FISH LARVAE OF THE ESTUARIES AND COAST OF CENTRAL MAINE

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ABSTRACT

Seasonal sampling of fish larvae in the central Maine coast took 22 kinds of larvae; 17 were identified to species, 3 to family, and 2 were not identified. Larvae of a few highly abundant species were present in the winter and early spring. These hatched from demersal eggs and were concentrated in the upper estuaries. The remaining species were less abundant and were present during the spring and summer. Most of these larvae hatched from pelagic eggs and were not greatly concentrated in the upper estuaries. The larvae of only one commercially important species, *Clupea harengus harengus*, were found abundantly in the region.

There is little information on the species composition and abundance of larval fishes in the numerous estuaries and bays of the coast of Maine. During the past 10 years (1961-70) samples of larval herring have been taken in the central area of the Maine coast for a program of research on the prerecruit stage of the herring. In three of those years (1961, 1968, and 1970) other fish larvae also were identified. An examination of the first year's catch was reported by Graham and Boyar (1965). This paper reports on the 1968 and 1970 identifications and gives a more complete picture of the seasonal abundance and spatial distribution of the larvae; it also compares the results with surveys in other adjacent areas.

The area sampled is a system of drowned river valleys and bays typical of the Maine coast. It is bounded on the west by the Sheepscot estuary and on the east by the Damariscotta estuary, extends offshore approximately 4 miles to lat 43°45'N, and will be referred to in this report as the Boothbay region. The general ecology of the Sheepscot estuary was described by Stickney (1959), and the hydrography of the area was reported by Graham and Boyar (1965). The portion of the Sheepscot estuary sampled during this study is 14 miles long, has a drainage area of 148 square miles, varies from 20 to 60 m in depth, and is more typical of a long, narrow bay than an estuary. The portion of the Damariscotta estuary sampled is 11 miles long, has more freshwater dilution in its upper portion than the Sheepscot, and has a smaller drainage basin. The bay separating the two estuaries is a typical coastal indentation with relatively deep water, steep rocky shores, and very little freshwater dilution.

Other surveys of fish eggs and larvae from areas close to the coastal Gulf of Maine are pertinent to this study. Perlmutter (1939) and Wheatland (1956) identified the larvae from Long Island Sound, and Merriman and Sclar (1952) from Block Island Sound. Herman (1963) reported on the fish eggs and larvae of Narragansett Bay, R.I., and Pearcy and Richards (1962) on those of the Mystic River estuary, Conn. Marak and Colton (1961), Marak, Colton, and Foster (1962), and Marak, Colton, Foster, and Miller (1962) have reported for the offshore area of Georges Bank and the Gulf of Maine, and Fish and Johnson (1937) for the Gulf of Maine and Bay of Fundy.

METHODS

Eight stations were sampled twice a month from January through August 1968 and from November 1969 through October 1970 (Figure 1). Additional information was available from occasional sampling in 1971. The larvae were

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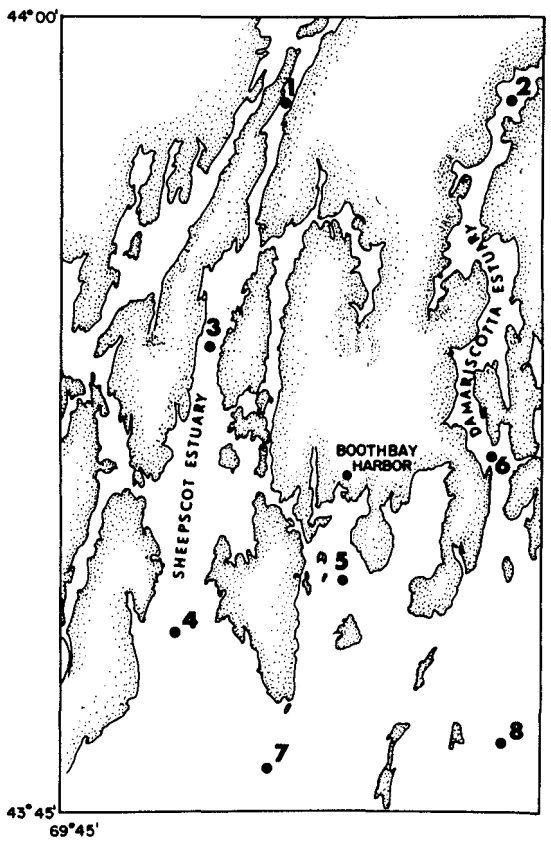


FIGURE 1.—Sampling stations in the Boothbay region, January through August 1968 and November 1969 through October 1970.

preserved in 5% Formalin[2] and identified in the laboratory. The stations were grouped according to general location within the sampling area and are termed upper estuarine stations (1, 2, and 3), lower estuarine stations (4, 5, and 6), and outer stations (7 and 8). The outer stations were approximately 4 miles from the headlands.

Larvae were collected with a Boothbay Depressor Trawl (Graham and Vaughan, 1966) using a 3-stepped oblique tow (10 min each level) from bottom to surface. The trawl was towed at 4 knots for 30 min. The amount of water strained was determined by using the opening of the net and the distance towed. The mesh opening of the trawl net (2 mm) was larger than that of the meter net (0.51 mm) used by Graham and Boyar (1965). Small larvae (<2 mm) probably escaped through the larger mesh, but the species composition of the larvae caught in both the Boothbay Depressor Trawl and meter net was similar.

Larval identification was based on known spawning time and on previously reported identifications. References used most often in identification were Colton and Marak (1969), Bigelow and Schroeder (1953), and Graham and Boyar (1965).

RESULTS

Twenty-two kinds of larvae were represented in the collections in the Boothbay region during January to August 1968 and November 1969 to October 1970 (Table 1); 17 kinds were identified to species, 3 to family, and 2 were not identified. All of the species were boreal with centers of abundance north of the mid-Atlantic coast, and many of the more abundant larvae do not occur south of New England. Most of the larvae, particularly the more abundant ones, hatch from demersal eggs.

SPECIES ABUNDANCE AND COMPOSITION

Larvae were most abundant during late winter to early spring (Figure 2). The dominant larvae at this time were *Pholis gunnellus*, *Liparis* sp., *Cryptacanthodes maculatus*, *Lumpenus lumpretaeformis*, and the Cottidae; they represented 91% of the total catch. In addition, *Anguilla rostrata* and a species of Gadidae (probably *Gadus morhua*) occurred in small numbers (0.1% and 0.01% of the total catch). The composition of the dominant kinds of larvae differed between years. The Cottidae was dominant in 1968 and *P. gunnellus* in 1970; *C. maculatus*, *L. lumpretaeformis*, and the *Liparis* sp. were more numerous in 1968 than in 1970.

Catches of larvae in the winter and early spring were large between February and April

[2] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

TABLE 1.—Larval fish taken in the central Maine coast region January to August 1968 and November 1969 to October 1970.

Scientific name	Common name	Number of larvae		Egg deposition
		Jan.-Aug.	Nov.-Oct.	
Cottidae	Sculpins	6,222	4,053	Demersal
Pholis gunnellus (Linnaeus)	Rock gunnel	2,336	5,531	Demersal
Liparis sp.	Seasnail	1,610	106	Demersal
Anguilla rostrata (Lesueur)	American eel	19	11	Unknown
Cryptacanthodes maculatus Storer	Wrymouth	164	96	Unknown
Lumpenus lumpretaeformis (Walbaum)	Snakeblenny	328	225	Demersal
Gadidae	Codfishes	3	0	Pelagic
Aspidophoroides monopterygius (Bloch)	Alligatorfish	139	29	Unknown
Merluccius bilinearis (Mitchill)	Silver hake	0	4	Pelagic
Ammodytes americanus DeKay	American sand lance	0	2	Demersal
Sebastes marinus (Linnaeus)	Redfish	4	1	Ovoviviparous
Cyclopterus lumpus Linnaeus	Lumpfish	4	6	Demersal
Limanda ferruginea (Storer)	Yellowtail flounder	22	17	Pelagic
Osmerus mordax (Mitchill)	Rainbow smelt	12	0	Demersal
Syngnathus fuscus (Storer)	Northern pipefish	15	2	Oviparous
Scophthalmus aquosus (Mitchill)	Windowpane	23	8	Pelagic
Ulvaria subbifurcata (Storer)	Radiated shanny	127	82	Unknown
Enchelyopus cimbrius (Linnaeus)	Fourbeard rockling	21	3	Pelagic
Clupea harengus harengus Linnaeus	Atlantic herring	619	792	Demersal
Tautogolabrus adspersus (Walbaum)	Cunner	8	11	Pelagic
Species A		0	5	Unknown
Species B		117	22	Unknown

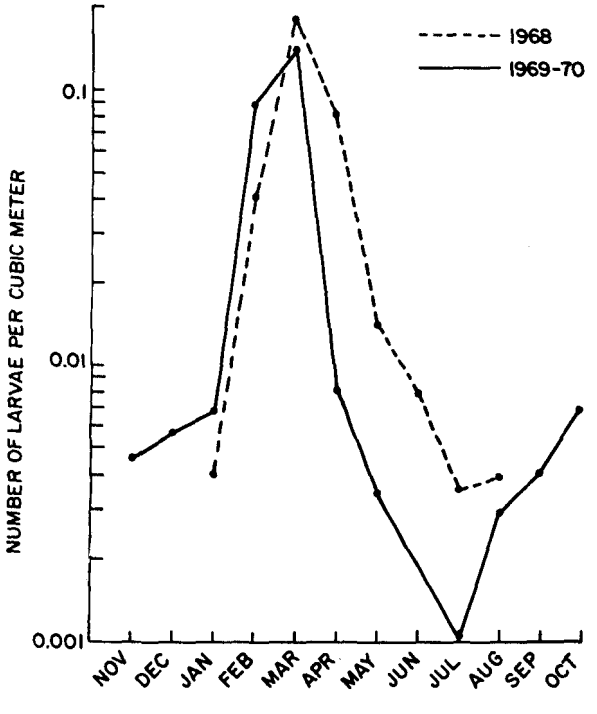


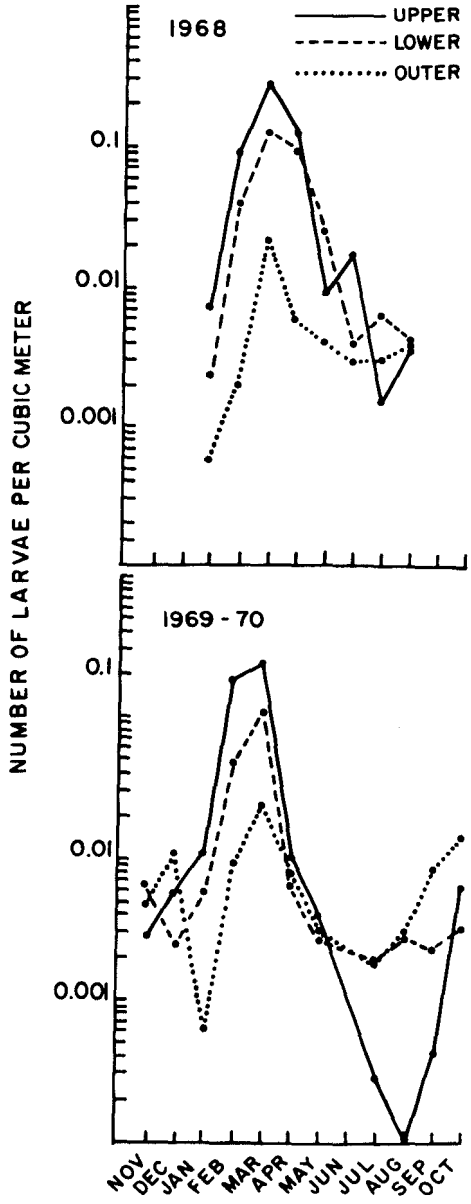
FIGURE 2.—Seasonal abundance of fish larvae in the Boothbay region, January through August 1968 and November 1969 through October 1970.

and largest during the first half of March. In both years the catches were similar. The average for the March peak was 0.18 per m^3 in 1968 and 0.14 per m^3 in 1970 and for the period between February and April, 0.08 per m^3 in 1968 and 0.09 per m^3 in 1970. The larvae were abundant longer in 1968 than in 1970; the large catches in 1968 extended into April and May.

In spring the numbers of larvae in the catch declined sharply with the end of the larval stage of the dominant species and continued gradually to decline to a low point in July and August. Most of the remaining larvae were taken in the spring and summer and, although fewer in numbers, more species were present. Species in this group were: *Aspidophoroides monopterygius, Merluccius bilinearis, Ammodytes americanus, Sebastes marinus, Cyclopterus lumpus, Limanda ferruginea, Osmerus mordax, Syngnathus fuscus, Scophthalmus aquosus, Ulvaria subbifurcata, Enchelyopus cimbrius, Tautogolabrus adspersus.* Of these, *U. subbifurcata* and *E. cimbrius* were obtained as larvae into the fall. *Clupea harengus harengus* hatched in September and October and was present in the area as larvae through May. The increased larval abundance in September and October was due to the hatching

of *Clupea harengus harengus* which was the only species abundant in the autumn.

The distribution of the larvae from offshore to the upper estuaries changed seasonally. Catches from the upper estuarine, lower estuarine, and outer stations (Figure 3) showed that the larvae in the winter and early spring were concentrated in the upper estuaries, while the larvae in the summer were more evenly distributed.



The upper estuaries are probably important as nursery areas for the winter-early spring larvae. Most of this group were captured within the estuaries. From January to May the three upper stations contributed 68% of the catch in 1968 and 70% of the catch in 1970. Station 2 in the upper Damariscotta estuary produced the highest catches, accounting for 40% of all the larvae taken in 1968 and 65% in 1970. The distribution of the winter-early spring group of larvae was different within the estuaries between years. In 1968 the larvae were more evenly distributed among the upper stations than in 1970.

The seasonal abundance for each kind of larvae taken in the Boothbay region is shown in Figures 4 and 5. The more common kinds are discussed below.

Cottidae

Cottid larvae were present from January to July and their abundance reached a peak in March. Their distribution was upper estuarine and they were most abundant at station 2 (50% of all cottids in 1968, 74% in 1970). The total abundance of these larvae differed between years (6,222 in 1968 and 4,053 in 1970) because more cottids were taken at the other stations in 1968 (Figure 4A). Spawning probably occurred in the upper estuaries, inasmuch as cottids lay demersal eggs which do not drift, and yolk sac larvae were taken at the upper stations.

All cottid larvae were not identified to species, but Nuzrat Khan, Department of Biology, University of Ottawa, Ottawa, Canada (personal communication) recognized five species from 1,387 specimens of cottids that I sent to him. Of these, 689 were *Myoxocephalus scorpius;* 456, *Myoxocephalus octodecemspinosus;* 183, *Myoxocephalus aenaeus;* and 59, *Triglops* sp.

FIGURE 3.—The seasonal abundance of fish larvae in three areas of the Boothbay region; the upper estuary, the lower estuary, and outside the headlands.

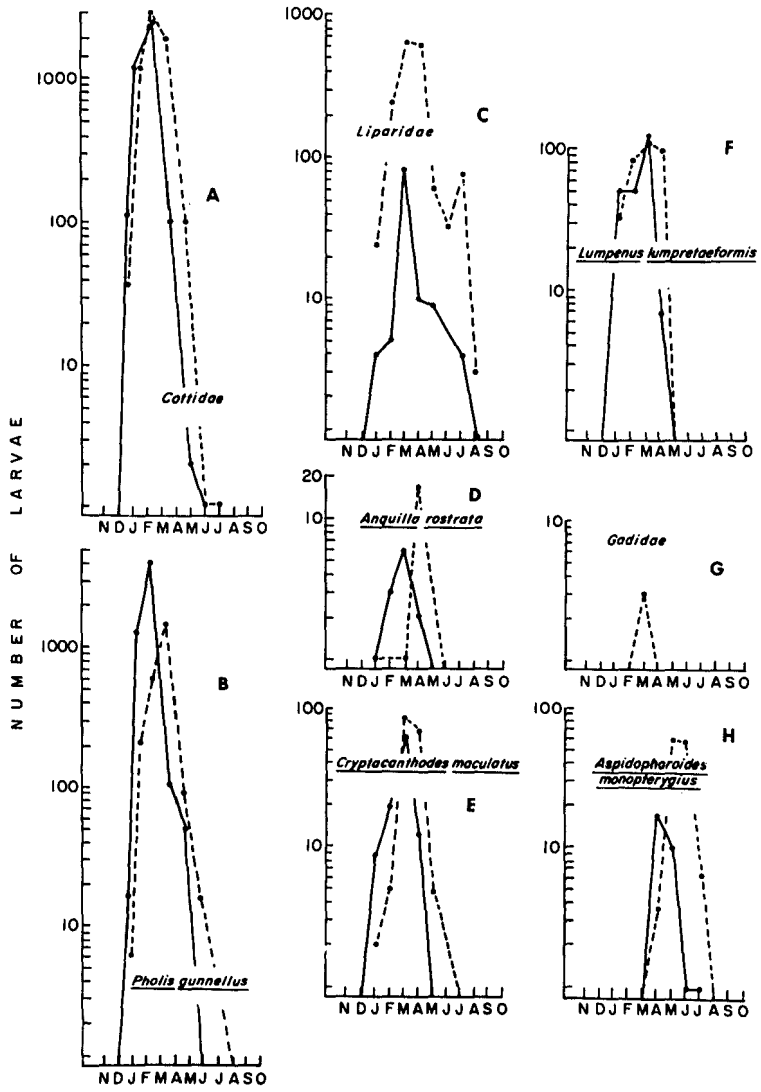


FIGURE 4.—Seasonal abundance of the following kinds of fish larvae in the Boothbay region, January through August 1968 and November 1969 through October 1970: A. Cottidae, B. *Pholis gunnellus*, C. Liparidae, D. *Anguilla rostrata*, E. *Cryptacanthodes maculatus*, F. *Lumpenus lumpretaeformis*, G. Gadidae, H. *Aspidophoroides monopterygius*.

Pholis gunnellus

The eggs of *P. gunnellus* are demersal, and yolk sac larvae were found in the upper estuaries during this study, suggesting that they were spawned there. The larvae appeared in the catches from January to July and reached peak abundance in February and March (Figure 4B). They represented 20% of the catch in 1968 and 50% of the catches in 1970. Their distribution was upper estuarine and, like cottids, they were most abundant at station 2 (28% of the catch in 1968 and 59% in 1970).

Liparis sp.

Liparid larvae were common in our catches in 1968 (14% of the catch) but less so in 1970 (1%) (Figure 4C). They probably spawn within the estuaries as they lay demersal eggs, and yolk sac larvae were found in the upper estuaries. The greatest number were taken in

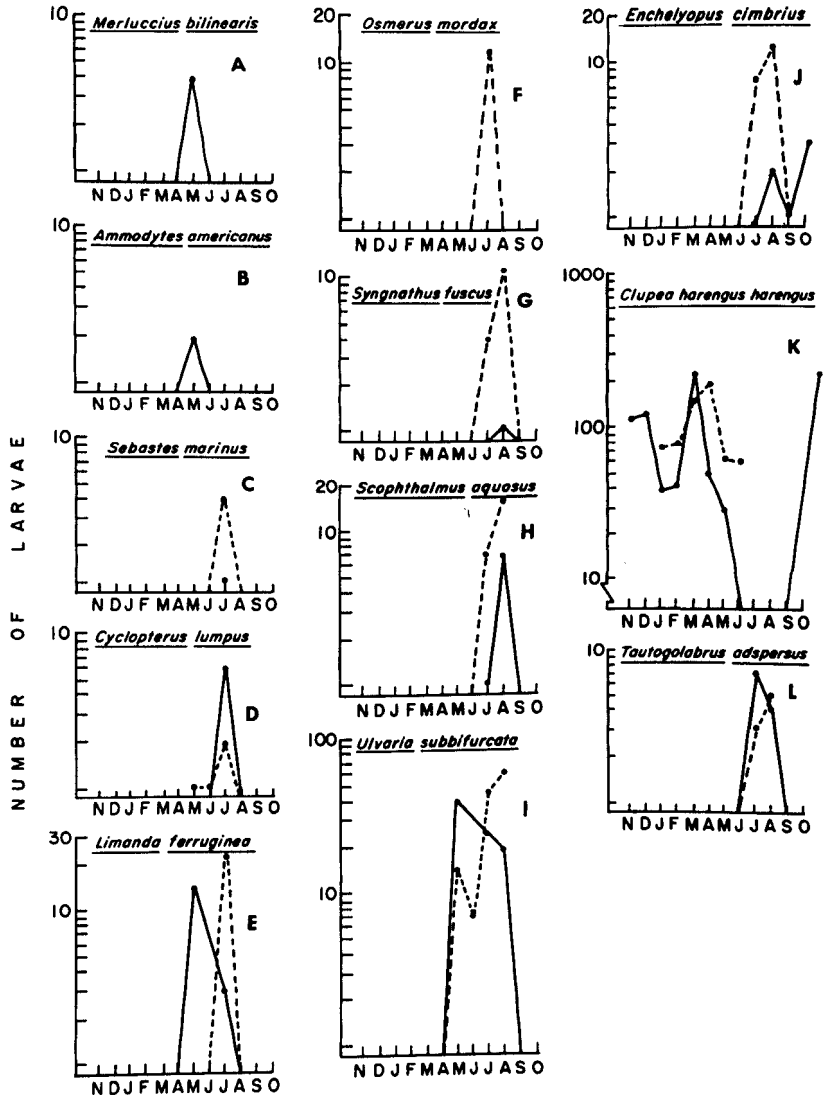


FIGURE 5.—Seasonal abundance of the following kinds of fish larvae in the Boothbay region, January through August 1968 and November 1969 through October 1970: A. *Merluccius bilinearis*, B. *Ammodytes americanus*, C. *Sebastes marinus*, D. *Cyclopterus lumpus*, E. *Limanda ferruginea*, F. *Osmerus mordax*, G. *Syngnathus fuscus*, H. *Scophthalmus aquosus*, I. *Ulvaria subbifurcata*, J. *Enchelyopus cimbrius*, K. *Clupea harengus harengus*, L. *Tautogolabrus adspersus*.

the upper estuaries, and the difference in abundance between years suggests that there was considerably less spawning in 1970 than 1968.

Lumpenus lumpretaeformis

L. lumpretaeformis probably spawns in the upper estuaries because yolk sac larvae were

found there and egg deposition, although not known, is probably demersal (it is for closely related forms). They were captured from January to April with a peak abundance in March (Figure 4F).

Aspidophoroides monopterygius

A. monopterygius larvae were abundant a little later than the winter-early spring group, ranging from April to July with a peak in April or May (Figure 4H). Their distribution was more lower estuarine than upper.

Ammodytes americanus and *Cyclopterus lumpus*

The larvae of *A. americanus* (Figure 5B) and *C. lumpus* (Figure 5D) were only rarely taken in this study but Graham and Boyar (1965) reported them abundant. However, these authors reexamined some of their specimens identified as *Cyclopterus lumpus* and *Ammodytes americanus* and found that most identified as *C. lumpus* were *Liparis* sp. and many identified as *A. americanus* were *Pholis gunnellus*.

Gadidae

Several kinds of gadids spawn in our sampling area. *Enchelyopus cimbrius* (Figure 5J) was one of the two dominant species from June until October in the lower estuaries and outer areas. A few larvae of *Merluccius bilinearis* (Figure 5A) were taken in May 1970. Three specimens of what was probably *Gadus morhua* (Figure 4G) were taken in March 1968. Subsequent sampling (1971) took a few more *G. morhua* in December as yolk sac larvae and also later stage larvae in February in the Sheepscot estuary.

Ulvaris subbifurcata

This was the other dominant species in the spring and summer (Figure 5I). It was present from April until September in the lower estuaries and outer areas.

Clupea harengus harengus

This is a pelagic species that lays demersal eggs and uses both the estuaries and bays as nursery areas during its larval stage from October to May (Figure 5K). It was the only commercially important species to do so and I would consider these areas important to the population density of the species.

Species A and B

At present we are attempting to identify these species. Species A is probably one of the Stichaeidae, possibly *Lumpenus maculatus*. Species B has been tentatively identified as *Hemitripterus americanus* but needs confirmation.

DISCUSSION

LARVAL NURSERY AREAS

Most of the fishes whose larvae were present in the Boothbay region may be placed in one of two groups: those that use the estuaries as primary spawning and nursery areas and those that do not.

The larvae found in the region during the winter and early spring (*Pholis gunnellus, Liparis* sp., *Cryptacanthodes maculatus* (Figure 4E), *Lumpenus lumpretaeformis,* and the Cottidae) belong to the first group. They were the most abundant species and their greatest concentration was in the upper estuaries. They are larvae of resident demersal fish that are not commercially important but are extremely abundant in the area. They use the bays and estuaries as nursery areas, depending to a large extent on these areas for their reproductive success. These species lay demersal eggs in the estuaries. Pearcy and Richards (1962) discussed the possibility that the larvae of demersal species in the Mystic River estuary maintained themselves there by concentrating in the counter currents near the bottom. The stepped oblique tow that was used in my study was not suitable for an analysis of the depth distribution of the larvae. The winter-early spring group of larvae,

however, were most abundant in the upper estuaries throughout their larval life, and therefore probably maintained themselves there by adapting to the circulation of water within the estuaries. These larvae disappeared from the catches very rapidly during April and May, which contributed to the rapidly declining spring catch. By this time they were approaching the juvenile stage and, being benthic fish, probably settled to the bottom and were not available to the sampling gear.

The remaining species (*Merluccius bilinearis, Sebastes marinus* (Figure 5C), *Cyclopterus lumpus, Limanda ferruginea* (Figure 5E), *Syngnathus fuscus, Scopthalmus aquosus* (Figure 5H), *Ulvaria subbifurcata, Enchelyopus cimbrius,* and *Tautogolabrus adspersus* (Figure 5L)) were present but not abundant in the spring and summer, suggesting that the estuaries were not their primary nursery areas. Possibly the numbers of spawning adults of these species were low in the bays and estuaries, or, as most of these species lay pelagic eggs, the eggs were dispersed before the larvae hatched.

Some species did not belong to either of the two above-mentioned groups: *Anguilla rostrata* (Figure 4D), a catadromous, and *Osmerus mordax* (Figure 5F), an anadromous species; *Aspidophoroides monopterygius,* which spawns later than the winter-early spring group, was not as common in the upper estuaries; *Ammodytes americanus*; and the Gadidae.

COMPARISON WITH OTHER AREAS OF THE NORTHWEST ATLANTIC

The results of surveys in other areas of the northwest Atlantic indicate the overall distribution of the three more abundant larvae of the Boothbay region. Cottid larvae occurred throughout the surveyed areas. *Myoxocephalus aenaeus* was dominant in the Mystic River estuary (Pearcy and Richards, 1962), Block Island Sound (Merriman and Sclar, 1952), and Long Island Sound (Wheatland, 1956); *M. octodecemspinosus* occurred in the offshore areas (Marak and Colton, 1961; Marak, Colton, and Foster, 1962; Marak, Colton, Foster, and Miller, 1962); and *M. scorpius* occurred in the Gulf of Maine (Fish and Johnson, 1937) and appears from my survey to be dominant along the central Maine coast. The larvae of *Pholis gunnellus* appear to be more abundant in the estuaries than offshore. They were one of the most abundant species in the Mystic estuary (Pearcy and Richards, 1961) where they also concentrated in the upper estuaries. They were less abundant in the more open Narragansett Bay (Herman, 1963), rare offshore (Marak and Colton, 1961; Marak, Colton, and Foster, 1962; Marak, Colton, Foster, and Miller, 1962), and absent from Long Island (Wheatland, 1956) or Block Island Sounds (Merriman and Sclar, 1952). Larvae of the Liparidae were taken in small numbers offshore (Marak and Colton, 1961; Marak, Colton, and Foster, 1962; Marak, Colton, Foster, and Miller, 1962) and in the Gulf of Maine (Fish and Johnson, 1937) but not at all south of Cape Cod.

Pearcy and Richards (1962) found a dominant winter-early spring group of larvae in the Mystic estuary, but the more abundant species differed from those in the central Maine coast. The dominant species in the Mystic estuary were *Pseudopleuronectes americanus, Microgadus tomcod,* and *Myoxocephalus aenaeus.* In Narragansett Bay (Herman, 1963) the demersal winter-early spring group of larvae was less evident with only *Myoxocephalus* sp. dominant, and with many more pelagic forms. An abundance of pelagic forms might be expected in Narragansett Bay because the Bay is characteristically more like the open ocean than the smaller estuaries.

The spring and summer species of larvae were abundant enough in southern New England (Pearcy and Richards, 1962; Herman, 1963) to create a second summer peak in larval abundance that was absent in my survey of the Boothbay region. This was probably due to the absence of larvae of such species as *Stenotomus chrysops, Anchoa mitchilli, Cynoscion regalis,* and *Tautoga onitis* which have a more southern distribution and are only occasionally taken as adults along the Maine coast (Bigelow and Schroeder, 1953).

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