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Seasonal Succession of the Food of Larval Herring in a Coastal Nursery Area

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Little is known of the trophodynamics of larval herring in the western Atlantic. Relationships between food-dependent survival of larvae and subsequent year-class strength of adults have been reported for herring in the Baltic (Lishev, Rannak, and Lisivnenkó, 1960) and the North Sea (Shirokov, 1964). As part of a study of the environmental factors influencing larval survival, a series of collections of larvae and their zooplankton food was made in the Sheepscot estuary, one of the coastal nursery areas of herring in the Gulf of Maine. To examine the seasonal changes in the availability of food to larvae, zooplankton was collected from October, 1968 to February, 1970, at five locations in the seaward end of the Sheepscot estuary and adjacent areas (fig. 1). Weather conditions permitting, the region was sampled semi-monthly using a 20 cm mouth diameter Gulf III fitted with 0.366 mm apertures metal netting (October and November, 1968) and 20 cm diameter bongo nets fitted with a calibrated flowmeter and nylon nets of 0.253 mm and 0.366 mm apertures (from December, 1969 to February, 1970). Step oblique tows of 30-minutes -- 10 minutes each at the bottom, middepth, and surface of the water column -- were made during daylight. Simultaneous collections of larval herring were made with a Boothbay trawl.

Zooplankton Volumes

During an annual cycle (March, 1969 to February, 1970) zooplankton volumes increased from a mid-spring low in April to an annual high in summer (July). Volumes then declined in late summer, and reached a secondary peak in mid-autumn, followed by a sharp reduction in abundance in late autumn and early winter (fig. 2).

Group and Species Composition

Twenty-two taxa were in the zooplankton samples, but only four were abundant (>10 percent of the zooplankton in a month), copepods, cladocerans, larval cirripeds, and appendicularians that swarmed only in May, when they constituted 20 percent of the zooplankton. Copepods were the dominant zooplankters from late summer through spring; larval cirripeds predominated in March and April prior to bottom settlement, and cladoceran swarms dominated in June and July (fig. 3).

Although 19 copepod species were in the samples only nine were numerous (>10 percent of the copepods in a month)-- Acartia clausi, Acartia longiremis, Calanus finmarchicus, Centropages hamatus, Centropages typicus, Eurytemora herdmani, Oithona spp., Pseudocalanus minutus, and Temora longicornis. The abundance of the species varied among seasons. In spring, C. finmarchicus and Oithona spp. were at an annual peak; they declined in summer and swarmed again in autumn. The congeneric species A. clausi and A. longiremis were the predominant species in summer; E. herdmani and C. hamatus were in abundance in late summer and early autumn, followed by an increase in C. typicus numbers in late autumn. The small calanoid, P. minutus, was at an initial peak in late summer (August), and at an annual high in autumn along with Temora longicornis. In winter P. minutus was the single dominant species.

Seasonal Variations in Larval Food

Examinations were made for food organisms in the alimentary tracts of 390 larvae collected from hatching in October, 1968 to the juvenile stage in May, 1969, using the laboratory methods described previously (Sherman and Honey, 1968). Larvae were preying principally on copepods (eggs, nauplii, copepodites, and adults). The only non-copepod food taken in significant numbers was larval cirripeds in spring. Although cirripeds were swarming in large numbers in spring, they were less important as food than the copepods P. minutus, Oithona spp. and Acartia spp., suggesting a larval preference for copepod prey (table 1).

Variations in Zooplankton Swarming and Food Availability

The timing of the secondary peak of zooplankton abundance in autumn and the hatching of larval herring in this season could be important to larval survival, and possibly the strength of subsequent year-classes in the commercial fisherv. Recently Bainbridge and McKay (1968) demonstrated the dependence of cod and redfish larvae on the production of Calanus finmarchicus eggs, nauplii, copepodites, and adults as a source of food in waters off Greenland and Iceland. In the Sheepscot region copepodites of three species of copepods predominate in the autumn spawning period of coastal herring -- Acartia longiremis, Pseudocalanus minutus and Temora longicornis (fig. 4). Temporal variations in the autumnal spawning of these species could effect larval survival. In autumn, 1968, larval herring preyed only on the eggs, nauplii and copepodites of P. minutus, suggesting that the production of the autumn generation of T. longicornis and A. longiremis was out of phase with the hatching of herring larvae. It is also possible that early larvae may reject some species of calanoid copepods though they may be abundant in the plankton as reported by Blaxter (1965) for Acartia sp. In the larval development period of 1967-68 and in the present study the incidence of T. longicornis was extremely low (1 percent of the total copepods) in relation to its abundance in the plankton. Following the autumn decrease in zooplankton abundance, the larvae are sustained through the winter by P. minutus, the only zooplankter in abundance in the Sheepscot region until the spring swarming of larval cirripeds. By late spring larvae develop into schooling juveniles that are numerous in the coastal embayments through summer.

Although a large number of taxa and copepod species constitute the zooplankton assemblage in the Sheepscot nursery area, the development of a single species, Pseudocalanus minutus, appears to be the prey most closely synchronized with the development of larval herring. Whether this relationship can effect the survival of a year-class is not clear, and is a problem presently under investigation.

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Table 1. Seasonal variations in the zooplankton food of larval herring. The number of larvae feeding on each of the zooplankton taxa and copepod species are listed by season. The number of larvae examined (N) and the percentage feeding (in parentheses) are given for each season.

Taxa	Autumn N =119 (39) Number	Percent	Winter N = 169(58) Number	Percent	Spring N = 102(72) Number	Percent	Total N = 390(56) Total	Percent
Pseudocalanus minutus(C)	1/20	43	60	61	41	56	121	56
Copepodites spp.	19	41	22	22	16	22	47	22
Copepod nauplii	9	20	--	--	--	--	9	4
Oithona spp. (C)	1	2	20	20	31	42	52	24
Crustacean eggs	1	2	13	13	4	5	18	8
Acartia spp.(C)	--	--	5	5	16	22	21	10
Cirriped larvae	--	--	2	2	14	19	16	7
Calanus finmarchicus(C)	--	--	1	1	5	7	6	3
Temora longicornis(C)	--	--	1	1	1	1	2	1
Harpacticoid spp. (C)	--	--	1	1	5	7	6	3
Crustacean nauplii	--	--	1	1	--	--	1	< 1
Tintinnids	--	--	--	--	5	7	5	2
Eurytemora herdmani (C)	--	--	--	--	1	1	1	< 1
Hensens larvae	--	--	--	--	1	1	1	< 1
Cladocerans	--	--	--	--	1	1	1	< 1
Diatom cells	--	--	--	--	1	1	1	< 1

1/ (C) = Copepods

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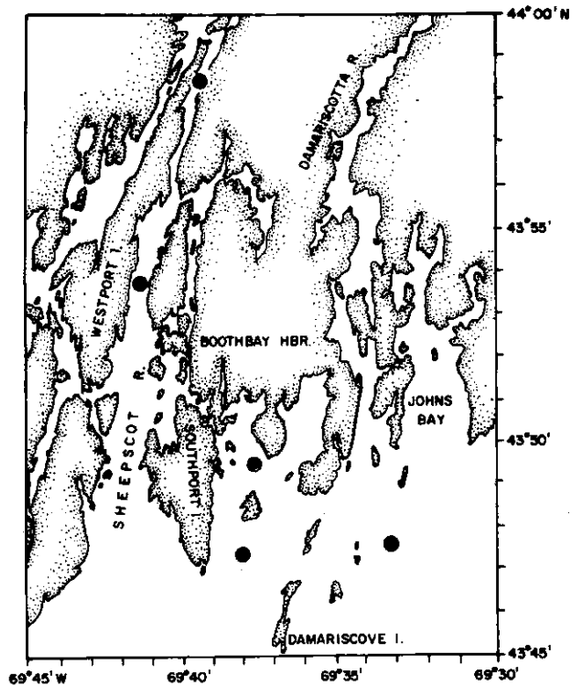


Figure 1. Zooplankton sampling stations in the Sheepscot region of the Gulf of Maine, 1968 to 1970.

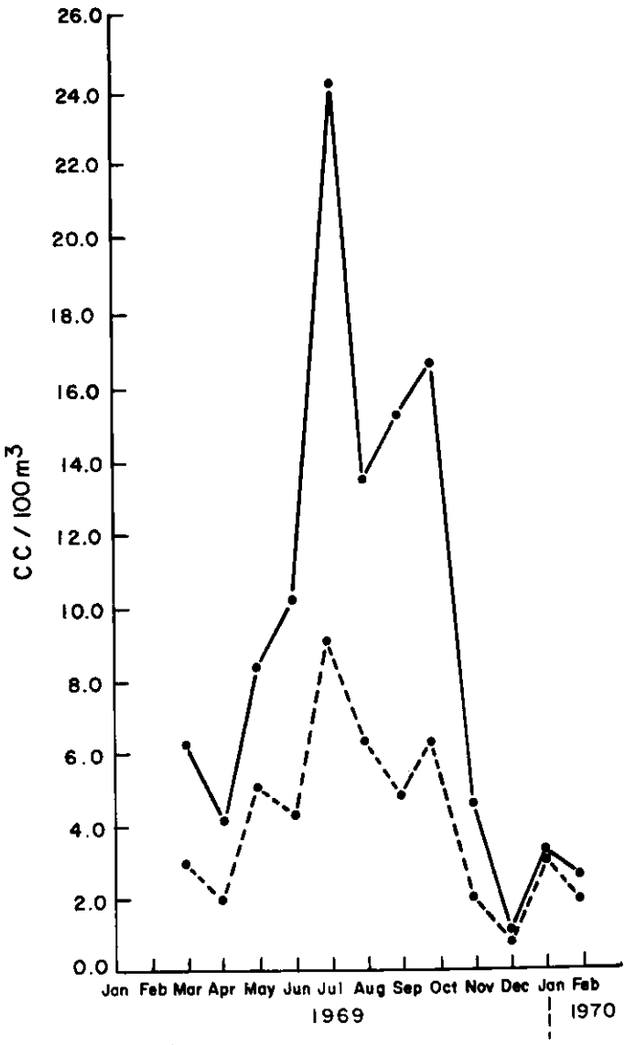


Figure 2. Mean monthly volumes of zooplankton in the Sheepscot region, January 1969 to February 1970. Solid line is for collection made with the 0.253 mm aperture net and the dotted line for the 0.366 mm aperture net.

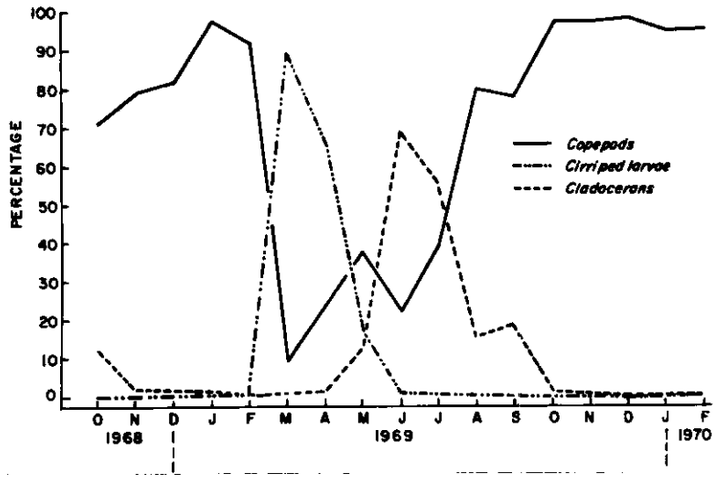
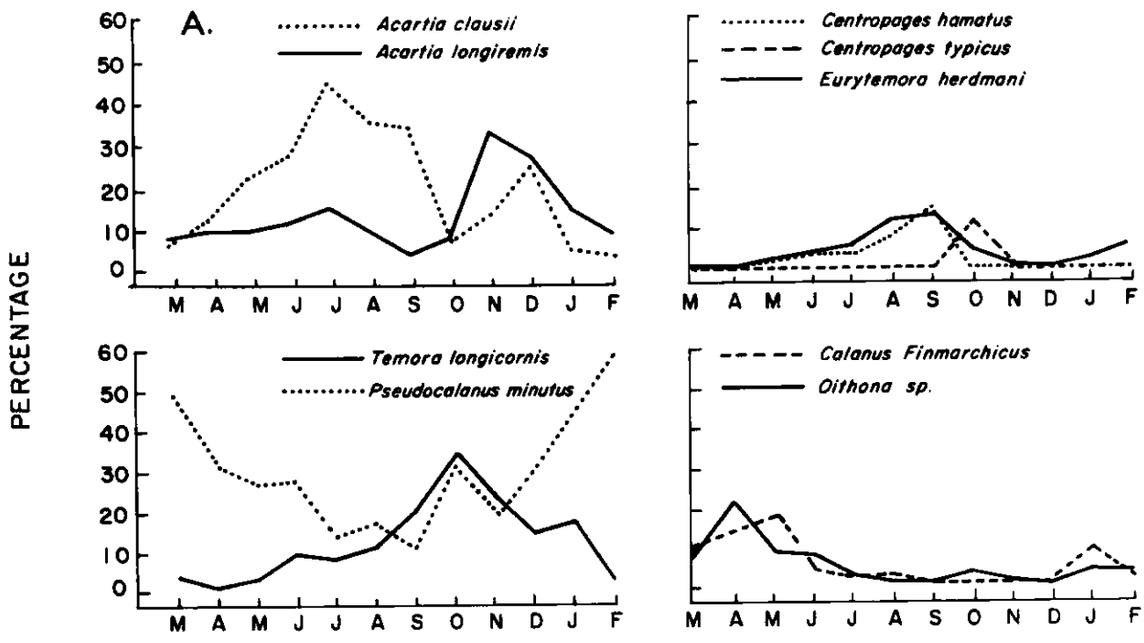


Figure 3. Monthly percentage composition of the predominant zooplankton taxa in the Sheepscot region, October, 1968 to February, 1970. Solid line is for copepods, dashed line for cladocerans, and dotted line for larval cirripeds.



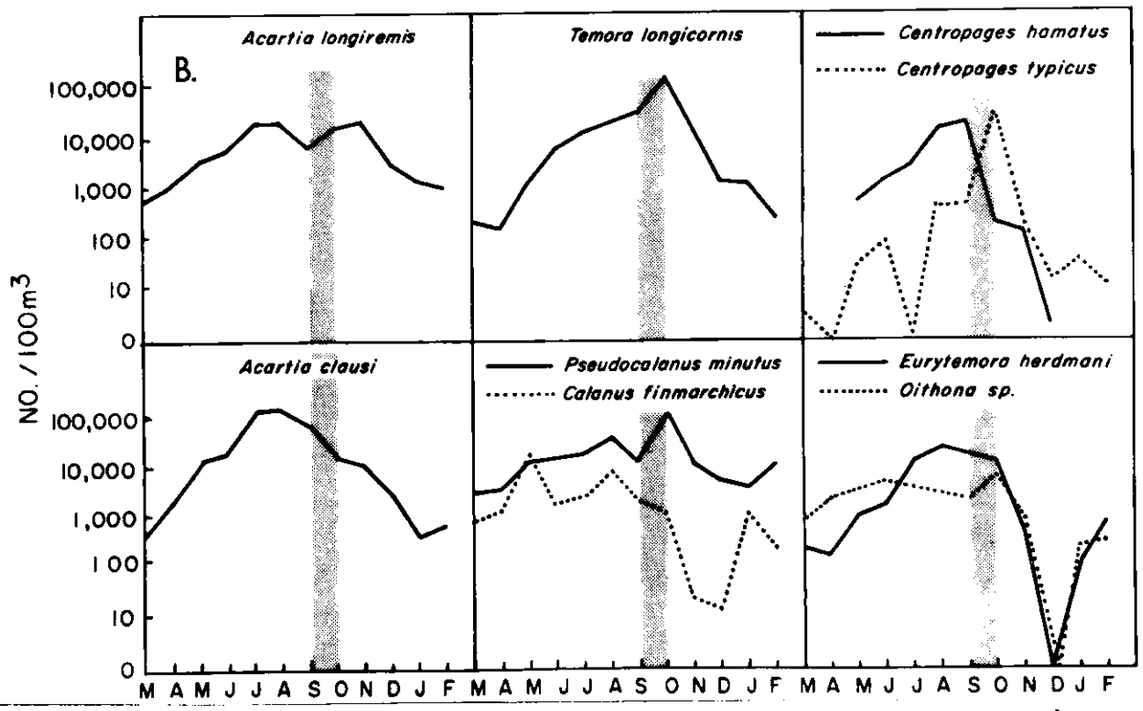


Figure 4. (A) Monthly percentage composition of the predominant copepod species in the Sheepscot region, March, 1969 to February, 1970. (B) Mean monthly abundance (No/100m^3/station) of the predominant copepod species in the Sheepscot region, March 1969 to February 1970.