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Relationship between larval fish communities and zooplankton prey species in an offshore spawning ground

by

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Introduction

The importance of zooplankton as a principal source of food of marine fish larvae has been long recognized. Little information is available on the community dynamics of larval fish with respect to inter-and intra-specific competition for zooplankton food. Reports by Marak (1960), Wyatt (1974), Oiestad et al. (1975), and Arthur (1976) describe the food ingested by several species during their respective studies but provide no specifics with respect to competition. Recently, attention has been focused on the influence of food quality and availability on larval survival in the water column (Lasker, 1975) and under controlled conditions (Lasker et al., 1970 and Laurence, 1974). However, these studies deal with single species. The present report describes the larval fish community on Georges Bank in spring along with the zooplankton populations. Aspects of the predator-prey interactions are discussed.

Methods

Collections of ichthyoplankton and zooplankton were made during a MARMAP Groundfish Survey conducted by the Northeast Fisheries Center (NEFC) in spring 1975. Samples were collected using the standard MARMAP gear, 61-cm bongos fitted with 0.505-mm and 0.333-mm mesh nets. Collections were made at 200 sampling locations from Western Nova Scotia to Cape Hatteras, spaced at approximately 15 mile (24 km) intervals. The present analysis was limited to 20 samples collected from Georges Bank (Figure 1). In the laboratory all fish larvae were identified and enumerated from the 0.505-mm mesh sample. For the zooplankton analysis approximately 500 organisms were aliquoted from each 0.333-mm mesh sample, identified and enumerated. The alimentary tracts of selected size groups of the dominant larval fish species were examined for food organisms under microscope fields ranging from 25-100x. Relative abundance and dominance indices were calculated for both larval fish and zooplankton following the method of Fager and McGowan (1963). Regression analyses were used to examine maxillary development between the two most abundant species.

Larval Fish Community

A total of 23 larval fish taxa were in the collections. Of this number seven, *Gadus morhua*, *Melanogrammus aeglefinus*, *Myoxocephalus octodecemspinosus*, *Pollachius virens*, *Sebastes marinus*, *Pholis gunnellus* and Cottidae were dominant at one or more of the sampling locations (Table 1). In addition to the dominants, *Ammodytes* and *Clupea*, species important to the Georges Bank ecosystem, were included in the analysis. The appearance of large concentrations of *M. octodecemspinosus* is of interest. Catch records from the Groundfish Survey of NEFC for the past five years suggest that commercially under-utilized species including sculpins and skates (*Raja* spp.) may be increasing in abundance. Whether these species are exploiting a food-base formerly utilized by other demersal species that have shown declines in abundance (e.g., haddock, yellowtail flounder) or the apparent increase in abundance is the result of other factors, is not clear. This is a problem area that is receiving increasing attention. Studies of trophic interactions of juvenile and adult fishes are now underway in NEFC.

Two size groupings of larvae were in the samples. *Gadus*, *Melanogrammus*, *Myoxocephalus*, *Pollachius*, *Sebastes*, *Pholis*, and Cottidae--were represented by small spring-spawned larvae ($\lesssim$ 10 mm). The largest specimens--*Ammodytes* and *Clupea* ($\gtrsim$ 20 mm long)--were the products of winter spawning (Figure 2).

Relative densities of the larval fish species over the Georges Bank area are shown in Table 2. The highest number of co-occurrences for any species pair was eleven, between cod and haddock. Redfish were distributed in deeper waters along the southeastern edge of the bank and co-occurred the least number of times with other species. All of the larvae dominant in the collections have been previously reported as indigenous to the Georges Bank-Gulf of Maine area.

Zooplankton Community

The zooplankton community is represented by 33 taxonomic categories. Of these only two, *Calanus finmarchicus* copepodites and *Pseudocalanus minutus* adults, were dominant (Table 1). It is likely that smaller forms including *Oithona similis* were undersampled in the 0.333-mm mesh nets (Colton et al., 1976). The abundance of copepodites of each species found in the samples suggest that the populations sampled were young and growing rather than senescent. This is consistent with other reports describing the zooplankton for Georges Bank in spring (Bigelow, 1926; Pavshtics and Gogoleva, 1964; Green et al., 1977).

Data from 0.333-mm mesh bongo samples taken on *Albatross IV* 75-03 were used to calculate a preliminary estimate of the wet weight percentage composition of 33 taxa of zooplankton. Mean weight per individual was calculated from the mean length of each taxon using the length-weight regressions derived by Gruzov and Alekseyeva of the ATLANTNIRO Laboratory in Kaliningrad (personal communication). Based on these values, the zooplankters *Calanus finmarchicus*, and *Pseudocalanus minutus* represented 74 percent of the total biomass in spring, 1975 (Figure 3).

Larval Feeding

The alimentary tracts of 752 fish larvae were examined for the presence of food organisms. Several areas of feeding overlap were observed. Four kinds of food were ingested most frequently (in ≥ 10% of the alimentary tracts)--*Pseudocalanus minutus*, copepod nauplii, invertebrate eggs and Thecosomata, among the more numerous species--cod, haddock, and sculpin (Table 3). Most of the nauplii were in poor condition making species identification difficult. Although the absolute numbers are not known the predominant forms were *C. finmarchicus* and *P. minutus*. The proportion of occurrence of *C. finmarchicus* to *P. minutus* was approximately 4 to 1. Invertebrate eggs comprised a major proportion of the diets of cod, sculpin, sand launce, and cottids.

Frequency of feeding is greatest in the gadids, sculpin, redfish, rock-gunnel, cottids, and lowest in herring and sand launce (Table 3). We speculate that this difference is related to the morphology of the alimentary tract as classified by Duka (1967). It is highly probable that food is retained with greater frequency, under the stress of capture and preservation, in species with a looped gut (e.g., gadids and sculpin) rather than in those with straight alimentary tracts (herring and sand launce). Laboratory observations confirm this tendency (Laurence, personal communication).

Two species of larvae, cod and haddock retained sufficient food organisms in their alimentary tracts and co-occurred in sufficient numbers to allow for an examination of possible inter-specific competition. The relative importance of similar items in the diet of cod and haddock from 3 adjacent stations appears in Table 4. Food items were listed in order of importance following a Ranking Index (Hobson, 1974). This index is computed by multiplying the ratio of fish containing the item to the number of fish sampled by the mean percent of that item in the larval diet. Both species were feeding most heavily on the naupliar stages of *C. finmarchicus* and *P. minutus*; copepodites and adults of *P. minutus* were second in importance for both cod and haddock. Size distribution of prey between cod and haddock was compared within larval length intervals of 4 mm (Table 5). The degree of overlap in prey size selection was highest in the 2-6-mm size class. Both species were feeding most intensively on 0.30-0.45-mm prey items. Some degree of overlap is evident in the larger size categories where both species were represented. The ability to feed on a wider range of prey sizes increases with fish length. Competition for food is potentially greater among early first feeding larvae when prey size restriction prevails. In an effort to examine the possibility of a morphological character displacement that could provide a competitive advantage, comparisons were made of maxillary lengths between the two species. Regression equations of maxillary length versus fish length are plotted in Figure 4. No significant differences between maxillary lengths were found at the 0.05% confidence level. The divergence in mouth morphology which effectively separates the trophic niche occupied by adult fish of these two species is not apparent at the early stages of larval development. It appears from our analysis within the size classes examined, both haddock and cod larvae utilize the same zooplankton food base. Additional studies concerned with the micro-distribution of larvae and their prey will be required to further examine the influence of this potential competition on larval survival.

Regardless of co-occurrences among various size groups of species, only a few taxa are important in the food of larval fish on Georges Bank. Of the 33 zooplankton taxa in the samples, only 2, *P. minutus* and copepod nauplii, were important to cod and haddock. Pollock and redfish were feeding principally on copepod nauplii (*C. finmarchicus* and *P. minutus*) and sculpin prey were predominately invertebrate eggs and small pteropods. Sculpin are apparently more opportunistic feeders than the gadids. Approximately 5% of the sculpin examined had ingested diatoms (*Coscinodiscus*). Although it was evident that we were underestimating the incidence of food organisms in *Ammodytes*, the prey remnants indicate that they, too, were feeding on only three principal zooplankters, *P. minutus*, invertebrate eggs and copepod nauplii.

Recently completed laboratory studies by Laurence (1977) have defined the quantity and quality of zooplankton ration required for growth and survival for two of the dominant larval species, cod and haddock, discussed in this report Both species displayed remarkably similar metabolic and growth characteristics during the early stages of larval development. The only difference detected was a somewhat greater growth rate of haddock at 9°C over cod at 10°C. Whether this could lead to a competitive advantage remains to be examined more rigorously. It is clear from this and other studies that microscale investigations are required to investigate the relationship between *in situ* concentrations of larval fish and their prey. In addition to fine-mesh net sampling and *in situ* large volume pumps, the use of meshed enclosures for studying the relationship between larvae and food should not be overlooked. Recent experiments at the Narragansett Laboratory have been completed using *in situ* Controlled Environmental Chambers (C.E.C.) enclosed by fine mesh.

To obtain a better understanding of interspecific growth and survival interaction between cod and haddock a large C.E.C. will be placed on their Georges Bank spawning ground in the spring of 1979. Larvae will be introduced and monitored for growth and metabolic condition under predator-free *in situ* conditions.

References

Arthur, D. K. 1976. Food and feeding of larvae of three fishes occurring in the California Current, Sardinops sagax, Engraulis mordax and Trachurus symmetricus. Fish. Bull. 74:1-14.

Bigelow, H. B. 1976. Plankton of the offshore waters of the Gulf of Maine. Bull. U. S. Bur. Fish. 40, Part II: 1-509.

Colton, J. B., Jr., J. R. Green, R. R. Byron and J. L. Frisella. Comparison of bongo net retention rates. Fish. Bull. In press.

Duka, I. A. 1967. Struktura I dinamika soob shchestv (Adaptive features in the feeding of pelagic larvae of fish living in different ecological conditions. Akad. Mauk. Ukr. SSR p. 136-143.

Fager, F. W. and J. A. McGowan. 1963. Zooplankton species groups in the North Pacific. Science 140(3566):453-460.

Green, J., J. B. Colton, Jr. and D. T. Bearse. 1977. Preliminary estimates of secondary production on Georges Bank. ICES C.M.1977/L:30.

Hobson, E. S. 1974. Feeding relationships of teleostean fishes on coral reefs in Kona, Hawaii. Fish. Bull. 72(4):915-1031.

Lasker, R., H. M. Feder, G. H. Theilacker, and R. C. May. 1970. Feeding, growth, and survival of Engraulis mordax larvae reared in the laboratory. Mar. Biol. 5:345-353.

_______. 1975. Field criteria for survival of anchovy larvae: the relation between inshore chlorophyll maximum layers and successful first-feeding. Fish. Bull. 73:453-462.

Laurence, G. C. 1974. Growth and survival of haddock (Melanogrammus aeglefinus) larvae in relation to planktonic prey concentration. J. Fish Res. Bd. Canada 31:1415-1419.

_______. 1977. Comparative growth, respiration and delayed feeding abilities of larval cod (Gadus morhua) and haddock (Melanogrammus aeglefinus) as influenced by temperature during laboratory studies. ICES C.M.1977/L:31.

Marak, R. R. 1960. Food habits of larval cod, haddock and coalfish in the Gulf of Maine and Georges Bank Area. J. cons. int. Explor. Mer. 25:147-151.

Oiestad, V., B. Ellertsen, P. Solemdal and S. Tilseth. 1975. Rearing of different species of marine fish in a constructed basin. 10th European Symposium on Marine Biology, Ostend, Belgium Vol. 1:303-329.

Pavshtics, Ye. A., and M. A. Gogoleva. 1964. Plankton distribution in the area of Georges and Browns Bank in 1962. Translation Series U.S. Naval Oceanographic Office, Trans. No. 420.

Wyatt, T. 1974. The feeding of plaice and sand-eel larvae in the Southern Bight in relation to the distribution of their food organisms. In: The Early Life History of Fish, ed. J. H. S. Blaxter, Springer-Verlag, Berlin. p. 245-251.

Table 1. Relative abundance and dominance indices (see Fager and McGowan 1963) describing ichthyoplankton and zooplankton communities from 20 selected stations on Georges Bank.

Albatross IV Cruise 75-03 Fish Larvae Statistical Summary

Species	Mean Rank	Dom.	Range	Median	Mean	Disp.	Std. Dev.	Freq.	% Occur.
Gadus morhua	18.85	2/20	1- 93	5	10.8	47.418	22.63	12/20	60.0
Melanogrammus aeglefinus	17.63	2/20	1- 125	2	12.4	79.969	31.49	10/20	50.0
Myoxocephalus octodecemspinosus	16.00	4/20	1- 94	4	5.9	73.611	20.84	8/20	40.0
Pholis gunnellus	15.50	1/20	1- 3	1	0.5	1.378	0.83	8/20	40.0
Pollachius virens	14.63	1/20	1- 11	2	1.4	6.776	3.03	6/20	30.0
Ammodytes americanus	14.55	0/20	1- 12	2	1.3	7.440	3.11	6/20	30.0
Hippoglossoides platessoides	13.82	0/20	1- 15	2	1.4	10.864	3.90	5/20	25.0
Clupea harengus	13.72	0/20	1- 6	1	0.6	4.108	1.57	5/20	25.0
Sebastes marinus	13.30	3/20	1- 9	1	0.6	6.734	2.01	4/20	20.0
Pleuronectidae	13.20	0/20	1- 19	1	1.1	16.266	4.23	4/20	20.0
Liparis inquilinus	12.90	0/20	1- 1	1	0.2	0.841	0.41	4/20	20.0
Cottidae	12.02	1/20	1- 10	*	0.5	10.035	2.24	2/20	10.0
Benthosema glaciale	11.92	0/20	1- 5	*	0.3	4.256	1.13	2/20	10.0
Agonidae	11.88	0/20	1- 1	*	0.1	0.961	0.31	2/20	10.0
Glyptocephalus cynoglossus	11.38	0/20	1- 1	*	0.0	*	0.22	1/20	5.0
Paralepididae	11.38	0/20	1- 1	*	0.0	*	0.22	1/20	5.0
Ceratoscopelus townsendi	11.38	0/20	1- 1	*	0.0	*	0.22	1/20	5.0
Ammodytidae	11.38	0/20	1- 1	*	0.0	*	0.22	1/20	5.0
Aspidophoroides monopterygius	11.38	0/20	1- 1	*	0.0	*	0.22	1/20	5.0
Cryptacanthodes maculatus	11.38	0/20	1- 1	*	0.0	*	0.22	1/20	5.0
Anguilla rostrata	11.38	0/20	1- 1	*	0.0	*	0.22	1/20	5.0
Notolepsis sp.	11.35	0/20	1- 1	*	0.0	*	0.22	1/20	5.0
Notolepsis rissoi	11.30	0/20	1- 1	*	0.0	*	0.22	1/20	5.0

Albatross IV Cruise 75-03 Zooplankton Statistical Summary

Species	Mean Rank	Dom.	Range	Median	Mean	Disp.	Std. Dev.	Freq.	% Occur.
Calanus finmarchicus [b]	32.25	6/20	1361- 206094	25573	38030.6	72373.188	52463.28	20/20	100.0
Pseudocalanus minutus [a]	30.47	1/20	149- 23930	9281	11405.2	7612.015	9317.54	20/20	100.0
Pseudocalanus minutus [b]	30.22	0/20	224- 31473	9835	9872.0	7688.640	8712.19	20/20	100.0
Oithona spp.	23.52	0/20	81- 4222	1544	1171.5	1195.542	1183.46	16/20	80.0
Euphausiacea	22.97	0/20	153- 8836	2360	2242.3	3764.568	2905.39	14/20	70.0
Metridia lucens [b]	22.77	0/20	162- 29162	734	2988.2	17108.077	7149.99	15/20	75.0
Calanus finmarchicus [a]	21.67	0/20	97- 4257	505	590.1	1591.222	969.01	15/20	75.0
Balanidea	20.35	0/20	78- 27676	2815	3732.0	14463.550	7346.97	11/20	55.0
Centropages typicus	18.82	0/20	39- 2310	247	279.1	1004.362	529.45	13/20	65.0
Sagitta spp.	17.45	0/20	78- 8705	292	572.3	6470.463	1924.33	10/20	50.0
Paracalanus parvus [a]	16.95	0/20	47- 7511	568	749.3	4559.354	1848.33	8/20	40.0
Ostracoda	16.35	0/20	32- 3235	1042	585.0	2155.277	1122.87	8/20	40.0
Sagitta elegans	16.17	0/20	75- 2807	554	393.6	1452.265	756.05	8/20	40.0
Centropages hamatus [a]	16.15	0/20	29- 2761	311	313.9	1790.109	749.61	8/20	40.0
Centropages hamatus [b]	15.90	0/20	85- 8528	1670	924.8	5362.620	2226.96	6/20	30.0
Metridia lucens [a]	15.42	0/20	105- 4639	163	311.9	3391.907	1028.56	8/20	40.0
Decapoda	14.75	0/20	97- 2773	367	251.7	1699.465	654.03	6/20	30.0
Pteropoda	14.72	0/20	29- 4312	1763	585.3	2895.098	1301.73	6/20	30.0
Paguridae	14.17	0/20	84- 221	134	55.1	123.286	82.42	7/20	35.0
Paracalanus parvus [b]	14.05	0/20	231- 1949	1386	292.4	1223.773	598.19	5/20	25.0
Hyperia spp.	13.85	0/20	23- 816	319	103.6	448.889	215.65	6/20	30.0
Caridea	13.47	0/20	124- 624	227	87.0	393.603	185.05	5/20	25.0
Appendicularia	13.47	0/20	699- 4825	1689	445.1	3042.876	1163.78	4/20	20.0
Temora longicornis	13.17	0/20	84- 462	387	77.6	329.402	159.88	5/20	25.0
Crangon septemspinosa	13.10	0/20	29- 458	134	51.5	294.532	123.16	5/20	25.0
Alteutha depressa	12.72	0/20	32- 406	218	43.7	274.276	109.48	4/20	20.0
Mecynocera clausi	12.67	0/20	117- 1046	283	86.4	712.139	248.05	4/20	20.0
Brachyura	12.63	0/20	81- 462	169	44.0	285.091	112.00	4/20	20.0
Thysanoessa longicaudata	12.63	0/20	39- 5128	448	280.8	4671.258	1145.29	3/20	15.0
Gastropoda	12.50	0/20	221- 1873	1606	185.0	1550.982	535.66	3/20	15.0
Gammaridea	12.50	0/20	32- 569	84	38.5	422.969	127.61	4/20	20.0
Neomysis americana	11.72	0/20	84- 162	134	19.0	121.972	48.14	3/20	15.0
Mysidopsis bigelowi	11.38	0/20	32- 168	*	10.0	143.414	37.87	2/20	10.0

NOTE: * Indicates not applicable.

[a] Adults.

[b] Copepodites.

Description of the Output Columns:

1. SPECIES: Genus and species name.
2. MEAN RANK: Species were ranked within each sample on the basis of numbers of individuals. Ranks for each species were averaged over the samples.
3. DOM: Dominance represent the number of samples in which the species made up 50 percent or more of the individuals.
4. RANGE: Smallest and largest nonzero values.
5. MEDIAN: Value for which there are an equal number of nonzero values above and below.
6. MEAN: Arithmetic mean of all station values including zeros.
7. DISP: Dispersion, the ratio of the variance to the mean. The expected value for a random (Poisson) distribution is 1.0.
8. FREQ: Frequency of occurrence; proportion of samples in which the species was found.
9. % OCCUR: Frequency of occurrence converted to percent.

Table 2: Occurrence of larval fish taxa on Georges Bank, expressed as relative density, numbers per 100 m^3.

Fish Species	Stations																			
	139	143	162	164	172	173	176	177	178	183	188	191	196	197	198	200	202	203	204	205
Melanogrammus aeglefinus	1.7	0.4	-	-	-	24.8	1.8	9.3	0.3	2.5	70.8	-	33.6	0.6	-	-	-	0.5	0.6	-
Pollachius virens	0.5	2.2	-	-	-	10.6	-	9.0	1.5	-	2.9	-	-	-	-	-	-	-	-	-
Gadus morhua	0.3	-	-	-	6.3	93.0	11.6	31.8	3.6	1.2	40.8	-	22.1	0.6	-	-	-	0.8	1.2	0.5
Myoxocephalus octodecemspinosus	-	0.4	-	-	0.3	4.7	0.7	0.3	-	-	-	-	3.5	4.8	-	0.1	2.2	94.2	7.3	0.9
Ammodytes americanus	-	0.8	0.4	-	1.9	-	12.0	7.5	2.5	-	-	-	-	-	-	-	-	0.1	0.5	0.1
Clupea harengus	1.0	-	-	-	0.7	-	1.1	6.0	4.2	-	-	-	-	-	-	-	-	-	0.2	-
Sebastes marinus	-	-	-	-	-	-	-	-	-	0.7	-	0.7	-	-	9.1	0.5	-	-	-	-
Pholis gunnellus	-	0.4	-	-	1.5	-	0.3	0.3	0.3	-	-	-	-	-	-	-	-	0.8	0.3	0.1
Cottidae	9.7	-	-	-	-	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-

Table 3. Summary of stomach contents of larval fish collected from Georges Bank, spring 1975

	Gadus morhua	*Melanogrammus aeglefinus*	*Pollachius virens*	*Myoxocephalus octodecemspinosus*	*Ammodytes americanus*	*Clupea harengus*	*Sebastes marinus*	*Pholis gunnellus*	Cottidae
No. Fish Examined	216	158	54	134	80	42	31	16	21
No. Feeding	176	95	31	111	22	1	19	12	10
Feeding Incidence (%)	81.5	60.1	57.4	82.8	27.5	2.4	61.3	76.0	47.6
Prey	% of Prey	% of Prey	% of Prey	% of Prey	% of Prey	% of Prey	% of Prey	% of Prey	% of Prey
Pseudocalanus minutus	25.2	7.7	11.2	1.1	11.4			66.7	
P. minutus frag.	(63)[a]	(17)			(6)			(4)	
Calanus finmarchicus	0.6				0.8				
C. finmarchicus frag.	(1)				(2)				
Centropages typicus	0.1			1.3					
C. typicus frag.									
C. hamatus	0.6		2.8		0.8	100.0			
C. hamatus frag.	(1)								
Centropages spp.			0.9						
Temora longicornis				0.6					
Harpacticoid				0.4					
Calanus spp.				0.4					
Calanoid	2.1		29.9	2.1					
Calanoid fragments	(30)	(2)							
Calanoid copepodites	0.4			1.5				6.3	
Calanoid copepodites frag.					(1)				
Calanoid nauplius	4.2							14.6	
Calanoid nauplius frag.									
Oithona spp. fragments		(1)							
Copepoda	0.1		2.8	0.4				2.1	
Copepoda fragments	(27)	(29)	(1)	(1)	(15)			(2)	(1)
Copepoda copepodites	1.7	0.9						6.3	
Copepoda copepodites frag.	(12)								
Copepoda nauplius	20.3	85.1	39.3	6.0	6.1		96.6	2.1	15.4
Copepoda nauplius frag.	(4)	(31)					(6)		
Crustacea				0.9					
Crustacea fragments	(10)	(12)	(1)	(11)					
Crustacea nauplius	2.2			1.7					
Euphausiacea			6.5	0.2					
Euphausiacea fragments									
Euphausiacea calyptopis				0.2					
Euphausiacea nauplius	0.1	2.1	4.7	3.6					
Cladocera	0.1								
Polychaeta				0.2					
Balanidae				8.1					
Ostracoda				0.4					
Thecosomata				29.3					
Invertebrate eggs	41.6	2.6		35.8	79.5		3.4	2.1	84.6
Coscinodiscus sp.	0.4	1.7		5.6					
Ceratium sp.				0.2					
Unidentified zooplankton			1.9	0.2					
Unidentified diatom	0.1								
Unidentified nauplius				0.4					
Unidentified fragments		(5)		(1)					

[a]Frequency of occurrence.

Table 4. A comparison of the importance of specific prey items found in co-occurring cod and haddock.

Prey	Cod Sta. 173	Cod Sta. 174	Cod Sta. 177	Cod Total	Cod % Occur.	Cod Mean % Total	Cod Ranking Index [a]	Haddock Sta. 173	Haddock Sta. 174	Haddock Sta. 177	Haddock Total	Haddock % Occur.	Haddock Mean % Total	Haddock Ranking Index
Copepod nauplii	141	12	3	156	41	55	23	153	15	2	170	57	84	48
Pseudocalanus minutus	5	26	41	72	52	26	14	3	11	7	21	20	10	2
Calanoid spp.	25	3	1	29	17	10	2	1	0	0	1	1	<1	<1
Invertebrate eggs	1	0	16	17	5	6	<1	1	3	1	5	5	3	<1
Centropages hamatus	1	0	0	1	1	<1	<1	0	0	0	0	-	-	-
C. typicus	1	0	0	1	1	<1	<1	0	0	0	0	-	-	-
Euphausiid nauplii	0	0	0	0	-	-	-	4	0	1	5	3	3	<1
Calanus finmarchicus	3	0	1	4	4	1	<1	0	0	0	0	-	-	-
Diatom	0	0	1	1	1	<1	<1	0	0	0	0	-	-	-
Evadne spp.	1	0	0	1	1	<1	<1	0	0	0	0	-	-	-

[a] Hobson 1974.

Table 5. Prey size selection, expressed as the percentage of measurable prey (length, mm) within larval fish size groups of 4 mm.

Prey Size Intervals, mm	2 - 6 mm Cod	2 - 6 mm Haddock	6 - 10 mm Cod	6 - 10 mm Haddock	10 - 14 mm Cod	10 - 14 mm Haddock	> 14 mm Cod	> 14 mm Haddock
1.50-1.35	-	-	-	7.1	-	-	-	-
1.35-1.20	-	-	-	7.1	20.0	14.3	53.3	-
1.20-1.05	3.4	-	2.4	7.1	30.0	-	20.0	-
1.05-0.90	-	-	4.8	14.3	10.0	28.6	-	-
0.90-0.75	-	-	11.9	7.1	-	28.6	-	-
0.75-0.60	3.4	3.9	7.1	-	-	14.3	-	-
0.60-0.45	6.9	20.6	4.8	7.1	-	14.3	-	-
0.45-0.30	69.0	67.6	19.0	50.0	-	-	-	-
0.30-0.15	17.2	7.8	38.1	-	40.0	-	26.7	-
0.15-0.0	-	-	11.9	-	-	-	-	-

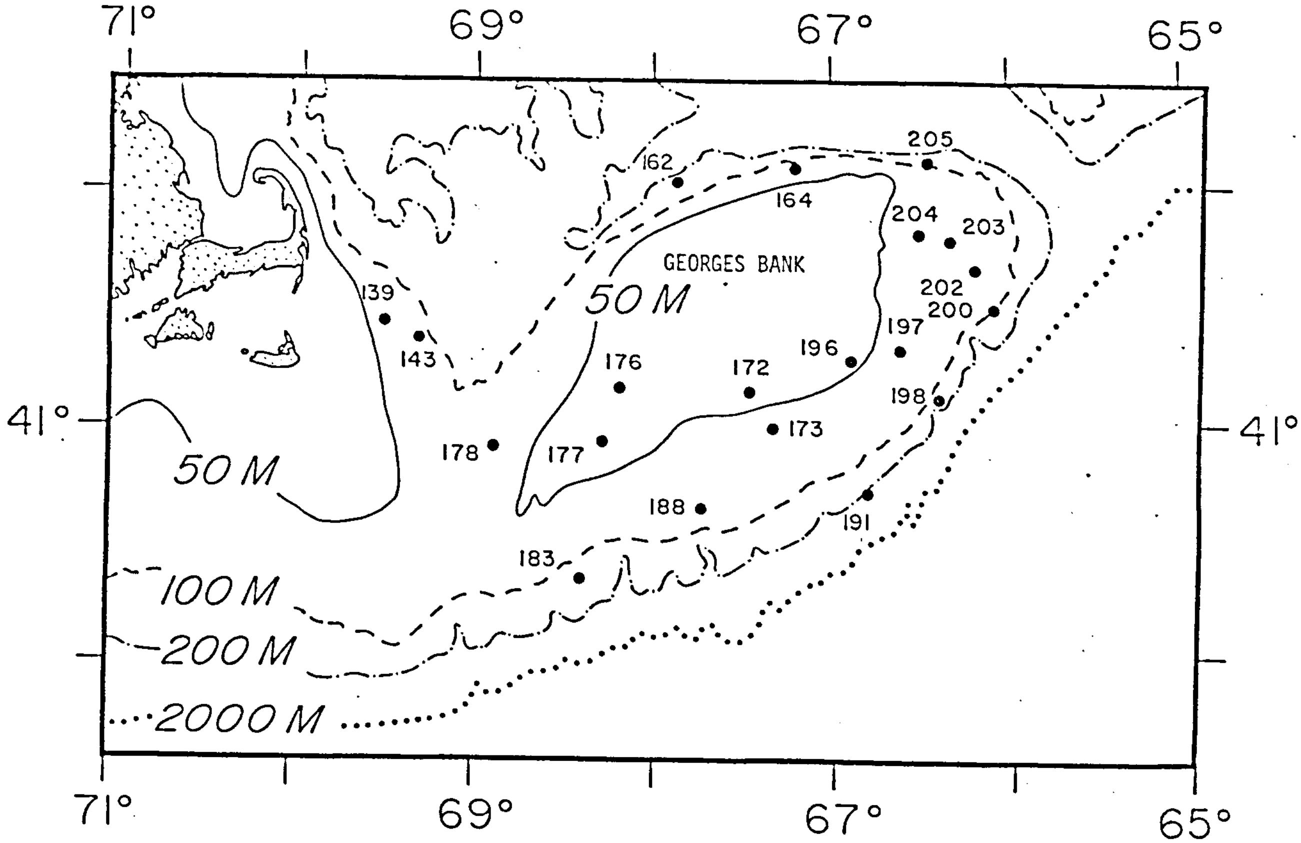

Figure 1. Sampling locations over the area of Georges Bank, bounded by the 200 m contour.

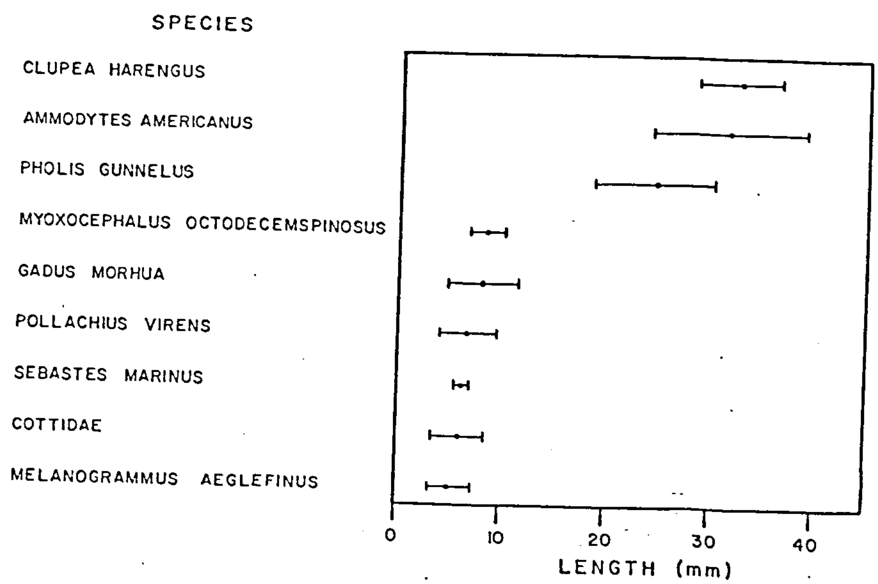

Figure 2. Mean lengths and standard deviations of larval fish collected from Georges Bank in spring 1975.

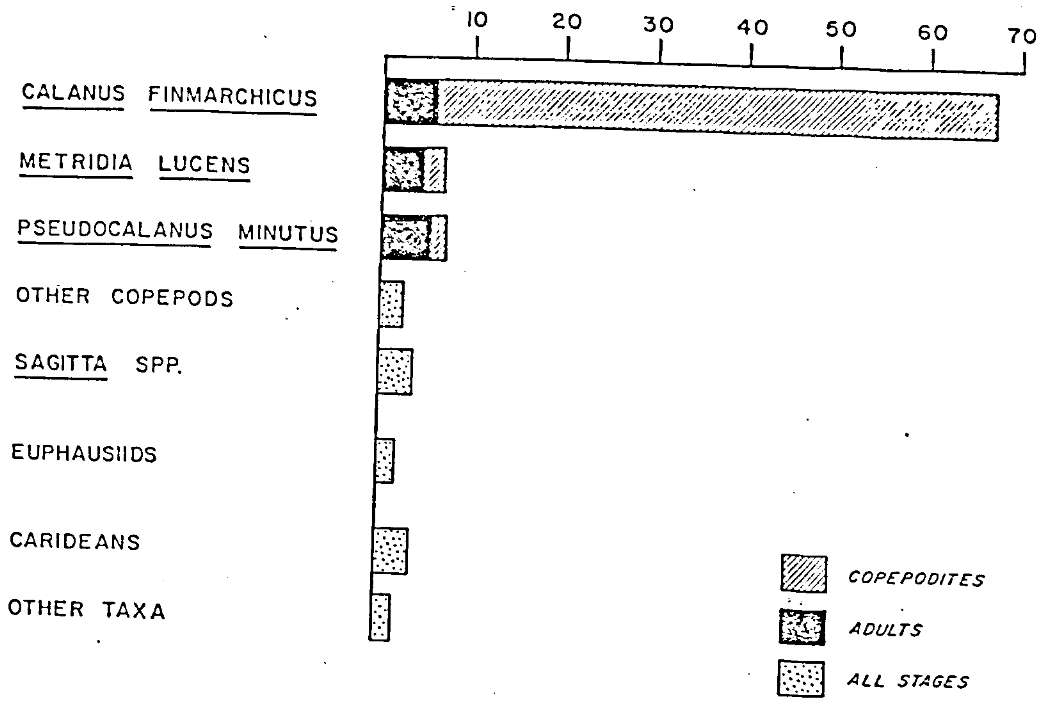

Figure 3. Percentage composition of the zooplankton biomass on Georges Bank in spring 1975.

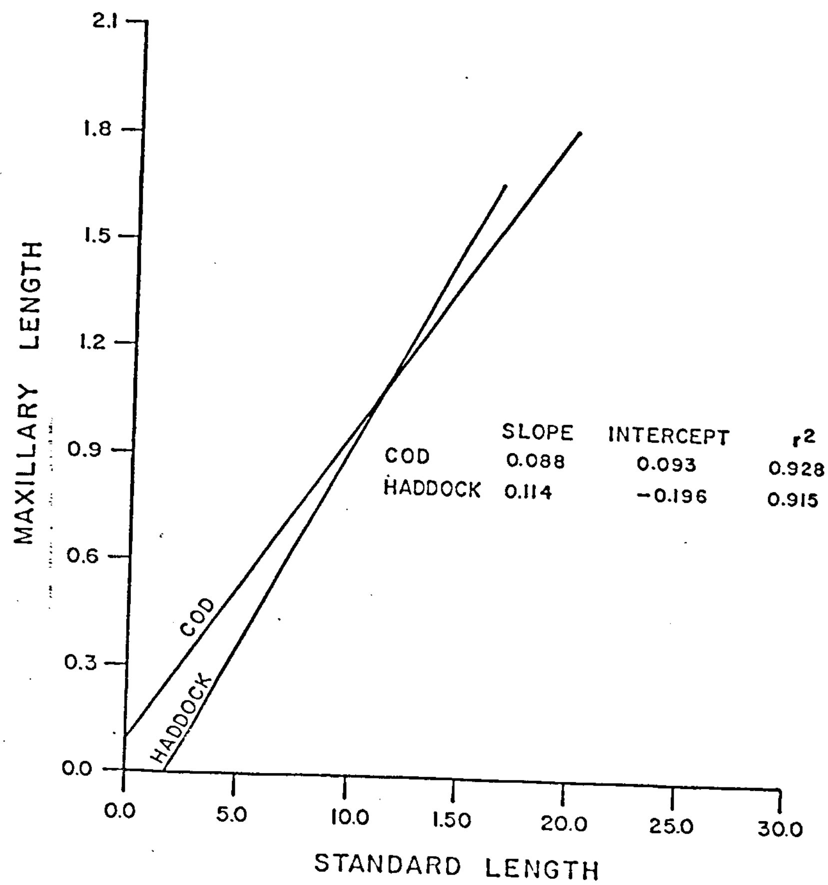

Figure 4. Comparison of maxillary development between cod and haddock. The F test for difference in regression slopes (F_S = 3.914) was not significant at α = 0.05.