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 selected by bongo nets in the standard array of samplers
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INTRODUCTION

The Recruitment Processes Task of the Northeast Fisheries Center in Woods Hole, Massachusetts, has been involved in an intensive multidisciplinary study of sea herring (Clupea harengus L.) in the Georges Bank - Gulf of Maine region to investigate the physical and biological factors influencing larval survival. The field sampling program developed through ICNAF (International Commission for the Northwest Atlantic Fisheries), has produced a large data base of information on the seasonal and geographic changes in zoo- and ichthyo-plankton distribution and abundance. The present study utilizes a portion of this information to compare species, developmental stage, size, and number of potential larval herring prey items (determined from a concurrent study, see Cohen et al. 1979 and 1980, and Table I) collected by 20 cm and 60 cm bongo frames fitted with .053 and .165 mm, and .333 and .505 mm mesh nets, respectively, during two spawning seasons, September through February 1974-75 and 1975-76. Davis (1980) has calculated some estimates of extrusion of Pseudocalanus sp. and copepod nauplii by the .333 and .165 mm mesh gongo samplers using a subset of the same data analyzed in the present study.

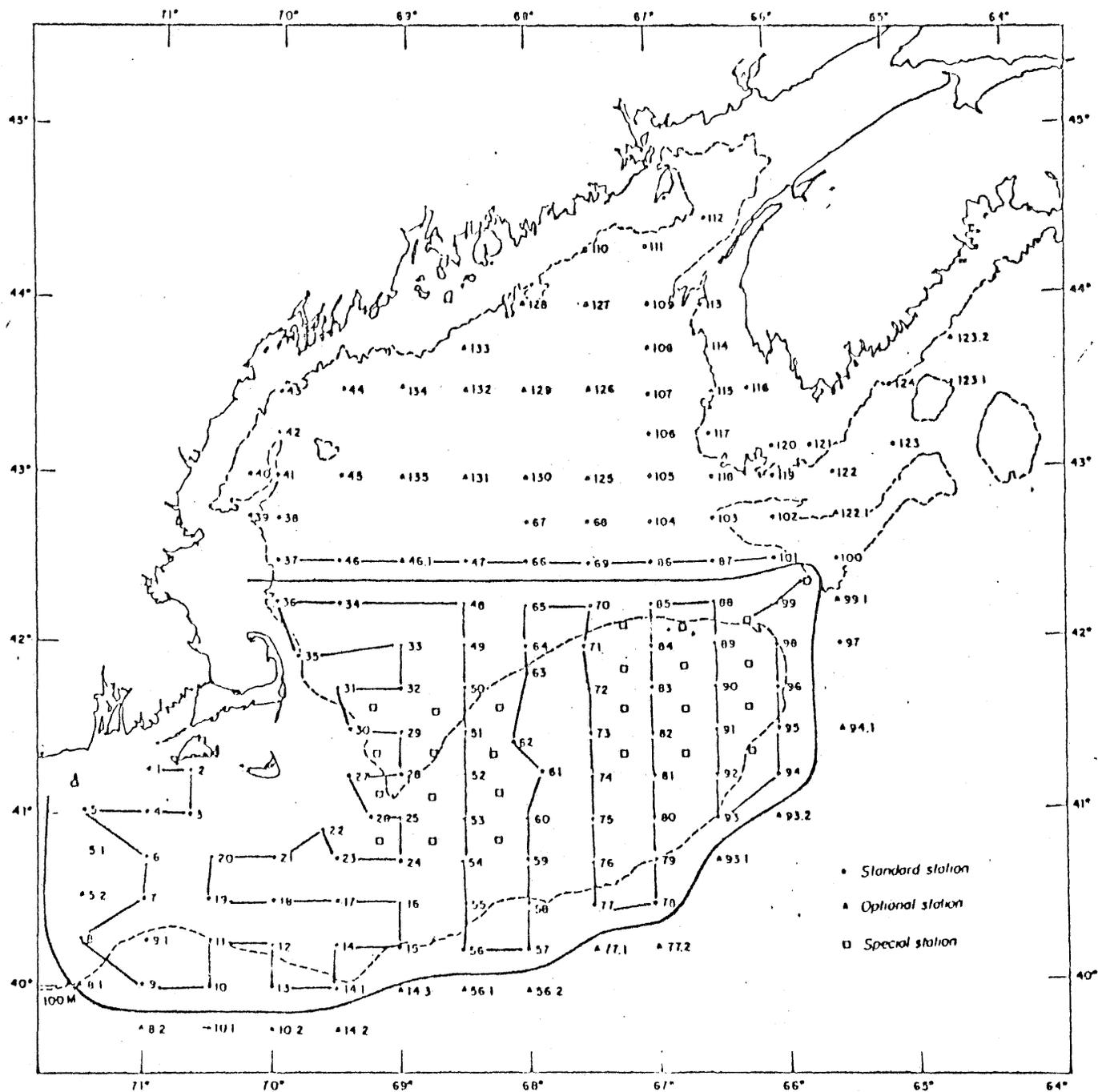
METHODS

The ICNAF larval herring surveys were conducted on a standard grid of stations 15-20 miles apart (Figure 1), covering the region at least once a

Table 1. Percent abundance of larval herring prey items in the guts processed from each survey cruise.

Species	Stage	Seasons: 1974-75 Cruises:						Seasons: 1975-76 Cruises:						Seasons: 1976-77 Cruises:					
		Cryos 74-04	Prognoz 74-01	Dohn 74-01	AlbIV 74-13	AlbIV 75-02	Year Total	Belogorsk 75-02	Belogorsk 75-03	Dohn 75-187	AlbIV 75-14	AlbIV 76-01	*Mlecno 76-01	Yearly Total	Mlecno 76-03	Dohn 76-02	Resercher 76-01	Ht. Mitchell 77-01	Yearly Total
<i>Nauplius-calanus minutus</i>	nauplius copepodite adult	36.7	3.0 6.1		2.3 0.5 5.2	3.1 56.1	2.1 1.4 19.7		8.1	1.6 4.9 2.5	1.7 10.8	0.8 16.3		0.4 1.7 11.4	12.1	42.9	37.5 37.5	47.7	3.3 33.7
<i>Parvocalanus parvus</i>	nauplius copepodite adult			2.2 15.6	0.5 2.6 10.1	0.3 1.8 7.5			13.1 13.9	7.6 29.6		3.0 3.6	5.4 18.3	3.0 6.1	42.9	25.0	2.3	24.2	
<i>Nauplius-pars</i>	nauplius copepodite adult	3.3	3.0		2.0 1.2 1.0	1.4 0.9 0.8		13.5 2.7	2.5	1.4 3.2	1.0 4.5		0.4 1.4 3.2	6.1 3.0				6.1 3.0	
<i>Centro-pagis typicus</i>	nauplius copepodite adult	26.7	3.0	33.3 6.7	19.3 1.7	1.4 2.6	0.4 14.2 2.0	2.7	1.6	7.9 0.3	1.0 1.5	1.2 0.6	0.08 4.7 0.7	6.1	14.3			6.1 3.0	
<i>Centro-pagis hamatus</i>	nauplius copepodite adult				15.2 5.1	5.1 10.8	11.4 6.5					1.8							
<i>Centro-pagis</i> spp.	nauplius copepodite adult		3.0		0.08 5.7 0.7	0.5 1.6	0.1 3.9 0.9		1.6				0.2	9.1				3.3	
<i>Olthona</i> spp.	nauplius copepodite adult		3.0 3.0 9.1		1.8 5.2	0.7	0.05 1.2 3.8		5.4			3.6 3.0	0.2 1.8	12.1				4.3	
<i>Calanus finmarchicus</i>	nauplius copepodite adult				0.3		0.2		4.1		0.3	5.4 10.2	0.7 0.08 0.08						
Unidentified cinnoid	nauplius copepodite adult	33.3	3.0 39.4 9.0	11.1 13.3	2.0 3.6 6.5	2.2 3.3 8.9		43.2 5.4 10.8	17.2 8.9 23.8	4.0 31.1	0.8 24.3		3.1 3.4 27.5	9.1 33.3			50.0	3.3 35.9	
Copepod eggs					2.8	1.7	2.3			0.2	41.3		13.7						
Invertebrate eggs					3.5		2.3		2.7	1.2	1.3	25.9	1.2						
Mollusc larvae					0.08		0.05		2.7	0.2			0.2						
<i>Spiratella retroversa</i>					0.2		0.1						0.2						
Hyalids												7.2							
Euphausiids												7.8							
Hyperiids												0.6							
Fish larvae					0.2		0.2												
<i>Canthala armata</i>										0.2			0.08						
<i>Acartia longiremis</i>												0.6							
Unident. invertebrate					0.08	0.2	0.1		2.7	0.2			0.2						
† Stations		4	3	3	34	23	67	3	2	15	32	35	14	101	8	4	4	9	25
1/3 larvae feeding		16/	17/	28/	475/	198/	734/	0	14/	64/	355/	85/	60/	518/	20/	4/	5/	25/	54/
		5.1	11.3	18.7	15.2	16.1	14.8		9.3	8.1	28.0	10.8	38.0	8.4	9.0	8.9	29.0	12.7	

* Not included in yearly total.



month from September through December since 1971; February surveys were added in 1974. At each standard station minimum sampling has included double oblique hauls with 61 cm diameter bongo nets (.505 and .333 mm mesh nets) and temperature-salinity profiles. Since autumn 1974, 20 cm bongos (.253 or .053 and .165 mm mesh nets) were added to the sampling array (Figure 2) to sample smaller organisms. A standard ICNAF haul consisted of lowering the bongo array at 50 m/min to a maximum depth of 100 m or within 5 m of the bottom, and retrieving at 10 m/min while the ship is underway at 3.5 knots. Ten minute neuston hauls (1x2, or .5x1 m rectangular frame fitted with a .505 m net) were usually made simultaneously with each bongo haul during the 1974-77 seasons.

Volume of water filtered was plotted against duration of tow for all net hauls in order to detect evidence of clogging.

In this study we included only those stations at which no clogging was evident. The .333 mm mesh samples were sorted by the Polish Sorting and Identification Center in Szczecin, Poland; selected .505, .165, .053, and Niskin bottle samples were sorted by the Recruitment Processes Group in Woods Hole. A summary of survey dates and samples is presented in Table II.

Table II. Number of samples available from each survey cruise.

Vessel & Cruise No.	Dates	Mesh size (mm): Number of stations available for comparison				
		.053	.165	.333	.505	Water bottles
CRYOS 7404	9/07-9/24/74		3	3		
WIECZNO 7401	9/27-10/18/74		3	3		
ANTON DOHRN 7401	11/11-11/25/74		3	3		
ALBATROSS IV 7413	12/04-12/19/74		5	5		
ALBATROSS IV 7502	12/12-12/28/75	7	30	30	12	
BELOGORSK 7502	9/15-10/08/75		6	6		
BELOGORSK 7503	10/17-10/30/75		8	8		
ANTON DOHRN 75187	11/01-11/18/75		4	4		
ALBATROSS IV 7514	12/05-12/17/75		10	10		
ALBATROSS IV 7601	2/10-2/25/76		9	9		
ALBATROSS IV 7813	10/16-11/10/78	2				2

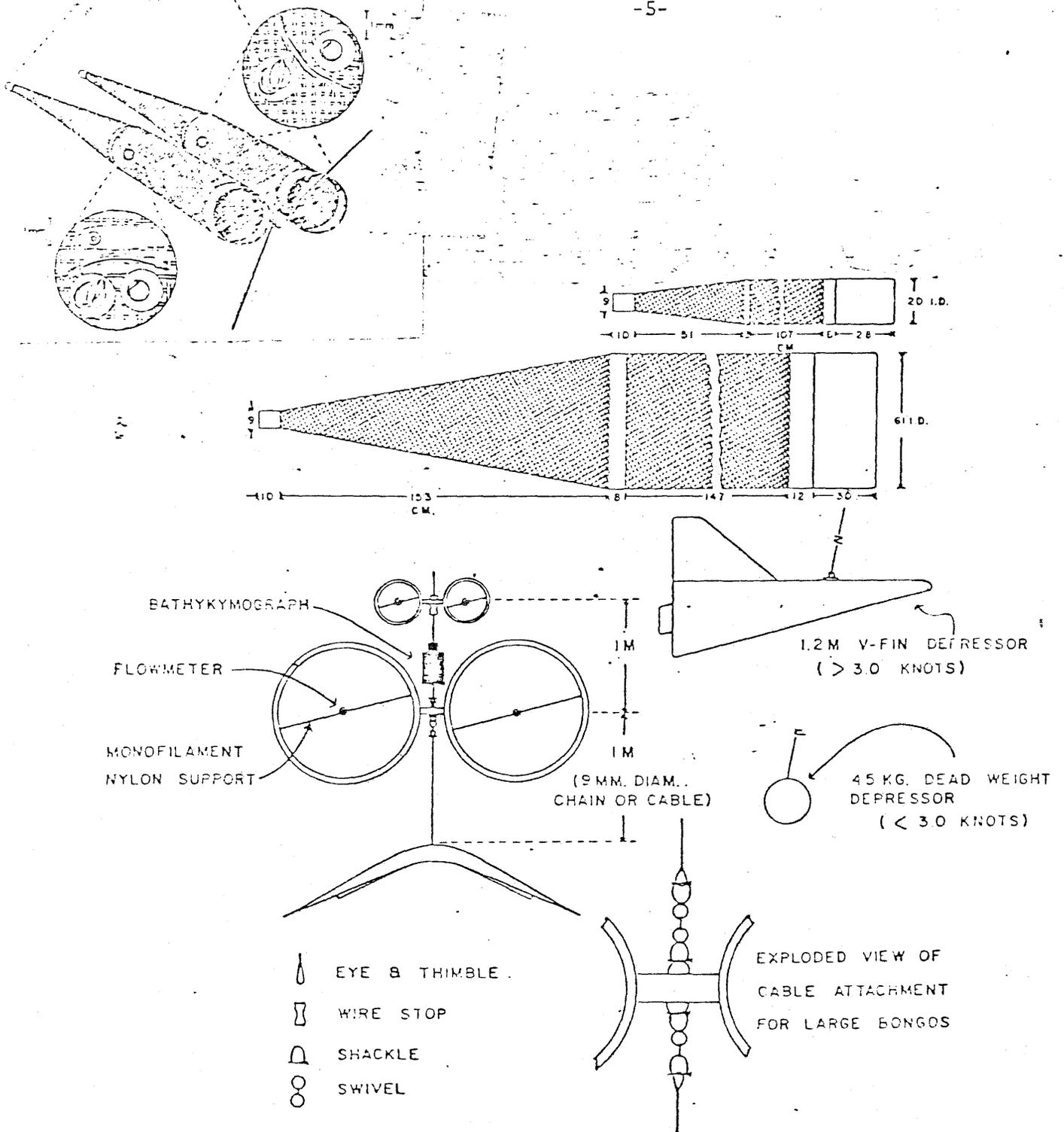


Figure 2. Standard bongo net array (Smith and Richardson, 1977).

Histograms comparing species abundances at each station from each mesh size were prepared for the following taxa:

1. Pseudocalanus sp. - CI-CVI
2. Paracalanus parvus - CV&CVI
3. Centropages typicus - CIV-CVI
4. Centropages hamatus - CIV-CVI
5. Centropages spp. - CI-CIII
6. Calanus finmarchicus - CV&CVI
7. Oithona spp. - CV&CVI
8. Copepod nauplii

Figure 3 compares the relative sizes of all the above species with the sampler mesh sizes.

For each taxon, randomized paired comparisons of the differences in abundance (number/m³) between samplers at each station with sufficient data for a valid comparison were carried out using a two-tailed t-test. The samplers were paired as follows: Niskin bottle and .053, .053 and .165, .165 and .333, .333 and .505.

RESULTS

Table III presents the results of the paired t-test comparisons.

1. .053 versus .165 - There were no significant differences between these two mesh sizes for all stages of Pseudocalanus sp., Paracalanus parvus adults and CV's, Centropages typicus adults and CIV and CV's, and Centropages spp. CI-CIII's. There was not enough data to compare catches of Calanus finmarchicus adults and CV's, and Centropages hamatus CIV and CV's. The difference in catch of Oithona spp. adults and CV's was significant at the .025 level, and the difference in catch of

LARVAL HERRING PREY ITEMS

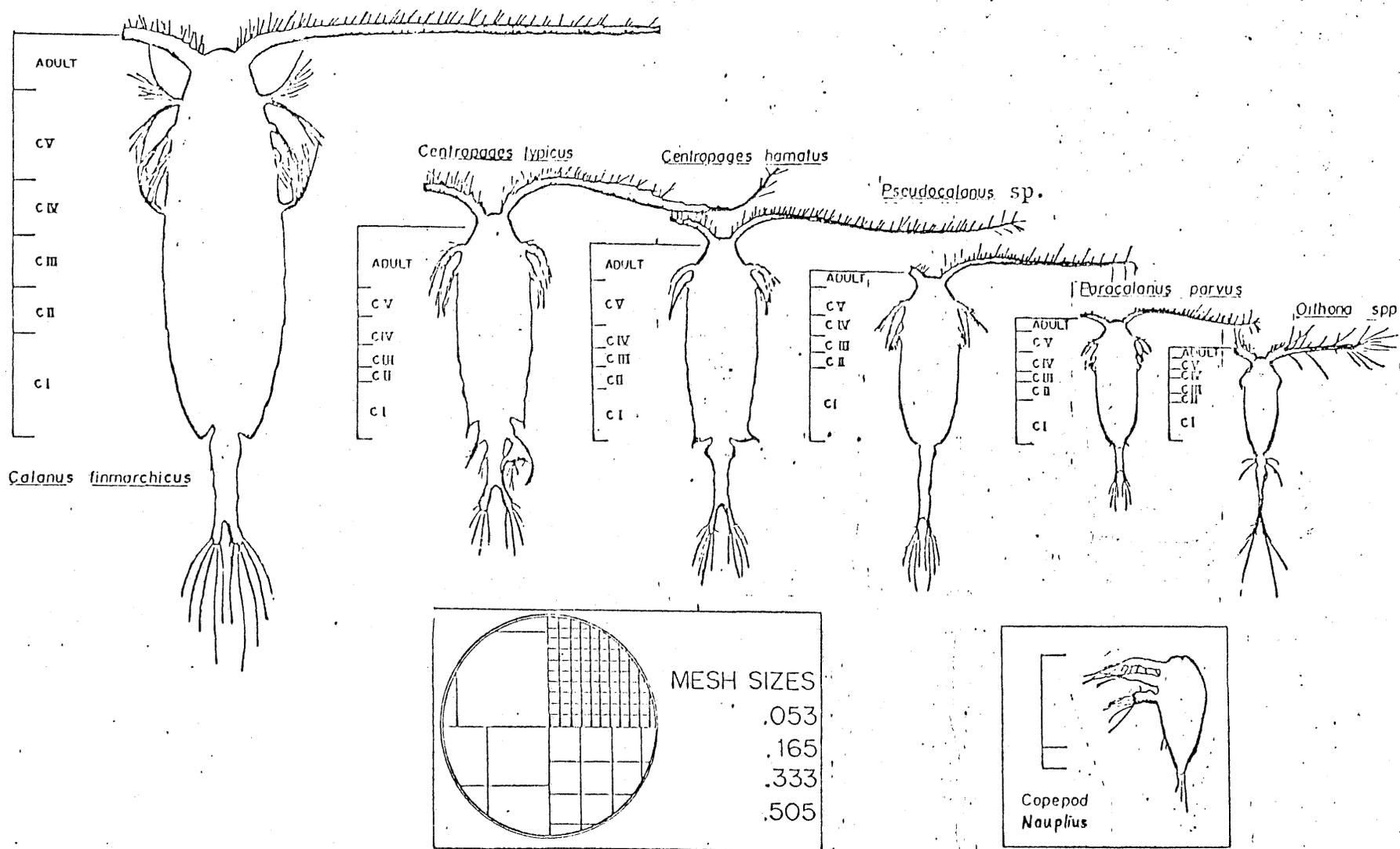


Figure 3. Relative size of larval herring prey items and meshes.

1 cm. = .349 mm.

Table III. Paired mesh comparisons of larval herring prey items in the plankton from two spawning seasons[@].

Species	Mesh size (mm)					
	.053	.165	.165	.333	.333	.505
<u>Pseudocalanus sp.</u>						
Adults	ND	ND	1*/ND	-/ND	ND	ND
CV	ND	ND	1*	-	--	-
CIV	ND	ND	1*	-	-	-
CIII	ND	ND	1*	-	-	-
CII	ND	ND	1*	-	-	-
CI	ND	ND	1*	-	-	-
<u>Paracalanus parvus</u>						
Adults & CV	ND	ND	1+3*	-	--	-
<u>Centropages typicus</u>						
Adults	ND	ND	ND	ND	ND	ND
CIV & CV	ND	ND	3+5*	-	-	-
<u>Centropages hamatus</u>						
Adults	-	5*	2*/ND	-/ND	ND	ND
CIV & CV	-	-	ND	ND	--	-
<u>Centropages spp.</u>						
CI - CIII	ND	ND	1*	-	-	-
<u>Calanus finmarchicus</u>						
Adults & CV	-	-	ND	ND	ND	ND
<u>Oithona spp.</u>						
Adults & CV	4*	-	1*	-	-	-
Copepod nauplii	2*	-	1*	-	-	-

Key

* - = Significant difference between nets with * indicating larger catch
 - - = Not enough data for a comparison
 ND = No significant difference

[@]Seasons = 1974-75/1975-76

Levels of significance of two-tailed t-test:

1.001 2.005 3.01 4.025 5.05

copepod nauplii was significant at the .005 level. There was a significant difference (.05 level) in the catch of Centropages hamatus adults which is the only case of a coarser mesh net retaining more organisms than a finer mesh net.

2. .165 versus .333 - There were significant differences between net collections of all stages of Pseudocalanus sp. (.001 level during both seasons), except for the adults during the 1975-76 season; Paracalanus parvus adults and CV's (.001 level during 1974-75 and .01 during 1975-76); Centropages typicus CIV and CV's (.01 level in 1974-75 and .05 level in 1975-76); Centropages hamatus adults (.05 level in 1974-75); Oithona spp. adults and CV's (.001 level both seasons); and copepod nauplii (.001 level both seasons).

There were no significant differences in numbers of Pseudocalanus sp. adults during the 1975-76 season; Centropages typicus adults during both seasons, Centropages hamatus adults during the 1975-76 season and CIV and CV's during both seasons, and Calanus finmarchicus adults and CV's during both seasons.

3. .533 versus .505 - There was only enough data for valid comparisons between adults of Pseudocalanus sp., both species of Centropages, and Calanus finmarchicus, and no significant differences were found.

4. Niskin bottles (5 depths) versus .053 (vertical haul)

Only two stations were available for comparison:

	Station 1	Station 2
Integrated Number of Copepod Nauplii in the Water Column	Net: $1.6 \times 10^5 / m^2$	Net: $2.6 \times 10^5 / m^2$
	Bottle: $2.53 \times 10^5 / m^2$	Bottle: $4.12 \times 10^5 / m^2$

DISCUSSION

During the fall and winter seasons in the Georges Bank-Gulf of Maine area clogging is not a serious problem, and the different mesh nets perform as expected. Water bottle samples and .053 mm mesh nets are required to sample Oithona spp. and copepod nauplii. They are probably also necessary to collect younger copepodite stages of Oithona spp. and Paracalanus parvus. The .165 net appears to sample all the other groups adequately.

It would be useful to be able to determine the "true" abundance of each species based upon estimates obtained from the different samplers employed. Unfortunately not enough .053 mm and water bottle samples are available at this time to permit us to calculate calibration factors for the abundances of an important fraction of the larval herring prey items, based upon the nets we used here. Future work should compare results obtained from .165 and .053 mm nets and Niskin bottles. Other important variables to consider in these studies are season and towing speed. Colton and Green (1979) concluded that extrusion of small zooplankton was reduced during tows at a ship speed of 1.5 knots instead of 3.5 knots, when comparing the catch of .355 and .255 mm mesh nets. They suggest using a .165 mm net in the

Georges Bank-Gulf of Maine area, and a .053 mm net in areas where plankton densities are lower, in order to sample many of the smaller larval herring prey items which the larger mesh nets miss or undersample. The critical dimensions for retention appear to be width of organism in comparison to diagonal of mesh size, but retention will vary with tow speed, abundance and composition of the plankton, morphology of the organisms, etc. (see Tranter, 1968 for a complete review).

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