27.4	13.5-89.6	21.3
1975							
August	17.6	3	1.7-2.0	21.8-25.4	26.6-27.3	11.1-15.8	1.8

* no data available

FIGURE 31. Abundance and distribution of *Trinectes maculatus* larvae in August 1971, 1973.


AUGUST 1971
AUGUST 1973
1–50
51–100
101–300
301–600
greater than 601
larvae/100m3
NOT SAMPLED
RAPPAHANNOCK R.
PIANKATANK R.
MOBJACK BAY
YORK R.
JAMES R.
CAPE CHARLES
CAPE HENRY
76° 30'
76° 20'
76° 10'
76° 00'
37° 40'
37° 30'
37° 20'
37° 10'
37° 00'

"Early planktonic larvae of the blackcheek tonguefish, Symphurus plagiusa (Pisces: Cynoglossidae), in the lower Chesapeake Bay".

ABSTRACT

One hundred ninety-four larvae of Symphurus plagiusa were taken in the lower Chesapeake Bay during a three-year zooplankton survey 1971-1974. Early larval stages (1.3-6.2 mm NL) are illustrated and described. Recently hatched larvae (1.3-2.8 mm NL) are distinguished by pigment patterns, gut configuration, and a fleshy occipital hump. Later larvae (2.8-6.2 mm NL) are identified by pigmentation, gut configuration, and produced dorsal rays.

Larvae were taken during July and/or August each year. Recently hatched larvae (1.3-2.9 mm NL) made up the majority of the catch and were most abundant in the deepest and most saline portions of the Bay. Large estuaries may be more significant spawning areas for Symphurus plagiusa than previously reported. Evidence is presented that earlier descriptions of S. plagiusa larvae may be in error.

Additional S. plagiusa larvae (n=6) were taken in August 1975 (1.6 mm NL-10.8 mm SL). One metamorphosed specimen (10.3 mm SL) was cleared and stained and yielded the following counts: D 91; A 75; C 10; thoracic vertebrae, 9; caudal vertebrae, 39; total vertebrae, 58. These counts agree with those presented for the largest S. plagiusa larvae in Olney and Grant's (1976) material and with adults (Ginsburg 1951; Miller and Jorgenson 1971).

Pelagic eggs tentatively identified as S. plagiusa consistently co-occurred with collections of early larvae. Eggs (n=192) were taken in August and September 1971; July and August 1972 and 1973; and in

August 1975.

The eggs of all Atlantic *Symphurus* spp. are undescribed but are believed to be pelagic (Bensam 1969). Lower Chesapeake Bay *Symphurus*-type eggs were 0.60-0.66 mm in diameter, with 6-10 small, scattered oil globules (.05-.08 mm) and a homogenous yolk. The eggs were smaller than those of *Trinectes maculatus* (0.77-0.83 mm egg diameter) and possessed fewer oil globules. The egg diameters and presence of small, scattered oil droplets agree with observations on eggs of the Indian Ocean cynoglossid, *Cynoglossus semifasciatus* (Bensam 1969), however, the absence of eggs with late stage embryos precluded a confirmed identification.

Tetradontiformes

Tetradontidae

Sphoeroides maculatus (Bloch and Schneider)

Five preflexion larvae of the northern puffer, *S. maculatus*, were taken in bongo collections. The larvae appeared at scattered stations in August 1971 and May, July 1972. Notochord length, temperature, and salinity ranges were 1.8-2.8 mm; 17.1-25.8°C, 17.4-23.9 ppt.

Occurrence of puffer larvae in the present collections agrees with data of Pearson (1941) and Laroche and Davis (1973) for Chesapeake Bay. Pearson (1941) took more and larger larvae, a discrepancy possibly resulting from gear avoidance. On the other hand a decline in northern puffer stocks has been apparent since 1970 (J. Musick, pers. commun.) and may account for the present scarcity of specimens.

DISCUSSION

Species of lower Chesapeake Bay ichthyoplankton can be separated into five ecological categories (Table 17) based on their relative abundance and distribution, the life history stage encountered (eggs, larvae, postlarvae, or juveniles), and known adult spawning behavior and range. Resident lower Chesapeake Bay spawners are characterized by eggs and/or early larvae (in moderate to high densities) occurring well within the study area and having no evidence of extra Bay input. At least 17 species are estuarine spawners and 7 (A. mitchilli, C. regalis, G. ginsburgi, T. maculatus, H. hentzi, S. plagiusa and larval atherinids) dominate lower Bay ichthyoplankton (Pearson 1941, and the present data). Two additional species, Sciaenops ocellata and Cynoscion nebulosus may utilize the Bay as a spawning site but their presence was not confirmed by Pearson (1941) or the present study.

At least 12 species occurring as eggs and/or larvae in the lower Bay are inner or central shelf spawners whose reproductive products are passively transported into lower Chesapeake Bay waters (Table 17). The eggs and/or larvae of these species are characterized by a limited distribution at the Bay's entrance and along its eastern margin and are never taken in large abundance. Their appearance in the Bay is highly variable and results from northerly and westerly flowing shelf water of high salinity (25-30 ppt) which intrudes along the eastern Bay basin as a salt wedge (Pritchard 1967; McHugh 1967). The highly

TABLE 17

ECOLOGICAL CATEGORIES OF FISH SPECIES OCCURRING AS EGGS AND/OR LARVAE IN THE LOWER CHESAPEAKE BAY BASED ON PEARSON (1941) AND THE PRESENT STUDY

I. Resident lower Chesapeake Bay spawners

A. With pelagic eggs and larvae:

Anchoa mitchilli

Bairdiella chrysoura[1]

Cynoscion nebulosus[3]

Cynoscion regalis

Menticirrhus sp.

Peprilus paru

Pogonias cromis[6]

Sciaenops ocellata[3]

Symphurus plagiusa

Tautoga onitis[7]

Trinectes maculatus

B. With pelagic larvae:

atherinid larvae

Gobiesox strumosus

Gobiosoma ginsburgi[2]

Hypsoblennius hentzi

Membras martinica[2]

TABLE 17 (continued)

Psuedopleuronectes americanus[2]

Sphoeroides maculatus[7]

Syngnathus floridae[1]

Syngnathus fuscus

II. Shelf spawners passively intruding as eggs or larvae into lower Chesapeake Bay waters

Ammodytes hexapterus[2]

Anchoa hepsetus[2]

Astroscopus guttatus[1]

Brevoortia tyrannus eggs and early larvae

Centropristis striata[1]

Etropus microstomus

Hippocampus erectus

Lophius americanus

Pomatomus saltatrix[1]

Prionotus sp.

Rissola marginata

Scomber scombrus[2]

Scopthalmus aquosus[5]

TABLE 17 (continued)

III. Shelf or oceanic spawners actively migrating to lower Chesapeake Bay nursery areas as postlarvae

Anguilla rostrata elvers[3]

Brevoortia tyrannus

Conger oceanicus elvers[3] and leptocephali

Leiostomus xanthurus[2]

Micropogonias undulatus[1]

Paralichthys dentatus

Peprilus triacanthus

Urophycis regius[2]

IV. Subtropical intruders[8]

Ancyclopsetta sp.[1,4]

six-spined gobiid larvae[2]

V. Oligo-and meso-haline spawners occasionally taken in lower Chesapeake Bay waters

Gobiosoma bosci[2]

Microgobius thallassinus

TABLE 17 (concluded)

---

1) species taken by Pearson (1941) but not occurring in the present collections

2) species occurring in the present collections but not taken by Pearon (1941)

3) species not previously reported in lower Chesapeake Bay plankton collections, and not taken in the present study, but which may occur.

4) probable misidentification (Gutherz 1970)

5) limited data (see previous section) indicates that postlarvae of this species may utilize estuarine nursery areas.

6) species hatched from pelagic eggs in lower Bay plankton samples (Joseph et al. 1964) but not occurring in the present collections.

7) the present data suggest limited spawning

8) additional species occur as juveniles but are not taken pelagically. These include priacanthids, caragids, chaetodontids and others (Hildebrand and Schroeder 1927, Musick 1972).

variable nature of their occurrence in the Bay results from a multitude of factors including spawning success and intensity on the shelf, meteorological conditions (onshore winds, above average surface runnoff), tidal action and related variability in water column stratification, and sampling intensity.

Postlarvae and juveniles of at least 8 species of shelf or oceanic spawners (Table 17) utilize estuarine nursery areas and are taken in lower Bay plankton collections at the onset of this life history phase. These species actively migrate into the estuary (Haven 1957, 1959; McHugh 1967; Dovel 1971 and others) and their absolute abundance is not easily measured by plankton nets due to their increased mobility resulting in high avoidance capabilities and tendency towards epi-benthic habitats. The paucity of postlarvae of L. xanthurus and the complete absence of Micropogonias undulatus in lower Bay plankton collections set against the high abundance of juveniles of these sciaenid species in trawls (McHugh 1967, Musick 1972, Markle 1976 and others) is ample testimony to this sampling bias.

Several species taken by Pearson (1941) or in the present study (Table 17) are postlarval stages of subtropical spawners. These larvae are probably transported north of Cape Hatteras, North Carolina by the Gulf Stream and deposited in the shoaler waters of the middle Atlantic Bight by warm-core Gulf Stream eddies or mixing along the Gulf Stream front. Summer conditions (warm surface temperatures, peak secondary production) in the Bight permit survival of these long-lived postlarval forms and possible entrainment in the Coastal Boundary Layer (Csanady 1976) allows for intrusion into the lower Bay. Their occurrence is extremely infrequent and the present list will undoubtedly expand with future sampling and improved identifiction techniques.

The final ecological category (Table 17) is represented by two goby species, M. thallassinus and G. bosci, which appear to spawn outside the study area (oligo- and mesohaline waters) and are only occasionally taken in the lower Bay. Additional sampling and improved identification techniques are required before the distribution of these species can be delimited. Apparently, the higher salinities of the lower Chesapeake Bay effectively prevent the larval occurrence of other oligo- and mesohaline spawners such as alosids, centrarchids, and percids, even during periods of high spring freshwater runoff.

Economically and ecologically, Anchoa mitchilli and Cynoscion regalis are the two most important species of resident Chesapeake Bay spawners and deserve special attention. The bay anchovy is of enormous trophic importance as a primary consumer and forage item for many predators (striped bass, weakfish, bluefish). The species is generally considered to be the most abundant fish in the Chesapeake Bay (McHugh 1967) although no quantitative adult abundance or biomass data exist. The weakfish, C. regalis, is prized as a sport fish and is of considerable commercial value, but a decline in commercial catch since 1945 is of concern and indicates a need for additional information, especially on early life history and the contribution of the Chesapeake Bay spawning grounds to northern stocks (Merriner 1976).

The present data on abundance and distribution of eggs and larvae of *A. mitchilli* and *C. regalis* confirms the important role of the lower Bay as a spawning site for these species and points out the accessibility of egg and larval material for future studies. These studies should emphasize biomass determinations using pelagic egg abundances and fecundity estimates (Houde 1973, Smith and Richardson 1977); vertical, tidal, and diel abundance variability; size composition and growth; feeding, mortality, energetics, and predation. In addition, a directed effort to delimit the eggs of various sciaenid species spawning in the Bay should be implemented.

Finally, a qualitative comparison (species composition) of the results of the present study with those of Pearson (1941) indicates that spawning activity of resident fishes in the lower Chesapeake Bay has not altered during the 47 year period 1929-1976. Of the 41 total species taken in the two studies, seven species (excluding *Gobiosoma* spp. and *A. hepsetus*) were taken in the present study but not by Pearson (1941); seven species were taken by Pearson but not between 1971-1976; and the remaining species (n=25) were taken in both surveys (Table 17). More importantly, numerical ranking of dominant species in both studies (Table 18) is remarkably similar despite inherent

TABLE 18

RANKED NUMERICAL LARVAL ABUNDANCE OF DOMINANT SPECIES OF LOWER CHESAPEAKE BAY ICHTHYOPLANKTON

species	Pearson (1941)		Present Study	
	total	rank	total	rank
Anchoa mitchilli	397	1*	6883	1
Cynoscion regalis	4298	2	556	2
Trinectes maculatus	114	8	425	3
Gobiosoma sp.	305	5	359	4
Hysoblennius hentzi	465	3	180	5
atherinid larvae	--	--	179	6
Symphurus plagiusa	--	--	152	7
Paralichthys dentatus	--	--	52	8
Prionotus sp.	424	4	--	--
Peprilus triacanthus	232	6	--	--
Menticirrhus sp.	175	7	--	--

* see footnote, Pearson (1941:80)
-- not ranked in the top eight species

differences between the two surveys (station locations, gear utilized, time of sampling). Both studies recognized A. mitchilli and C. regalis as the top two species in abundance with hogchokers, blennys and gobies all considered in the dominant eight species. Variation in species ranking in the two studies can be attributed to sampling differences. Thus, P. dentatus and larval atherinids were not taken by Pearson due to the absence of neuston sampling, and early larvae of S. plaguisa were most likely misidentified (Olney and Grant 1976). In like manner, low numbers of P. triacanthus larvae in the present study are the result of gear avoidance. Despite these limitations, this consistency suggests that since 1929, environmental pertubations caused by increased population, industrialization, shipping, and pollution have not yet affected lower Bay ichthyoplankton species composition and relative abundance. Whether or not spawning activity of resident fishes is a good measure of anthropogenic stress on the environment is questionable, but, given the lack of historical data and more sensitive criteria, it would appear prudent to continue assessment of Chesapeake Bay ichthyoplankton.

SUMMARY OF SIGNIFICANT FINDINGS

1. The lower Chesapeake Bay ichthyoplankton assemblage is a typical north-temperate, pliomeso-polyhaline estuarine community exhibiting low species diversity and marked year to year fluctuations in density.

2. Eggs and/or larvae of 32 species representing 22 families of fishes were taken in lower Chesapeake Bay plankton collections, 1971-1976. Peak spawning activity occurs between May and August, but eggs, larvae or juvenile stages can be taken year round.

3. Species of lower Chesapeake Bay ichthyoplankton can be divided into five ecological categories based on relative abundance, distribution, and known spawning ranges. These are: a) resident Chesapeake Bay spawners; b) shelf spawners passively intruded into lower Bay waters via tidal currents; c) shelf and oceanic spawners which actively migrate as postlarvae into the estuarine nursery grounds; d) larvae of subtropical species infrequently intruding into lower Bay waters; and e) oligo- and mesohaline spawners occasionally occurring in higher salinities.

4. Eggs and larvae of the bay anchovy, *Anchoa mitchilli*, dominated the ichthyoplankton assemblage, making up 96% of the total eggs and 88% of all larvae taken. The Chesapeake Bay appears to be the center of spawning distribution for this species.

5. Eggs and larvae of several sciaenids, especially the grey trout, *Cynoscion regalis*, rank second in numerical abundance after *A. mitchilli*, emphasizing the value of the lower Chesapeake Bay as a spawning area for these economically important species.

6. Additional important species represented by eggs and/or larvae were *Trinectes maculatus*, *Hypsoblennius hentzi*, *Gobiosoma ginsburgi*, *Symphurus plagiusa*, atherinid larvae and *Paralichthys dentatus*. The remaining species occurred infrequently.

7. Although the relative abundances of ichthyoplankton vary from year to year, species composition and general distributional patterns remain consistent on a yearly basis and apparently have not significantly changed historically. This feature suggests that anthropogenic alterations have not significantly modified the lower Bay environment as judged by ichthyoplankton species composition.

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VITA

John Edward Olney

Born in Newport News, Virginia on April 6, 1947. Graduated June, 1965 Homer L. Ferguson High School, Newport News, Virginia. Received B.S. degree in Biology, May, 1971 from the College of William and Mary, Williamsburg, Virginia. Taught senior biology at York High School, Yorktown, Virginia for one year prior to employment as a laboratory specialist at the Virginia Institute of Marine Science, Gloucester Point, Virginia in 1972.

In January 1974, entered the School of Marine Science at the Virginia Institute of Marine Science, College of William and Mary.

Presently employed as an Assistant Marine Scientist, Planktology Department, Virginia Institute of Marine Science.

JOHN E. OLNEY

John is a local product, a constant source of pride for backward eastern Virginia. He was born and raised in Hilton Village, recently named after a passing hotel, but originally the site of Olney Mountain. The mountain was a prominent and well-known feature of the Peninsula until the arrival of bulldozers and 5-ton trucks, which hauled it away to Virginia Beach, where it is now known as Mt. Trashmore. The ancestral Olney home is now marked only by a slight dip in Warwick Boulevard.

John arrived at VIMS seven years ago in January, after a long, but invigorating swim across the York River. His failure to use the bridge was the first of many noticeable gaps in his knowledge, stemming from having bypassed elementary and secondary schooling to get a bachelor's degree at William and Mary. When asked if he had ever been on the southside of the James River, he responded that it was too far to swim.

He kept overhearing the word "thesis" being used by other graduate students during his first couple of years as chief oarsman for the Planktology Dept., and finally came to my office to "splain" it to him. Using familiar terms, and fish eggs as an example, I told him that a student looks at the eggs through a microscope for awhile, sits back and "thinks on it" for an even longer time, then writes about it. So, lacking in any great powers of imagination, John started looking at fish eggs from our two years of monthly collections from the lower Bay.

After a couple years had passed, John noticed that some of the eggs were oval rather than round and asked me to "splain" it to him. I told him they were eggs of anchovies, which because of their small size have to try harder -- hence the oval shape. He accepted that, and returned to write his thesis on "Strain in Bay Anchovy Populations". The writing, however, was interrupted by the discovery of three (3) eggs in an offshore collection. John wrote a 40 page paper on these 3 eggs and submitted it to a previously prestigious journal for publication. The reviewers, never having considered that so much could be written about so little, have altered their entire outlook on scientific publication. They accepted the paper. One of them was later observed, while walking to class and thinking about John's paper, to stub his toe, sit down, hold his toe in his left hand, and write a paper about it with his right hand.

Here's John --

GCG