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Larval Herring (*Clupea harengus* L.) Gut Content and Morphological Condition Data from Three Spawning Seasons (1974, 1975 and 1976) in the Georges Bank-Gulf of Maine Area[1]

by

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INTRODUCTION

Larval herring surveys have been conducted by the Northeast Fisheries Center in the Georges Bank - Gulf of Maine area since 1971 in order to investigate the physical and biological factors influencing larval survival and, ultimately, recruitment into the fishery. The major program objectives and field sampling techniques have been developed through ICNAF (International Commission for the Northwest Atlantic Fisheries), and are more fully described in Lough and Bolz (1980).

Starvation and predation are generally acknowledged as major causes of larval fish mortality (Hunter, 1976). There is some evidence that the size of the recruited year class of fall spawned larval herring is dependent upon overwinter survival when food organisms are scarce in this area (Sherman, 1971; Dubé et al., 1977; Lough, 1976; Graham and Davis, 1971; and Chenoweth, 1970). There have been many investigations into larval fish feeding which have provided evidence for a linkage between larval survival and the production cycle of their prey organisms. The major objective of our study is to examine the interrelations among larval herring survival, feeding, and morphological condition during the first six months of life. In this report the basic larval herring gut content and morphological condition data are presented on an individual cruise basis, for the 1974, 1975, and 1976 spawning seasons. These data are still undergoing extensive analyses which will be interpreted more fully, along with the corresponding information on the distribution and abundance of larval herring prey and predators in the environment, in future reports by Cohen et al. (1980), and Cohen and Lough (1980a).

METHODS

1. Field Sampling

Cruise tracks and dates for each survey conducted in the 1968-1978 ICNAF time series are presented along with details of the sampling methods in Lough and Bolz (1980). Our efforts have been focused on the following 15 cruises:

Vessel Cruise No.	Survey Dates
1. Cryos 74-04	9/07 - 9/24/74
2. Prognoz 74-01	10/18 -10/30/74
3. A. Dohrn 74-01	11/16 -11/23/74
4. Albatross IV 74-13	12/04 -12/19/74
5. Albatross IV 75-02	2/12 - 2/28/75

[1] NEFC Woods Hole Lab. Ref. Doc. No. 80-23

6.	Belogorsk 75-02	9/25 -10/08/75
7.	Belogorsk 75-03	10/17 -10/30/75
8.	A. Dohrn 75-187	11/01 -11/18/75
9.	Albatross IV 75-14	12/05 -12/17/75
10.	Albatross IV 76-01	2/10 - 2/25/76
11.	Wieczno 76-01	4/09 - 5/04/76
12.	Wieczno 76-03	10/14 -11/03/76
13.	A. Dohrn 76-02	11/15 -11/29/76
14.	Researcher 76-01	11/27 -12/11/76
15.	Mt. Mitchell 77-01	2/13 - 2/24/77

Beginning in 1971, the ICNAF surveys were conducted on a standard grid of stations 15-20 miles apart, attempting to cover the entire region approximately once a month from September/October through December. February surveys were added in 1974, and since the 1975 season sampling effort has been concentrated on the Georges Bank - Nantucket Shoals spawning areas. A double oblique bongo haul (61-cm diameter frame with .333 and .505-mm mesh nets, and starting in fall 1974, also a 20-cm diameter frame with .053 or .253, and .165-mm mesh nets) was made at each station. A 10-minute neuston haul (1x2, or .5x1 m rectangular frame with a .505-mm mesh net) also was made at most standard stations during the 1974-1977 seasons. During a standard bongo haul the sampling array was lowered at 50 m/min to a depth of 100 m or within 5 m of the bottom and retrieved at 10 m/min at a ship speed of 3.5 knots.

2. Laboratory and Data Processing Methods

A complete description of the laboratory and data processing methods has been outlined in Cohen and Lough (1979). Over 7,000 larval herring have been processed from the 15 survey cruises covering three spawning seasons (September/October through February, and through April in 1976). A series of measurements (standard length, head height, eye height, body height, maxillary length, pectoral angle, and skull width) were taken on a subsample of larvae in order to estimate the approximate age, various condition factors, and mouthgape. Larvae were staged according to Doyle (1977) and then processed for gut content and noted for incidence of parasites. Prey items were identified as specifically as possible based on the available literature (Murphy and Cohen, 1978) and measured for a length-weight conversion for eventual use in biomass estimates of prey consumed (Cohen and Lough, 1980b). An attempt was made to correct the environmental abundance estimates of prey items collected by .053, .165, .333, and .505-mm mesh bongo nets for losses due to extrusion and avoidance (Cohen, 1980; Davis, 1980), so that these data and the larval gut content information could be used in the calculation of selectivity indices (Cohen et al., 1980). This information will also be used to investigate the relationship between prey density and larval growth and survival examined in a recent paper by Werner and Blaxter (1980).

All the data were processed using statistical and organizational routines from "Statistical Package for the Social Sciences" (Nie et al., 1975) in use on the Sigma-7 computer of the Woods Hole Oceanographic Institution.

3. Presentation of Data

The larval herring gut content and morphological condition data for the three spawning seasons are presented in this report for each individual survey cruise in the following breakdown of tables and figures:

A. Tables

1. Mean length and width of larval herring prey items by 5-mm length class.

2. Abundance of larval herring prey items by 5-mm length class.

3. Diel distribution (2-hourly) of feeding larval herring by 5-mm length class.

4. Mean values of larval herring condition factor measurements by 5-mm length class.

B. Figures (individual cruise plots)

1. Percentage of larval herring feeding per station.

2. Mean number of prey items per larval herring per station.

3. Mean value of larval herring eye height/head height ratios per station.

4. Mean value of larval herring body height/standard length ratios per station.

SUMMARY OF RESULTS

The dominant prey items of herring larvae over the three seasons studied were adults and developmental stages of the following copepods ranked by the approximate frequency with which they were selected as prey:

1. Pseudocalanus sp.
2. Paracalanus parvus
3. Centropages typicus
4. Centropages hamatus
5. Oithona spp.
6. Calanus finmarchicus

The larvae feed more intensively on copepod nauplii early in the season when they are small, and gradually shift to a higher proportion of copepodites and adults in their diet later on in the season. Larvae commonly contained 1 to 5 organisms in their hind guts; on several occasions large numbers of copepod eggs (up to 60 per larva) were found throughout the length of the gut. In December 1974, both species of Centropages were common as prey, but in December of 1975 and 1976 their occurrence in the larval guts decreased markedly and Pseudocalanus sp. and Paracalanus parvus became dominant. There is some evidence that this change in diet may reflect a change in composition of the zooplankton available, according to Sherman et al. (1978), who found a decrease in the percentage of Centropages typicus adults and an increase in Pseudocalanus sp. adults on Georges Bank in autumn of 1975 compared to autumn of 1974.

In our study the highest incidences of feeding occurred during December 1975 (28.04%), April 1976 (37.97%), and February 1977(29.01%). In all the other surveys percentage of larvae feeding ranged between 5-18%, except in September 1975 when no larvae were examined with food in their guts. These percentages are somewhat low compared to other studies of larval herring feeding reported:

Author		Feeding incidence
Sherman and Honey (1970):		57%
Rudakova (1971):		1961-morning maximum=38.6% 1967-day maximum=40.8% evening maximum=55%
Bainbridge and Forsythe (1971):		sunset maximum=70%
Bjorke (1971):		51%
Bowers and Williamson (1951):		Yolksac larvae=28% Post larvae=60-70%
Schnack (1972):	North Sea	50%
	Baltic Sea Firth of Schlei	= ∿ 100%
Bhattacharyya (1957):		35.2%

Percentages varied with the time of day, age of larvae, depth of of sampling, geographic area, and season. Most other studies have observed a diurnal feeding pattern. In our study, feeding incidence usually appeared to increase around sunset for all three seasons. We were not able to estimate the degree of digestion of the gut contents as other authors have done (Schnack, 1972,

and Bhattacharyya, 1957) in order to calculate the length of time food was in the gut, and obtain a better estimate of the time when feeding occurred.

The morphological measurements were used to calculate several measures of larval condition based on the indices described in Ehrlich et al. (1976). Cruise plots of the eye height/head height and body height/standard length ratios show some indication that larvae retained on the shoal spawning grounds located in the highest larval density centers were more robust than larvae outside these areas. The multivariate techniques of factor and discriminant analyses were used to try to separate robust from starving larvae based on their morphological measurements and feeding incidence, however, neither technique was successful because of various problems encountered in analyzing this data set which are discussed in Cohen and Lough (1979).

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Table 1. Albatross IV 75-02, 2/12-2/28/75, mean length and width of larval herring prey items by 5-mm larval length class.

CRUISE ALB IV 75-02 GEAR 61 cm Bongo 0.5x1m Neuston MESH .505 mm

PREY SIZE DISTRIBUTION · LARVAL GUT CONTENTS · SPECIES *Clupea harengus*

LARVAL LENGTH (MM)	NUMBER LARVAE EXAMINED	NUMBER LARVAE FEEDING	TOTAL NUMBER PREY	MEAN NO. PREY/ LARVA	NUMBER OF PREY AT SIZE RANGES (MM) Length						
					≤0.19	0.2 - 0.49	0.5 - 1.09	1.1 - 1.59	1.6 - 2.59	2.6 - 4.59	5.0
< 10											
10 - 14	2	0									
15 - 19	7	0									
20-24	231	42	95	2.26			64				
25-29	658	120	367	3.06	10		228	2			
30-39	327	36	122	3.39			54	13			
>40											
LENGTH MISSING	5	0									
TOTAL	1230	198	584	2.95	10		346	15			

PREY SIZE DISTRIBUTION · LARVAL GUT CONTENTS · SPECIES *Clupea harengus*

LARVAL LENGTH (MM)	NUMBER LARVAE EXAMINED	NUMBER LARVAE FEEDING	TOTAL NUMBER PREY	MEAN NO. PREY/ LARVA	NUMBER OF PREY AT SIZE RANGES (MM) Width						
					≤0.19	0.2 - 0.49	0.5 - 1.09	1.1 - 1.59	1.6 - 2.59	2.6 - 4.59	5.0
< 10											
10 - 14	2	0									
15 - 19	7	0									
20-24	231	42	95	2.26		55					
25-29	658	120	367	3.06	10	207	2				
30-39	327	36	122	3.39		63					
>40											
LENGTH MISSING	5	0									
TOTAL	1230	198	584	2.95	10	325	2				

Table 2. Albatross IV 75-02, 2/12-2/28/75, abundance of larval herring prey items by 5-mm mesh larval length class.

61 cm Bongo
CRUISE Albatross IV 75-02 GEAR 0.5 x 1m Neuston MESH .505 mm

TAXA SELECTION — LARVAL GUT CONTENTS · SPECIES *Clupea harengus*

LARVAL LENGTH (MM)	NUMBER LARVAE EXAMINED	NUMBER LARVAE FEEDING	*Pseudo m*	*Para p*	*Pseud- para*	*Cent typ*	*Cent ham*	*Cent spp*	*Oithona spp*	*Cal fin*	*Invert egg*	*Unident Cal adult*	*Unident Cal juv*	*Unident*
< 10														
10- 14	2	0												
15- 19	7	0												
20-24	231	42	2-C 47-A		3-A	1-C 6-A	11-C 6-A	3-C				16		
25-29	658	120	15-C 203-A	3-A		4-C 19-A	18-C 33-A	8-A	2-A		10	52		
30-39	327	36	1-C 61-A	4-A		3-C 10-A	23-A	1-A	2-A			17		
>40														
LENGTH MISSING	5	0												
TOTAL	1230	198	18-C 311-A	7-A	3-A	8-C 35-A	29-C 62-A	3-C 9-A	4-A		10	85		

N = copepod nauplius C = copepodite A = adult copepod

Table 3. Albatross IV 75-02, 2/12-2/28/75, diel distribution of feeding larval herring by 5-mm length class.

61 cm Bongo
0.5 x 1 m

TIME (GMT) CRUISE ALB IV 75-02 GEAR Neuston MESH .505 mm

DIURNAL FEEDING-LARVAL GUT CONTENTS — SPECIES *Clupea harengus*

LARVAL LENGTH (MM)	0000-0200	0201-0400	0401-0600	0601-0800	0801-1000	1001-1200	1201-1400	1401-1600	1601-1800	1801-2000	2001-2200	2201-2400	TOTAL
<10													
10-14													
15-19													
20-24	40	1	0	0		0	0	1	0				42
25-29	93	9	3	0		1	9	4	0				119
30-39	25	2	1	2		1	2	2	1				36
>40													
LENGTH MISSING													
TOTAL	158	12	4	2		2	11	7	1				197

□ = Day ▨ = Twilight ■ = Night

Table 4. Albatross IV 75-02, 2/12-2/28/75, mean value of larval herring condition factor measurements by 5-mm length class.

MEAN VALUES OF CONDITION FACTOR MEASUREMENTS - LARVAL GUT CONTENTS SP Clupea harengus

CRUISE ALB IV 75-02 GEAR 61 cm Bongo 0.5x1m Neuston MESH .505 mm

STD LENGTH (MM)	NUMBER LARVAE EXAMINED	SKULL WIDTH (MM)			MOUTH GAPE (MM)			MAXILLARY LENGTH (MM)			EYE HEIGHT (MM)			HEAD HEIGHT (MM)			EYE/HEAD HEIGHT RATIO			BODY HEIGHT (MM)			PECTORAL ANGLE (°)			BODY HEIGHT/ STD LENGTH RATIO			WEIGHT (MGDRY) X 1000 / STD LENGTH (MM) 3		
		NO	X	CL	NO	X	CL	NO	X	CL	NO	X	CL	NO	X	CL	NO	X	CL	NO	X	CL	NO	X	CL	NO	X	CL	NO	X	CL
<10																															
10-14	2	1	.520								1	.600		1	.880					2	.380	±.254				2	.034	±.013	2	.103	±.046
15-19	7	4	1.02	±.122	4	1.36	±.244	4	.960	±.172	1	.600		5	1.00	±.186	1	.600		6	.740	±.087	4	149.2	±15.3	6	.040	±.003	7	.227	±.014
20-24	231	204	1.28	±.013	200	1.82	±.028	200	1.29	±.019	144	.864	±.020	215	1.29	±.025	143	.648	±.014	222	1.05	±.077	213	149.2	±.982	222	.045	±.003	231	.345	±.003
25-29	658	618	1.46	±.013	596	2.22	±.037	596	1.57	±.026	570	1.10	±.012	635	1.70	±.028	567	.644	±.006	645	1.30	±.017	636	153.2	±1.18	645	.048	±.000	65	.445	±.003
30-39	327	321	1.68	±.017	313	2.86	±.045	313	2.02	±.032	314	1.46	±.023	322	2.37	±.042	312	.619	±.006	323	1.89	±.045	318	157.6	±.615	323	.060	±.001	327	.573	±.005
40																															
LENGTH MISSING	5	1	1.36		1	1.92		1	1.36		1	.920		1	1.40		1	.657		2	1.08	±1.02	1	150.6							
TOTAL	1230	1149	1.49	±.011	1114	2.32	±.032	1114	1.64	±.023	1031	1.17	±.016	1179	1.81	±.029	1024	.637	±.004	1200	1.41	±.027	1172	153.	±.706	1196	.051	±.001	1226	.458	±.005

NOTE: CL = 95% confidence level.

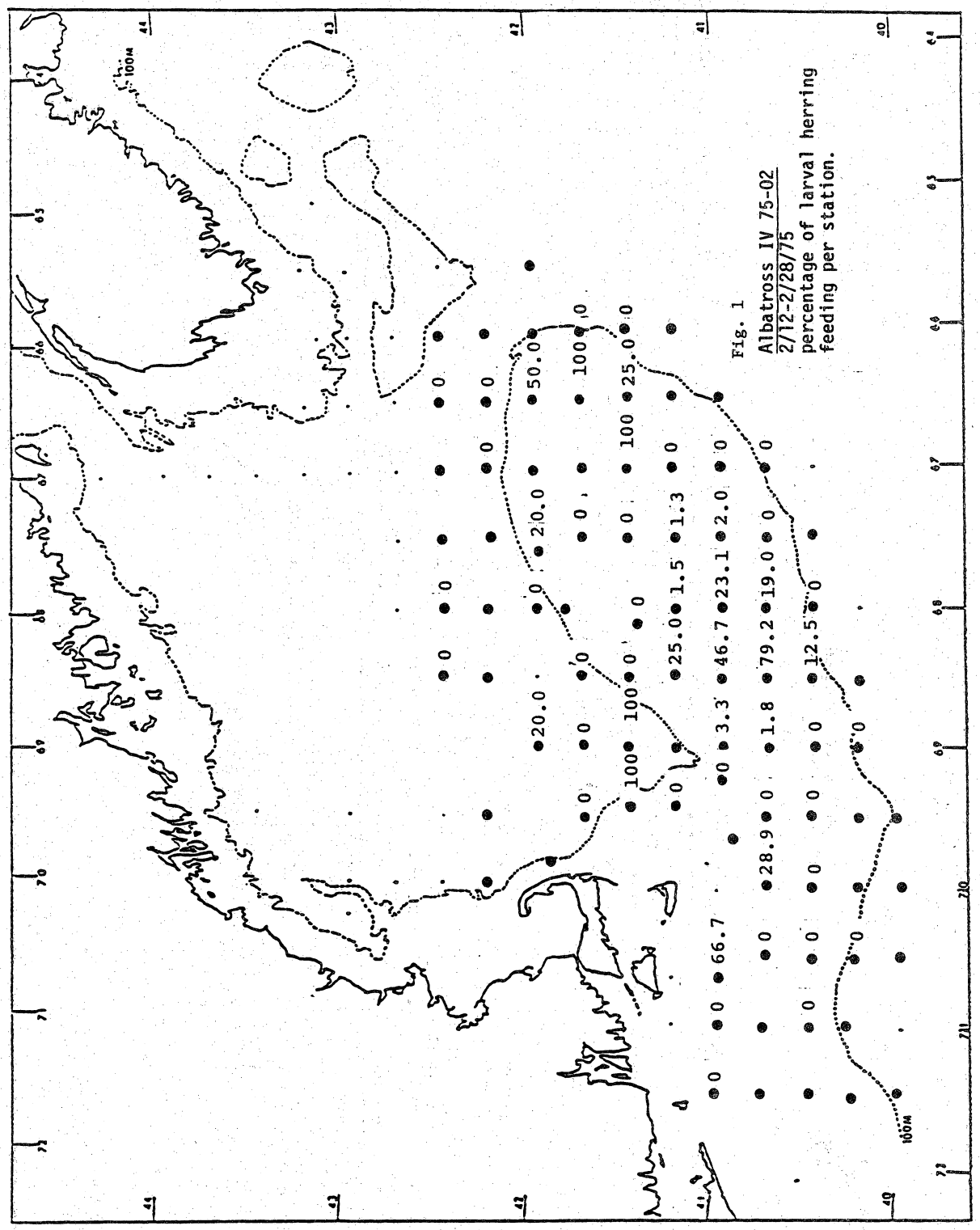

100M
100M
Albatross IV 75-02
2/12-2/28/75
percentage of larval herring
feeding per station.

Fig. 1

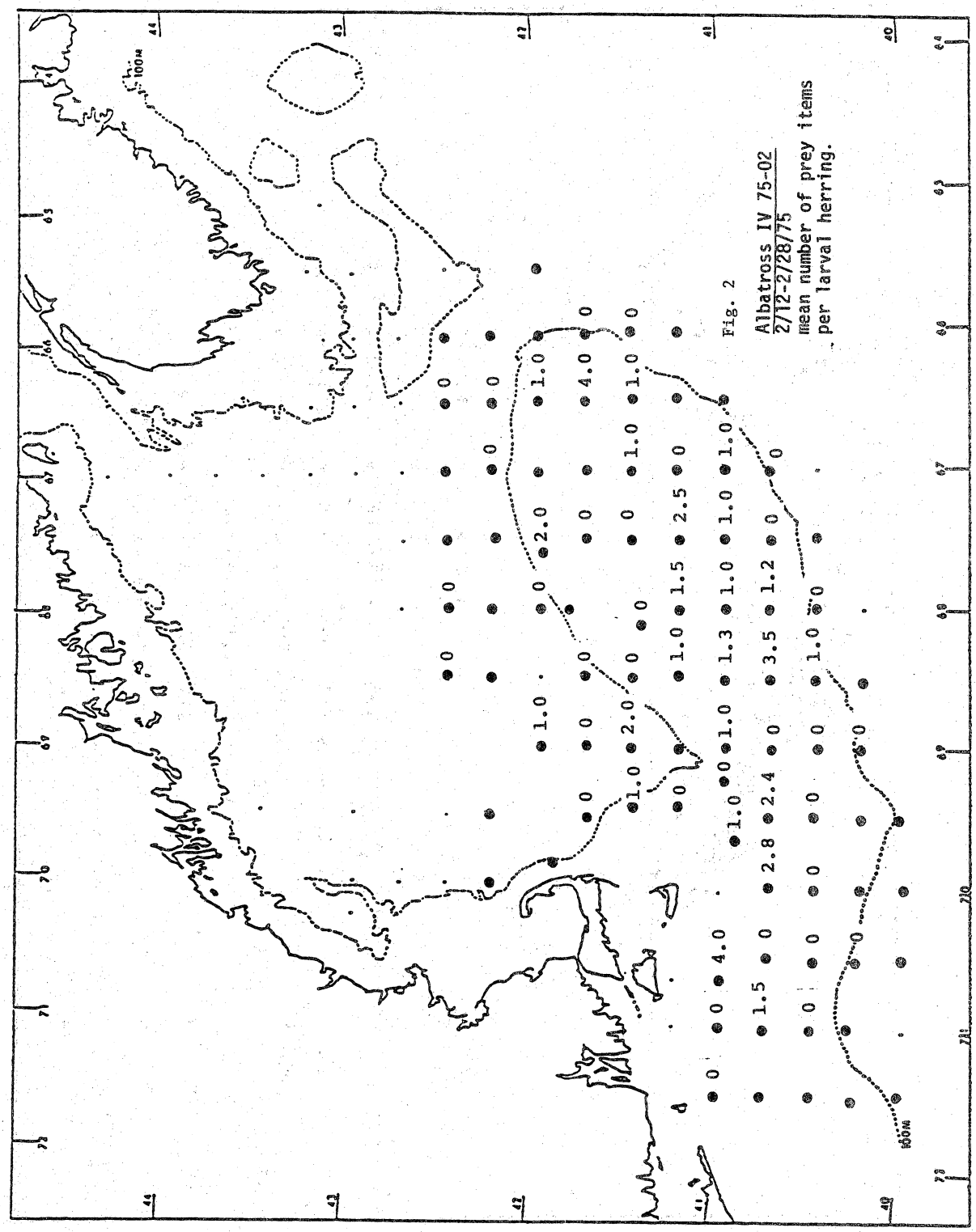
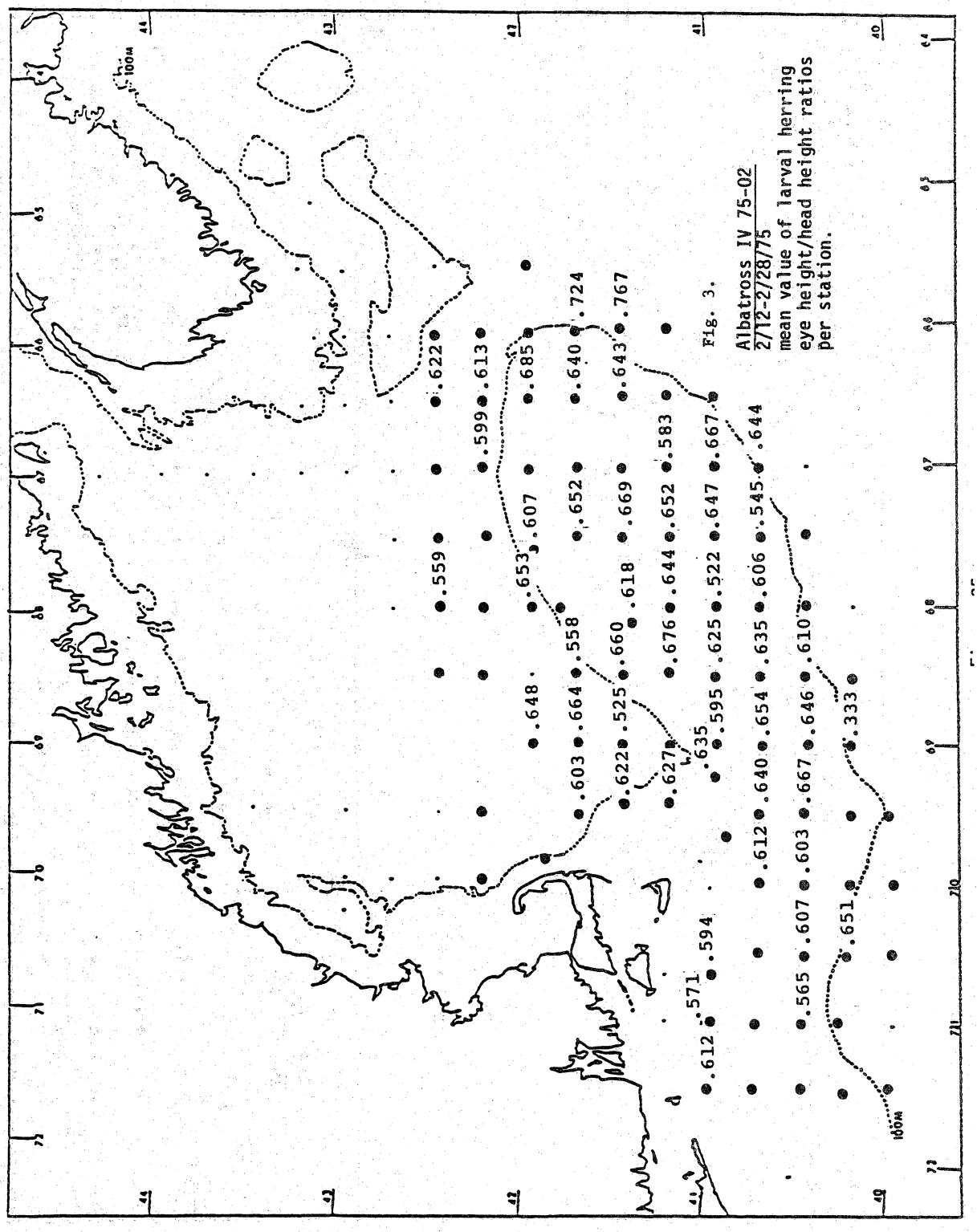
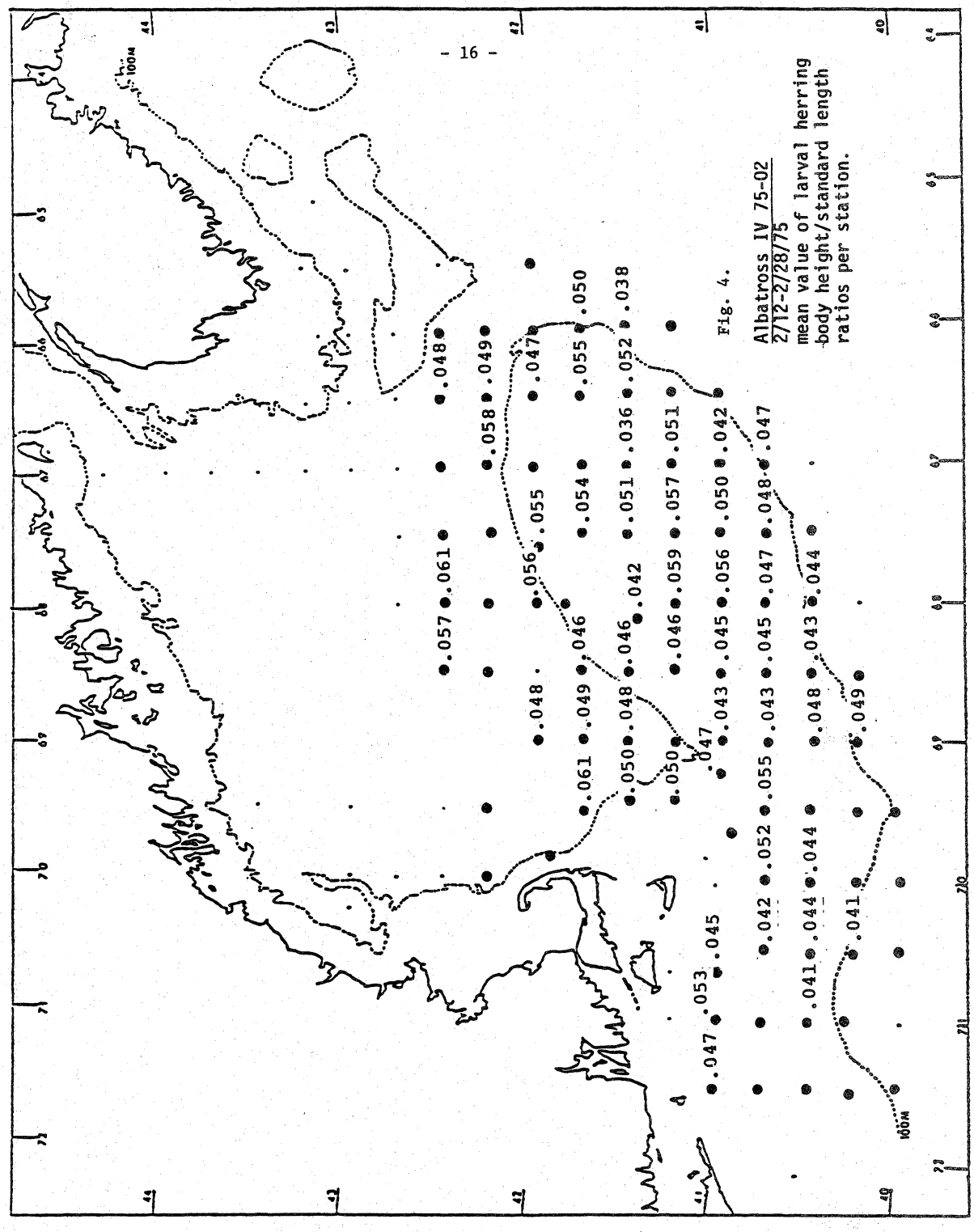

Albatross IV 75-02
2712-2728/75
mean number of prey items
per larval herring.

Fig. 2



Albatross IV 75-02
2/12-2/28/75
mean value of larval herring
eye height/head height ratios
per station.

Fig. 3.



Albatross IV 75-02
2/12-2/28/75
mean value of larval herring body height/standard length ratios per station.

Fig. 4.