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OF
THE BINGHAM OCEANOGRAPHIC COLLECTION
Volume 15

Oceanography of Long Island Sound, 1952-1954

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OCEANOGRAPHY OF LONG ISLAND SOUND, 1952–1954

VII. PELAGIC FISH EGGS AND LARVAE

By

Sarah B. Wheatland

Bingham Oceanographic Laboratory

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ABSTRACT

The pelagic fish eggs and larvae of Long Island Sound, obtained in weekly oblique plankton tows from March 1952 until March 1954, are discussed in detail. An annotated list of 23 identifiable species, plus an unidentifiable one, contains pertinent information on spawning seasons, identification and measurements of eggs and larvae, their distribution, etc. Information derived from previous surveys is compared with that from 1952–1954. The physical and biological factors which may influence the abundance of eggs and larvae as well as a variety of explanations for the decrease in egg diameter of species with long spawning seasons are also presented.

INTRODUCTION

One of the many aspects of a broad oceanographic survey such as that discussed by Riley (see his Introduction in this volume) is a study of the spawning fish population. It is of more than passing interest to obtain information on the identity and seasonal fluctuations of the various components of the fish population and to evaluate and assess the environmental factors which may be responsible for changes in their annual abundance.

The present paper is limited primarily to an account of the identity, spawning locations, and seasonal fluctuations of those species taken from Long Island Sound in plankton tows from March 1952 until March 1954. In a few instances, observations and data attained after March 1954 have been included. Subsequent studies will concentrate on the causes of annual fluctuations, survival, growth, and abundance of the identified species. Surveys of the juvenile population are also planned.

Previous contributions on fish eggs and larvae which are particularly pertinent to the present study are those of Perlmutter (1939) and of Merriman and Sclar (1952). In the summer of 1938 Perlmutter surveyed the eggs and larvae in waters which immediately surround Long Island. His generalized account includes new data on identification as well as a few observations on temperature and salinity tolerance of some spawning species. In 1943–1946, Merriman and Sclar studied the eggs and larvae in northeastern Block Island Sound. Their paper includes an annotated list combined with a key for identification of the eggs and larvae, as well as a discussion of possible meteorological and oceanographical features influencing the success of year-classes of cunner, weakfish, and butterfish.

The 1950 catch statistics, the most recent data available with county tabulations (U. S. Fish and Wildlife Service, 1951–1952), indicate that the waters adjacent to the three Connecticut counties on the north shore of L. I. S. produce less fish than the waters in the vicinity of New London County (Conn.) at the eastern end, where the catch is derived primarily from the B. I. S. population. Though L. I. S. is larger than B. I. S. and is confined almost entirely by two coastlines, it supports a much smaller commercial fishery than B. I. S., with the possible exception of menhaden. The shallow depth and less saline water of L. I. S. (Riley, 1952a) are factors that may deter the commercially valuable fish, such as cod and mackerel, from entering central and western L. I. S. in great numbers.

Of the migratory commercial species, the menhaden (*Brevoortia tyrannus*) enters L. I. S. during the warm months and is caught in abundance at that time. The greatest numbers in L. I. S. occur at the eastern end, and a large population may also be found just outside L. I. S. proper in the Peconic-Gardiners Bay area. The 1950 statistics indicate that 82,510,400 pounds of menhaden were landed at Suffolk County, New York (the center of the menhaden industry in this area), and some of this catch undoubtedly came from L. I. S. There is a variable and small recorded catch of herring, scup, and butterfish, but no appreciable catch of cod, haddock, mackerel, and fluke. No statistics are available on the number of weakfish and bluefish removed from these waters by sports fishermen. Two anadromous migrants, shad and alewife, are taken occasionally on the way to their spawning grounds, and these constitute the most lucrative river fishery in the southern New England area. However, they add relatively little to the total value of the Connecticut catch.

Of the permanent residents in the Sound, the blackback flounder (*Pseudopleuronectes americanus*) forms the backbone of the existing fishery. Even so, the recorded catch of blackbacks in 1950 was only 1/20th of that from B. I. S. *Lophopsetta aquosa*, *Myoxocephalus aeneus*, the minnow, and others, utilized as bait as well as food for humans and mink, add little to the total value of the fishery.

Except for the menhaden, it is clear that L. I. S. does not support an important commercial fishery. Nevertheless, from observations

by Greeley (1939), Perlmutter (1939), and Warfel and Merriman (1944), it appears that L. I. S. may well be a suitable area for young fish. Their reports show the presence of juveniles of commercially valuable forms as well as the young of inedible species which are an important part of the food chain. The juveniles of some species probably immigrate while others are hatched locally. No eggs or larvae of whiting (*Merluccius bilinearis*) and spotted hake (*Urophycis regius*) have been recorded from L. I. S. proper, but first-year specimens of both species have been collected in May and June by a local commercial oyster vacuum dredge. The juveniles hatched locally are subdivided into two groups; those spawned by seasonal immigrants such as menhaden, rockling, and kingfish (*Menticirrhus saxatilis*), and those spawned by residents, namely the blackback, sculpin, windowpane flounder, and others. A few, such as weakfish, may stem from both major sources. Thus, the Sound appears to be a nursery ground. How valuable a rôle these waters play in this respect is a matter of conjecture, but from the high concentration of plankton (see Riley and Conover in this issue) and the tremendous quantities of bottom organisms (see Sanders in this issue) it would appear that L. I. S. is a favorable location for young fish.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge not only the guidance of Gordon A. Riley but also his helpful advice on problems pertaining to the hydrography of L. I. S. I am also indebted to Daniel Merriman for assistance in the identification of various fish eggs and for his constructive criticism of the manuscript.

Gordon Riley and Shirley M. Conover took the samples of zooplankton from which the eggs and larvae were obtained. Herbert W. Graham kindly provided working space at the U. S. Fish and Wildlife Service Laboratory in Woods Hole during the summer of 1954; and John Colton made available for examination the collections taken aboard the Albatross III in the spring of 1953 and also made accessible the 1929 collections and unpublished data of O. E. Sette. Alfred Perlmutter provided unpublished material from the 1938 survey of Long Island waters and helped in identifying certain larvae. Special collections were made with the help of Captain Herman R. Glas, skipper of the Shang Wheeler, the Gargano Brothers who fish aboard the Two Brothers, Jack Fu, Harvard 1957, and R.

Wade Covill, Yale 1957. To all I extend my gratitude and appreciation.

Special thanks are extended to Mr. Louis K. Mowbray, Yale 1955, who, with patience and thoroughness, sorted most of the material, identified and measured some of the samples, and prepared all of the menhaden data as well as some of the rockling material.

MATERIALS AND METHODS

Oblique zooplankton tows from L. I. S. from March 1952 until March 1954 were taken at a speed of two knots with a 12.5 cm No. 2 net attached to a Clarke-Bumpus sampler. Each entire 15-minute sample was immediately preserved in a 10% solution of neutralized formalin and sea water.

The tows were taken regularly at stations 1, 2, 5, and 8 (see Riley's INTRODUCTION to this volume for station positions). Two stations were sampled one week and two the next so that each of the four stations was sampled at biweekly intervals. During the first year, two cruises of wider geographical range were also made, one in June (hereafter referred to as the 100-cruise) and the other in September–October (the 200-cruise); each of these cruises was divided into two sections, the first part to the eastern end of the Sound and the second to the western end a week later. On these cruises, samples were taken at some 20 stations, from the Race at the eastern end to Execution Rock at the western end. A third long trip (the 300-cruise) in the spring of 1953 was cut short by poor weather. No samples were taken on the bottom during any of these cruises.

For various purposes, special tows were taken at different times throughout the two years. Studies were made of the eggs and larvae from hauls taken with the closing nets at two different depths as well as from night-day collections (see R. J. Conover in this issue). Seven hauls were taken in April and May 1954 to compare the catch in two nets towed simultaneously, one being a 12.5 and the other a 30 cm net.

A few samples of demersal juveniles were taken aboard the QUINNIPIAC, a suction oyster dredge operated by F. Mansfield and Sons Co. of New Haven, Conn. This apparatus sucks oysters and other organisms from the bottom through a rubber and steel pipe attached amidships (for details, see Anonymous, February, 1948), and it was possible to hang a net so as to sample the small demersal fish from

the overflow of water, but this method of sampling did not produce quantitative estimates.

After the eggs and larvae had been removed from the plankton sample they were identified, counted, and measured. The samples were not divided into aliquot portions. In all numerical analyses the exact number of eggs and larvae was standardized to the number taken per cubic meter of water sampled. Usually the diameter of all eggs was measured, but if numerous eggs of one species were found in a sample, 10 or 25 eggs were removed at random from the collection and measured. The total lengths of all larvae under 30 mm were measured by an ocular micrometer, but accurate measurements were sometimes difficult because the larvae curled.

Identifications were accomplished on the basis of known spawning seasons, diameter size of egg and oil globule, presence or absence of oil globule or globules, pigmentation of the embryo, and comparison with known material. The identification of larvae was made on the basis of apparent size at hatching, pigmentation, size at which the fins appear, number of metameres, fin ray counts where possible, and comparison with known material. The most useful references were: Kuntz, 1914, 1916; Kuntz and Radcliffe, 1917; Welsh and Breder, 1923; Nichols and Breder, 1926; Sette's unpublished drawings and descriptions from 1929; Hildebrand and Cable, 1930, 1934, 1938; Perlmutter, 1939; Merriman and Sclar, 1952; and Bigelow and Schroeder, 1953. For general information on spawning seasons, growth rates, and relative abundance, the following were helpful: Greeley, 1939; Sette, 1943; Warfel and Merriman, 1944; Moore, 1947; and Morrow, 1951. Hubbs' (1943) classification of the early stages was followed wherever possible.

The data are presented in sections according to species, following the classification of Berg (1940). Methods of identification are included where necessary; spawning seasons and locations are noted, and any variation in spawning between years is discussed; measurements of egg diameters are listed to demonstrate possible differences between spawning populations and to demonstrate the decrease in egg size with progress of the spawning season; measurements manifesting possible growth of the larvae during the year and brief reviews on the presence of juveniles are presented wherever possible; some environmental factors which may affect all of the above are discussed; and comparison with results of former surveys are made and evaluated.

TABLE I. RELATIVE ABUNDANCE OF FISH EGGS AND LARVAE PER CUBIC METER IN L. I. S, 1952–54

	1952									
	March		April		May		June		July	
Species	eggs	larv.	eggs	larv.	eggs	larv.	eggs	larv.	eggs	larv.
Clupea harengus	—	.007	—	—	—	—	—	—	—	—
Brevoortia tyrannus	—	—	—	—	—	—	2.28	.008	.01	—
Anchoa mitchilli mitchilli	—	—	—	—	—	—	10.62	—	33.36	1.05
Anguilla rostrata	—	—	—	—	—	—	—	—	—	—
Enchelyopus cimbrius	.44	—	.96	—	1.48	.027	.19	.01	—	—
Syngnathus peckianus	—	—	—	—	—	—	—	—	—	.01
Menidia menidia notata	—	—	—	—	—	—	—	.004	—	—
Cynoscion regalis	—	—	—	—	—	—	.36	—	.02	.08
Menticirrhus saxatilis	—	—	—	—	—	—	.004	—	.09	—
Stenotomus chrysops	—	—	—	—	.009	—	.67	—	.09	.02
Tautogolabrus adspersus	—	—	—	—	.96	—	2.38	—	1.37	—
Tautoga onitis	—	—	—	—	.24	—	.76	—	.01	—
Ammodytes americanus	—	1.98	—	.51	—	—	—	—	—	—
Scomber scombrus	—	—	—	—	—	—	.03	—	—	—
Poronotus triacanthus	—	—	—	—	—	—	.03	—	.19	—
Prionotus carolinus	—	—	—	—	—	—	.03	—	.03	.02
Prionotus evolans	—	—	—	—	—	—	.09	—	.01	—
Myoxocephalus spp.	—	.01	—	—	—	—	—	—	—	—
Paralichthys oblongus	—	—	—	—	—	—	—	—	—	—
Lophopsetta aquosa	—	—	.03	—	.93	—	1.2	.03	.04	.01
Limanda ferruginea	—	—	—	.009	—	—	—	—	—	—
Pseudopleuronectes americanus	—	—	—	.04	—	.10	—	.01	—	—
Sphaeroides maculatus	—	—	—	—	—	—	—	—	—	—
"Unknown 1"	—	—	—	—	—	—	—	—	—	—

TABLE I. (continued)

	1952									
	August		September		October		November		December	
Species	eggs	larv.	eggs	larv.	eggs	larv.	eggs	larv.	eggs	larv.
Clupea harengus	—	—	—	—	—	—	—	—	—	—
Brevoortia tyrannus	.03	—	.27	.16	.10	.26	—	—	—	—
Anchoa mitchilli mitchilli	21.84	3.58	.41	1.26	—	.02	—	—	—	—
Anguilla rostrata	—	—	—	—	—	—	—	—	—	—
Enchelyopus cimbrius	—	—	—	—	—	—	—	—	—	—
Syngnathus peckianus	—	—	—	—	—	—	—	—	—	—
Menidia menidia notata	—	—	—	—	—	—	—	—	—	—
Cynoscion regalis	.03	—	—	—	—	—	—	—	—	—
Menticirrhus saxatilis	—	.01	—	—	—	—	—	—	—	—
Stenotomus chrysops	—	—	—	—	—	—	—	—	—	—
Tautogolabrus adspersus	.16	.05	.09	.04	.05	.02	—	—	—	—
Tautoga onitis	—	—	—	—	—	—	—	—	—	—
Ammodytes americanus	—	—	—	—	—	—	—	—	—	.05
Scomber scombrus	—	—	—	—	—	—	—	—	—	—
Poronotus triacanthus	.01	—	—	—	—	—	—	—	—	—
Prionotus carolinus	.03	.01*	—	—	—	—	—	—	—	—
Prionotus evolans	—	—	—	—	—	—	—	—	—	—
Myoxocephalus spp.	—	—	—	—	—	—	—	—	—	—
Paralichthys oblongus	—	—	—	.009	—	—	—	—	—	—
Lophopsetta aquosa	—	—	.36	.006	.37	.005	—	—	—	—
Limanda ferruginea	—	—	—	—	—	—	—	—	—	—
Pseudopleuronectes americanus	—	—	—	—	—	—	—	—	—	—
Sphaeroides maculatus	—	.01	—	—	—	—	—	—	—	—
"Unknown 1"	—	—	.009	—	.01	—	—	—	—	—

* In the text these larvae are referred to as *Prionotus* sp.

TABLE I. (continued)

Species	1953 January eggs	larv.	February eggs	larv.	March eggs	larv.	April eggs	larv.	May eggs	larv.
Clupea harengus	—	—	—	—	—	—	—	—	—	—
Brevoortia tyrannus	—	—	—	—	—	—	—	—	—	—
Anchoa mitchilli mitchilli	—	—	—	—	—	—	—	—	—	—
Anguilla rostrata	—	.02	—	—	—	—	—	—	—	—
Enchelyopus cimbrius	—	—	—	—	.41	—	.94	.01	.29	—
Syngnathus peckianus	—	—	—	—	—	—	—	—	—	—
Menidia menidia notata	—	—	—	—	—	—	—	—	—	—
Cynoscion regalis	—	—	—	—	—	—	—	—	—	—
Menticirrhus saxatilis	—	—	—	—	—	—	—	—	—	—
Stenotomus chrysops	—	—	—	—	—	—	—	—	—	—
Tautogolabrus adspersus	—	—	—	—	—	—	—	—	1.14	—
Tautoga onitis	—	—	—	—	—	—	—	—	.24	—
Ammodytes americanus	—	.13	—	.18	—	.22	—	.08	—	.02
Scomber scombrus	—	—	—	—	—	—	—	—	.02	—
Poronotus triacanthus	—	—	—	—	—	—	—	—	—	—
Prionotus carolinus	—	—	—	—	—	—	—	—	—	—
Prionotus evolans	—	—	—	—	—	—	—	—	—	—
Myoxocephalus spp.	—	—	—	—	—	—	—	.03	—	—
Paralichthys oblongus	—	—	—	—	—	—	—	—	—	—
Lophopsetta aquosa	—	—	—	—	—	—	.006	—	.21	—
Limanda ferruginea	—	—	—	—	—	—	.006	—	—	—
Pseudopleuronectes americanus	—	—	—	—	—	.02	—	.07	—	.03
Sphaeroides maculatus	—	—	—	—	—	—	—	—	—	—
"Unknown 1"	—	—	—	—	—	—	—	—	—	—

TABLE I. (continued)

Species	1953 June eggs	larv.	July eggs	larv.	August eggs	larv.	September eggs	larv.	October eggs	larv.
Clupea harengus	—	—	—	—	—	—	—	—	—	—
Brevoortia tyrannus	—	—	—	—	.01	—	.14	.07	.27	.35
Anchoa mitchilli mitchilli	.04	—	5.68	.68	3.16	.78	—	.22	—	—
Anguilla rostrata	—	—	—	—	—	—	—	—	—	—
Enchelyopus cimbrius	.07	—	—	—	—	—	—	—	—	—
Syngnathus peckianus	—	—	—	—	—	—	—	—	—	—
Menidia menidia notata	—	—	—	—	—	—	—	—	—	—
Cynoscion regalis	—	—	.25	.05	.07	.02	—	—	—	—
Menticirrhus saxatilis	—	—	.18	—	—	—	—	—	—	—
Stenotomus chrysops	.14	—	.22	.02	—	—	—	—	—	—
Tautogolabrus adspersus	7.08	—	1.73	.05	2.08	—	—	—	—	—
Tautoga onitis	.89	—	.05	.01	.03	—	—	—	—	—
Ammodytes americanus	—	—	—	—	—	—	—	—	—	—
Scomber scombrus	—	—	—	—	—	—	—	—	—	—
Poronotus triacanthus	—	—	.01	—	—	—	—	—	—	—
Prionotus carolinus	.008	—	.02	—	.07	—	—	—	—	—
Prionotus evolans	.008	—	—	—	—	—	—	—	—	—
Myoxocephalus spp.	—	—	—	—	—	—	—	—	—	—
Paralichthys oblongus	—	—	—	—	—	—	—	—	—	—
Lophopsetta aquosa	.13	—	.06	.02	.02	—	—	—	.30	.02
Limanda ferruginea	—	—	—	—	—	—	—	—	—	—
Pseudopleuronectes americanus	—	—	—	—	—	—	—	—	—	—
Sphaeroides maculatus	—	—	—	—	—	—	—	—	—	—
"Unknown 1"	—	—	—	—	—	—	—	—	—	—

TABLE I. (continued)

Species	1953 November eggs	1953 November larv.	1953 December eggs	1953 December larv.	1954 January eggs	1954 January larv.	1954 February eggs	1954 February larv.	1954 March eggs	1954 March larv.
Clupea harengus	—	—	—	—	—	—	—	—	—	—
Brevoortia tyrannus	—	.47	—	.02	—	—	—	—	—	—
Anchoa mitchilli mitchilli	—	.02	—	—	—	—	—	—	—	—
Anguilla rostrata	—	—	—	—	—	—	—	—	—	—
Enchelyopus cimbrius	—	—	—	—	—	—	.04	—	.11	—
Syngnathus peckianus	—	—	—	—	—	—	—	—	—	—
Menidia menidia notata	—	—	—	—	—	—	—	—	—	—
Cynoscion regalis	—	—	—	—	—	—	—	—	—	—
Menticirrhus saxatilis	—	—	—	—	—	—	—	—	—	—
Stenotomus chrysops	—	—	—	—	—	—	—	—	—	—
Tautogolabrus adspersus	—	—	—	—	—	—	—	—	—	—
Tautoga onitis	—	—	—	—	—	—	—	—	—	—
Ammodytes americanus	—	—	—	.46	—	.50	—	.43	—	—
Scomber scombrus	—	—	—	—	—	—	—	—	—	—
Poronotus triacanthus	—	—	—	—	—	—	—	—	—	—
Prionotus carolinus	—	—	—	—	—	—	—	—	—	—
Prionotus evolans	—	—	—	—	—	—	—	—	—	—
Myoxocephalus spp.	—	—	—	—	—	—	—	—	—	.03
Paralichthys oblongus	—	—	—	—	—	—	—	—	—	—
Lophopsetta aquosa	.02	—	—	—	—	—	—	—	—	—
Limanda ferruginea	—	—	—	—	—	—	—	—	—	—
Pseudopleuronectes americanus	—	—	—	—	—	—	—	—	—	.01
Sphaeroides maculatus	—	—	—	—	—	—	—	—	—	—
"Unknown 1"	—	—	—	—	—	—	—	—	—	—

TABLE II. Pertinent Data from the 1952–54 Survey of L. I. S.

Species	Eggs: Date	Eggs: Number	Eggs: Size range (mm)	Eggs: Av. & Stand. deviation	Oil globules: Size range (mm)	Oil globules: Av. & Stand. deviation	Oil globules: Number egg
Clupea harengus	—	—	—	—	—	—	—
Brevoortia tyrannus	{June–July, Aug.–Oct.}	633	1.04–1.94	1.61±.05	.06–.20	.14±.02	1–2
Anchoa mitchilli mitchilli	June–Sept.	8333	0.70–1.05	0.84±.05	—	—	0
Anguilla rostrata	—	—	—	—	—	—	—
Enchelyopus cimbrius	Feb.–June	595	0.74–1.12	0.89±.04	.05–.30	—	1–25
Syngnathus peckianus	—	—	—	—	—	—	—
Menidia menidia notata	—	—	—	—	—	—	—
Cynoscion regalis	June–Aug.	123	0.75–0.96	0.84±.03	.05–.30	.20±.04	1–6
Menticirrhus saxatilis	June–Aug.	27	0.75–0.91	0.81±.03	<.05–.14	—	6–22
Stenotomus chrysops	May–July	209	0.85–1.15	0.96±.04	.14–.28	.22±.02	1–2
Tautogolabrus adspersus	May–Oct.	2105	0.76–1.03	0.86±.04	—	—	0
Tautoga onitis	May–Aug.	340	0.91–1.15	1.05±.03	—	—	0
Ammodytes americanus	—	—	—	—	—	—	—
Scomber scombrus	May–June	9	1.14–1.29	1.18±.02	.24–.35	.29±.01	1
Poronotus triacanthus	June–Aug.	26	0.69–0.80	0.75±.02	.14–.22	.18±.01	1–2
Prionotus carolinus	June–Aug.	22	1.00–1.25	1.10±.02	<.10–.17	—	7–20
Prionotus evolans	June–July	25	1.05–1.25	1.14±.03	<.10–.16	—	7–30
Myoxocephalus spp.	—	—	—	—	—	—	—
Paralichthys oblongus	—	—	—	—	—	—	—
Lophopsetta aquosa	{April–Aug., Sept.–Nov.}	571	0.90–1.38	1.07±.06	.05–.30	.16±.03	1–4
Limanda ferruginea	April	1	0.81	—	—	—	0
Pseudopleuronectes americanus	—	—	—	—	—	—	—
Sphaeroides maculatus	—	—	—	—	—	—	—
"Unknown 1"	Sept.–Oct.	4	0.72–0.89	.78	.14–.24	.17	1–3

TABLE II. (continued)

Species	Larvae Date	Larvae Number	Larvae Range (mm)
Clupea harengus	Mar.	1	34.90
Brevoortia tyrannus	June; Aug.–Dec.	150	2.35–20.6
Anchoa mitchilli mitchilli	July–Nov.	672	1.60–28.0
Anguilla rostrata	Jan.	1	56.90
Enchelyopus cimbrius	April–June	8	2.00–4.90
Syngnathus peckianus	July	1	10.90
Menidia menidia notata	June	1	5.30
Cynoscion regalis	July–Aug.	14	2.10–4.40
Menticirrhus saxatilis	Aug.	1	3.70
Stenotomus chrysops	July	4	2.50–3.20
Tautogolabrus adspersus	July–Oct.	16	2.40–4.60
Tautoga onitis	July	1	2.50
Ammodytes americanus	Dec.–May	506	3.10–33.5
Scomber scombrus	—	—	—
Poronotus triacanthus	—	—	—
Prionotus carolinus; *Prionotus evolans*	July–Aug.	2	2.20–3.00
Myoxocephalus spp.	Mar.–Apr.	10	3.70–9.10
Paralichthys oblongus	Sept.	1	3.00
Lophopsetta aquosa	June–July; Sept.–Oct.	17	1.80–7.60
Limanda ferruginea	April	1	13.80
Pseudopleuronectes americanus	Mar.–June	63	2.80–8.50
Sphaeroides maculatus	Aug.	1	5.00
"Unknown 1"	—	—	—

SPECIES

Clupea harengus Linnaeus; Herring

No demersal eggs were obtained, and only one larva (34.90 mm) was taken, at St. 2 on March 26, 1952. The fin counts showed 18 dorsal and 17 anal rays. According to Breder (1929), the herring spawns in November in the latitude of New York, so this larva was presumably the product of early to mid-winter spawning.

The water temperature in L. I. S. during the herring spawning season agreed with that given by Bigelow and Schroeder (1953) for Cape Cod and with the range given by MacFarland (1913) for successful hatching. However, the bottom salinity in the Sound in November, c 28‰, was lower than the minimum given by Bigelow and Schroeder (31.9‰) for successful reproduction.

Merriman and Sclar (1952) have pointed out the inherent difficulties in separating larvae of *C. harengus* and *Brevoortia tyrannus*. They identified the clupeoid larvae taken in fall and winter from B. I. S.

as *C. harengus*, but re-examination of these same larvae by Merriman and the author has revealed that most of them were actually *B. tyrannus*. The length at which the anal fin is formed, 30 mm in the herring and 13–20 mm in the menhaden, was the dominant consideration. On this basis, the small larvae taken in their fall tows from B. I. S. were *B. tyrannus*. Some other specimens (between 23 and 27 mm) taken a little later the same fall were so mangled that re-identification was impossible. The largest (30 mm), taken in January 1946, was originally identified correctly as *C. harengus*.

Figure 1. Locations of egg and larvae collections in L. I. S., 1952–54.

Brevoortia tyrannus (Latrobe); Menhaden

This species usually enters the Sound in late spring and stays until October, during which time it is caught in large quantities for processing into oil, fertilizer, and poultry feed on Long Island.

Spawning. Kuntz and Radcliffe (1917) reported that menhaden spawn in summer at Woods Hole, Mass. and in late fall and early winter in Chesapeake Bay. They suggested the possibility of two spawning seasons in Chesapeake Bay, but Hildebrand and Schroeder (1928) maintained that there was only one. Perlmutter (1939) reported spawning from May until October in the Long Island area, the height of the season being in May. According to Bigelow and Schroeder (1953) the menhaden is a summer spawner in the Gulf of Maine.

On the basis of our collections, there appears to have been a considerable time difference in spawning during 1952–1953. In 1952 two peaks occurred, one in June and the other in September. During the six weeks between these two spawning periods no eggs or larvae were collected at the regular stations. In 1953, the eggs were found only from August until October.

Eggs. Compared with the eggs of other species, those of the menhaden ranked third in abundance and were exceeded only by eggs of *Anchoa mitchilli mitchilli* and *Tautogolabrus adspersus.* Table I shows that eggs were taken in 1952 during June and July and from August to October, and in 1953 during September and October only. Also, in 1952 eight times as many eggs were taken in June as in September. While more eggs were taken in 1952 than in 1953, the peaks in September 1952 and October 1953 were quantitatively equal. Fig. 1 shows the scattered distribution of the eggs throughout the Sound.

During the two years, 633 menhaden eggs were taken; the size ranged from 1.04–1.94 mm, with an average of 1.61 ± 0.05 (see Table II). These sizes compare fairly well with those reported by Bigelow and Schroeder for the Gulf of Maine (1.5–1.8 mm) and by Kuntz and Radcliffe for Woods Hole, Mass. (1.4–1.6 mm). In Perlmutter's published data for the Sound, no egg diameters were given.

The surface temperatures when menhaden eggs were taken ranged from 13.30° to 23.25° C for the two years. The lowest temperature was obtained at St. 119 on June 6, 1952 and the highest at St. 5 on August 19, 1952. In 1953 the over-all temperature range was less

than that in 1952: from 22.50° at St. 5 on August 25 down to 18.70° by October 14 at St. 5. Presumably these fish spawn when the temperature is above 16°. The water in Peconic-Gardiners Bay warms up earlier, and Perlmutter found menhaden spawning there in May.

The surface salinities at the time the menhaden eggs were collected ranged from 18.15 to 28.41‰ during 1952–1953; the lowest salinity was at St. 113 on June 5, 1952, the highest at St. 5 on October 14, 1953. The temperature and salinity data did not reveal differences that were significant enough to account for the paucity of menhaden eggs during the spring of 1953.

Examination of the data reveals seasonal differences in egg diameter as well as seasonal and regional variations in egg abundance. Table III compares the data from the June and September-October cruises in 1952 with data for 1953. Also included for comparative purposes are data for three geographical subdivisions of the Sound—eastern, central, and western.

The eggs taken during the two spawning peaks, in June and September-October 1952, differed in size. Those from the earlier cruise were larger than those of the later one. The average size of the eggs decreased in 1952, but no similar decrease was noted in 1953. However, the average size of the eggs in the fall of 1952 and of 1953 was the same. The oil globule was noticeably smaller in 1953. The major portion of the spring collections was taken in June from the eastern part of the central area; no particular concentration appeared anywhere in the Sound in September 1952.

At the eastern end, near the Race, menhaden eggs were taken at seven stations. Each of the stations was located within a few miles of the next. The eggs taken in June were noticeably larger than those obtained in September, but there was no appreciable difference in the numbers taken during either cruise, with the exception of St. 115. Possibly the increase in numbers at this station can be explained by its proximity to Peconic Bay, a recognized spawning locale of this species in spring.

In the east-central section, as in the eastern portion of the Sound, the average diameter of the eggs decreased from spring to fall and more eggs were found during the spring. However, in the west-central area a decrease was noted only at St. 5, where the largest number of eggs was collected.

TABLE III. SEASONAL AND REGIONAL VARIATIONS IN ABUNDANCE AND SIZE OF EGGS OF *Brevoortia tyrannus*

Eastern End			Central Portion: East				Central Portion: West					Western End		
St.	Eggs/m³	Av. diam.	St.	Eggs/m³	Av. diam.	Date	St.	Eggs/m³	Av. diam.	'52	'53	St.	Eggs/m³	Av. diam.
119	0.48	1.64	121	1.05	1.74		105	0.17	1.55			130	0.49	1.71
222	0.58	1.58	224	0.10	1.54		205	0.22	1.53			241	0.10	1.45
117	0.68	1.68	113	1.13	1.69		103	0.18	1.74			234	0.10	1.60
219	0.49	1.56	215	0.29	1.55		203	0.00	—					
							107	4.96	1.67					
115	2.02	1.71	111	0.77	1.71	VI	1	0.03	1.65	0.04	0.00			
218	0.22	1.53	123	22.72	1.71	IX-X	1	0.00	—					
			109	10.46	1.73									
220	0.47	1.52	210	0.26	1.47	VI	2	0.22	1.55	0.03	0.00			
						IX-X	2	0.03	1.53					
						VI	5	1.09	1.63	1.02	0.51			
						IX-X	5	0.70	1.44					
						VI	8	0.00	—	0.00	0.00			
						IX-X	8	0.00	—					

SUMMARY:

Date	Cruise	No. eggs measured	Range (mm)	Av. diam.	Stand. dev.	Av. diam. globule
1952 VI	100	108	1.46–1.82	1.68	0.073	0.15
IX-X	200	43	1.36–1.65	1.51	0.034	0.14
1953 IX-X	—	23	1.05–1.61	1.48	0.049	0.11

Although only a few eggs were taken in the western section in either spring or fall, a decrease in egg size was evident. (Perlmutter found a number of eggs in this region in June, but none in the fall.) The October 1952 collections may have been made after the end of the spawning season. No doubt the menhaden spawned here, because many small larvae were taken at this time.

From the available data it appears that two groups of menhaden migrated into L. I. S. in the summer of 1952. The first group arrived in early June, moved westward, and produced larger eggs than the menhaden of the later group, which had moved into the center of the Sound by August 19th. In 1953 only a later group arrived and produced eggs of the same size as those of the later group in 1952.

Merriman and Sclar (1952) did not find eggs of this species in B. I. S., nor did Perlmutter find them in his samples from B. I. S. despite the reported abundance of eggs in Peconic-Gardiners Bay. According to Bigelow and Schroeder, "the abundance of microscopic plants in waters of bays and estuaries . . . has often been invoked to explain the concentration of menhaden close to shore." This reasoning may account for the presence of this species in L. I. S. and not B. I. S. Comparison of data in Riley (1952b) and in S. M. Conover in this issue shows a greater abundance of phytoplankton in L. I. S. than in B. I. S. Also, the plankton populations in L. I. S. during June and July 1952 were greater than those of 1953. However, the menhaden, in entering Peconic Bay and eastern L. I. S., may come around Montauk Point without entering northern B. I. S. at all.

Larvae. A total of 150 larvae (2.35–20.6 mm) was taken in L. I. S. in 1952–1953. Two specimens were taken in June 1952, 71 in September-October 1952, and 77 in September-December 1953. The menhaden larvae were exceeded in abundance by only those of *Anchoa mitchilli mitchilli* and *Ammodytes americanus.* The numerical ratio of larvae to eggs varied as follows during the two years: 1:2 in 1952, 3.2:1 in 1953. The 1952 ratio was high when compared with that of other species, and the 1953 ratio indicates that we did not collect the eggs at the time or location of greatest spawning. In 1952 a large sampling error, failure of the larvae to survive, or a combination of these and other factors may account for the fact that the greatest number of eggs was taken in spring and the greatest number of larvae in the fall.

According to Bigelow and Schroeder (1953), menhaden are unable to survive in water temperatures below 10° C. Warfel and Merriman (1944) did not find juveniles in Morris Cove after the temperature fell below 8°. In L. I. S. the larvae were not taken in 1952 after the surface temperature decreased to 13.55° (October 29 at St. 8), but in 1953 the larvae were taken until the surface temperature decreased below 10.30° (December 2, St. 1). The early disappearance of the larvae during the fall of 1952 may have been due to the fact that the waters of the Sound cooled faster that year, since 10.30° was recorded as early as November 17.

The salinities where the larvae were collected ranged from 25.11 (St. 1, June 19, 1952) to 28.44‰ (St. 1, December 2, 1953). Massman (1954) found juveniles in fresh water 35 miles above brackish water in rivers of Virginia. Possibly the juveniles had a greater tolerance for lower salinities than the adults.

Comparison of our data with those of others reveals some pertinent information about early growth. Kuntz and Radcliffe (1917) reported that the newly hatched larva at Woods Hole, Mass. is 4.5 mm long, but some larvae in our collections from the Sound were as short as 2.4 mm. Considering that newly hatched larvae appeared constantly during the early fall, it is impossible to obtain an estimate of seasonal growth rate based on length frequencies. However, three larvae (12.5, 13.4, 20.6 mm long) were taken on December 2, 1953 seven weeks after the last eggs had been found. If we assume that these larvae hatched around October 14 and had grown to these sizes in seven weeks, then their growth rate must have been slower than 50 mm in three months, as estimated by Perlmutter and by Warfel and Merriman. The decreasing temperatures of the water column may have accounted for this decreased growth rate in the Sound. In this connection Hildebrand and Schroeder (1928) reported that the growth rate over the winter in Chesapeake Bay was very slow. At the present time an estimated growth rate of 50 mm in three months during the summer and of 12–20 mm in two months during the fall is the best available.

Warfel and Merriman (1944) maintained that the wide fluctuations in mean length as well as the constant presence of 30 mm fish in each sample indicated that successive waves of different populations were moving into Morris Cove. This phenomenon might be attributed to spawning by different populations at various times. The smaller fish in their October samples might have been products of late summer spawning, the larger ones the products of early summer spawning. Migrations of juveniles from areas of later spawning have also been postulated by Nichols and Breder (1926).

Anchoa mitchilli mitchilli (Cuv. & Val.); Anchovy.

Though not important commercially, the anchovy is a common prey, hence its importance to the economy of L. I. S. may be great even though indirect.

Spawning. Perlmutter (1939) ascertained that anchovy eggs were the most abundant of all species in Peconic-Gardiners Bay and in L. I. S., and Nichols and Breder (1926) and Sumner, *et al.* (1913) have listed it as abundant in the summer at Woods Hole, where it undoubtedly spawns. However, neither Perlmutter nor Merriman and Sclar found it in B. I. S., possibly because the area they sampled is not sufficiently protected from the open sea to support a large population.

Eggs. The eggs of this species were more abundant in our catches than those of any other fish. Table II shows a total of 8,333 eggs (0.70–1.05 mm) for 1952–1953. In 1952 they were found from June 4 to September 3, and in 1953 from June 23 to August 25. The quantity of eggs taken in 1952 was five times greater than that in 1953 (see Fig. 1 for locations of collections).

In 1952 the lowest surface temperature in which these eggs were collected was 13.30° C at St. 119 on June 6 and the lowest salinity was 19.93‰ at St. 128 on June 11; the warmest surface temperature was 23.30° on August 12 and the highest salinity was 27.89‰ on August 26, both at St. 8. In 1953 the temperature range, from 18.45° on June 23 at St. 1 to 23.50° by July 21 at St. 1, was less than that in 1952; the salinity in 1953 varied between 25.15 and 27.23‰. On the basis of these data and Perlmutter's, the eggs may be expected to occur anytime after the temperature of the water column reaches 13°. However, in 1953 they were not taken at the regular stations until the surface temperature was 18.45°. Another factor that may have been partially responsible for their delayed appearance was the lower salinity in the spring of 1953.

In June 1952 the 100-cruise was made during the beginning of the spawning season, when eggs were collected from 14 of the 19 stations scattered throughout the Sound. In actual numbers, more eggs were taken at the western than at the eastern end, perhaps because the cruise to the western part came as the spawning season was well underway whereas the cruise to the eastern section came at the beginning of the spawning season. In 1938 Perlmutter found the greatest number of eggs in Peconic Bay and to the south of Long Island whereas in L. I. S. proper he found comparatively few.

Table IV indicates that, on the whole, anchovy eggs were more abundant inshore at Sts. 1 and 8 than offshore at Sts. 2 and 5. However, there were occasional abundant collections of eggs at Sts. 2 and 5 also. This suggests the possibility of a correlation between northerly (offshore) winds and the abundance of eggs at the offshore stations. In Table IV the number of eggs is given for each collection from these four stations during the summers of 1952 and 1953; also given is an average of the wind direction for the collection date plus the two preceding days (determined from monthly summaries of the U. S. Weather Bureau Office at New Haven, 1952–1953). In 1952, when there was a prevalance of southwesterlies on or before the collection dates and when more eggs were taken, the majority was found inshore; on the other hand in 1953, when the winds were more variable and the eggs less abundant, the majority was found offshore at St. 2. However, when each collection is considered individually, the greater egg abundance at the offshore stations does not appear to be related to wind direction. If one considers the data for St. 5 only, it is seen that the greatest fluctuation in abundance during 1952 occurred primarily between June 24 and July 8. It is possible that eggs were carried through this station on the ebbing tide which sweeps by this location fairly rapidly (Riley, 1952a), but since more eggs were sometimes taken following an easterly wind, the eggs at such times may have been prevented from moving out of this area with the tide. In 1953 there was less variation in the numbers of eggs except at St. 2 on July 28, when a tremendous increase occurred. No north wind was responsible. Although St. 1 appears to have been the locale of the heaviest spawning in 1952, it was not so in 1953. Evidence suggests that the large fluctuations that have been discussed were caused by movements of the fish. There may have been some scattered groups of anchovies whose eggs were found chiefly at Sts. 1, 2, and 8 and other groups whose eggs were swept through St. 5 from a more westerly or inshore locale.

Discussion of the noticeable changes in shape and size of anchovy eggs is advisable to aid future studies. The egg is elliptical and

TABLE IV. Abundance of *A. m. mitchilli* per Cubic Meter and the Wind Direction for the Date of Collection Plus the Two Preceding Days

Date	Stations: Inshore		Offshore		Wind direction
	1	*8*	*2*	*5*	
1952					
VI–4	1.2	—	0.09	—	NW, SE, S
VI–19	123.0	24.2	—	—	SW, NW, SW
VI–24	31.8	—	—	24.5	NE, E, SW
VII–1	—	—	26.9	—	S, N, N
VII–8	16.7	—	—	4.8	SW, SW, E
VII–15	65.5	93.4	46.1	—	NW, SW, SW
VII–22	19.8	—	—	7.4	SW, SW, SW
VII–29	—	5.8	12.8	—	SW, SW, NW
VIII–5	6.7	—	—	9.3	SW, SE, S
VIII–12	—	36.3	37.8	—	E, SW, SW
VIII–19	79.8	—	—	4.9	NW, W, W
VIII–26	—	2.4	4.6	—	NW, SW, SW
1953					
VI–23	0.15	0.16	—	—	E, SW, W
VI–30	—	—	0.11	0.0	S, SW, S
VII–7	0.0	1.7	—	—	S, SE, SW
VII–14	—	—	0.6	0.26	E, N, E
VII–21	4.2	0.76	—	—	E, N, N
VII–28	—	—	29.3	0.9	S, S, N
VIII–4	3.0	8.4	—	—	N, N, S
VIII–11	—	—	0.43	2.3	E, S, W
VIII–18	5.5	3.3	—	—	S, W, N
VIII–25	—	—	0.65	0.0	S, SW, SE

Summary of annual relative abundance of eggs and larvae at each station.

EGGS				
1952	31.10	24.49	17.28	8.86
1953	2.29	3.06	6.83	0.66
LARVAE				
1952	2.05	2.42	5.94	0.46
1953	0.15	0.48	0.69	0.15

contains no oil globule. Most of the investigators who have referred to this species in more northern latitudes quote Kuntz (1914), who found that eggs taken in plankton tows near Beaufort, North Carolina were 0.65–0.75 mm in length and about 0.55–0.61 mm in width. In the L. I. S. survey, usually only the long axis was measured, but the length of the short axis was ascertained for eggs from a few hauls in June, July, and August 1952. The shape varied widely from nearly round to long and narrow, but this difference appeared to be random. The size also varied considerably during the spawning season. Table V summarizes the egg measurements for each month during the spawning seasons of both years.

TABLE V. SUMMARY OF MEASUREMENTS OF *A. m. mitchilli* EGGS

Date	*No. meas.*	*Range*	*Av. of long axis*	*Ratio long/short axis*	*Stand. dev.*
1952					
June	671	0.75–1.00	0.89	1.17	.046
July	716	0.70–1.00	0.82	1.15	.047
August	481	0.70–0.95	0.79	1.19	.040
Sept.	25	0.75–0.91	0.80	—	.037
1953					
June	5	0.80–0.93	0.86	—	.024
July	105	0.76–0.95	0.86	—	.040
August	154	0.71–0.91	0.82	—	.039
Total					
1952	1893	0.70–1.05	0.84	—	.045
1953	264	0.71–0.95	0.84	—	.039

From the available evidence it appears that the L. I. S. anchovies produce larger eggs than those from the south. Although the average size within L. I. S. was the same in both years, there was considerable variation within each year. In 1952, although the size range remained relatively constant, the average decreased in July through August and then increased again in September; in 1953 the average decrease was less obvious. The decrease in size is an important variable which is helpful in proper identification. While the shape of the engraulid egg identifies it from those of other families, size variations are important when separating the eggs of two or more species of anchovies. Since the phenomenon of decreasing diameter has occurred in other species, possible explanations are presented in the DISCUSSION, p. 307.

Larvae. Of all larvae taken during the summer, these were the most abundant with a total of 672, of which 520 were obtained in 1952 from July through October and 152 in 1953 from July through November. Their length ranged from 1.60–28.0 mm. The numerical ratio of larvae to eggs varied from 1:14.4 in 1952 to 1:5.5 in 1953; as in the case of menhaden larvae, sampling errors, failure to survive, and other factors probably account for this difference in the two years.

Inasmuch as most of the larvae were taken from stations of greatest egg abundance, the temperature range for the larvae was similar to that recorded for the eggs, excepting St. 5 on November 23, 1953, where the temperature had decreased to 12.90° C when the larvae were taken.

The anchovy tolerates a wide range of salinity, as shown by Massman (1954) who collected adults and juveniles as much as 40 miles upstream from brackish water in Virginia rivers. His recorded salinities varied between 0 and 12.6‰. As yet it is not known how far anchovies travel up Connecticut rivers.

During prolarval and early postlarval stages, *A. m. mitchilli* and *B. tyrannus* resemble each other for the most part, but there are two primary characteristics by which they may be separated: (1) proportionate distance from vent to tip of tail in total length, and (2) the time of finray differentiation. In *A. m. mitchilli* the distance from vent to tip of tail is between 25–34% of the total length whereas in *B. tyrannus* it is usually between 16–25%. In the former the dorsal fin rays begin to differentiate at 5–6 mm while in *B. tyrannus* they do not appear until 9 mm (Kuntz, 1914; Kuntz and Radcliffe, 1917).

An estimate of the early growth rate from the 1952–1953 data is impossible because the continual addition of newly hatched larvae masks recognition of resampled homologous groups and prevents accurate analysis. Perlmutter has estimated early growth as about 10 mm per month.

Anguilla rostrata[1] (Le Seuer); American eel.

According to Bigelow and Schroeder, young eels appear in March at Woods Hole, Mass. and in middle or late April in Narragansett Bay, Rhode Island. Nichols and Breder (1926) have reported that elvers were common in April in bays and estuaries of the New York area. In L. I. S., one elver 56.90 mm long was taken on January 27, 1953 at St. 8; not only did it appear earlier than usual but it was larger than those previously taken by others during the spring. It may have been a product of earlier spawning.

Eels have been collected by Perlmutter, by Greeley, and by Warfel and Merriman in their surveys; they have also been taken with the oyster vacuum dredge in June. The commercial catch of eels from Connecticut rivers (12,700 pounds in 1951) varies little from year to year.

Enchelyopus cimbrius (Linnaeus); Four-bearded rockling.

The rockling inhabits areas of soft bottom from the Gulf of St. Lawrence to Cape Fear, N. C. and is usually found at depths of

[1] The specific name is listed in Ege's (1939) revision of the genus *Anguilla*.

25–800 fathoms (Bigelow and Schroeder, 1953). West of Cape Cod, where it is known to occur in depths of 5.5 to 9.0 fathoms, it has been recorded in abundance, in L. I. S. in the area from Bridgeport to Larchmont (early summer, 1914) and in Smithtown Bay (Nichols and Breder, 1926). However, it has been taken so seldom in trawl nets in this area that it is unfamiliar to commercial fishermen.

Spawning. Spawning may begin any time from late winter to late spring, depending upon the latitude. The depths at which eggs and larvae have been collected vary. Dannevig (1918) noted that the rockling spawned in May and June in shallow areas on the east coast of Canada. More recently in Europe, Mańkowski (1948) reported that eggs were found from May through July in the deeper regions of the Gdańsk Gulf, Poland; in this case the spawning location may have been limited by the lower salinity inshore. In the southern New England area, Perlmutter collected eggs in May and June and juveniles from May until October in widely separated places of varying depths down to 48 fathoms. Merriman and Sclar (1952) collected no eggs from B. I. S. at any time, and John Colton, aboard the ALBATROSS III (personal communication), found no evidence of spawning in B. I. S. or in the area 4–5 miles south of Long Island during the spring of 1953. However, Colton did collect eggs and larvae 20 miles south of Long Island and in numerous deeper areas to the eastward. In L. I. S. the eggs and larvae were collected from late winter through late spring 1952–1953 in areas where the depth varied from 8 to 60 m (4.4–32.8 fathoms).

Eggs. The eggs of the rockling ranked fourth in total abundance, and from March to mid-May they were more common than those of any other species. A total of 595 eggs (0.74–1.12 mm) was taken during this survey.

In 1952, 377 eggs were taken from March 13 to June 11, and in 1953, 206 eggs were collected between March 2 and June 1. In 1954 they were found as early as February 10. The height of the spawning season in 1952 occurred during May and in 1953 during April.

The water temperatures when they were collected were lower than 13° C, which Battle (1929) found was the minimum limit for normal egg development. Battle, as a result of studies of the effect of various temperatures and salinities on the developing egg, reported that normal development for this species took place between 13–19° at a wide range of salinities, 18.6–45.0‰. As would be expected,

the percentage of eggs that developed normally declined rapidly as unfavorable conditions increased. She also discovered that the spawning peak in Passamaquoddy Bay occurred when the temperature was 9–10° (1930). In L. I. S. the surface temperatures during which the eggs first appeared were: 1952–3.10°; 1953—3.40°; and 1954—1.15°; at the end of the spawning season the warmest surface temperatures were: 1952—16.10°; 1953—13.85° C. During these times there was little temperature gradient. The rockling appeared to stop spawning in this area as the temperature of the water column approached the 13–19° optimum limit reported by Battle. The peak of spawning in L. I. S. occurred at temperatures of 8–9° in 1952 and of 6–8° in 1953.

Eggs occurred at all of the regularly sampled stations and at many of the 100- and 300-cruise (April, 1953) stations. At the regular stations, more eggs were collected at Sts. 1 and 5 than at 2 and 8, perhaps due to the more westerly position of Sts. 1 and 5. Supplementary data (see Table VI) from the long cruises suggest that the

TABLE VI. REGIONAL ABUNDANCE OF *E. cimbrius* EGGS† IN L. I. S. FROM MARCH 1952 THROUGH JUNE 1953

Eastern End		*Central Portion*			*Western End**	
St.	*Eggs/m³*	*St.*	*Eggs/m³*		*St.*	*Eggs/m³*
117	0.11	101	0.44		128	0.12
313	0.11	103	0.55		129	0.45
314	0.26	105	0.34		130	0.37
316	0.33	107	1.02		131	0.75
318	0.20	305	2.64			
320	0.09	309	0.57			
			1952	*1953*		
		1	1.09	0.68		
		2	0.57	0.49		
		5	1.39	1.19		
		8	0.64	0.16		

† No eggs taken at unlisted stations.
* Inclement weather prevented collections during the second half of the 300-cruise to the western end of the Sound.

rockling spawned more heavily in the western and central regions than in the eastern end of the Sound.

From an analysis of egg measurements of nearly every collection (Table VII), the monthly averages of egg diameter and size range for 1952 are nearly equal to those for 1953. However, a decrease in diameter was noted as each spawning season advanced. The recorded

TABLE VII. Summary of Measurements of *E. cimbrius* Eggs from L. I. S. from March 1952 through March 1954

	Eggs				Oil Globules			
Date	*No. meas.*	*Range*	*Av. diam.*	*Stand. dev.*	*No. meas.*	*Range*	*Av. diam.*	*% eggs with 1 oil glob.*
1952								
Mar.	63	0.88–1.12	0.95	.039	113	0.05–0.30	0.15	36.7
April	106	0.82–1.00	0.92	.040	172	0.10–0.25	0.15	64.0
May	163	0.75–0.95	0.84	.042	206	0.05–0.28	0.14	74.0
June	45	0.74–0.93	0.82	.037	52	0.05–0.22	0.15	90.0
1953								
Mar.	30	0.79–0.99	0.93	.040	21	0.18–0.30	0.22	41.0
April	120	0.83–1.00	0.92	.036	55	0.14–0.25	0.18	75.0
May	19	0.76–0.89	0.84	.022	114	0.11–0.28	0.16	73.0
June	8	0.81–0.85	0.83	.010	40	0.12–0.22	0.16	87.0
1954								
Feb.	3	1.00–1.05	1.01	.019	—	—	—	—
Mar.	9	0.90–1.03	0.97	.035	—	—	—	—
Totals								
1952	377	0.74–1.12	0.88	.037	543	0.05–0.30	0.15	—
1953	177	0.76–1.00	0.91	.033	230	0.11–0.30	0.17	—

decrease is large enough to be important in any future identification of these eggs.

Shrinkage of the eggs (see Discussion, p. 307) may be related to the length of time they are preserved before being measured, but in all probability other factors are more influential. In the case of the rockling, eggs taken from March through May 1952 and from March through June 1953 were measured 6–8 months after they were preserved whereas those taken in June 1952 during the 100-cruise were measured 15 months after preservation; measurements indicate that shrinkage had been uniform regardless of the time interval between preservation and measurement. A few of the March through June 1953 eggs were measured again after 12 to 16 months preservation, and they showed varying amounts of further shrinkage. During the spring of 1954, rockling eggs from special tows were immediately measured after preservation, after which they were put aside for comparative measurements at the end of 6 and 12 months. It appears that the greatest amount of shrinkage occurs within the first six months, but final results await further investigation.

Larvae. Eight larvae (2.00–4.90 mm) were taken in 1952–1953. Six were collected between May 1 and June 5, 1952, one on April 9, 1953, and one on April 15, 1953. The numerical ratio of rockling larvae and eggs was low when compared to that of either menhaden or anchovy. In 1952 this ratio was 1:63, in 1953 1:103. Possibly mortality during development is higher in the rockling than in that of the other two species.

According to Battle, incidence of abnormal development of the larvae, as indicated by contorted bodies and enlarged pericardial cavities, increased below 13°. As seen in Table VIII, most of our larvae were taken in water less than 13.0°, but only one abnormality was noted, that being an enlarged pericardial cavity in the larva from St. 8 (May 1, 1952).

TABLE VIII. Summary of Abundance and Size of *E. cimbrius* Larvae from L. I. S. in 1952–1953

Date	*St.*	*No. larvae*	*Length*	*Surf. temp. °C.*
1952				
V–1	8	1	2.35	8.80
V–8	5	1	3.50	10.45
V–21	5	1	4.90	11.57
VI–4	107	1	2.00	16.20
VI–5	113	1	2.90	16.00
VI–5	118	1	3.50	14.20
1953				
IV–9	320	1	2.35	7.80
IV–15	1	1	2.40	6.50

Battle also reported that larvae from Passamaquoddy Bay developed normally in salinities of 20 to 40‰. All of the L. I. S. specimens were taken from waters having salinities well within that range except for one taken at St. 113 (June 5, 1952), where the salinity was below 20‰; this specimen appeared to be normal. Separation of the effect of salinity and temperature on development is probably unrealistic when dealing with organisms not raised under experimental conditions. Our observations indicate that larval growth up to 4.80 mm will proceed normally in L. I. S. at temperatures below 13° and at the usual spring salinities.

Knowledge of growth and habits of young rockling is limited. Huntsman (1922) reported rockling of all sizes throughout the year in the Bay of Fundy from six fathoms (St. Mary's Bay) to considerable depths. Bigelow and Schroeder assumed that the young became demersal after a few months of pelagic life, at a length of 40–45 mm, since longer ones were never found in their plankton tows from the Gulf of Maine. Sumner, *et al.* (1913) reported ten juveniles about

1.5 inches (40 mm) long for April (1906) from the bottom of shallow water at Woods Hole, Mass. Perlmutter (1939) collected larvae and juveniles as large as 29 mm from May to July in his plankton tows from all regions of L. I. S. except the central portion; from July through October he took 75–219 mm specimens from bottom or near-bottom of the Huntington Bay-Coldspring Harbor area, near the region where the 1914-group was taken. It is of interest to note that he collected no individuals between 29 and 75 mm. Evaluation of early growth rates in the Sound is difficult because the age at various lengths is unknown and because collections of various length groups were inadequate. However, it appears that rockling reach a size of 75–80 mm in the first year and up to 200 mm or more by the end of the second year; juveniles spawned in shallow water may remain there a year or two before retiring to deeper water.

The rockling is the only member of the Gadidae which was taken in this survey. However, eggs and larvae of other species such as *G. morrhua*, *M. bilinearis*, and *Urophycis* spp. were collected by Merriman and Sclar from northeastern B. I. S., and *P. virens*, *M. aeglefinus*, and *E. cimbrius* were collected by Perlmutter in B. I. S. and south of Long Island. Juveniles of pollack, whiting, squirrel hake, and tomcod have been taken in L. I. S. with beach seine, oyster vacuum dredge, and Griek trawl. From the limited information available, the Sound appears to be a nursery but not a spawning ground for some gadids.

Syngnathus peckianus Storer; Pipefish

This species, a common resident of the shallow waters of L. I. S., has been found in abundance in many different localities by Greeley, by Perlmutter, and by Warfel and Merriman.

One postlarva (10.9 mm long) which had recently abandoned its parent was collected at St. 5 on July 8, 1952.[2] The postlarvae obviously lead a pelagic existence since they do not appear in the sublittoral zone until they are nearly 30 mm long (Warfel and Merriman, 1944; Merriman, 1947).

[2] Warfel and Merriman felt that the breeding season did not begin as early as March, as indicated by Bigelow and Welsh (1925), since they found no spawning individuals earlier than June. Of the pipefish taken aboard the oyster vacuum dredge from the Lighthouse Point area in New Haven Harbor on May 3, 1954, the mature females had nearly fully developed roe but were not ready to spawn whereas all mature males had empty brood pouches.

Menidia menidia notata (Mitchill); Silversides.

This species is a permanent resident and spawns from May until mid-July. Both postlarvae and juveniles have been collected previously in L. I. S., but since it usually remains in brackish, shallow weedy areas, few would be expected at our station locations.

One postlarva (5.3 mm long) was taken at St. 5 on June 24, 1952. Hildebrand (1922) claimed that only by its larger size at hatching and faster development in respect to size could the larvae of *M. m. notata* be distinguished from that of *M. beryllina cerea*. Since the latter is less abundant in this area, inhabits mostly fresh and brackish water, and would not be as well developed as *M. m. notata* at 5 mm, our L. I. S. specimen has been identified as *M. M. notata*.

Although Bigelow and Schroeder postulated that silversides require a temperature of 20° C for successful reproduction, the data from our own observations and from those of Perlmutter and of Warfel and Merriman suggest that *M. m. notata* reproduces successfully at 15° or lower.

Cynoscion regalis (Bloch and Schneider); Weakfish.

The weakfish, a consistent summer immigrant, appears at the eastern end of the Sound in May and in the central and western portions in June. However, it does not approach its peak of abundance until early July.

Spawning. According to our data this species spawned in 1952 from early June until late August and in 1953 from mid-July to mid-August. During the 100-cruise in June 1952 the eggs were found to be widely scattered throughout the Sound (see Fig. 1).

Eggs. In 1952, 93 eggs were taken between June 4 and August 26, with the peak of abundance in early June. In 1953, 30 eggs were collected between July 14 and August 11, with the peak near the end of July. These weakfish eggs were compared with Perlmutter's identified specimens and with material at the U. S. Fish and Wildlife Service Laboratory at Woods Hole. Unfortunately, we were not successful in our attempts to carry the eggs to the hatching stage under laboratory conditions.

Surface temperatures which coincided with these egg collections increased in 1952 from 13.80° C on June 5 at St. 115 to 22.70° at St. 5 on August 5. In 1953 the temperature range during spawning was well within the limits given for 1952. Although Sherwood and

Edwards (1901) reported that large adult weakfish appeared near Woods Hole when the temperature was only 10.0°, our data indicate that it does not spawn until the water is close to 13.0°. The combined salinity range for 1952 and 1953 was 18.40 to 27.73‰. Lower salinities in spring 1953 may have been partially responsible for the later appearance of eggs in that year.

Although the eggs were fairly well distributed throughout the Sound, more were collected during the 100-cruise (see Table IX) from central regions than from either eastern or western ends. Considering only the regular stations, slightly more eggs were taken at St. 2 during both years.

TABLE IX. Regional Abundance of *C. regalis* Eggs* in L. I. S. in 1952–1953

Eastern End		Central Portion			Western End	
St.	*Eggs/m³*	*St.*	*Eggs/m³*		*St.*	*Eggs/m³*
115	0.08	103	0.37		131	0.47
117	0.11	105	2.05			
		107	0.36			
		109	2.69			
		111	0.26			
			1952	*1953*		
		1	0.12	0.13		
		2	0.18	0.40		
		5	0.08	0.07		
		8	0.00	0.04		

* No eggs were collected at stations not listed.

In Table X, which lists the egg diameter for each month during the spawning season of 1952 and 1953, it is seen that the diameter remained constant throughout the spawning season. Both average size and range were alike for each year and variation in the standard deviation was only 0.04 and 0.02 mm, a considerably smaller range of variation than has been given in the literature. Welsh and Breder (1923) and Pearson (Hildebrand and Cable, 1934) reported size ranges of 0.70–1.10 and 0.70–1.13 mm respectively, while Merriman and Sclar (1952) gave a range of 0.68–1.18 mm.

According to Welsh and Breder (1923), the size of eggs from two different weakfish varied markedly; Hildebrand and Cable (1934), basing their argument on a statement by Delsman (1931), pointed out that the eggs may have been raised in waters of unequal density, which might produce a difference in size; however, they also pointed out that a large variation in size under identical conditions might

TABLE X. Summary of Measurements of *C. regalis* Eggs from L. I. S.

	Eggs				Oil Globules				
Date	*No. meas.*	*Range*	*Av. diam.*	*Stand. dev.*	*No. meas.*	*Range*	*Av. diam.*	*Stand. dev.*	*% with more than 1 globule*
1952									
June	88	0.76–0.96	0.84	.041	100	0.11–0.30	0.21	.039	18
July	2	0.78–0.82	0.80	.028	3	0.15–0.20	0.18	.027	50
August	2	0.82–0.90	0.86	—	2	0.18–0.20	0.18	—	0
1953									
July	24	0.75–0.87	0.83	.015	38	0.05–0.24	0.16	.060	46
August	6	0.83–0.95	0.87	.027	8	0.12–0.24	0.17	.044	12.5
Totals									
1952	93	0.76–0.96	0.84	.040	114	0.11–0.30	0.21	.039	19.5
1953	30	0.75–0.95	0.84	.018	46	0.05–0.24	0.16	.057	40

suggest the presence of two races. The large size variation in eggs from B. I. S., as indicated by Merriman and Sclar, may suggest the presence of more than one race, and Perlmutter postulated that local races may exist in L. I. S., but the relatively uniform measurements and short spawning season observed by us in L. I. S. may indicate the presence of only one.

The weakfish egg contains from one to six oil globules, which vary in size primarily according to the number of globules in the egg. Note in Table X, for 1953, that an increase in the percentage of eggs with more than one oil globule is reflected in the generally smaller size of the globules. When only one globule was present its size varied between 0.18–0.25 mm (average 0.23 mm) with a standard deviation of about 0.02 mm. When more than one per egg was present the minimum globule diameter decreased as much as 0.13 mm; the smallest globule measured 0.05 mm.

Larvae. In 1952 seven larvae (2.1–4.1 mm long) were taken during July and in 1953 seven more (2.8–4.4 mm) were collected in July and August. Throughout the summer these larvae were taken more commonly than those of any other species except *A. m. mitchilli* and *T. adspersus.* In fact, the numerical ratio between larvae and eggs was 1:2.1 in 1952 and 1:4.3 in 1953. Since it is quite unlikely that the larvae of *C. regalis* were more easily caught in the plankton nets than those of other species, either the eggs were inadequately sampled or the larvae survived better than those of other species. Most of the larvae were taken at St. 8, none were taken at St. 1, and only a few were found at Sts. 2 and 5.

According to Perlmutter and Warfel and Merriman, juveniles which remain inshore increase in length to 100 mm by mid-October. Previous investigators have reported finding juveniles in river mouths, and Raney and Massman (1953) took them during the summer in a surface tow five miles upstream from brackish water in the Pamunkey River, Virginia where the salinity was less than 5‰ but where tidal influence was still apparent. Their possible occurrence in Connecticut rivers has not been investigated.

Menticirrhus saxatilis (Bloch and Schneider); Kingfish

A summer visitor like the weakfish, kingfish usually appear at the eastern end of L. I. S. in June and in the central portion in June or July. They remain in the area until mid-October, by which time most of them have begun their southward journey.

Spawning. In southern New England waters the kingfish spawns close to shore from June until August. Perlmutter collected kingfish eggs during June and July in Peconic-Gardiners Bay and in inlets near Moriches Bay, Long Island, which, according to Welsh and Breder (1923), are habitats preferred by spawning kingfish. Merriman and Sclar collected no kingfish eggs in their samples from B. I. S. Our data indicate that kingfish spawned at the inshore stations from early June until mid-July.

Eggs. In both years, 27 eggs (0.75–0.91 mm) were taken; in 1952 10 were taken between June 6 and July 15, and in 1953 17 were taken between July 7 and 21. All of them were collected at inshore Sts. 1 and 8 (see Table XI), and more might have been collected had the samples been taken from even shallower areas. At present, *M. saxatilis* appears to be one of the least abundant pelagic spawners of the area sampled.

Temperature and salinity ranges when these eggs were collected were small. For both years combined, the water temperature ranged from 17.00 to 22.75° C, the salinity from 24.79 to 26.71‰. On the basis of Perlmutter's data as well as our own, kingfish apparently do not spawn in water below 15°; more probably it waits until the temperature approaches 17°.

From measurements of all kingfish eggs collected (Table XI), it appears that a decrease in diameter occurred from June through July. The diameters agreed well with the range of 0.76–0.92 mm given by Welsh and Breder (1923).

Larvae. Only one larva, 3.7 mm long, was collected, that being taken at St. 5 on August 19, 1952. Although the last eggs in 1952 were collected on July 8, spawning undoubtedly persisted longer than our data indicate; Warfel and Merriman also felt that spawning continued beyond mid-July.

Stenotomus chrysops (Mitchill); Scup

During the last decade this species increased tremendously in commercial importance in the Connecticut and Rhode Island fisheries. Statistics show that in 1940 the Connecticut catch was only 485,700 pounds with a value of $19,753, whereas in 1950 it was 1,573,900 pounds with a value of $104,377. In Rhode Island the increase was even more striking: 1,398,700 pounds in 1940 (value $22,521) to 4,467,000 pounds in 1950 ($234,553). These data would indicate that either the commercial demand for scup increased during this

TABLE XI. SUMMARY OF THE RELATIVE ABUNDANCE AND SIZE OF *M. saxatilis* EGGS FROM THE REGULAR STATIONS IN L. I. S.

Date	Eggs: *No. meas.*	Eggs: *Range*	Eggs: *Av. diam.*	Eggs: *Stand. dev.*	Globules: *No. meas.*	Globules: *Range*	Globules: *Av. diam.*
1952							
VI-6	1	—	0.91	—	7	0.06–0.08	—
VII-8	8	0.76–0.84	0.81	.030	6–20 (Av. 12)	0.07–0.12	0.10
VII-15	1	—	0.75	—	15	—	0.10 largest
1953							
VII-7	15	0.75–0.85	0.81	.030	8–22 (Av. 16)	0.06–0.14	0.09
VII-21	2	0.80–0.83	0.81	.020	15, 18	—	0.10 largest

Eggs/m³	*St. 1*	*2*	*5*	*8*
1952	0.11	0.00	0.00	0.01
1953	0.33	0.00	0.00	0.04

decade or its abundance in southern New England waters had increased, or both.

This species, a summer visitor to this area, is found in water temperatures higher than 7.2° C; it usually arrives in mid-spring and departs in October or November.

Spawning. The scup is a summer spawner. Perlmutter's samples from the vicinity of Long Island contained scup eggs from May until August. Our egg collections from L. I. S. proper indicate shorter spawning periods, from the end of May to the end of July and from the beginning of June to the first week of July in 1952 and 1953 respectively.

Eggs. In 1952, 172 eggs were collected from May 29 to July 22, and in 1953, 37 eggs were taken between June 1 and July 7, giving a total of 209. Their size range was 0.85 to 1.15 mm. The number of eggs per cubic meter in 1952 was nearly three times greater than that in 1953.

Since the scup is demersal, seldom rising far off the bottom (Bigelow and Schroeder), its spawning habits would be influenced more by bottom than by surface temperatures. But, since the eggs rise when laid, they would be affected more by surface temperatures. Therefore, both bottom and surface temperature ranges are listed. In 1952, bottom temperatures from the end of May until July 22 ranged between 10.10 and 17.80° while those at the surface varied from 13.30 to 22.75° C. In 1953, bottom temperatures during the spawning period ranged from 11.25° to 17.25°, while those at the surface were 13.45 to 20.70°. Though taken occasionally in water below 11°, scup eggs are not often found until the bottom temperature has risen above this point.

When data from all of L. I. S. is broken down into regional groupings, as in Table XII, it is seen that *S. chrysops* eggs were present only in the eastern and central portion of the Sound, particularly in the latter; no eggs were collected west of Long. 73° 04′ W, that is, west of a line from Port Jefferson, Long Island to Bridgeport, Conn. (See Fig. 1). Of the regularly visited stations, scup eggs were most abundant at St. 8. The greater number of eggs at this Station and at St. 2 as well may be due to the more easterly positions of these two stations. Perlmutter recorded no eggs west of Long. 73° 12′ W, but he did find a large quantity in Peconic-Gardiners Bay and eastward to Southwest Ledge off Montauk Pt. Since it is believed that most adult scup spawn on this coast in relatively shallow water, it seems strange that Merriman and Sclar found none in northeastern B. I. S.

Identification of these eggs was difficult for two reasons, first, because of the similarity between eggs of *S. chrysops* and *M. bilinearis*, and second, because of the discrepancies in the literature and in our data concerning the size of these eggs. Scup and whiting not only spawn during the same seasons but produce eggs which appear similar, with an overlap in size of both egg and globule. However, once the embryo is well developed there is less difficulty; although the dorsal side of the head in these two species has similar pigmentation, the whiting embryo has a distinct black vertical band located across

TABLE XII. Regional Abundance of *S. chrysops* Eggs from L. I. S. in 1952–1953 None Were Taken from the Western End

Eastern End		Central Portion		
St.	*Eggs/m³*	*St.*	*Eggs/m³*	
113	0.17	101	0.09	
115	1.00	107	0.22	
117	0.68	109	2.54	
118	0.18	111	0.17	
119	0.58	123	3.36	
121	0.47	125	0.38	
		126	0.22	
			1952	*1953*
		1	0.06	0.06
		2	0.28	0.13
		5	0.05	0.09
		8	0.93	0.44

its caudal end from one-half to one-third of the distance from the tip of the tail to the vent; this is lacking in scup embryos. No eggs of *M. bilinearis* were collected in L. I. S.

Regarding discrepancies in egg size, Kuntz and Radcliffe (1917) recorded a range of 0.85–0.90 mm for scup taken at Woods Hole, and Perlmutter gave measurements of 0.80–0.96 mm for his 66 scup eggs. Our collections, however, show a range of 0.85–1.15 mm. In view of the larger size of our eggs, their identification was checked against those obtained from stripped fish taken in a fish trap near Quisset Harbor at Woods Hole (see Table XIII for pertinent data). The eggs obtained at Woods Hole were taken on two different dates and were preserved in three different strengths of formalin. No apparent difference in egg size was caused immediately by the different concentrations of formalin, but future measurements of these same eggs are contemplated to ascertain whether the combined effect of time and formalin concentration will cause shrinkage. The average diameter of the eggs from Woods Hole was greater than the maximum given by Kuntz and Radcliffe, but it was slightly less than that of our 1952 eggs and about equal to that of our 1953 eggs. Since the eggs were stripped and fertilized prior to natural spawning, they may have been smaller than they would have been normally, and furthermore, they may have had less time to absorb the water from their surroundings. Oil globules from the stripped eggs ranged from 0.10–0.20 mm and averaged 0.18 mm. Usually only one globule was present in a single egg.

TABLE XIII. Comparison of the Size of *S. chrysops* Eggs Obtained at Woods Hole, Mass. and Preserved in Three Different Concentrations of Formaldehyde in 1954

	Percent formalin		
June 21	*3*	*5*	*10*
N. meas.	—	—	50
Range	—	—	0.89–0.99
Av. diam.	—	—	0.94
Stand. dev.	—	—	.024
June 30, and July 2			
Eggs			
No. meas.	12	12	14
Range	0.92–0.96	0.89–0.95	0.90–0.96
Av. diam.	0.94	0.93	0.93
Stand. dev.	.01	.017	.022
Oil Globules			
No. meas.	12	13*	14
Range	0.16–0.20	0.10–0.20	0.16–0.20
Av. diam.	0.18	0.18	0.18
Stand. dev.	.018	.018	.014

* One egg with two oil globules.

As shown in Table XIV, the average size of the L. I. S. scup eggs was 0.99 mm in 1952 and 0.93 mm in 1953, and the average size of the oil globule was 0.22 mm. Little decrease in egg diameter was noted throughout either spawning season.

Larvae. Two recently hatched larvae (3.00 and 3.05 mm long) were taken on July 1 and 15 at St. 2. On July 7 and 21, 1953, two more (2.50 and 3.20 mm) were taken at St. 8. Merriman and Sclar found only one larva in B. I. S. (in July). Larvae and juvenile scup are rarely mentioned in the literature on L. I. S. though taken in numbers from Peconic-Gardiners Bay and along the south shore of

TABLE XIV. SUMMARY OF MEASUREMENTS OF *S. chrysops* EGGS FROM L. I. S. IN 1952–1953

Date	Eggs				Oil globules			
	No. meas.	Range	Av. diam.	Stand. dev.	No. meas.	Range	Av. diam.	Stand. dev.
1952								
May	1	—	0.95	—	1	—	0.28	—
June	156	0.85–1.15	1.00	.047	153*	0.18–0.27	0.23	.017
July	9	0.90–0.98	0.95	.006	9	0.15–0.23	0.19	.010
1953								
June	15	0.91–1.10	1.00	.025	16†	0.16–0.25	0.21	.028
July	21	0.85–0.96	0.92	.030	21	0.14–0.22	0.20	.022
Total								
1952	166	0.85–1.15	0.99	.045	163	0.15–0.28	0.23	.017
1953	37	0.85–1.10	0.93	.030	38	0.14–0.25	0.20	.027

* 3 oil globules were squashed.
† 2 eggs had 2 oil globules apiece.

Long Island. Larval development may not be successful in the two Sounds, but more likely juveniles, not abundant in the previously sampled shore-line communities, remain in deeper water or migrate from the Sound during late summer.

Tautogolabrus adspersus (Walbaum); Cunner
Tautoga onitis (Linnaeus); Tautog

These two species are considered jointly because the eggs are nearly identical in appearance and occur at approximately the same time and location. Both species are common residents of L. I. S., particularly in water of less than 10 fathoms. The cunner frequents pilings, floats, and eel grass (*Zostera*) during summer, and the tautog haunts mussel beds and particularly rocky places such as breakwaters and reefs.

Spawning. The spawning season of the cunner is sometimes more prolonged than that of the tautog, as in 1952 in L. I. S., when our observations confirmed those of Perlmutter. In 1953, however, the spawning season of these two species was essentially the same, apparently due to a shorter spawning season of the cunner. Cunner eggs were taken in 1952 from mid-May until the second week of October while tautog eggs, initially found on the same day, were taken until mid-July only. In 1953, eggs of both species were found from the end of May until mid-August.

Eggs. A total of 2,105 cunner eggs (0.76–1.03 mm) and 340 tautog eggs (0.91–1.15 mm) were taken in the two years (Table II): in 1952, 848 cunner eggs between May 21 and October 8, 211 tautog eggs from May 21 to July 15; in 1953, 1,257 cunner eggs and 129 tautog eggs between May 25 and August 18. In abundance, cunner eggs were second only to those of *A. m. mitchilli*.

Although Johansen (1925) found cunner eggs in the Gulf of St. Lawrence in water of 4.79° C, Perlmutter took them at a minimum of only 7.89°. In L. I. S., neither cunner nor tautog eggs were taken at temperatures below 10.01°. In 1952 and in 1954 they were taken when the water reached 10°, but in 1953 they were taken 10 days after the water reached this temperature. Some other factor may have caused this 10-day difference. Possibly it was due to a lower salinity that resulted from heavy precipitation in 1953.

Both cunner and tautog spawned throughout the entire Sound (see Fig. 1, Table XV). According to the 100-cruise data, the cunner spawned more heavily at the western end than at either the central or eastern portions of the Sound, and furthermore, it spawned more heavily in all regions than did the tautog. The spawning of the tautog at the western end of the Sound was almost as great as that at the eastern end, but in the central area it was considerably less than that at either end. The data from the regular stations confirm the opinion that both species tend to be inshore spawners, the cunner more so than the tautog. The fluctuations in egg abundance at the stations were notable, as indicated by a ten-fold increase of cunner eggs at St. 2 in 1953.

The annual variation of these species (see Table XV) was of the same order of magnitude as that of weakfish, scup, kingfish, and menhaden, but it was less than that of the anchovy and greater than that of the rockling. Greater variation in egg abundance is expected among schooling species, but such was not always the case. Whereas menhaden and anchovy are schooling forms, cunner and tautog are semischooling, but cunner egg collections sometimes fluctuated as much as those of the anchovy. While less eggs of menhaden, anchovy, rockling, et al. were taken in 1953 than in 1952, less eggs of the cunner were taken in 1952 than in 1953. It appears that the number of eggs of this shallow water fish at any one station does not depend on variations in surface movements produced by differences in prevailing winds and recognized by changes in the inshore horizontal density gradient (see Riley's PHYSICAL OCEANOGRAPHY in this issue). In 1952, when there was considerable offshore water movement, more eggs

TABLE XV. REGIONAL ABUNDANCE OF *T. adspersus* AND *T. onitis* EGGS AND LARVAE FROM L. I. S. IN 1952–1953

EGGS

Eastern End		
St.	*T. adsper.* *Eggs/m³*	*T. onitis* *Eggs/m³*
113	0.00	0.26
115	0.08	0.92
117	0.79	0.45
118	5.97	2.59
119	0.86	0.48
121	1.16	0.35
Total	1.58	0.95

Central Portion		
St.	*T. adsper.* *Eggs/m³*	*T. onitis* *Eggs/m³*
101	1.77	0.71
103	0.09	0.00
105	0.00	0.09
107	0.00	0.07
111	0.86	0.17
125	0.89	0.76
126	10.44	0.55
Total	1.84	0.17

Western End		
St.	*T. adsper.* *Eggs/m³*	*T. onitis* *Eggs/m³*
128	1.57	0.96
129	3.28	1.19
130	3.68	0.62
131	4.34	1.31
241	0.09	0.00
Total	3.24	0.73

	T. adsper.		*T. onitis*	
	1952	*1953*	*1952*	*1953*
1	1.1	1.6	0.72	0.22
2	0.11	1.1	0.00	0.21
5	0.14	0.11	0.04	0.00
8	4.5	8.5	0.36	0.90

LARVAE

	T. adspersus		*T. onitis*	
	No.	*Size mm*	*No.*	*Size mm*
1952				
St. 1	6	2.7–3.5	—	—
2	1	2.4	—	—
5	0	—	—	—
8	1	2.5	—	—
241	1	2.8	—	—
243	1	2.5	—	—
244	1	2.7	—	—
1953				
St. 1	2	3.2–3.8	—	—
2	2	3.1–4.6	—	—
5	0	—	—	—
8	1	2.7	1	2.5

were collected at St. 1 (inshore) than elsewhere, while in 1953, when there was less offshore movement, more eggs were taken at St. 2 (offshore). However, at St. 8 (inshore) twice as many eggs were taken in 1953 than at the same station in 1952. No definitive explanation for differences in egg abundance between 1952 and 1953 has been ascertained.

Until the embryo is developed, size is the only criterion by which the eggs of these two species may be distinguished. Previous workers have recorded a considerable range in diameter for cunner and tautog eggs. Kuntz and Radcliffe reported that living eggs of the cunner from Woods Hole ranged from 0.75 to 0.85 mm and those of the

tautog from 0.90 to 1.00 mm. For stripped cunner eggs from Peconic Bay, Perlmutter obtained a range of 0.84–1.00 mm and an average of 0.96 mm; for 106 naturally spawned tautog eggs, the range was 1.00–1.20 mm. Merriman and Sclar collected only cunner eggs in B. I. S., the majority of which varied between 0.75 to 0.85 mm, with some as large as 1.30 mm. They assigned the largest eggs to the cunner rather than the tautog because the eggs of two different species in the same haul would not be consistently in the same stage of development and because more cunner larvae were collected. In L. I. S., the cunner egg diameters (see Table XVI) were smaller than those given by

TABLE XVI. SUMMARY OF MEASUREMENTS OF *T. adspersus*(A) AND *T. onitis*(O) EGGS FROM L. I. S. IN 1952–1953

Date	*No. meas.*		*Range*		*Av. diam.*		*Stand. dev.*	
	A	*O*	*A*	*O*	*A*	*O*	*A*	*O*
1952								
May	106	26	0.82–0.95	1.01–1.14	0.90	1.09	.028	.041
June	475	148	0.76–1.03	0.95–1.14	0.87	1.04	.032	.030
July	131	4	0.75–1.00	0.92–0.99	0.84	0.95	.050	.035
Aug.	12	0	0.81–0.93	—	0.84	—	.075	—
Sept.	1	0	—	—	0.81	—	—	—
Oct.	1	0	—	—	0.84	—	—	—
1953								
May	26	16	0.86–0.95	1.01–1.15	0.91	1.09	.028	.033
June	113	47	0.78–0.95	0.97–1.14	0.88	1.05	.033	.033
July	110	5	0.76–1.00	0.94–1.02	0.84	0.99	.046	.025
Aug.	21	3	0.78–0.85	0.91–0.98	0.82	0.94	.020	.036
Totals								
1952	726	178	0.76–1.03	0.94–1.15	0.86	1.05	.050	.030
1953	270	71	0.76–1.00	0.91–1.15	0.86	1.05	.040	.030

Perlmutter but they agreed well with the figures of Kuntz and Radcliffe. Possibly the difference between Perlmutter's measurements and ours is due to the presence of two races of cunners. The mean diameter and range of tautog eggs in L. I. S. were greater than the figures given by Kuntz and Radcliffe but were similar to those of Perlmutter.

Table XVI shows that there is considerable overlap in the size range of the eggs of these species. In May and June the size difference was sufficient for distinction, but in July and August, the critical months, the egg size was similar enough so that clear-cut differentiation was difficult. During the first two weeks of July, the number of tautog eggs between 0.90–1.00 mm increased from 15 to 80% of the total number of tautog eggs, whereas the number of cunner eggs in this range, originally 15% of the total number of cunner eggs, decreased to 10%. Thus, the overlap at this size range was much greater in July and August than at any earlier time of the year. Also, in July and August 1952 a few large eggs were listed as cunner (Table XVI). In 1952, relative to June, the standard deviation increased in July and August, particularly so in the latter month, which indicates that either the variation in egg size increased greatly or the eggs were incorrectly identified. However, although the standard deviation in July 1953 was greater than that in June 1953, it was less than that of July 1952; in August 1953 it decreased relative to August 1952 and July 1953. In further investigation of this question, two unpreserved tows from Sts. 1 and 3 on July 8, 1954 were examined. It was found that larvae of the tautog hatched from the larger eggs and of the cunner from the smaller ones. It was concluded that: (1) difficulty in separation may have been partially responsible for such a large standard deviation in cunner egg measurements in July and August; (2) the larger eggs found by Merriman and Sclar (those over 1.00 mm) may have been tautog eggs or they may have been cunner eggs from a group in B. I. S. and Peconic Bay which normally produces larger eggs. On the basis of our present data, the presence of more than one race of cunners cannot be postulated for L. I. S.

Larvae. In all collections, only one tautog larva (2.5 mm) was taken, that at St. 8 on July 21, 1953, whereas 16 cunner larvae were taken from the regular stations and from three stations at the western end of the Sound: 11 (2.4–3.5 mm) in 1952 between August 12 and October 9 (Table XV) and 5 (2.65–4.6 mm) in 1953 between July 7 and 28. The numerical ratio of cunner larvae to eggs was 1:77 in 1952 and 1:257 in 1953.

In 1952, surface temperatures where cunner larvae were found ranged from 22.80° at St. 2 on August 12 to 19.10° C at St. 243 on October 9. The surface salinity during this period varied between 27 and 30‰.

According to reports, juvenile cunners in this area, probably attaining a size of 40–45 mm by autumn (Johansen, 1925), are widely distributed but only moderately common in beach seine hauls. On the other hand, the tautog is taken more commonly with this gear and is 15–48 mm by August. As to their whereabouts, Baird (1855) presumably found juvenile tautogs in New Jersey rivers; Bean (1903) and Johansen (1925) reported that juvenile cunners 1–2 inches long

prefer sandy bottoms near shallow river mouths. Gunter (1942) reported neither species as occurring in both fresh or sea water. Juveniles of these two species in L. I. S. may not prefer a salinity much lower than that found near river mouths in the spring.

Ammodytes americanus De Kay; Sand eel

This species, a permanent resident of L. I. S., is demersal. Greeley found that adults prefer the sandy or gravelly beaches of the north shore of Long Island to those of the south shore. This species was taken in neither the beach seine hauls at Morris Cove nor in the oyster dredge.

Spawning. On the east coast of North America the sand eel spawns from Canada to Virginia; south of Cape Cod its spawning is limited to the inner half of the continental shelf and to regions where the bottom temperature is 9° C or lower (Sette, unpubl.). The exact time of spawning has not been determined, but postlarvae have been taken from January to March in the Gulf of Maine (Bigelow and Schroeder) and from March to May at Woods Hole (Sumner, *et al.*, 1913). In L. I. S. the larvae were taken from December to May. As in the case of the European sand eel, the eggs are probably demersal, which may account for their absence in the L. I. S. collections. Estimates of the initial occurrence of spawning of the American species is therefore deduced from studies of the speed of growth of the embryo and larva of the European sand eel.

Ehrenbaum (1909), quoted by Einarsson (1951), has given the only estimate of embryonic development time. According to Ehrenbaum, the spawning of *A. tobianus* occurs in autumn at about 20 m depth; the eggs are submersal and stick to sand grains on the bottom. Some larvae emerge in autumn, but the majority do not appear until early the following year, from January–March. According to our data, spawning in L. I. S. starts during the last two weeks of November, or earlier, and continues to mid-February or March.

Eggs. None.

Larvae. A total of 506 larvae, ranging in length from 3.10–33.5 mm, were collected in L. I. S. in 1952–1954. In 1952, 343 were taken between March 5 and April 21, 87 were collected between December 15, 1952 and May 13, 1953, and 76 between December 9, 1953 and April 27, 1954. The peaks of abundance occurred in March of 1952 and 1953 and in January–February 1954 (Table I). Compared with other species in our collections, *A. americanus* ranked second in relative abundance; only *A. m. mitchilli* were taken in greater quantity. By May the larvae had disappeared, presumably to the bottom in shallower areas.

The temperature of the water column in L. I. S. at the time of the initial appearance of the larvae, during the first two weeks of December, ranged from 10.05–7.75° C. These figures agree fairly well with those recorded by Sette (unpubl.) and Einarsson (1951) for the first appearance of larvae of *A. americanus* and *A. lancea lancea* farther offshore in northeastern North America and Iceland respectively. In 1953, temperatures in L. I. S. in early December were higher, between 10.80–8.25°. Despite small temperature fluctuations, larvae were taken in L. I. S. two to three weeks after the initial occurrence of positive temperature gradients in the fall, and spawning terminated in spring at about the time thermal stability was established. In 1953 spawning seems to have come to an end somewhat earlier.

TABLE XVII. Regional Abundance of *A. americanus* Larvae in L. I. S. in 1952–1954
None Were Taken at the Eastern End

Central Portion		Western End	
St.	*Larvae/m³*	*St.*	*Larvae/m³*
303	0.19	422	0.24
403	0.11		
418 (I–IV)	0.37		
518	0.07		

	1952	*1953*	*1954*
1	0.27	0.04	0.16
2	2.30	0.13	0.10
5	2.70	0.25	1.20
8	0.32	0.03	0.03

The salinity tolerance of *A. americanus* is not known. In L. I. S. the salinities during the first two weeks of December in 1952 and 1953 varied between 27.98–28.76‰ but in April the larvae encountered salinities as low as 24.18‰.

Larvae were found more abundantly in the central portion of the Sound than in the eastern and western ends (Fig. 1, Table XVII). During the 300-cruise to the eastern area in April 1953, no larvae were taken except at St. 303, near St. 2. During the second half of the 400-cruise to the western end in April 1954, only two were taken at St. 422 off S. Norwalk. By far the greatest number was collected

at the regular offshore stations where the depth is more than 15 m. Though reported to spawn at 10 fathoms, it appears that sand eels do spawn in shallower water.

The number of larvae taken at the regular stations in March–April 1952 far exceeded those taken from December–May in either 1953 or 1954. Such fluctuations may be partially understood when it is considered that sand eels form huge schools which probably move about and spawn at different localities.

The lengths of 462 larvae ranged from 3.1 with yolk sac to 33.5 mm with fins almost completely differentiated. Table XVIII presents the distribution and abundance of size categories after the method of Einarsson: 1–4, 5–9, 10–14, . . . 30–34 mm. A majority of the larvae were in the 10–14 mm size, with the 5–9 mm category a close second. When seasonal size progression is considered, variations between the different years are noted. In March 1952 our collections included a few short larvae of a size not collected later than January in subsequent years; this would seem to indicate either slower embryonic development, delayed spawning, or a prolonged spawning season in 1952. In March–April 1953 we found only the larger larvae which were not taken before January, although, as indicated earlier, larvae first appeared in the collections during the second week of December; the presence of only larger larvae in March–April indicates either rapid development or a shorter spawning season in 1953 than in 1952.

From December–May the average length increased about 3–5 mm a month, but this figure is not a measure of the actual growth rate, first, because any noticeable increase is always influenced by newly hatched individuals that enter the older population, and second, because growth may be exceedingly uneven and significantly varied in the different months due to various factors such as water temperature, etc. The decrease in percentage of those in the larger size categories (Table XVIII) implies that the sand eels either migrate to an unsampled area, show a greater ability to escape the net at increasing sizes, or suffer an increasing mortality at the larger sizes. If the larvae grow as slowly as it appears, then they are probably subject to a high degree of predation throughout their entire early growth rather than at just one stage. Hence, net escapement probably accounts in large measure for the decrease in percentage of larger larvae as compared with those of the 5–9 mm group.

TABLE XVIII. NUMBER AND PERCENTAGE OF *A. americanus* LARVAE BY MM SIZE CATEGORIES DURING EACH MONTH OF THE SPAWNING SEASON IN L. I. S. FROM 1952–1954

Date	*1–4*	*5–9*	*10–14*	*15–19*	*20–24*	*25–29*	*30–34*
1952							
Mar.	5 2%	69 28%	123 49%	50 20%	2 0.8%	0 0%	0 0%
Apr.	0 0%	15 28%	18 34%	13 25%	6 11%	1 2%	0 0%
Dec.	0 0%	3 100%	0 0%	0 0%	0 0%	0 0%	0 0%
1953							
Jan.	0 0%	5 63%	3 37%	0 0%	0 0%	0 0%	0 0%
Feb.	0 0%	0 0%	6 86%	1 14%	0 0%	0 0%	0 0%
Mar.	0 0%	0 0%	7 50%	7 50%	0 0%	0 0%	0 0%
Apr.	0 0%	0 0%	1 25%	3 75%	0 0%	0 0%	0 0%
May	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	1 100%
Dec.	6 13%	41 87%	0 0%	0 0%	0 0%	0 0%	0 0%
1954							
Jan.	1 5%	10 50%	9 45%	0 0%	0 0%	0 0%	0 0%
Feb.	0 0%	12 36%	18 55%	3 9%	0 0%	0 0%	0 0%
Mar.	0 0%	2 13%	3 19%	5 31%	4 25%	0 0%	0 0%
Apr.	0 0%	0 0%	2 40%	0 0%	3 60%	0 0%	0 0%
Total							
462	12 3%	157 34%	193 42%	83 18%	15 3%	1 0.2%	1 0.2%

Sette (unpubl.), following an observation by Russell (1926) that the larger larvae migrate diurnally, found that the total ratio of *A. americanus* larvae in surface waters to deeper layers over the continental shelf was 18–1 and that many more were at the surface at night than during the day. However, he observed no depth preferences associated with larval size. In L. I. S. six tows with closing nets at two levels were taken March 30, 1954, and, although few larvae were collected, the results indicate that the sand eel, while preferring the surface, was present in the entire water column both day and night. It seems likely that daylight escapement is a more important variable than diurnal migration, as in the case of Silliman's (1943) results with *Sardinops caerulea*.

The relationship between the American and European sand eels has never been completely established, but the spawning seasons, larval development, and vertebral numbers of *A. americanus* and the lesser sand eels (*A. lancea*-group) of Europe and Iceland are sufficiently similar to warrant consideration of *A. americanus* as a subspecies. Einarsson (1951) found that 57 larvae of *A. lancea lancea* (*tobianus*) over 20 mm in length, taken in Icelandic waters, had a mean vertebral count of 63.03 while all other Icelandic species had over 69. Six larvae from L. I. S. had an average vertebral count of 62.67.

Scomber scombrus Linnaeus; Mackerel

Spawning. Merriman and Sclar collected mackerel eggs in B. I. S. in April–June, and Sette (1943), in discussing its spawning localities, wrote that ". . . as far as is now known, no spawning takes place in the enclosed bays and sounds west and south of Block Island." However, we collected a small number in L. I. S. in May and June, hence there is at least a limited amount of spawning within this area, since it is highly unlikely that the eggs in our collections were transported from B. I. S. The net transport of bottom water is slower than the period of egg development.

Bigelow and Schroeder indicated that mackerel do not converge on special breeding grounds but spawn wherever they happen to be. It is likely then that some are present in the Sound at the time of spawning, though the number is probably quite limited and would not attract the attention of commercial fishermen as in B. I. S.

Eggs. Eight were collected in the first week of June in 1952 between Sts. 101 (1) and 113; only one was taken in 1953, at St. 2 on May 13.

The water temperatures which coincided with these collections ranged from 16.00–17.55° C in 1952; in 1953, the surface temperature at St. 2 was as low as 13.80°. The reported temperature ranges in the literature are 13.94–17.50° (Perlmutter), 7.3–17.6° (Sette), and 4.0–app. 14.5° (Merriman and Sclar). Obviously the temperatures just given for L. I. S. are within the upper limits set by Sette.

The salinity during the spawning period ranged from 18.15 to 24.42‰, which is much lower than that reported for B. I. S. or other areas discussed above. No evidence has been found to indicate that these salinities were detrimental to embryonic development.

Egg diameters in 1952 ranged between 1.14–1.20 mm, averaged 1.16 mm, and had a standard deviation of .014; the oil globules ranged from 0.24–0.30 mm, averaged 0.28 mm, and had a standard deviation of .01 mm. The egg taken in 1953 was 1.29 mm, the oil globule 0.35 mm. These egg measurements are in agreement with Sette's figures but not with the lower limits given by Merriman and Sclar. On the whole, the globules were slightly smaller than those measured by Sette and by Merriman and Sclar. These eggs were compared with identified material at the U. S. Fish and Wildlife Service Laboratory at Woods Hole.

With so few eggs collected, it is not surprising that larvae were not taken. The mackerel is apparently one of the least abundant members of the spawning population in the Sound.

Poronotus triacanthus (Peck); Butterfish.

This species, a summer visitor to L. I. S., arrives in May and stays until October. While it is present in this area, it is frequently taken in small numbers by commercial fishermen.

Spawning. Our data indicate a shorter spawning season in L. I. S. than in B. I. S. Eggs were taken from L. I. S. from mid-June to mid-August only, whereas in B. I. S. they were taken from June through September (Merriman and Sclar). It appears that this species spawns more heavily offshore than in shallow enclosed areas.

Eggs. In 1952, 25 butterfish eggs (0.69–0.80 mm) were collected intermittently from June 19 until August 19. In 1953, only one egg (0.70 mm) was collected, on July 14. The numbers taken in these two years probably reveal either a variance in the abundance of the schools or a sampling deficiency. The temperature during the 1952 spawning season ranged from 16.40–22.30° C.

From our limited data (Table XIX), butterfish apparently preferred to spawn offshore at Sts. 2 and 5 rather than inshore at Sts. 1 and 8. Measurements in this table are insufficient to demonstrate a decrease in average egg diameter with progression of the spawning season, but the size range agrees well with that found in the literature.

Difficulties in separating butterfish eggs from those of squirrel hake (*U. chuss*) have been adequately reviewed by Merriman and Sclar. Since Merriman and Sclar's butterfish eggs could not be located, the eggs from L. I. S. which we considered to be those of the butterfish were compared with specimens taken by Sette in 1929

as well as with others taken aboard the ALBATROSS III in 1953 (stored at the U. S. Fish and Wildlife Service Laboratory at Woods Hole). Examination of butterfish and hake eggs together revealed that differences existed in both diameter and embryonic pigment. The dorsal embryonic pigmentation of the hake eggs, which are smaller than butterfish eggs, appeared in large paired blotches, much as illustrated by Perlmutter (1939), whereas that of the butterfish eggs was less pronounced and consisted of smaller irregular dots. No eggs of *U. chuss* were collected at any time in L. I. S. by us or by Perlmutter.

TABLE XIX. ABUNDANCE AND SIZE OF *P. triacanthus* EGGS FROM L. I. S. IN 1952–1953

SIZE

	Eggs				Oil globule			
Date	*No. meas.*	*Range*	*Av. diam.*	*Stand. dev.*	*No. meas.*	*Range*	*Av. diam.*	*Stand. dev.*
1952								
June	6	0.74–0.78	0.75	.023	9	0.14–0.20	0.17	.011
July	18	0.70–0.80	0.74	.025	19	0.15–0.22	0.18	.010
Aug.	1	—	0.69	—	1	—	0.16	—
Total	25	0.69–0.80	0.75	.023	29	0.14–0.22	0.18	.014
1953								
July	1	—	0.70	—	2	—	0.15	—

ABUNDANCE/M³

St.	*1952*	*1953*
1	0.01	0.00
2	0.21	0.00
5	0.15	0.04
8	0.04	0.00

In comparing butterfish and weakfish eggs at the lower size ranges, we found less pronounced differences than those between butterfish and hake eggs. Eggs of both butterfish and weakfish were collected simultaneously from the same localities in L. I. S., and measurements of our butterfish eggs (see Table XIX) agreed well with those given in the literature: a range of 0.69–0.80 mm for the eggs and an average diameter of 0.17–0.21 mm for the usually single oil globule. Although the size range of weakfish eggs in L. I. S. was 0.75–0.96 mm, for comparative purposes we will consider only those in the 0.75–0.80 mm range. Where there was more than one oil globule in eggs of this range, the globule measured 0.05–0.20 mm; however, when single globules occurred, the average size was 0.23–0.24 mm. In butterfish eggs, when more than one globule is present, the size range is 0.14–

0.22 mm. The dorsal embryonic pigmentation of the weakfish resembled that of the butterfish; in weakfish embryos the black pigment was dispersed to produce a spotty covering in the median dorsal head region whereas in butterfish it was lightly scattered along the dorsal edges of both head and body. Since fresh material, stripped from both species, should provide a clearer definition, an attempt was made at Woods Hole to strip and fertilize the eggs, but, as Kuntz and Radcliffe had discovered previously in 1915, completely ripe butterfish are unattainable from the traps near Quisset Harbor. As mentioned earlier, all attempts failed to raise eggs stripped from weakfish taken in L. I. S.

Larvae. None.

In conclusion, the butterfish spawning season in L. I. S. is considerably shorter and less prolific than that to the eastward in B. I. S., and butterfish eggs are difficult to separate from those of the weakfish.

Prionotus carolinus (Linnaeus); Common sea robin.
Prionotus evolans (Linnaeus);[3] Striped sea robin.

Both of these species are commonly found in southern New England waters from April to October, and in the winter they move into deeper water (Bigelow and Schroeder).

Spawning. Perlmutter and others have affirmed that both species spawn in summer at this latitude, but Merriman and Sclar collected neither eggs nor larvae in B. I. S. During our survey, *P. carolinus* spawned from the first week in June until the end of August in both years; in 1952 *P. evolans* spawned from the first week of June to the first week of July, and in 1953 during June only.

Eggs. In both years, 22 *P. carolinus* eggs (1.00–1.25 mm) and 25 *P. evolans* eggs (1.05–1.25 mm) were taken in L. I. S.: in 1952, 13 *P. carolinus* eggs from June 4 to August 19, and in 1953 only nine between June 1 and August 5; in 1952, 24 *P. evolans* eggs from June 4 to July 8, and in 1953 only one on June 15.

[3] Ginsburg (1950) investigated the populations of *P. evolans* along the Atlantic Coast of North America and found that there is no basis for separating *P. evolans* from *P. strigatus* (Cuv. & Val.).

The egg of this species has never been positively identified. Nichols and Breder (1926) maintained that it was demersal but Marshall (1946) doubted that this was so. Perlmutter (1939), on the basis of its resemblance to unfertilized eggs, made the tentative identification followed here. He reported that the eggs are similar in appearance and of approximately the same diameter as eggs of *P. carolinus* but that the oil globules are clustered at one pole rather than scattered throughout the yolk.

The distribution of these two demersal species is similar (Ginsburg, 1950). Although *P. evolans* may inhabit shallower water (Marshall, 1946), it appears likely that both species spawn at similar temperatures. When *P. carolinus* eggs were taken, the water temperature was 14.65–22.30° C, the salinity 25.42–27.12‰; for *P. evolans* eggs it was 13.80–18.42°, the salinity 19.93–26.17‰ (low salinity value at St. 128 due to outflow from the Housatonic River).

The eggs of both species were scattered throughout the eastern and central portions of the Sound almost exclusively; only one *P. evolans* egg was obtained at the western end (Fig. 1), at St. 128 off Stratford Point. At the regular stations (Table XX), a few more *P. carolinus* eggs were collected offshore in 1952; in 1953 a few more were collected inshore. In 1952 the eggs of *P. evolans* were fairly evenly distributed, except at St. 1.

TABLE XX. Abundance and Measurements of *P. carolinus* and *P. evolans* Eggs from the Regular Stations in L. I. S. in 1952–1953

Station	*Eggs/m³*			
	1952		*1953*	
	carolinus	*evolans*	*carolinus*	*evolans*
1	0.01	0.00	0.04	0.00
2	0.03	0.02	0.01	0.02
5	0.06	0.03	0.03	0.00
8	0.02	0.03	0.04	0.00

	P. carolinus				*P. evolans*			
Date	*No. meas.*	*Range*	*Av. diam.*	*Stand. dev.*	*No. meas.*	*Range*	*Av. diam.*	*Stand. dev.*
1952								
June	8	1.09–1.18	1.12	.027	22	1.05–1.25	1.13	.028
July	3	1.05–1.15	1.10	.050	1	—	1.10	—
Aug.	2	1.00–1.09	1.05	—	—	—	—	—
1953								
June	1	—	1.25	—	1	—	1.15	—
July	2	1.01–1.20	1.10	—	—	—	—	—
Aug.	6	1.01–1.14	1.06	.010	—	—	—	—

The size of the eggs of these two species varied only slightly; our limited data suggest that *P. evolans* eggs are slightly larger than those of *P. carolinus* (Table XX). A decrease in diameter as the summer progressed was noted in the few eggs taken.

Larvae. One larva (2.2 mm long) taken at St. 2 on July 15 and another (3.0 mm) taken at St. 1 on August 19, 1952 were identified as *Prionotus* spp. Larvae and juveniles have been taken previously from this area (see Perlmutter as well as Warfel and Merriman).

Myoxocephalus spp.; Sculpins.

M. aeneus is a common resident in L. I. S. whereas *M. octodecimspinosus* is presumably present in L. I. S. in late winter only, since it has not been taken in the summer by previous investigators. In B. I. S. it migrates offshore in June where it stays until October. Morrow (1951) postulated that adults of *M. octodecimspinosus* enter L. I. S. in early spring, move westward, and, after reaching the area off Port Jefferson, turn and leave the Sound again, not to return until the following year. He demonstrated that this species spawns in winter off southern New England, and all investigators are of the opinion that it does not spawn west of B. I. S. However, to date no definite evidence has been produced to prove that the longhorn does not spawn in L. I. S.

Records of collections taken in L. I. S. by beach seine and the oyster dredge (unpublished) as well as reports by Greeley and by Warfel and Merriman show that juveniles of the brassy sculpin are more abundant in L. I. S. than those of the longhorn.

Spawning. *M. aeneus* spawns in winter at the same time as *M. octodecimspinosus* (Bigelow and Schroeder, 1953; Morrow, 1951).

Eggs. None.

Larvae. It is virtually impossible to separate the larvae of these two species until the fins are differentiated. Perlmutter collected 19 *M. aeneus* larvae (4.5–12.2 mm) from B. I. S. and off Montauk Pt. during the last two weeks in May, but, since he did not begin sampling until May 5, they may have been present in the area before that date. In collections from B. I. S., Merriman and Sclar obtained larvae of *M. aeneus* (8–10 mm) during the first two weeks of May and of *M. octodecimspinosus* (7–10 mm) from February to April. From their data it appears that *M. aeneus* hatches later than *M. octodecimspinosus*. In L. I. S. we took ten sculpin larvae (3.7–9.1 mm) in March and April only. The April larvae were well scattered throughout the eastern end of the Sound and were smaller than those taken in March (Table XXI); these compared favorably in size with the larvae of both species from B. I. S. Only one specimen (9.1 mm), taken on March 26, 1952, was identified as *M. aeneus* by anal fin ray count and by comparison with Perlmutter's illustrations; however, its body shape was essentially the same as Merriman and Sclar's preserved specimens of *M. octodecimspinosus*. For obvious reasons discussed, it is impos-

TABLE XXI. Measurements of *Myoxocephalus* spp. Larvae from L. I. S. in 1952–1954

Date	St.	Length
1952		
Mar. 5	7	7.9 mm
Mar. 26	5	9.1
1953		
April 8	316	3.7
	318	4.0
	318	5.0
	318	6.5
April 9	319	5.3
1954		
Mar. 30	411	8.4
Mar. 31	418 (IV)	6.0
April 12	426	5.3

sible to conclude whether these larvae are those of *M. aeneus* or *M. octodecimspinosus* or both.

The water temperature at the time these larvae were found varied from a minimum of 1.70° on March 5, 1952 to a maximum of 6.65° C on April 12, 1954 (St. 426).

Paralichthys oblongus (Mitchill); Four-spotted flounder.

This species is reported to be an early summer spawner (Perlmutter, 1939; Bigelow and Schroeder, 1953). Ripe *P. oblongus* were found in L. I. S. in July 1954 but the spawning season has not been ascertained.

Eggs.? It is not known whether the eggs of *P. oblongus* were taken in L. I. S. in 1952–1953, since they are not distinguishable from eggs of *L. aquosa*.[4]

In July 1954, eggs of both species were artificially fertilized, and, although the eggs of *P. oblongus* survived slightly better than those of *L. aquosa*, neither developed beyond the 25-somite stage. Only these features of identification have been acquired thus far: (1) *P. oblongus* and *L. aquosa* were both in spawning condition in central L. I. S. in mid-July; (2) fertilized eggs of *P. oblongus*, which averaged 0.98 mm (average oil globule 0.15 mm), were slightly smaller than those of *L. aquosa*, which averaged 1.04 mm (average oil globule 0.17 mm); (3) embryonic pigment had appeared on *L. aquosa* at the 14-somite stage, whereas on *P. oblongus* it had not appeared at the 25-somite stage. With such meager information, the eggs of these

[4] Efforts to locate the eggs of *P. oblongus* mentioned by Bigelow and Schroeder as artificially hatched by O. E. Sette were fruitless.

two species were not separated. However, they were considered as the eggs of *L. aquosa* because this species is more abundant in the area, because a greater number of definitely identified *L. aquosa* larvae were collected following the two peaks of egg abundance, and because, on the whole, the eggs in the plankton samples were the same size as the artificially fertilized eggs.

Larvae. Perlmutter collected larvae of this species in Gardiners Bay and off Montauk Point from late June through July. In our collections, one larva 3.0 mm long and in poor condition was taken on September 16, 1952 at St. 1, and this resembled Perlmutter's illustration of one 5.7 mm long. Our larva did not fit the illustrations of *Paralichthys* sp. in Hildebrand and Cable (1930) which they thought may have been *P. dentatus.* It is possible that the *P. oblongus* spawning season lasted longer than has been indicated by Perlmutter.

Lophopsetta aquosa (Mitchill); Windowpane flounder.

This species is a common year-round resident in the shallow waters of southern New England. It is seldom eaten, but it does form a considerable part of the trash fishery in this area.

Spawning. According to Perlmutter, the windowpane is a summer spawner with maximum egg production in late May to mid-June. In 1952–1953, a split spawning season was observed in L. I. S. —from late April through July and from mid-September through late October or early November. This was similar to the split spawning season of the menhaden in 1952. If one ignores the nonspawning interval in August and early September, then the windowpane's spawning season was more prolonged than that of any other species taken in this survey.

Eggs. The eggs (0.90–1.38 mm) taken in the collections in 1952–1953 totaled 571 and ranked fourth in abundance (see Table I). The four groups were taken as follows: in 1952, 398 from April 16 to July 29, and 115 from September 9 to October 21; in 1953, 38 between April 15 and August 11, and 20 from October 14 to November 12. In general, during both years the eggs were more abundant during the earlier spawning season than during the later one (see Table I). This may indicate that a larger group of fish was spawning during the spring or that a similar spawning intensity in the fall was missed due to sampling errors.

In L. I. S. the surface temperatures that corresponded to the spawning seasons were: 7.0–22.2° and 21.45–15.2° C in 1952; 6.5–22.0° and 18.7–13.5° in 1953. Apparently temperature was not the primary cause for the split spawning season, for the average temperatures in the water column during the nonspawning periods (19.39° to 21.42°) were within the range of those recorded for the spawning season. According to Bigelow and Schroeder the eggs of this species were successfully hatched at Woods Hole at temperatures of 10.00–21.11°, but in L. I. S. eggs were taken in waters as low as 6.5°. Thus, the temperatures in the Sound during early spring spawning were much lower than those given by the aforementioned investigators, and it is possible that conditions for egg development are less favorable than at higher temperatures. In the spring, a period of six to eight weeks intervened between the appearance of the first eggs and the first larvae whereas in the fall the interval was only two weeks.

The salinity range during the spawning seasons of both years in L. I. S. was 18.15–30.00‰. Thus the maximum salinity in the Sound was considerably lower than that in certain other areas where they also spawn.

Perlmutter collected the eggs of this species by the hundreds between Peconic-Gardiners Bay and Montauk Point, to the south of Long Island, and in L. I. S. itself, and we found them in abundance from all portions of the Sound in 1952–1953. But, Merriman and Sclar record none from northeastern B. I. S. In our survey this was the only species whose eggs were collected at every station during the 100-cruise and at all but two of the stations in the 200-cruise (see Fig. 1). The data show that spawning (Table XXII) in both spring and fall in the central and western areas was greater than that in the eastern portion, where the quantity of eggs varied from station to station much more so than in the other portions, possibly due to stronger current movements in the eastern end. Apparently the windowpane seeks a somewhat sheltered spawning location.

Comparison shows that the average diameter of the eggs from the 100-cruise was the same as that from the 200-cruise—1.05 mm. At the regular stations, the average diameter in spring 1952 decreased from 1.19 to 1.05 mm, which is the same as the diameter obtained during the mentioned cruises. In spring 1953 there was a similar decrease. For the fall of both years, the data were insufficient to indicate a valid increase or decrease. The oil globule, usually only one per egg, ranged from 0.15–0.30 mm; when two or three globules were present in a single egg, the range was 0.05–0.16 mm.

TABLE XXII. Regional Abundance of *L. aquosa* Eggs from L. I. S. in 1952–1953

Eastern End		*Central Portion*		*Western End*	
St.	*Eggs/m³*	*St.*	*Eggs/m³*	*St.*	*Eggs/m³*
113	1.65	101	0.80	128	0.72
115	0.67	103	0.83	129	2.09
117	0.68	105	1.11	130	0.74
118	0.09	107	0.58	131	1.23
119	0.29	109	2.31	238	0.67
121	1.16	111	4.66	241	0.59
123	5.38	125	0.51	243	0.64
215	0.40	126	0.11	244	1.24
218	0.22	201	0.81		
219	0.16	203	0.53		
220	0.09	208	0.90		
222	0.10	210	1.45		
224	1.15	227	0.20		
225	0.44	229	0.98		
		234	0.20		

Total		Total		Total		Grand Totals	
100	0.83	100	1.49	100	1.42	100	1.37
200	0.38	200	0.48	200	0.78	200	0.52

	1952	*1953*
1	0.48	0.06
2	0.17	0.15
5	0.20	0.09
8	0.30	0.09

In this investigation the identity of windowpane eggs has always remained tentative because of the difficulty in ascertaining the identity of what appears to be three types of *L. aquosa* eggs (discussed below) and because of their similarity to the eggs of *P. oblongus* (see p. 287). Three groups of eggs of similar appearance are recorded as those of *L. aquosa* because they overlapped in size and in time of collection and because the developing embryos were similarly pigmented. Of the three, type A (actually intermediate between types B and C) is considered here as being most typical of the *L. aquosa* egg. The A eggs, when compared with artificially fertilized eggs, showed more similarity to the latter than did the B and C eggs. Further support for the belief that the A eggs are more nearly representative is found in the facts that the larvae of this species are readily identifiable and appeared four to eight weeks after A eggs were taken in the spring and that larvae in fall 1953 appeared later when the eggs also appeared later.

Type A eggs: Eggs fitting the following description were taken in 1952 from May through July and during September and October and in 1953 from May through July and in October. In 1952 they

TABLE XXIII. Measurements of *L. aquosa* Eggs and Oil Globules from L. I. S. in 1952–1953

	Egg				Oil globule			
Date	*No. meas.*	*Range*	*Av. diam.*	*Stand. dev.*	*No. meas.*	*Range*	*Av. diam.*	*Stand. dev.*
1952								
April	3	1.15–1.23	1.19	.030	3	0.19–0.20	0.20	.000
May	100	1.00–1.38	1.16	.073	110	0.06–0.30	0.18	.037
June	224	0.91–1.15	1.05	.039	246	0.05–0.26	0.16	.031
July	4	0.94–1.16	1.05	.090	3*	0.15–0.22	0.17	.040
Sept.	38	0.96–1.15	1.06	.044	51	0.06–0.18	0.14	.025
Oct.	73	0.95–1.15	1.04	.046	94	0.06–0.20	0.14	.027
100	205	0.95–1.25	1.05	.044	225	0.05–0.26	0.16	.050
200	98	0.95–1.15	1.05	.046	120	0.06–0.20	0.14	.027
1953								
April	1	—	1.25	—	1	—	0.22	—
May	12	1.05–1.20	1.12	.042	14	0.06–0.20	0.14	.037
June	15	1.02–1.16	1.08	.050	15	0.14–0.20	0.16	.017
July	6	0.90–1.08	0.99	.076	7	0.12–0.16	0.14	.014
Aug.	2	1.04–1.09	1.07	.036	2	0.16–0.19	0.18	.020
Oct.	18	0.98–1.10	1.03	.035	19	0.10–0.19	0.15	.022
Nov.	2	1.05–1.20	1.12	.020	2	0.18–0.20	0.19	.010
Totals								
1952	442	0.91–1.38	1.07	.050	507	0.05–0.30	0.16	.030
1953	56	0.90–1.20	1.07	.067	60	0.06–0.20	0.15	.028

* 1 oil globule squashed.

were more abundant than in 1953. Their diameters ranged from 0.90–1.24 mm, but the majority were between 1.00–1.20 mm. There was a recognizable decrease in their size during spring and early summer. The oil globules ranged from 0.05–0.22 mm; when single (the more usual condition) they were never less than 0.12 mm. The globule was either amber or dark and was occasionally spotted with black chromatophores. The embryonic pigmentation in preserved specimens usually was present as early as the 14-somite stage. Black spots were most abundant along the dorsal side from the snout to the tip of the tail, less abundant on the sides, and least abundant on the ventral side. In well developed embryos a short horizontal streak was vaguely discernible along both caudal fin-folds halfway between the tip of the tail and the vent.

Type B eggs: In both years these were taken in spring only; in 1952 from April to June, in 1953 in May only. The egg diameters ranged from 1.02–1.38 mm, the oil globules from 0.10–0.30 mm; when single, the globule diameter was never less than 0.15 mm. The globule varied in color from amber to dark brown and was occasionally covered with scattered black chromatophores. The pigmentation on well developed embryos was faintly streaked on the dorsal side of both head and nape; dorsally and ventrally it appeared spotty along the trunk and tail; a short and narrow horizontal streak, similar to that in type A, was faintly visible along both caudal finfolds.

Type C eggs: These were collected in the fall only, in September and October of 1952 and in October and November of 1953. They ranged in diameter from 1.0–1.2 mm (approximately the same size as the A eggs but smaller than the B eggs). At stations where both A and C eggs were collected simultaneously, the latter averaged slightly larger. The oil globules ranged from 0.06–0.20 mm; if single, the globule was never smaller than 0.15 mm. The embryonic pigmentation resembles that of B rather than A eggs.

In summary, type A eggs were taken in both spring and fall, whereas B eggs were taken only in the spring, C eggs only in the fall. A eggs were the same size but had different pigmentation than C eggs; the B eggs were larger than the A and C eggs and their pigmentation was similar to type C.

Due to prolonged absence in the field in 1953, we examined the samples in which these three types of eggs occurred after varying periods of preservation, and it is possible that changes in both size and pigmentation occurred in varying degrees with varying preservation. The 1952 spring samples were examined six months later, the 1952 100-cruise tows 15 to 20 months later, the 1952 summer and fall samples 12 months later, and the 1953 tows six to eight months later. In the spring of 1954 some windowpane eggs were examined within two days of preservation; comparison showed no differences between these and types A and B taken during the spring of 1952–1953. The diameter range of the 1954 eggs was 1.07–1.30 mm, and the embryonic pigmentation was both streaked and spotted.

Larvae. Unlike the eggs, the larvae of this species are easily identified. Seventeen larvae (1.8–7.6 mm) were collected during this survey from all portions of the Sound (Table XXIV). In 1952, nine (2.7–7.6 mm) were taken between June 4 and July 1 and most of them were obtained on the 100-cruise; only four were collected in the fall—on September 23 and October 8. In 1953, only four larvae were taken and they appeared later in both spring and fall collections; two were taken between July 7 and 28, and two more on

October 28. As in the case of the eggs, we note here a bimodality in the larvae collections; also we note that the fall larvae in both years were smaller than the spring larvae, and that both larvae and eggs appeared a month later in 1953 than in 1952. The numerical ratio of larvae to eggs was as follows: 1:44 in spring 1952, 1:38 in fall 1952, 1:19 in spring 1953, 1:9 in fall 1953. Bigelow and Schroeder estimated that embryonic development was completed in eight days in temperatures from 10.65–13.33° C, but temperatures in L. I. S. were above 15° during the time when larvae were collected. Earlier

TABLE XXIV. Distribution, Size and Abundance of *L. aquosa* Larvae from L. I. S. in 1952–1953

Date	*St.*	*No.*	*Length (mm)*	*Larvae/m³*
1952				
June 4	107	1	3.7	
5	113	1	3.4	
5	115	2	4.1	
			2.7	
5	118	2	4.4	
			4.3	
6	121	1	5.6	
11	130	1	7.6	June—0.03
July 1	2	1	2.8	July—0.01
Sept. 23	2	3	2.4	
			2.5	
			3.5	Sept.—0.006
Oct. 8	241	1	2.1	Oct.—0.005
1953				
July 7	8	1	2.4	
28	2	1	1.8	July—0.02
Oct. 28	2	2	3.5	
			2.4	Oct.—0.03

in the spring, before the larvae were collected, temperatures were below 10°, which may have prevented normal development of the eggs and which may explain, in part at least, the differences between the aforementioned spring and fall larvae-egg ratios.

Perlmutter obtained larvae in all areas sampled around Long Island, and his collections showed decreasing percentages from spring to fall: 62% in May, 37% in June, 1% in July and August, and none in the fall. Merriman and Sclar collected 4 larvae from B. I. S. in July. Juveniles, apparently quite common in the sublittoral zone, were obtained by Perlmutter, by Warfel and Merriman, and with the oyster dredge. Warfel and Merriman have inferred that there is a possibility that two races of windowpane occur in L. I. S., and Moore (1947), on the basis of vertebral counts, otoliths, and scale appearance, postulated that there were two races spawning at different times, one in May-June, the other in July-August. Moore has estimated that the growth of windowpanes in the first year is 2.95–3.54 inches (roughly 50–65 mm), that they attain this size by the following February or March, and that the 1+ age-group from L. I. S. is smaller and grows more slowly than the same age-group outside of the Sound. If L. I. S. windowpanes stem from two spawning stocks, then a true annual increment will be extremely difficult to judge.

Limanda ferruginea (Storer); Yellowtail flounder.

Spawning. This species spawns in southern New England in spring and summer. Perlmutter obtained larvae in B. I. S. and along the south shore of Long Island in May and June and Merriman and Sclar found them in B. I. S. from May to August.

Eggs. Only one egg (0.81 mm) was taken, that on April 8, 1953 at St. 316, outside Plum Island.

Larvae. Only one postlarva, 13.8 mm long and easily identified, was collected on April 9, 1952 at St. 1. This larva was not large enough to have originated in B. I. S., hence the yellowtail, which is not ordinarily considered a spawner in L. I. S., appears to spawn occasionally in this body of water. Considering the size of the specimen, it must have hatched in late March.

Pseudopleuronectes americanus (Walbaum); Blackback flounder.

The blackback, a nonmigratory species, is one of the most common flounders in L. I. S. It is of more value commercially in southern New England than any other demersal species. For example, the total catch in 1951 from Rhode Island and Connecticut was 3,029,200 pounds, valued at $290,000. The total Connecticut catch alone has fluctuated little during the past 15 years, although the catch taken from L. I. S. by fishermen in New Haven and Fairfield Counties has fluctuated greatly. Perlmutter has stated that the blackback population here is made up of many localized stocks that inhabit shallow areas and that the young in any one area are probably the product of fish spawning in that area.

Spawning. In southern New England waters the blackback spawns from December to May. However, in L. I. S. we took no eggs at any time and obtained no larvae until late March. As dis-

cussed below, it is estimated that the spawning season in L. I. S. during this survey extended from February or early March until the last week of May.

Eggs. None.

Larvae. In 1952–1954, 63 larvae (2.8–8.5 mm) were taken and the majority were still upright: in 1952, 17 between April 9 and June 6; in 1953, 14 between March 23 and May 25; and in 1954, 32, the first of these appearing in our samples on March 30. Blackback larvae were fourth in relative abundance of all species, and the peak of abundance occurred in April, excepting 1952, when the peak was in May.

When larvae were present in our collections the surface temperature

TABLE XXV. Regional Abundance of *P. americanus* Larvae from L. I. S. from March 1952–April 1954

No Stations Were Made in the Western End during the 300-Cruise in April

Eastern End		Central Portion		
St.	*Larvae/m³*	*St.*	*Larvae/m³*	
119	0.10	107	0.07	
313	0.12	302	0.09	
314	0.26	303	0.09	
318	0.20	405	0.11	
319	0.17	418 (IV)	0.03	
			1952	*1953*
		1	0.05	0.05
		2	0.04	0.02
		5	0.06	0.00
		8	0.04	0.00

ranged from 5.65–13.30° C, although it is known that they occur in water as warm as 22.17° (Perlmutter, 1939). The known salinity range when blackbacks spawn is great—from over 30.0‰ in the Gulf of Maine to 11.14‰ in Woods Hole, Mass. (Bigelow and Schroeder). The spring salinity range in L. I. S. is well within these limits.

Our data show that blackback larvae were widely scattered throughout the Sound and displayed no center of abundance (Fig. 1 and Table XXV). Preliminary examination of material collected in 1954 indicates that depth may be a limiting factor.

Bigelow and Schroeder have maintained that larvae in the Gulf of Maine are 3.0–3.5 mm at hatching. In L. I. S. we found larvae 3.0 mm long and a minimum hatching length of 2.8 mm. Perlmutter has maintained that eggs are initially laid in December in southern New England, and Bigelow and Schroeder have reported that embryonic development takes place in 13–15 days at temperatures of 2.78–3.33° and that larval growth to 5 mm takes place in 12–14 days at temperatures of 3.89°. Thus, larvae should have been present in L. I. S. in January, but, as noted, they were not taken until late March. If the rate of development is as Bigelow and Schroeder have stated it, then the 5.7 mm specimen taken in 1952 on June 6 at St. 119 should have hatched during the first week of June; the two larvae (av. 5.9 mm) taken in 1953 on May 25 at St. 1 should have hatched during the third week of May; and in 1954 the metamorphosing larvae (7.5 and 8.5 mm) taken on May 10 at St. 524 (not included in Table XXV) should have hatched in late April. The 5.7 mm specimens collected in 1952 on June 6 indicate that spawning may have continued until the end of May while in 1953 the last specimens which were collected on May 25 indicate that spawning may have ended in mid-May. It is quite possible that temperature variation in winter and spring was at least one of the factors that delayed the appearance of larvae in 1952 and prolonged their appearance later that same year. The colder water temperature during the spring of 1952 as compared with that of 1953 and 1954 may have delayed spawning and hatching and decreased the growth rate, which would have resulted in a delayed appearance of the larvae plus a longer pelagic life. After metamorphosis the larvae became demersal and no longer appeared in our samples.

Postlarvae have been taken from many localities within the Sound by: Perlmutter; Greeley; Warfel and Merriman; Merriman (1947); and the oyster dredge. Juveniles, also taken in abundance, grow roughly 20 mm between June and September.

Sphaeroides maculatus (Bloch and Schneider); Puffer.

A summer visitor to L. I. S., this species arrives in mid-May and remains until mid-October.

Spawning. In this general latitude it lasts from late May until August with the peak in July (Welsh and Breder, 1922).

Eggs. None.

Larvae. Only one larva (5 mm) was taken, on August 19, 1952 at St. 5. This indicates that spawning continued well into August. Its brilliant coloration over the anterior section of the body (faded in preservative) and its shape permitted unmistakable identification. This larva was taken from an area of greater depth than would be

normally expected. Juveniles have been taken frequently by previous investigators on shallow sandy beaches and in estuaries, and it is quite likely that we would have taken more had our collections included such habitats. Probably our specimen had been carried out into deeper water. The growth increment during the summer has been estimated as *circa* 41 mm.

"Unknown 1."

During the 200-cruise, four unidentified eggs of similar appearance were collected from scattered localities (see Table XXVI). The embryonic pigmentation in the egg taken X-9-52 resembled that of a developing scup, but its time of appearance, late in the year, and its small size suggest that it might be either *Leiostomus xanthurus* or

TABLE XXVI. Distribution and Size of "Unknown 1" Eggs from L. I. S. in 1952–1953

Date	*St.*	*Egg diam.*	*Globule diam.*
1952			
Sept. 29	208	0.72	0.20
Oct. 1	222	0.74	0.17, 0.15, 0.16
2	225	0.76	0.24
9	243	0.89	0.14, 0.14
		Av. 0.78	Av. 0.17

Cynoscion regalis, more likely the latter. Adults of *L. xanthurus* have been reported in L. I. S. from May to November or December (Nichols and Breder, 1926) and juveniles have been taken occasionally in beach seine hauls, but there is no available information concerning their spawning in the Sound. Hildebrand and Cable (1930) have maintained that the spot spawns in autumn and that the unidentified eggs must be small because the recently hatched prolarva is small (1.5 mm). This is not necessarily so, since the egg of *L. aquosa* is little more than 1.0 mm while the recently hatched larva is 1.8 mm (see p. 292). Regarding the possibility of their being *C. regalis*, Welsh and Breder (1926) have pointed out that their spawning season continued until September, Perlmutter (1939) has mentioned the possibility of local races spawning at different times, and we have found that the diameters of both egg and oil globules conform to the same characters observed in weakfish eggs.

DISCUSSION

The data in this paper are based on 272 oblique plankton tows taken in the Sound during this survey; most of the hauls were made at the regular stations in the central portion. In addition, a few experimental observations were carried out, and these are discussed under MATERIALS and METHODS and later in this section. Although our data by no means supply the answers to many of the questions raised in an investigation of this nature, they do serve as a sound basis for further study. Analysis is complicated by the variations which result from changes in environmental conditions, from sampling procedures, and from movements of the spawning populations. Comparison of plankton hauls taken simultaneously have indicated the significance of such variations. Winsor and Walford (1936) felt that an increase in the "total catch" by using a larger net did not necessarily provide a more accurate estimate of the population, since such an estimate is limited by the volume of water sampled. Winsor and Clarke (1940) maintained that the catch with a small 12.7 cm net gave as reliable an indication of the plankton types as any of the larger nets (75 and 30 cm) and that the variability between oblique tows was less than that between vertical tows. Silliman (1946), in an analysis of duplicate laboratory samples of 24 paired plankton hauls for eggs of the pilchard, demonstrated that the variability was due to variation in egg concentration in the water and that a single count may be considered significantly different from another if it is less than half or more than double the other.

On some occasions, two nets of different size, 12.5 and 30 cm, both with No. 2 mesh, were towed simultaneously. Although the larger net strained more water and took a larger number of organisms, little difference in the number of organisms was noted after prorating the volume of water sampled by each net. However, it appears that the larger net collected larger larvae. Generally the 30 cm net has not been used extensively since no valid way has been found to measure the volume of water filtered. Also, two 12.5 cm nets, one with No. 2 and the other with No. 10 mesh, were towed successively at the same station. No significant differences were noted in the number of eggs and larvae or in the size of the larvae, but the No. 2 mesh collected a significantly greater variety of the less abundant summer species, possibly because it filtered more water. In the

1952–1953 samples, the larvae that were present at the time of sampling are probably represented with a fair degree of accuracy qualitatively but not quantitatively, particularly if some of the larvae could escape the net, especially in daylight. On the other hand, the eggs in the samples probably give a valid representation both qualitatively and quantitatively. At any rate, regional and seasonal differences based on these tows are probably fairly representative of the sampled areas. Of course, further observation is desirable.

The pelagic eggs and larvae of 24 species of fish were collected in the course of this study. Of these, 12 species were represented by both eggs and larvae, nine by larvae only, and three by eggs only. Of the nine species represented by larvae *C. harengus*, *M. m. notata*, *A. americanus*, *Myoxocephalus* spp., *P. americanus*, and *S. maculatus* hatched from demersal eggs which were not collected in our tows; *A. rostrata* spawns in the mid-Atlantic, and *S. peckianus* carries its eggs in a pouch. The eggs of *P. oblongus* were not identified, and, if collected, they were included with the eggs of *L. aquosa*. Regarding the three species represented by eggs alone (*P. triacanthus*, *S. scombrus*, and "Unknown No. 1"), the eggs of only *P. triacanthus* were taken in fair quantity; the absence of the larvae remains unexplained.

During the past 15 years two surveys (Perlmutter, 1939; Merriman and Sclar, 1952) in addition to ours have been made in southern New England waters and the eggs and larvae of 45 or 46 species have been identified. Because of the different gear used in each survey, only qualitative comparison is possible (Table XXVII). Perlmutter, whose collections extended over a much wider area than those of the other two surveys and covered a much shorter period of time (May–October), took 23 species which were not taken by Merriman and Sclar and 18 which were not taken by us. In collections which cover such a wide range of habitats, it is inevitable that one survey will include eggs and larvae of some species which are not present in others. In view of the fact that Perlmutter's survey included the south shore of Long Island and southern B. I. S., he collected some species whose range seldom extends into L. I. S. Among these are *Hippocampus hudsonius*, *Vomer setapinnis*, *Bairdiella chrysura*, *Achirus fasciatus*, and *Chilomycterus schoepfii*.

While the B. I. S. area has yielded the eggs and larvae of a number of species that came from the eastward and northeastward of this region, none except the larvae of the pollack have been taken in

TABLE XXVII. LIST OF SPECIES TAKEN IN EACH SURVEY OF PELAGIC FISH EGGS AND LARVAE IN SOUTHERN NEW ENGLAND WATERS

Species	*Perlmutter, 1938 L. I. S., southern B. I. S. and south of Long Island*	*Merriman and Sclar 1943–1946 northeastern B. I. S.*	*Wheatland 1952–1953 L. I. S.*
Clupea harengus	×	×	×
Brevoortia tyrannus	×	×	×
Anchoa m. mitchilli	×	–	×
Anguilla rostrata	×	–	×
Conger oceanicus	×	–	–
Merluccius bilinearis	×	×	–
Gadus morrhua	×	×	–
Melanogrammus aeglefinus	×	–	–
Pollachius virens	×	–	–
Urophycis chuss	×	×	–
Urophycis regius and/or *tenuis*	–	×	–
Enchelyopus cimbrius	×	–	×
Syngnathus peckianus	×	×	×
Hippocampus hudsonius	×	×	–
Menidia m. notata	×	–	×
Centropristes striatus	×	–	–
Pomatomus saltatrix	×	–	–
Vomer setapinnis	×	–	–
Bairdiella chrysura	×	–	–
Cynoscion regalis	×	×	×
Menticirrhus saxatilis	×	–	×
Stenotomus chrysops	×	×	×
Ulva subbifurcata	×	–	–
Gobiosoma bosci	×	–	–
Gobiosoma ginsburgi	×	–	–
Tautogolabrus adspersus	×	×	×
Tautoga onitis	×	×	×
Ammodytes americanus	–	–	×
Scomber scombrus	×	×	×
Poronotus triacanthus	×	×	×
Prionotus carolinus	×	–	×
Prionotus evolans	×	–	×
Cryptacanthodes maculatus	–	×	–
Cyclopterus lumpus	×	×	–
Myoxocephalus aeneus	×	×	×
Myoxocephalus octodecimspinosus	–	×	?
Paralichthys oblongus	×	–	×
Paralichthys dentatus	–	×	–
Lophopsetta aquosa	×	×	×
Limanda ferruginea	×	×	×
Pseudopleuronectes americanus	×	–	×
Achirus fasciatus	×	–	–
Sphaeroides maculatus	×	–	×
Chilomycterus schoepfii	×	–	–
Lophius americanus	×	×	–
Total	40	22	23

L. I. S. These species are *Gadus morrhua*, *Melanogrammus aeglefinus*, *Pollachius virens*, *Merluccius bilinearis*, *Urophycis chuss*, *Ulva subbifurcata*, *Cryptacanthodes maculatus*, and *Lophius americanus*. Some species, namely *Centropristes striatus*, *Pomatomus saltatrix*, and *Paralichthys dentatus*, probably spawn offshore, hence their eggs and larvae have been taken more frequently in B. I. S. than in L. I. S. The larvae and juveniles of many inshore species that were taken by Perlmutter in shallow protected areas were not taken by Merriman and Sclar and by us in more open waters. Some inshore species, such as *B. tyrannus*, *A. m. mitchilli*, *M. m. notata*, *M. saxatilis*, *P. americanus* and *S. maculatus*, which were taken from L. I. S. and the south shore of Long Island apparently do not congregate in northeastern B. I. S. during the spawning season.

There is no satisfactory explanation to account for the scarcity in B. I. S. of eggs and larvae of such species as *Prionotus* spp., *P. oblongus*, *E. cimbrius* and *A. americanus*, all of which were taken in L. I. S. *Prionotus* spp. and *P. oblongus* are supposedly common along the entire New England coast during the spawning season in the summer, and *A. americanus* spawns in winter and early spring. Perlmutter could not have taken *A. americanus*, since his collections were made from May to October, but it seems reasonable to expect that *A. americanus*, as well as *E. cimbrius*, should have been taken in northern B. I. S., since the larvae of these two species have been collected in open waters in the Gulf of Maine and to the east and south of Block Island. Either environmental factors not yet known or sampling errors may account for their absence in B. I. S.

It is common knowledge that many species move between deeper and shallower waters during certain seasons of the year. In the summer, *B. tyrannus*, *C. regalis*, *S. chrysops*, *M. saxatilis*, *P. triacanthus*, *P. carolinus* and *P. evolans* move into the Sound and probably return to deeper waters outside in the fall. In winter, *C. harengus*, *E. cimbrius* and occasionally *L. ferruginea* move into the Sound and subsequently move outside in late winter and spring. Of the L. I. S. residents, *A. m. mitchilli*, *S. peckianus*, *M. m. notata*, *T. adspersus*, *T. onitis*, *P. carolinus*, *P. evolans*, *L. aquosa*, and *P. oblongus* move into deeper water in late fall and remain there until April. However, *P. americanus* and *Myoxocephalus* spp. remain in shallower areas during the winter.

If we consider observations from all sources (e. g., Perlmutter, Greeley, Warfel and Merriman, Merriman, oyster dredge samples, etc.) we find that in L. I. S. as a whole there is a greater variety of species represented by the juveniles than by the eggs and larvae. On the other hand, if we exclude those juveniles that are spawned in fresh water or in waters close to the littoral zone, then we find a larger number of species represented by eggs and larvae than by juveniles. Frequently we find some species represented by the eggs and larvae which are not represented by the juveniles, and vice versa.

Of the 43 species represented by juveniles, 25 were not represented by eggs and larvae in our survey in 1952–53. Some of those not collected by us, such as *Pomolobus pseudoharengus*, *Osmerus mordax*, *Morone americana*, spawn in fresh water. Others, such as *Fundulus majalis*, *Fundulus heteroclitus*, *Fundulus luciae*, *Menidia beryllina cerea*, *Caranx hippos*, *Microgadus tomcod*, *Pholis gunnellus*, either lay demersal eggs or spawn close to shore in weedy habitats. Still others appear not to spawn within the Sound, namely *Conger oceanicus*, *Urophycis chuss*, *Urophycis regius*, *Urophycis tenuis*, *Merluccius bilinearis*, *Bairdiella chrysura*, and *Pomatomus saltatrix*. *Synodus foetens*, a southern form and spring spawner (Breder, 1944), appears in the Sound during summer.

A total of 18 species which have been represented by juveniles in previous collections from L. I. S. were also represented by eggs and larvae in our samples from 1952–53. This group includes the majority of the most abundant species, such as *A. m. mitchilli*, *M. m. notata*, *T. adspersus*, *P. americanus* and *L. aquosa*. But there were three species represented in our samples by eggs and larvae which have never been recorded before as juveniles: *S. scombrus*, *L. ferruginea*, and *P. oblongus*.[5]

It is evident from the little we know about the life histories of all species that inhabit these waters that there is a constantly shifting population of juveniles; many which are hatched outside enter the Sound during their first year, and almost as many which are hatched in the Sound move outside. In the over-all picture of L. I. S. the importance of the sublittoral noncommercial groups of fishes must be emphasized as well as that of the commercially important species.

During the two years of our survey, the average number of eggs taken throughout the entire Sound decreased from 7.42 in 1952 to

[5] On October 10, 1955 one specimen of this species was taken at St. 1.

$2.30/m^3$ in 1953, and the average number of larvae decreased from 0.73 to $0.36/m^3$. At the regular stations, a striking decrease in both numbers and variety of eggs and larvae occurred in 1953 (Table XXVIII). This appears to be due in large measure to anchovy spawning at the inshore stations, where larger quantities of eggs were taken in 1952 as compared with 1953, and furthermore, in the latter year the eggs of all species appeared more evenly distributed. The greater variety of eggs in 1952 may have been due to the fact that a greater volume of water was sampled that year.

When a complete annual cycle of spawning activity in L. I. S. is considered, its seasonal nature is apparent (Fig. 2). Following a period of low spawning activity in late fall and winter, a peak in both variety and number of eggs occurred in late spring and summer when conditions were undoubtedly optimal for the greater percentage of the spawners. The low in abundance of eggs occurred from November through February and of larvae from April through June; the maximum of eggs was recorded in June and July and of larvae in September and October. The peak in larvae abundance during winter clearly reflects the spawning of *A. americanus*.[6] No doubt some of the spring spawners produced eggs before conditions were suitable for successful development of the larvae.

TABLE XXVIII. Regional Abundance of Eggs and Larvae of All Species in L. I. S. in 1952–1953

Station	*Eggs/m³*		*Larvae/m³*	
	1952	*1953*	*1952*	*1953*
1	36.0	1.3	0.82	0.24
2	7.7	2.9	1.7	0.43
5	4.4	0.69	1.1	0.42
8	24.0	4.8	0.79	0.29
100a*	8.9	—	0.07	—
b*	1.9	—	0.07	—
200a*	0.74	—	0.04	—
b*	0.61	—	1.00	—
300a	—	1.1	—	0.16

* a indicates eastern end, b western end.

The data for the long cruises more or less reflect the same seasonal nature of spawning. On the 100-cruise, a greater number and variety

[6] At the southern end of its range this genus spawns in winter, but farther north it spawns later in the spring, and in Iceland and Greenland it spawns as late as June (Einarsson, 1951).

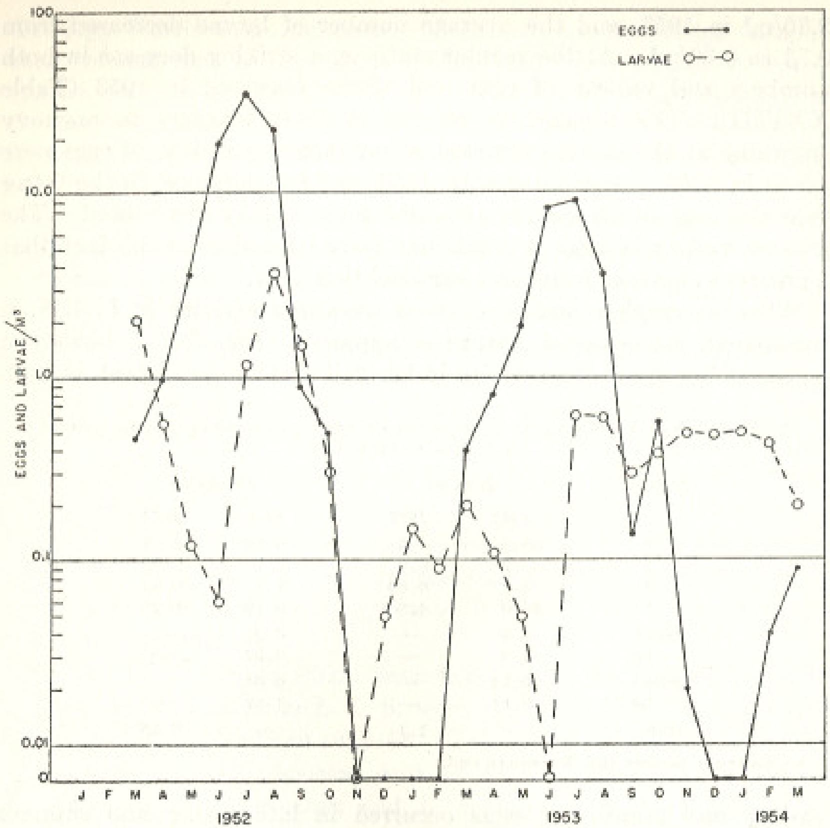

Figure 2. Total number of eggs and larvae per cubic meter from L. I. S. taken each month during 1952–1954.

of eggs were obtained, whereas on the 200-cruise, when the actual spawning of many species had ceased, we found better representation of larvae. The 300-cruise showed the decline of *A. americanus* larvae, the continued spawning of *E. cimbrius,* and the initial appearance of *P. americanus* larvae.

Regional variations in abundance of eggs and larvae were also apparent. At the regular stations, those offshore yielded eggs and larvae of the greatest variety of species, the major ones being *A. m. mitchilli, B. tyrannus, E. cimbrius, A. americanus,* and *L. aquosa.* Eggs and larvae of *A. m. mitchilli, E. cimbrius, T. adspersus, T. onitis, A. americanus,* and *P. americanus* occurred in greater abun-

dance at the inshore stations. A few larvae, more usually collected near shore, were taken at St. 5: *M. m. notata, S. peckianus, M. saxatilis,* and *S. maculatus.* Eggs and larvae of more species were collected at the eastern than at the western end of the Sound, but more eggs were actually taken at the western end; these facts were more evident from data of the 100-cruise than from those of the 200-cruise.

Though desirable, a discussion of the larval survival of each species on the basis of the information at hand is not possible, since data on size composition of the larval population, net selectivity, escapement, differences in daily growth rates, etc. (Ahlstrom, 1954) would be necessary to arrive at a reasonable figure. Ahlstrom, in work on *S. caerulea,* arrived at a minimum survival figure of 1 in 1,000 for larvae up to 21 mm. In our survey, the number of larvae captured in 1952 was 10% of the total number of eggs, and in 1953 it was 15%, including larvae that were hatched from demersal eggs which were not collected. Obviously this rough estimate of 10 and 15% is unduly high and is not a valid indication of larval survival. Therefore, it seems feasible to limit our considerations to the physical and biological factors that influence the location and abundance of eggs and larvae.

The primary physical factors that may cause fluctuations in egg abundance are salinity and temperature, tidal currents and nontidal drifts, wind force and direction, and precipitation. Since each species has definite salinity and temperature requirements for successful egg development, it is quite reasonable to assume that oceanic fish were prevented from spawning in the Sound where salinity over a year ranged between 24.00 and 30.00‰ and dropped as low as 18.15‰ near river mouths during spring. In spring 1953, a lowered salinity due to abnormal precipitation may have been one of the factors that delayed the summer spawning season of a number of species (see also Merriman and Sclar for a discussion of the possible effect of abnormal salinity on survival of butterfish, weakfish and cunner eggs in B. I. S.).

In the Sound the annual temperature range is great, from 0.85 to 23.50° C. While such extensive variations may discourage some species from spawning here, it does provide a varied environment which is suitable for a greater number of species than would be expected otherwise. A delayed spawning of *L. aquosa* and the continued appearance of *A. m. mitchilli* and *B. tyrannus* larvae in autumn 1953 may have been due to a consistently higher temperature at that time.

According to Walford (1938) and Carruthers and co-workers (1951), surface drift and wind variations may have a decided effect on larval survival. In the Sound, surface drift may have been responsible for the presence of larvae of sublittoral spawners at offshore St. 5, but it was concluded that the surface drift of inshore waters was not influential in causing the varied distribution of the eggs of cunner, tautog, and anchovy.

The major biological factors which influence egg abundance include the habits of each species, the food available for both larvae and adults, and predation. While much is known about the life history of some species that frequent the Sound, relatively little is known about others. Such information is extremely valuable in a study of this nature, and much remains to be done in obtaining the basic information. However, even if fairly complete biological data become available, variations in biological as well as physical factors which influence egg production will complicate analysis. In L. I. S. the number and distribution of eggs of schooling species fluctuated somewhat more than did those of the semischooling or solitary fish, probably due in large measure to the uniform behavior patterns and requirements of these schooling fish. In 1952 the menhaden appeared in early summer when the phytoplankton was abundant whereas at the same time in 1953 it did not turn up when the phytoplankton was less plentiful. Actually, less species spawn during the phytoplankton bloom than at other times. It appears that the larvae do not fully utilize the plentiful supply of zooplankton that is available in the Sound, and a study of feeding analyses would be highly desirable.

From our data we estimate that the average number of eggs per year for all species is 2–7 per cubic meter. When we consider other studies in this survey, L. I. S. has a high potential as a spawning area and nursery ground for the young. Unfortunately, no organized quantitative studies of juveniles have been made in this area, hence the importance of this element of the population in the over-all picture cannot be evaluated. But previous observations have indicated that the adult fishery in the Sound is considerably smaller than that of B. I. S. Although data indicate a rich planktonic and benthic fauna it appears that the fish population in L. I. S. does not completely utilize the available food supply.

Addendum on Egg Diameter Decrease

The eggs of some species which have long spawning seasons, such as *B. tyrannus*, *E. cimbrius*, and *T. adspersus*, showed a decrease in egg diameter as the season progressed. Whether this decrease was natural or artificial we do not know, but five possible explanations seem pertinent.

1. The decrease in diameter may be correlated with the length of time the eggs were preserved. Gorbunova (1952) found that eggs of the gadid *Theragra chalcogramma*, taken in the Japan Sea, shrank noticeably when preserved for 5 to 10 months in 2% formalin. Measurements of eggs of some species taken in L. I. S. indicate that a decrease occurred in both nature and preservative. Of eggs taken during spring 1952 at the same time and location, some were measured after 6 to 8 months while the others were measured after 24 to 26 months in the identical preservative, giving an interval of 18 months between measurements; the latter eggs were smaller than the former, thus indicating an artificial decrease due to preservation beyond a progressive natural decrease that had also been observed. A natural decrease in size during the spawning season was demonstrated in the eggs of *A. m. mitchilli* and of other species; those taken on the 100-cruise in June were larger than those obtained during the summer at the regular stations; further confirmation is found in the fact that the larger eggs, taken earlier, were measured 12 months later than the others.

While preservation may bring about some decrease in egg size, our data indicate that there is quite certainly a decrease in nature due to one or more factors. More complete observations are being performed to determine, if possible, the effect of long preservation on the egg size of each species. Further study is also needed to ascertain the extent of changes in egg size in nature.

2. The decrease in size may be correlated with the shape and structure of the eggs. Many eggs, such as those of *S. caerulea* (Ahlstrom, 1943), *Hippoglossoides platessoides* (Bigelow and Schroeder, 1953), *Sardinops ocellata* (Davies, 1954), and *T. chalcogramma* (Gorbunova, 1952), swell and develop a large perivitelline space when they come in contact with water. Similar behavior is found in the egg of *B. tyrannus*, which showed marked diameter differences during spring and fall in L. I. S. While eggs with a large perivitelline space

may be more susceptible to changes in either sea water or preservative, it is probably not the only factor, since eggs without such a space also show a tendency to decrease.

3. The size may be affected by changes in environmental factors such as salinity, temperature, or density of the water mass. Delsman (1931), in observations on the size of *Cybium guttatum* eggs, demonstrated that an increase in salinity caused a decrease in diameter, and he maintained that this same phenomenon had been observed in the Baltic and North Sea. Hildebrand and Cable (1934) believed that the apparent descrepancy in the size of *C. regalis* eggs measured by Welsh and Breder (1923) may have been due to differences in salinity. Other investigators have maintained that temperature was the more important factor. Fish (1928) demonstrated that cod eggs fertilized in cold water were larger than those fertilized in warm water, and Sette (1943), on the basis of Fish's observations, maintained that temperature alone could be responsible for differences in the size of fish eggs of the same species. Sette, in his own work on *S. scombrus* eggs, reported a tendency of the eggs to decrease in size as the spawning season advanced, a tendency which he felt might be applicable to the eggs of all species taken during his investigation. Ehrenbaum (1923) noted the same condition in the eggs of the European mackerel. Some years later, Fridriksson and Timmermann (1951), working with herring, concluded that the eggs of the Icelandic race were larger than those of European or Norwegian races, but they make no mention of comparative sizes of the adults relative to the locality, a factor which may be important. It seems reasonable to postulate that lower temperatures around Iceland may have been responsible for the larger eggs. Farran (1938) discovered that the ovary of spawning Irish herring had fewer but larger eggs in the spring than in the fall. This phenomenon is primarily genetic in origin, but he maintained that it may have resulted from the cooler spring water temperatures.

Rass (1941) stated that the size of eggs of aquatic animals was inversely proportional to the breeding temperature, but Marshall (1953) maintained that this was an oversimplification. According to Marshall's viewpoint, the larger eggs of species that inhabit oceanic bathypelagic and polar inshore waters hatch into relatively larger larvae; these in turn have an advantage over smaller larvae in that they require less food for their size and have greater swimming

powers, thus enabling them to obtain planktonic food more successfully in areas where it is less abundant.

In L. I. S., menhaden eggs in the spring were larger than those in the fall, and the spawning period of most species whose eggs decreased in size occurred when water temperatures were steadily increasing.[7]

4. The size of the egg may be correlated with the size of the parent fish. Toots (1951) demonstrated that the larger whitefish (*Coregonus*) from seven northern Swedish lakes usually have larger eggs on the average than the smaller fish. But he did not state whether the smaller fish as a group spawned earlier or later than the larger fish in the same population, nor did he indicate whether the populations of different lengths spawned simultaneously in the different lakes. Since the number of eggs per gram weight was greater in fish of smaller length, he reasoned that the eggs must therefore be smaller. Both Clark (1934) and Kisselwitch (1923) found that the total number of eggs was greater in larger specimens of the California sardine and the Caspian herring and that the number of eggs increased with the square of the length. But they draw no conclusions as to whether or not the size of the eggs changed with length of the fish. Clark observed that the larger sardines spawned longer and later than the smaller ones, but she did not note the size of the eggs throughout the season. No information on this subject is available for L. I. S., since the parents were not collected.

5. The size of the egg is affected by the metabolism of the parent. In the process of producing the genital products and of spawning, a fish is probably sufficiently affected physiologically so that eggs of equal size are not produced over the whole period. Clark (1934), working with *S. caerulea* which spawns as much as three times during its long spawning period (February to August), found that a new group of the eggs was ripening as the ripe ova were being spawned. She stated ". . . the decrease throughout the season in ratios of the different groups of eggs [of small to large eggs in the ovary] did not result from changes in the sizes of fish making up the catch but was brought about by the spawning out of successive batches of eggs . . . presumably as the spawning season advanced, succeeding groups of eggs failed to undergo a corresponding growth and spawning finally ceased after the largest group of eggs had been spawned out."

[7] Of the four fall spawners, only the menhaden eggs showed a change in size—a slight increase between August and October.

This then would leave us in doubt as to whether smaller eggs resulted with each successive spawning.

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