Laboratory and Data Processing Methods Recommended for Larval Fish Gut Content and Condition Factor Analysis Studies using Larval Atlantic Herring (*Clupea harengus* L.) as a Prototype

by

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Laboratory Reference No. 79-39
October 1979
Revised October 1981

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Abstract

This investigation has attempted to quantitatively relate larval herring survival to their morphological condition and food habits as determined by prey selection and availability over several spawning seasons, employing portions of the ICNAF larval herring data base. The laboratory and data processing techniques which we have found useful in analyzing condition factor measurements and gut content information on larval sea herring have been outlined here in detail.

Introduction

The Larval Dynamics Investigation of the Northeast Fisheries Center in Woods Hole, Massachusetts has been involved in an intensive international, multidisciplinary study of Atlantic herring (*Clupea harengus* L.) in the Georges Bank-Gulf of Maine region to identify and measure the physical and biological factors influencing larval survival during the first six months of life. Participation by NOAA, National Marine Fisheries Service, Northeast Fisheries Center, was conducted through a fisheries ecosystem program called MARMAP (Marine Resources Monitoring, Assessment, and Prediction) (Sherman, 1980). In 1971 a systematic mesoscale sampling of zooplankton and ichthyoplankton was initiated over the continental shelf from Cape Hatteras to Nova Scotia. The field sampling program for this study, developed through ICNAF (International Commission for the Northwest Atlantic Fisheries), was designed to detect significant variations in timing and dispersal of larvae from spawning sites, and in the population parameters of larval production, growth, and mortality within and among spawning seasons and areas. A recent analysis of available data

(Lough et al., 1979) for the 1971-77 seasons found no close relationship between initial production of larvae and recruitment. There is sufficient evidence available to support the general hypothesis that the size of the recruited year class of herring is determined sometime during the early larval period, between spawning in early autumn and survival over-winter into early spring. A major hypothesis which we are investigating is that recruitment is dependent upon over-winter survival of the larvae when food organisms are relatively scarce. Starvation and predation (possibly starvation-linked) have been identified as the major causes of larval mortality. Theoretical studies of larval fish survival illustrate how mortality and growth can be linked as density dependent processes regulated by food availability.

Many field and laboratory investigations have been undertaken to examine larval fish feeding. None have successfully produced a predictive recruitment index, but they have provided some evidence in support of Cushing's match-mismatch hypothesis of larvae and the production cycles of their prey. Due to the complex nature of the processes being studied, very intensive field and laboratory programs of broad scope are necessary, encompassing all important aspects of recruitment. The data bases generated by the ICNAF larval herring surveys are among the most extensive and complete available sources of information with which to investigate some of the leading hypotheses of larval survival.

Our main objective is to compare the general morphological "condition" of larval herring and prey selection based upon their gut contents with prey availability over several spawning seasons (autumn-winter). This manual provides a detailed outline of the laboratory and data processing methods used in our work which we hope will serve as a useful guideline for similar studies. We have incorporated existing methods of analysis with our own ideas as the project developed. Field sampling methods and a rationale for sample selection and number of larvae processed are reviewed briefly. Examples of laboratory forms, data summary sheets and analyses, and computer routines used are included in the appendices. Refer to Cohen and Lough (1981) for the completed study.

Methods

I. Field Sampling

The ICNAF larval herring surveys were conducted on a standard grid of stations 15-20 miles apart (Figure 1), covering the Georges Bank-Gulf of Maine region at least once a month from September through December since 1971. February surveys were added in 1974 to examine the over-winter picture. The Georges Bank-Nantucket Shoals area represents our most complete time series of data, and since 1975 this area has received intensive coverage in terms of extra stations, nutrients, chlorophyll, primary productivity, and hydrography. A complete list of participating vessels and survey dates can be found in Lough and Bolz (1980). The fifteen surveys selected for larval herring gut content analysis are as follows:

Vessel and Cruise No.	Date
Cyros 74-04	9/7 - 9/24/74
Prognoz 74-01	10/18 - 10/30/74
Anton Dohrn 74-01	11/16 - 11/23/74
Albatross IV 74-13	12/4 - 12/19/74
Albatross IV 75-02	2/12 - 2/28/75

Vessel and Cruise No.	Date
Belogorsk 75-02	9/15 - 10/8/75
Belogorsk 75-03	10/17 - 10/30/75
Anton Dohrn 75-187	11/1 - 11/18/75
Albatross IV 75-14	12/5 - 12/17/75
Albatross IV 76-01	2/10 - 2/25/76
Wieczno 76-01	4/9 - 5/4/76
Wieczno 76-03	10/14 - 11/3/76
Anton Dohrn 76-02	11/15 - 11/29/76
Researcher 76-01	11/27 - 12/11/76
Mt. Mitchell 77-01	2/13 - 2/24/77

At each standard station, minimum sampling has included double oblique hauls with 61-cm diameter bongo nets (0.505- and 0.333-mm mesh nets) and temperature-salinity profiles. Since autumn 1974, 20-cm bongos (0.253- or 0.053- and 0.165-mm mesh nets) were added to the sampling array in order to collect smaller organisms. A standard haul consisted of lowering the bongo array at 50 m/min to a maximum depth of 100 m or to within 5 m of the bottom, and retrieving at 10 m/min while the ship is underway at 3.5 knots (Posgay and Marak, 1980). Ten minute neuston hauls (1 x 2, or .5 x 1 m rectangular frame fitted with a 0.505-mm mesh net) usually were made simultaneously with each bongo haul during the 1974-77 seasons.

II. Laboratory Procedures

A. Sample Selection and Processing Rationale:

Previous studies of larval herring feeding on both sides of the Atlantic have documented the species and size ranges of selected prey items, as well as feeding rates and metabolic requirements of the larvae. We felt that any significant new information relating survival and feeding conditions of Georges Bank larval herring could only be revealed by a systematic in-depth study.

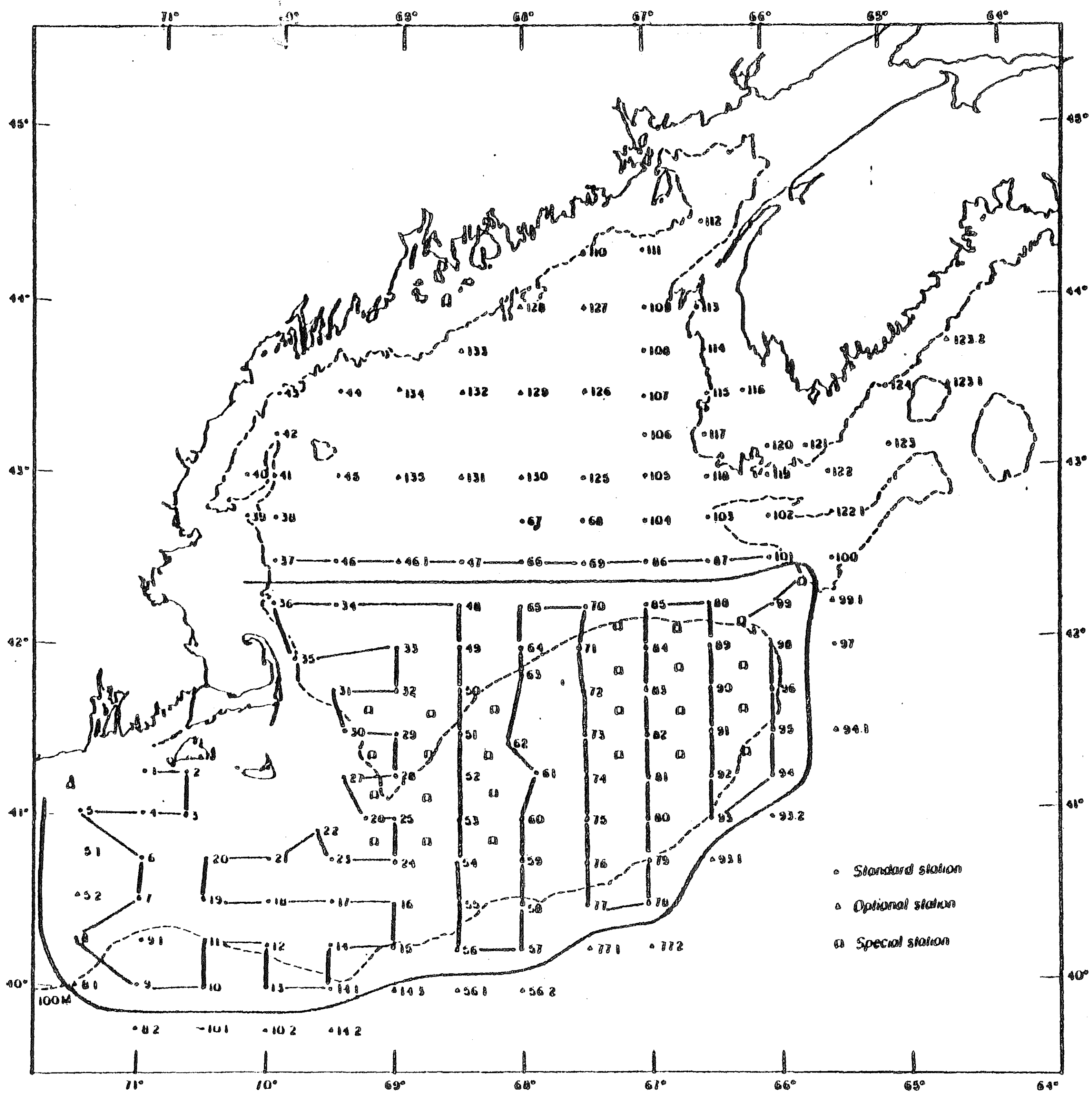


Figure 1. Standard station grid of Georges Bank-Gulf of Maine area.

Over 7,000 larvae have been examined to-date for gut contents and condition for 15 cruises over three spawning seasons, September-February in 1974 and 1976 and April in 1975. When this task was initiated in 1976, these three spawning seasons represented our best coverage of the time series, and preliminary studies by Lough et al. (1980), and Dubé et al. (1977) indicated differences between the three seasons in larval production, growth, mortality, potential food organisms, and environmental conditions. These differences appeared to be accentuated during the winter period, and so our effort was concentrated on the December and February surveys. Up to 100 larvae per station were processed from the winter cruises in order to detect any differences in prey selection and physical condition within and among larval concentrations in the Georges Bank-Nantucket Shoals area. Our decision to undertake such an extensive analysis was influenced by the low incidence of prey in the guts and the variability of the condition factor measurements. Processing of the larger larvae from the winter surveys was more rapid than the smaller autumn survey larvae because the larger larvae usually fed on easily identifiable adult copepods, in contrast to the more difficult-to-identify copepod developmental stages favored by smaller larvae. By February, larval densities were low (<100 larvae per station, usually 1-10 larvae per station) and larvae were captured at only one-third or less of the grid stations, so as many larvae as possible were processed to provide a representative and statistically valid data base.

Over-winter larval survival may have been influenced by biological and physical conditions the previous autumn, therefore we also needed to examine feeding and condition of larvae from the 1974, 1975, and 1976 autumns. The high densities of early larvae (>100 per station) occurring at many more stations than later larvae made processing 100 larvae per station prohibitive in terms of time and resources, and to do as thorough an analysis on the autumn samples was secondary to the main over-winter hypothesis. Preliminary work indicated that larvae of the same size at a given station generally fed on similar numbers of prey of the same species and size. Therefore, we reduced the number of larvae examined from the autumn surveys to 30 per station, and selected only 5 stations per survey located in high density larval patches across the survey area. Corresponding stations were selected for fine (0.165 mm) and coarse (0.333 mm) mesh zooplankton processing to assess available prey. These samples were sorted by the Polish Sorting Center and the Northeast Fisheries Center. We have attempted to obtain as much significant information as possible from each larva because once dissected for gut contents, the specimen is essentially useless for further measurements.

B. Records, Data Sheets and Labeling:

The laboratory data were recorded on standard "Gut Content Data Record" (GCDR) forms. A copy of this data sheet and instructions for its completion are presented in Figure 2. This format facilitates data entry into computer files. Our data were keypunched by the Automated Data Processing (ADP) group here in Woods Hole, and entered into computer files at the Woods Hole Oceanographic Institution's (WHOI) Sigma-7

Figure 2. "Gut Content Data Record" - Data Sheet and Instructions

MARMAP Gut Content Data Record - Fish Larvae (GCDR)

Type of Information	Columns	Possible No. of digits	Coding Details
Cruise Code No.	1-3	3	First cruise processed becomes No. 1 (e.g., 1 = ALBATROSS IV 76-1, 10-25 Feb 1976)
Station No.	4-6	3	Use whole no. for extra stations prior to OPTSCAN
Haul No.	7, 8	2	
Date	9-14	6	GMT - Day (2) Month (2) Year (2)
Time	15-18	4	GMT - Nearest whole minute, beginning of tow
Latitude	19-22	4	Nearest whole minute, beginning of tow
Longitude	23-26	4	Nearest whole minute, beginning of tow
Gear type code no.	27	1	Gear type / Code No.: 61 cm bongo 1; 20 cm bongo 2; 1 x 2 m neuston 3; ½ x 1 m neuston 4; MOCNESS 5
Net mesh type code no.	28	1	Mesh / Code No.: .505 mm 1; .333 mm 2; .253 mm 3; .165 mm 4; .053 mm 5; .202 mm 6
Predator code no.	29-37	9	MARMAP coding
Predator specimen no.	38-41	4	Consecutive no. within a station haul
Predator weight	42-47	6	Dry weight. Nearest 1/100th mg

Figure 2 continued.

Type of Information	Columns	Possible No. of digits	Coding Details
Predator length	48-50	3	Standard length, nearest 1/10th mm
Predator skull width	51-53	3	Nearest 1/100th mm
Predator maxillary length	54-56	3	Nearest 1/100th mm
Predator eye height	57-59	3	Nearest 1/100th mm
Predator head height	60-62	3	Nearest 1/100th mm
Predator body height	63-65	3	Nearest 1/100th mm
Predator pectoral angle	66-68	3	Nearest whole degree
Predator conditions	69	1	Good, intact specimen = 0 Damaged so that one or more measurements are missing = 1
Predator diseases	70	1	Presence of parasites in gut: 1 = <u>Bothriocephalus scorpii</u> 2 = <u>Scolex pleuronectis</u> 3 = Unidentified cestode 4 = 1 & 2 5 = 1 & 3 6 = 2 & 3 7 = 1, 2 & 3 *Note position in gut
Predator gut contents	71	1	Gut empty = 0 Gut with prey remains identifiable to some taxonomic code = 1 Gut with unidentifiable prey remains = 2 Gut with identifiable and unidentifiable prey remains = 3 Gut not examined = 4
Position of prey in predator gut	72	1	Anterior gut = 1 Mid gut = 2 Hind gut = 3 1 & 2 = 4 1 & 3 = 5 2 & 3 = 6 1, 2 & 3 = 7

Figure 2 continued.

Type of Information	Columns	Possible No. of digits	Coding Details
Larval life stage code no.	78,79	2	See Doyle (1977) for stage description Code No. Stage 10, Substage 11-13 Stage 20, Substage 21-23 Stage 30, Substage 31-33 Stage 40, Substage 41-44
Prey flag	80,81	2	Enter 1 for first record of each larva whether larva is feeding or not. If prey items are present, number each additional record for the same larva consecutively
Prey code no.	82-85	4	MARMAP coding If gut is empty, enter 9 in column 85.
Prey life stage code no.	86-88	3	MARMAP coding
Prey sex	89	1	MARMAP coding Male = 1 Female = 2 Immature = 3 Ovigerous female = 4
Prey condition	90	1	Good, intact specimen = 0 Fragment(s) = 1 Only one measurement possible = 2
Prey length	91-94	4	Nearest 1/100th mm
Prey width	95-98	4	Nearest 1/100th mm

Type of information not coded for computer entry:

1. Vial no.
2. Photograph no.
3. Gut length
4. Prey name
5. Other remarks for predator and prey
6. Technician's initials

Figure 2 continued.

MARMAP GUT CONTENT DATA RECORD – FISH LARVAE (GCDR)

CRUISE			STN			HAUL		DATE (GMT)						TIME (GMT)				LAT				LONG			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

GEAR	
27	28

PREDATOR CODE								
29	30	31	32	33	34	35	36	37
1	2	1	0	5	0	6	0	1

SPECIMEN NO.			
38	39	40	41

GUT LGTH. ____________

VIAL NO.			

WEIGHT						LENGTH			SKULL W.			MX LGTH			EYE HT.			HEAD HT.			BODY HT.			PCTL ⊥		
42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68

C	D	G	P						LS	
69	70	71	72	73	74	75	76	77	78	79

PHOTOGRAPH NO.											

PF		PREY				LIFE ST.			S	C	LENGTH				WIDTH				PREY NAME
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99

INITIALS ____________

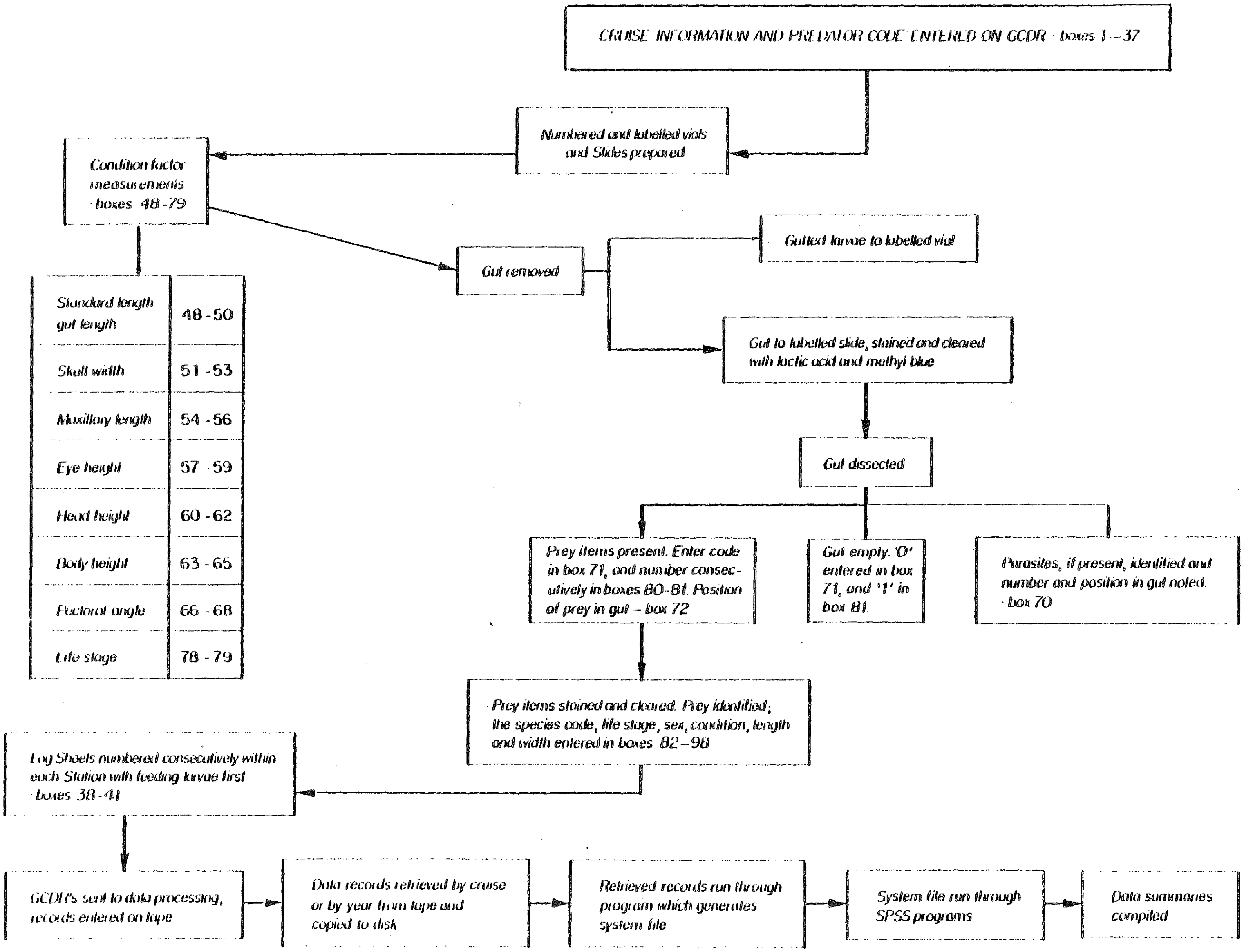
Computer Center. Figure 3 presents a summary flow sheet of the laboratory and data processing methods which will now be described in detail. The data entries are dicussed in the order in which they appear on the GCDR.

1. <u>Cruise Code No.</u> - Numbers arbitrarily assigned.
2. <u>Station No.</u> - Information obtained from original cruise logs or "Station Activities Summary" (SAS) printouts of cruise data stored in computer files at the University of Rhode Island as part of MARMAP Information System (MIS) (See sample in Appendix 1).
3. <u>Haul No.</u>
4. <u>Date</u>
5. <u>Time</u>
6. <u>Latitude</u>
7. <u>Longitude</u>
8. <u>Gear Type Code No.</u> - On GCDR instruction sheet.
9. <u>Net Mesh Type Code No.</u> - On GCDR instruction sheet.
10. <u>Predator Code No.</u> - Obtained from standard MARMAP code system on file in MIS (Appendix 1).
11. <u>Predator Specimen No.</u> - Determined after all larvae at a station are examined; consecutive numbers assigned beginning with feeding larvae.
12. <u>Gut Length</u> - Measured from pharynx to anus.
13. <u>Vial No.</u> - Consecutive number of larvae examined at a station.

(Items 12 and 13 are not keypunched).

Items 1 through 10 are entered on a master copy of the GCDR prior to processing larvae at a given station, and the GCDR is xeroxed the appropriate number of times.

Figure 3. Flowsheet diagram of methods for processing larval herring gut contents.



Before proceeding, three labels for each larva should be prepared as follows:

1. Slide Label

   Station #
   Vial #

2. Vial Cap Label

   C# - Vessel & Cruise #
   S# - Station #
   V# - Vial #

3. Inside Vial Label

   Vessel & Gear
   Cruise # Mesh Size
   Station #

C. Sorting, Measuring, Staging and Dissection:

Herring larval had previously been sorted from the 0.333 and 0.505 mm mesh bongo samples by the Plankton Sorting and Identification Center in Szczecin, Poland and the Northeast Fisheries Center, vialed separately by station, and grouped by cruise. Larvae for this investigation were randomly chosen from these vials of larvae at each of the selected stations. Each larva was gently straightened out on its side on a flat microscope slide in a small amount of water to secure it in place and prevent dehydration. Dissections, measurements, and routine identifications were performed using a Wild M5 dissecting microscope. A Zeiss compound microscope was used to identify (if possible) fragments and unknown gut contents; photographs were taken of rare prey items. Damaged areas of herring larvae or prey items were not measured. In order to achieve consistent measurements, technicians should practice on extra larvae before beginning the analyses.

The remaining information can now be entered on the GCDR's. Refer to Figure 4 for an illustration of the measurements.

14. <u>Predator Length</u> - In preflex larvae measured from tip of upper jaw to end of notochord, and in postflex larvae to end of hypural plate. Length may be used as indication of age and in calculations of biomass and condition factors (Ehrlich et al., 1976).
15. <u>Predator Skull Width</u> - Viewed dorsally, widest portion of skull measured just posterior to orbital region.
16. <u>Predator Maxillary Length</u> - Measured maxillary bone comprising most of upper jaw for calculation of mouthgape (Shirota, 1970).
17. <u>Predator Eye Height</u> - Measured according to Ehrlich et al. (1976) for use as indicators of condition.
18. <u>Predator Head Height</u>
19. <u>Predator Body Height</u>
20. <u>Predator Pectoral Angle</u>
21. <u>Predator Condition</u> - See GCDR instructions.

Larvae were staged prior to dissection (in all except three winter surveys, Alb. IV 75-02, Alb. IV 75-14, Alb. IV 76-01) according to procedures described by Doyle (1977), and coded in Item 26 of the GCDR. Summary diagrams of the major features of each stage are presented in Figure 5.

The gut was teased away from the larval body with minutien insect pins held in stainless steel loop holders. It was usually possible to dissect the gut intact, and the larva was then transferred to a labeled vial of 4% neutral formalin.

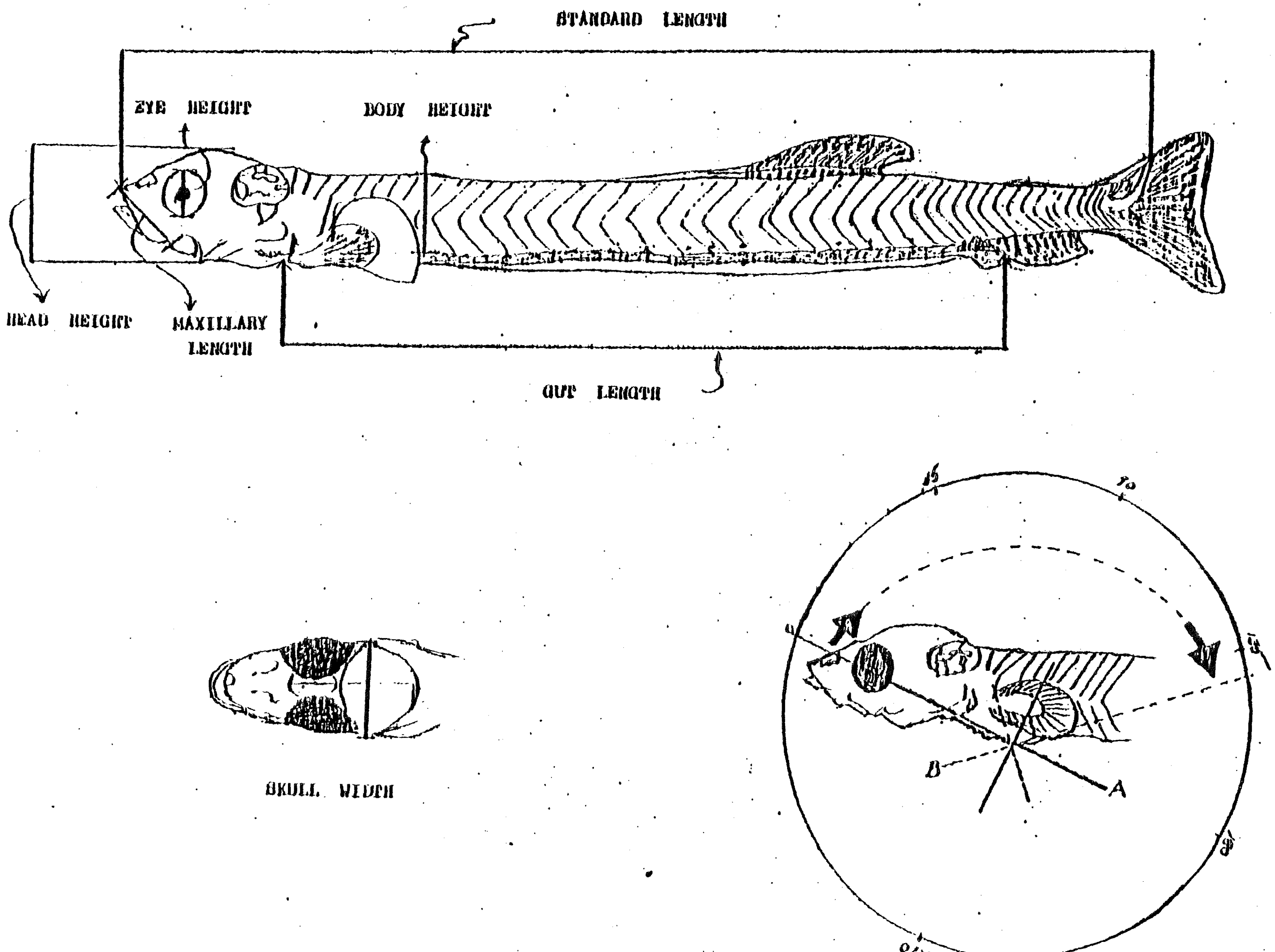
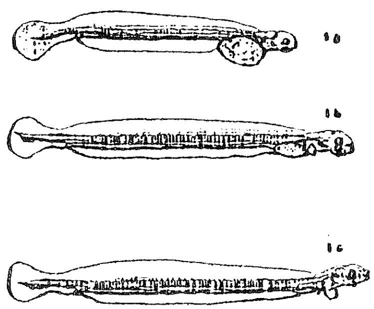


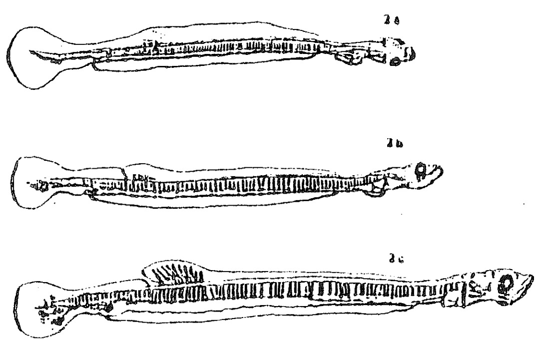
Figure 4. Condition factor measurements recorded from larval sea herring.

Figure 5. Staging method for larval sea herring according to Doyle (1977).

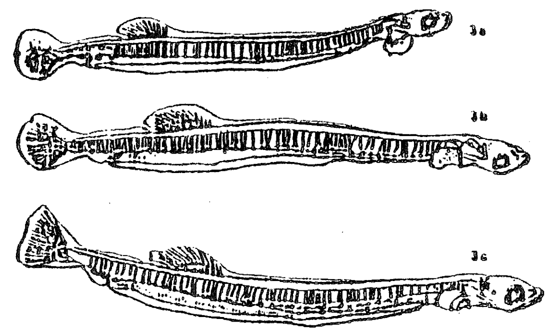
Staging - a method of staging the larval development of herring is described by M.J. Doyle (1977). Upon careful examination of the larva, classify it according to the following scheme.



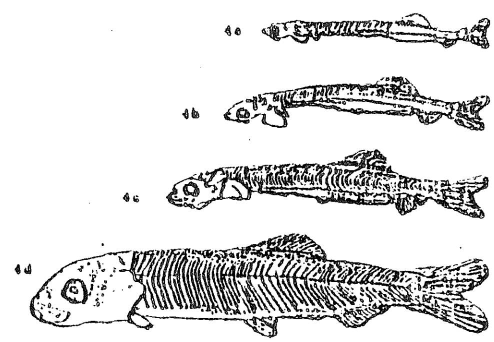
STAGE 1 - Yolksac present



STAGE 2 - Yolksac absent
Dorsal fin differentiating



STAGE 3 - Notochord turns dorsally at posterior tip
Dorsal fin clearly differentiated



STAGE 4 - Pelvic fin visible below gut when viewed from the side
Gut shortened relative to body

A dilute solution of lactic acid and methyl blue was used to clear and stain the gut and its contents. Prey items in very young larvae were often visible immediately through the thin gut walls; older, thicker larval guts took several hours to clear. The gut was then slit open by lightly running the sharp pin point along the length of the gut and folding back the flaps as it opened. Returning to the GCDR:

22. Predator Diseases - See GCDR instructions and Rosenthal (1967) and Dolfus (1956); our identifications were made by B. Hayden, NMFS, Woods Hole.

23. Predator Gut Contents - See GCDR instructions. Useful in selecting feeding versus non-feeding larvae; analagous to index tabs in a notebook in computer analysis.

24. Position of Prey in Gut - See GCDR instructions.

25. Larval Life Stage - Explained previously.

26. Prey Flag - Explained in GCDR instructions; useful in determining the number of prey per larva in computer analyses.

Gut contents were now transferred to labeled depression slides containing fresh lactic acid and methyl blue solution.

27. Prey Code No.
28. Prey Life Stage
29. Prey Sex

- Codes obtained from MIS listings (Appendix 1). See Murphy and Cohen (1979) for summary of literature and illustrations of developmental stages of common prey items in Georges Bank-Gulf of Maine region.

30. Prey Condition - See GCDR instructions.

31. Prey Length - Cephalosome length of adult and juvenile copepods; total length of nauplii excluding caudal armature; maximum dimension of other items.

32. Prey Width - Maximum width of item.

Prey biomass may be calculated from item 31 based upon information in the literature. This topic will be discussed in the "General Comments" section.

III. Data Processing Methods

A. Larval Gut Content and Condition Factor Measurements:

All GCDR's were scrutinized for errors and then submitted to our ADP section for keypunching. Computer listings of the 98 column data records were then compared to the original data sheets, and any additional errors were corrected before generating permanent magnetic tapes of these raw data files. It is recommended procedure to make backup tape copies of all files. Initially, cruises were stored in separate files; later it was found more convenient to combine them into a single file. A sample data retrieval program is included in Appendix 2. Any variables may be substituted or added to "year" and "cruise" in the example. Individual cruises or complete seasons of data were then processed by a routine which generates a system file for use in programs of the Statistical Package for the Social Sciences (SPSS) (Nie et al., 1975). Examples of the SPSS routines used for all our data organization and analyses can be found in Appendix 2. Additional summary tables, graphs, and cruise plots presenting some of our data are included in Appendix 3 (Complete information in Cohen et al., 1980).

Some additional variables were calculated by computer:

MOUTHGAPE = Maxillary length x $\sqrt{2}$ (Shirota, 1970)

WGTLEN 1 $= \frac{\text{Dry weight (mg)} \times 10^3}{\text{Standard length (mm)}^3}$ (Blaxter, 1965)

EYEHEAD $= \frac{\text{Eye height}}{\text{Head height}}$ (Ehrlich et al., 1976)

BODYSTDL $= \frac{\text{Body height}}{\text{Head height}}$ (Ehrlich et al., 1976)

Suggested computer routines, tables, graphs, and plots which we have found useful in organizing and examining our data are presented below. The data may be organized by cruise, season, gear type, time of day, feeding larvae, etc. Additional programs and statistical packages are available through WHOI on the Sigma-7 computer (they have recently installed a new system).

1. SPSS Routines:
   a. Scattergram plots of
      (1) Condition factor measurements (normalized by dividing all non-derived measurements by standard length to remove this source of variation) plotted in all possible combinations.
      (2) Mouthgape versus standard length.
      (3) Predator skull width versus standard length.
      (4) Prey length versus prey width.
   b. Frequency tables and histograms of
      (1) Length frequency distributions of feeding larvae and all larvae by length class (intervals may be 1, 5, 10 mm).
      (2) Mean number of prey items per larva over each season and by length class and station.
      (3) Percent (%) parasitism occurring in larvae.

c. Condescriptive tables

Summaries of basic statistics of all condition factor measurements.

d. Crosstabs tables of

(1) Diel feeding distribution of each larval length class using two hour time intervals.

(2) Diel distribution of prey items by larval length class.

(3) Number of larvae in each length class by station (for all larvae, feeding larvae, and prey items).

(4) Species and number of parasites by station.

(5) Prey length and width by larval length class.

e. Breakdown tables of

(1) Mean prey length and width by predator length class, including prey species, stage, and sex.

(2) Mean values of larval condition factors by length class (for feeding larvae and all larvae).

(3) Standard condition factor (WGTLEN 1) and body height/standard length (BODYSTDL) by larval length class and station (for all larvae).

(4) Normalized condition factors of non-feeding and feeding larvae by station.

(5) Mean condition factor values by station (for all larvae).

(6) Mean prey length and width by station including prey species, stage, and sex.

(7) Mean prey biomass/larva at each station.

f. Factor analysis of condition factor variables.

g. Discriminant analysis using condition factor variables of

(1) Feeding versus non-feeding larvae.

(2) Day versus night caught larvae

(3) Bongo versus neuston samples.

2. Summary Tables:

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

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

c. Diel distribution (2-hourly) of feeding larval herring by 5-mm length class over 24 hours and during daylight hours only.

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

3. Graphs:

a. Frequency of occurrence plot of mean number of food items per gut.

b. Plot of prey length (and width) versus predator standard length, and including regressions of mouthgape versus standard length and maximum skull width versus standard length, and also including size frequency distribution histograms of prey items at each larval standard length (see example in Appendix 3 for clarification).

4. Cruise plots - Station by station representation of:

   a. Stations sampled.

   b. Percentage of larval herring feeding per station.

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

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

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

B. Zooplankton Data:

The 0.333-mm mesh zooplankton data available from 13 of the 15 cruises were organized into computer files also on the Woods Hole Oceanographic Institution's Sigma-7.

A summary program was written to generate "Fager Tables" for each cruise which lists:

1. Species name
2. Mean rank
3. Dominance and percent dominance at all stations
4. Occurrence and percent occurrance at all stations
5. Total number of stations processed
6. Abundance (median, mean, standard deviation) and percent abundance based on total number of organisms
7. Shannon-Wiener diversity index for each station
8. Equitability for each station
9. Simpson's diversity index for each station

Another program, FISHMAP, was used to generate cruise plots of:

1. Distribution and abundance of the dominant larval herring prey species.
2. Distribution and abundance of potential larval predators.
3. Distribution and abundance of zooplankton biomass (using displacement volumes).

These figures and tables will be available in a data report by Cohen and Lough (1981a).

The 0.165-mm mesh zooplankton data were organized into computer files on a Hewlett-Packard HP85. A complete analysis of these data will be available shortly (Davis, 1982). The abundance of major larval prey items were used to calculate selectivity indices at those stations where information on larval gut content was available (Berg, 1979). Comparisons also were made between plankton supply and gut content in terms of numbers and biomass (see Cohen and Lough, 1981b for discussion) of prey species for each length class of larvae.

General Comments

The clarification of the relationship between larval herring survival and their morphological condition and choice of prey as determined from gut contents and prey availability over several spawning seasons has been stated as our principal goal. Some of the problem areas encountered in this investigation have been explored in the literature. Two major difficulties in the interpretation of our results arise from the variability of the condition factor measurements and the low incidence of feeding compared with previous studies. Two possible explanations of both results are:

1. Larvae were damaged during capture by the bongo nets, and

2. Formalin preservation caused shrinkage and loss of gut contents.

An additional explanation for the variability of the measurements is:

3. Postmortem changes occurred before preservation leading to variable larval shrinkage.

In reference to the first statement, we did find large numbers of damaged larvae with missing or detached guts; as previously mentioned, no measurements were taken on obviously damaged areas which should have reduced this source of error. There is evidence from recent work at this laboratory that larval herring captured during slower hauls (1.5 instead of 3.5 knots) sustain less damage. It will be interesting to determine the variability of these measurements and the percentage of feeding in a representative sample of larvae from this series of samples for comparison with the results of the present investigation. Kjelson et al. (1975) found evidence that menhaden larvae lost significant amounts of their gut contents during bongo tows. Hay (1979) obtained similar results with ten-day old herring; his tests on older larvae were inconclusive.

The second explanation offered here has been the subject of several investigations. Blaxter (1965) concluded that only ten percent of the larval herring emptied their guts when preserved in formalin, considerably lower than losses estimated from net damage. Shrinkage caused by formalin preservation varies with species and age of fish, but the general consensus is that major dimensional changes occur during the first couple of days and then continue at a reduced rate over the next two to eight weeks (Davis, 1977; Sameoto, 1972; Hay, 1979; and Lockwood, 1973). Lockwood and Daly (1975) note that percentage change in wet weight is much larger than percentage change in length but is dependent upon age and species; they recommend 4% netural formalin and tap water as a preservative. We waited at least two months after sample preservation before taking any measurements, and so this source of error should be reduced as well.

Hay (1979), Lockwood and Daly (1975), and Theilacker (1980) observed that larvae killed during capture (a common occurrence in the bongo nets) undergo considerable shrinkage before preservation. This factor may be the most plausible explanation for the variance in our measurements because we cannot control this effect except by preserving the catch promptly after collection. In order to minimize damage to the larvae and preserve moribund larvae more rapidly, Hay recommends tows of shorter duration.

In summary, we have tried to reduce the amount of error in our data as effectively as possible by omitting measurements on damaged larvae and by permitting preserved samples to equilibrate for at least two months prior to taking measurements. Future studies may clarify the effects of tow speed and duration on condition factor measurements and gut contents. Zooplankton samples are available with which to assess prey distribution and abundance, and these results indicate that the low incidence of larval feeding may be, in fact, representative of environmental food levels. Some of the difficulties encountered in our work with larval herring will not arise in investigations of other species. Larval herring have a cylindrical gut which is delicately suspended from their ventral body; the gut and its contents are therefore easily damaged. Species possessing coiled guts protected by the body cavity will be more resistent to damage.

Histological and morphological condition of larvae have been successfully used as criteria for distinguishing healthy from starved animals by discriminant analysis (O'Connell, 1976-anchovy larvae; and Theilacker, 1978-jack mackerel larvae). In our study, discriminant analysis based upon the condition factor measurements from several cruises has been attempted in order to separate feeding from non-feeding classes of larvae, however, a clear distinction was not obtained. In order to reduce the number of variables measured, these condition factor measurements were subjected to factor analysis; due to the variability of the data this technique was not successful.

The 0.333-mm zooplankton data base is useful in inferring general patterns of larvae prey distribution and abundance but this mesh size only retains copepods greater than 0.9-1.0 mm cephalothorax length (Davis, 1980). Most of the prey are smaller than this size. The 0.165-mm mesh net retains prey greater than 0.26-mm cephalothorax length (Davis, 1980) which includes most prey species. However, this series of samples was located along a five-station transect across central Georges Bank for each cruise, and showed very high station-to-station variability in species abundance making any generalizations difficult. The individual station data is useful in the calculation of selectivity indices and the comparisons of available plankton supply with larval gut content as previously mentioned.

Although our results may not be quantitative enough for use in bioenergetic models of larval survival, as the one presented in a recent study by Beyer and Laurence (1978), they provide a sufficient base with which to compare the diversity and variability of prey selection among spawning areas and seasons with general larval condition, and population growth, mortality, and dispersal in order to suggest possible causes of larval mortality.

Acknowledgements

Sincere appreciation is extended to John Laird and other members of the ADP group for their valuable assistance and patience, and to Janet A. Murphy and others who helped perform the laboratory work.

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MARMAP INFORMATION SYSTEM - STATION ACTIVITIES SUMMARY

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE

TIME IS EXPRESSED IN GMT AND DEPTH IN METERS. S MEANS SURFACE AND C MEANS CONTINUOUS. ZOOPLANKTON NET SIZES ARE EXPRESSED AS MOUTH DIMENSIONS IN CM (BONGO DIAMETER) OR METERS (NEUSTON HEIGHT X WIDTH)/MESH IN MICRONS. BONGO DEPTH IS FROM TDR (A INDICATES DEPTH CALCULATED FROM WIRE ANGLES). ASTERISKS INDICATE DATA NOT AVAILABLE. E INDICATES AN ESTIMATE.

ALBATROSS IV: CRUISE 74-13
4 DECEMBER 1974 - 19 DECEMBER 1974

STATION	DATE	POSITION LAT.	POSITION LONG.	OBSERVATIONS TYPE		OT	HAUL	START TIME	DURATION (MIN:SEC)	FREQUENCY/ MAX. DEPTH
1		41 12 N	071 02 W	BONGO	61/505		1	1312	5:54	1/35
2		41 10 N	070 40 W	BONGO	61/505		1	1645	5:06	1/35
3		41 06 N	070 40 W	BONGO	61/505		1	1906	9:42	1/49
4		41 02 N	071 00 W	BONGO	61/505		1	2153	7:54	1/44
5		41 01 N	071 26 W	BONGO	61/505		1	0112	10:24	1/55
6		40 45 N	071 00 W	BONGO	61/505		1	0413	12:18	1/60
7		40 30 N	071 00 W	BONGO	61/505		1	0715	15:40	1/81
8		40 14 N	071 31 W	BONGO	61/505		1	1029	18:12	1/92
9		39 59 N	071 00 W	BONGO	61/505		1	1905	24:30	1/107
10		40 01 N	070 30 W	BONGO	61/505		1	2200	23:48	1/93
11		40 16 N	070 30 W	BONGO	61/505		1	0056	26:00	1/100
12		40 16 N	070 00 W	BONGO	61/505		1	0352	17:42	1/90
13		40 00 N	070 00 W	BONGO	61/505		1	0629	24:24	1/115
14		40 15 N	069 29 W	BONGO	61/505		1	1225	15:00	1/80

Appendix 1

4300 ACARINA
0112 ACARTIA CLAUSI
0148 ACARTIA DANAE
4110 ACARTIA DISCAUDATA
0107 ACARTIA LONGIREMIS
4037 ACARTIA NEGLIGENS
0129 ACARTIA SP.
4027 ACARTIA SPP
0151 ACARTIA TONSA
2401 ACHELIA SPINOSA
0851 AEGININA LONGICORNIS
4061 AETIDEIDAE
4038 AETIDEINAE
0154 AETIDEOPSIS ROSTRATA
0120 AETIDEUS ARMATUS
0192 ALTEUTHA DEPRESSA
4069 ALTEUTHA SPP.
4401 AMPELISCA AGASSIZI
4402 AMPELISCA VUDORUM
0873 AMPELISCIDAE
0400 AMPHIPODA
0844 AMPHITHYRUS BISPINOSUS
0845 AMPHITHYRUS SCULPTURATUS
0481 ANAPRONOE REINHARDTI
0476 ANCHYLOMERA BLOSSEVILLEI
0118 ANOMALOCERA PATERSONI
3200 ANOMURA
0875 ANONYX LILJEBORGI
> 3800 ANURIDA MARITIMA
0700 APPENDICULARIA
3100 ASTACIDEA

>Anonyx Sarsi 4404

MARCH 12, 1979

147010100	ABLENNES
147010101	ABLENNES HIANS
170270100	ABUDEFDUF
	ABUDEFDUF ANALOGUS - SEE ABUDEFDUF TAURUS
170270101	ABUDEFDUF SAXATILIS
170270102	ABUDEFDUF TAURUS
160010300	ACANTHOCHAENUS
160010301	ACANTHOCHAENUS LUETKENI
170440900	ACANTHOCYBIUM
170440901	ACANTHOCYBIUM SOLANDERI
170392100	ACANTHONUS
170392101	ACANTHONUS ARMATUS
189070100	ACANTHOSTRACION
189070101	ACANTHOSTRACION POLYGONIUS
189070102	ACANTHOSTRACION QUADRICORNIS
170160000	ACANTHURIDAE
170160100	ACANTHURUS
170160101	ACANTHURUS BAHIANUS
170160102	ACANTHURUS CAERULEUS
170160103	ACANTHURUS CHIRURGUS
170160105	ACANTHURUS HEPATUS
183040100	ACHIRUS
183040102	ACHIRUS INSCRIPTUS
183040105	ACHIRUS LINEATUS
183040103	ACHIRUS MACULATUS
183040104	ACHIRUS PAULISTANUS
117010100	ACIPENSER
117010101	ACIPENSER OXYRHYNCHUS
117010000	ACIPENSERIDAE
117000000	ACIPENSERIFORMES
161110300	ADIORYX

MARMAP CODES FOR ZOOPLANKTON LIFE STAGES
-ALPHABETICAL LISTING-

CODE	STAGE
035	ACANTHOSOMA (ZOEA)
002	ACTINULA
000	ADULT
009	ATOKE
048	AURICULARIA
044	BIPINNARIA
045	BRACHIOLARIA
028	CALYPTOPIS (PROTOZOEA)
052	COPEPODITE
020	COPEPODITE I
021	COPEPODITE II
022	COPEPODITE III
023	COPEPODITE IV
024	COPEPODITE V
007	CYDIPPID
058	CYPHONAUNTES
025	CYPRIS
030	CYRTOPIA (POSTLARVA)
040	DIPLEURULA
049	DOLIOLARIA
047	ECHINOPLUTEUS
034	ELAPHOCARIS (PROTOZOEA)
005	EPHYRA
008	EPITOKE
029	FURCILIA (ZOEA)
042	GLAUCOTHOE (POSTLARVA)
004	POLYP
054	IMMATURE (SEXUALLY), or JUVENILE
050	INVERT. EGG
051	LARVA
026	MANCA (POSTLARVA)
033	MASTIGOPUS (POSTLARVA)
003	MEDUSA
043	MEGALOPA (POSTLARVA)
053	METATROCHOPHORE
032	MYSIS (ZOEA)
013	NAUPLIUS
014	NAUPLIUS I
015	NAUPLIUS II
016	NAUPLIUS III
017	NAUPLIUS IV
018	NAUPLIUS V
019	NAUPLIUS VI
046	OPHIOPLUTEUS
037	PARVA (POSTLARVA)
039	PHYLLOSOMA (ZOEA)
027	PHYSOSOMA
001	PLANULA
038	POSTLARVA
012	PROTONYMPHON
031	PROTOZOEA
041	PUERULUS, NISTO, or PLEUDIBACCUS (POSTLARVA)
006	SCYPHISTOMA
055	STROBILA
010	TROCHOPHORE
011	VELIGER

CODE	STAGE
056	VITELLARIA
999	UNKNOWN
036	ZOEA

SEX

1 = Male

2 = Female

3 = Immature

4 = Ovigerous ♀

```
RUN NAME        CREATE MARMAP HERRING PREY FILE (LAUGH)
FILE NAME       HERRING PREY
VARIABLE LIST   CRU,STAT,HAUL,DATE,TIME,LAT,LONG,GEAR,MESH,
                PREDCODE,SPECNUMB,PREDWGT,PREDLEN,STDLEN,PREDSKUL,
                MAXIL,PREDEYE,PREDHEAD,PREDBODY,PECTORAL,
                PREDCOND,PREDIS,GUTFLAG,PREYPOS,PREDSTG,PREYFLG,
                PREYCODE,STAGE,PREYSEX,PREYCOND,PREYLEN,PREYWID,

INPUT FORMAT    FIXED (F3.0,F3.0,F2.0,F6.0,F4.0,F4.0,F4.0,F1.0,F1.0,

'FIXED' FORMAT VARIABLES' POSITION TABLE
```

VARIABLE	FORMAT	RECORD	COLUMNS
CRU	F 3. 0	1	1 - 3
STAT	F 3. 0	1	4 - 6
HAUL	F 2. 0	1	7 - 8
DATE	F 6. 0	1	9 - 14
TIME	F 4. 0	1	15 - 18
LAT	F 4. 0	1	19 - 22
LONG	F 4. 0	1	23 - 26
GEAR	F 1. 0	1	27 - 27
MESH	F 1. 0	1	28 - 28

T29,F9.0,F4.0,T42,F6.2,F3.1,T48,F2.0,T51,F3.2,

VARIABLE	FORMAT	RECORD	COLUMNS
PREDCODE	F 9. 0	1	29 - 37
SPECNUMB	F 4. 0	1	38 - 41
PREDWGT	F 6. 2	1	42 - 47
PREDLEN	F 3. 1	1	48 - 50
STDLEN	F 2. 0	1	48 - 49
PREDSKUL	F 3. 2	1	51 - 53

T54,F3.2,F3.2,F3.2,F3.2,F3.0,

VARIABLE	FORMAT	RECORD	COLUMNS
MAXIL	F 3. 2	1	54 - 56
PREDEYE	F 3. 2	1	57 - 59
PREDHEAD	F 3. 2	1	60 - 62
PREDBODY	F 3. 2	1	63 - 65
PECTORAL	F 3. 0	1	66 - 68

T69,F1.0,F1.0,F1.0,F1.0,T78,F2.0,T80,F2.0,

VARIABLE	FORMAT	RECORD	COLUMNS
PREDCOND	F 1. 0	1	69 - 69
PREDIS	F 1. 0	1	70 - 70
GUTFLAG	F 1. 0	1	71 - 71
PREYPOS	F 1. 0	1	72 - 72
PREDSTG	F 2. 0	2	78 - 79
PREYFLG	F 1. 0	1	80 - 81

T82,F4.0,F3.0,F1.0,F1.0,F4.2,F4.2,

VARIABLE	FORMAT	RECORD	COLUMNS
PREYCODE	F 4. 0	1	82 - 85
STAGE	F 3. 0	1	86 - 88
PREYSEX	F 1. 0	1	88 - 88
PREYCOND	F 1. 0	1	89 - 89
PREYLEN	F 4. 2	1	90 - 93
PREYWID	F 4. 2	1	94 - 98

```
THE INPUT FORMAT PROVIDES FOR  32 VARIABLES.   32 WILL BE READ
 IT PROVIDES FOR  1 RECORDS ('CARDS') PER CASE.
  A MAXIMUM OF 98 'COLUMNS' ARE USED ON A RECORD.

                 N OF CASES       UNKNOWN
                 INPUT MEDIUM     DC/RC7514H
                 IF                 (PREYLEN GT 0 AND LT .1) PPL=1
                 IF                 (PREYLEN GE .1 AND LT .2) PPL=2
                 IF                 (PREYLEN GE .2 AND LT .3) PPL=3
                 IF                 (PREYLEN GE .3 AND LT .4) PPL=4
                 IF                 (PREYLEN GE .4 AND LT .5) PPL=5
                 IF                 (PREYLEN GE .5 AND LT .6) PPL=6
                 IF                 (PREYLEN GE .6 AND LT .7) PPL=7
                 IF                 (PREYLEN GE .7 AND LT .8) PPL=8
                 IF                 (PREYLEN GE .8 AND LT .9) PPL=9
                 IF                 (PREYLEN GE .9 AND LT 1.0) PPL=10
                 IF                 (PREYLEN GE 1.0 AND LT 1.1) PPL=11
                 IF                 (PREYLEN GE 1.1 AND LT 1.2) PPL=12
                 IF                 (PREYLEN GE 1.2 AND LT 1.3) PPL=13
                 IF                 (PREYLEN GE 1.3 AND LT 1.4) PPL=14
                 IF                 (PREYLEN GE 1.4 AND LT 1.5) PPL=15
                 IF                 (PREYLEN GE 1.5 AND LT 1.6) PPL=16
                 IF                 (PREYLEN GE 1.6 AND LT 1.7) PPL=17
                 IF                 (PREYLEN GE 1.7 AND LT 1.8) PPL=18
                 IF                 (PREYLEN GE 1.8 AND LT 1.9) PPL=19
                 IF                 (TIME GE 0000 AND LE 0200) TT=1
                 IF                  (TIME GT 0200 AND LE 0400) TT=2
                 IF                   (TIME GT 0400 AND LE 0600) TT=3
                 IF                  (TIME GT 0600 AND LE 0800) TT=4
                 IF                  (TIME GT 0800 AND LE 10000) TT=5
                 IF                   (TIME GT 1000 AND LE 1200) TT=6
                 IF                   (TIME GT 1200 AND LE 1400) TT=7
                 IF                  (TIME GT 1400 AND LE 1600) TT=8
                 IF                  (TIME GT 1600 AND LE 1800) TT=9
                 IF                  (TIME GT 1800 AND LE 2000) TT=10
                 IF                   (TIME GT 2000 AND LE 2200) TT=11
                 IF                    (TIME GT 2200) TT=12
                 IF                  (STDLEN EQ 0) LL =0
                 IF                  (STDLEN GE 1 AND  LE 9)  LL=1
                 IF                  (STDLEN GE 10 AND LE 14) LL =2
                 IF                  (STDLEN GE 15 AND LE 19) LL =3
                 IF                  (STDLEN GE 20 AND LE 24) LL=4
                 IF                  (STDLEN GE 25 AND LE 29) LL=5
                 IF                  (STDLEN GE 30 AND LE 39) LL=6
                 IF                  (STDLEN GE 40)           LL =7
                 COMPUTE             P=PREYLEN*100
                 IF                 (PREYWID GT 0 AND LT .1) PPW=1
                 IF                 (PREYWID GE .1 AND LT .12) PPW=2
                 IF                 (PREYWID GE .12 AND LT .14) PPW=3
                 IF                 (PREYWID GE .14 AND LT .16) PPW=4
                 IF                 (PREYWID GE .16 AND LT .18) PPW=5
                 IF                 (PREYWID GE .18 AND LT .20) PPW=6
                 IF                 (PREYWID GE .20 AND LT .22) PPW=7
                 IF                 (PREYWID GE .22 AND LT .24) PPW=8
                 IF                 (PREYWID GE .24 AND LT .26) PPW=9
                 IF                 (PREYWID GE .26 AND LT .28) PPW=10
                 IF                 (PREYWID GE .28 AND LT .30) PPW=11
                 IF                 (PREYWID GE .30 AND LT .32) PPW=12
                 IF                 (PREYWID GE .32 AND LT .34) PPW=13
                 IF                 (PREYWID GE .34 AND LT .36) PPW=14
                 IF                 (PREYWID GE .36 AND LT .38) PPW=15
                 IF                 (PREYWID GE .38 AND LT .40) PPW=16
                 IF                 (PREYWID GE .40 AND LT .42) PPW=17
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IF          (PREYWID GE .42 AND LT .44) PPW=18
IF          (PREYWID GE .44 AND LT .46) PPW=19
IF          (PREYWID GE .46 AND LT .48) PPW=20
IF          (PREYWID GE .48 AND LT .50) PPW=21
IF          (PREYWID GE .50 AND LT .52) PPW=22
IF           (P      LE 19) PL =1
IF           (P      GE 20 AND LE 49)   PL =2
IF           (P      GE 50 AND LE 109)  PL =3
IF           (P      GE 110 AND LE 159) PL=4
IF           (P      GE 160 AND LE 259) PL=5
IF           (P      GE 260 AND LE 459) PL=6
IF           (P      GE 460)           PL =7
COMPUTE       WGT=((LG10(PREDLEN))*4.66)-5.73
COMPUTE        DRYW=10**WGT
COMPUTE        MAUTHGAPE=MAXIL*(SQRT(2))
COMPUTE        EYEHEAD=PREDEYE/PREDHEAD
COMPUTE         BODYSTDL=PREDBODY/PREDLEN
COMPUTE        WGTLEN1=((DRYW/(PREDLEN**3)))*1000
COMPUTE         WGTLEN2=((DRYW*(10**5))/(PREDLEN**4.66))
COMPUTE      NPREDSKUL=PREDSKUL/PREDLEN
COMPUTE       NMAXIL=MAXIL/PREDLEN
COMPUTE       NPREDHEAD=PREDHEAD/PREDLEN
COMPUTE      NPREDBODY=PREDBODY/PREDLEN
COMPUTE      NPREDEYE=PREDEYE/PREDLEN
VAR LABELS   CRU,CRUISE/ STAT,STATION/
             STDLEN,LARVAL LENGTH/
              PREYLEN,PREY LENGTH/
              PREYWID,PREY WIDTH/
              PREYSEX,PREY SEX/
              PREDSKUL,SKULL WIDTH/MAXIL,MAXILLARY   LENGTH/
             PREYCODE,PREY CODE/
VAR LABELS    LL,LARVAL SIZE CLASS
VAR LABELS     PPL,PREYLENGTH CLASS
VAR LABELS     PPW,PREY WIDTH CLASS
VAR LABELS           TT,TIME  GMT
VAR LABELS         PL,PREY LENGTH
VALUE LABELS        PPW (1) 0-.09 (2) .1-.119 (3) .12-.139
              (4) .14-.159 (5) .16-.179
              (6) .18-.199 (7) .20-.219 (8) .22-.239
              (9) .24-.259 (10) .26-.279 (11) .28-.299
              (12) .30-.319 (13) .32-.339 (14) .34-.359
               (15) .36-.379 (16) .38-.399 (17) .40-.419
              (18) .42-.439 (19) .44-.459 (20) .46-.479
              (21) .48-.499 (22) .50-.519
VALUE LABELS        TT (1) 0000-0200 (2) 0201-0400 (3) 0401-0600
             (4) 0601-0800 (5) 0801-1000 (6) 1001-1200
               (7) 1201-1400 (8) 1401-1600 (9) 1601-1800
              (10) 1801-2000 (11) 2001-2200 (12) 2201-2400
VALUE LABELS        PPL (1) 0-.09 (2) .1-.19 (3) .2-.29
            (4) .3-.39 (5) .4-.49 (6) .5-.59 (7) .6-.69
            (8) .7-.79 (9) .8-.89 (10) .9-.99 (11) 1.0-1.1
            (12) 1.1-1.19 (13) 1.2-1.29 (14) 1.3-1.39
            (15) 1.4-1.49 (16) 1.5-1.59 (17) 1.6-1.69
            (18) 1.7-1.79 (19) 1.8-1.89
VALUE LABELS   LL (0) LENGTH MISSING  (1) 1-9 (2) 10-14 (3) 15-19 (4) 20-24
            (5) 25-29 (6) 30-39 (7) 40-99
VALUE LABELS        PL (1) 0.0-0.19 (2) 0.20-0.49 (3) 0.50-1.09
               (4) 1.10-1.59 (5) 1.60-2.59 (6) 2.60-4.59
         (7) 4.60-9.99
VALUE LABELS   GEAR (1) BONGO 61  (2) BONGO 20  (3) NEUSTON 1X2
          (4) NEUSTON 0.5 X 1  (5) MOCNESS/
        MESH (1) .505MM (2) .333MM (3) .253MM (4) .165MM (5) .053MM
            CRU (1) ALB IV 76-01, (2) ALB IV 75-14,
             (3) ALB IV 75-02, (4) ALB IV 74-13/
VALUE LABELS      PREYCODE (1) UNIDENTIFIED (100) COPEPODA
            (102) PSEUDOCALANUS M.
         (103) CENTROPAGES T. (135) PARACALANUS P. (138) OITHONA SP.
```

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```
                    (101) CALANUS F.
                    (133) CENTROPAGES SPP. (109) CENTROPAGES H.
                    (117) CANDACIA AR. (1300) PELECYPODA/
VALUE LABELS            STAGE (050) INVERT EGG (051) LARVA (013) NAUPLIUS
                    (999) UNKNOWN (052) COPEPODITE (054) JUVENILE
                     (000) ADULT (11) VELIGER/
VALUE LABELS            PREYSEX (1) MALE (2) FEMALE (3) IMMATURE/
ASSIGN MISSING       NPREDSKUL,NMAXIL,NPREDHEAD,NPREDBODY,
                          EYEHEAD,NPREDEYE            (-1)
ASSIGN MISSING          MOUTHGAPE,BODYSTDL,DRYW,WGTLEN1,WGTLEN2 (-1)
MISSING VALUES            PREYCODE(9),PREYLEN(0),PREYWID(0),PREDWGT(0),
                    PREDSKUL(0),MAXIL(0),PREDEYE(0),PREDHEAD(0),PREDBODY(0),
                     PECTORAL(0),    PREDLEN(0),  PREDSTG(0),
                     PREYFLG(-1)/
PRINT FORMATS       PREDLEN (1)/
                    PREDWGT,PREDSKUL,MAXIL,PREDEYE,PREDHEAD,PREDBODY (2) /
FREQUENCIES     INTEGER = STDLEN(0,99)
READ INPUT DATA
```

END OF FILE ON FT106 AFTER 2085 CASES IN SUBFILE HERRING

FILE HERRING (CREATION DATE 08/07/78) PREY

STDLEN LARVAL LENGTH

CATEGORY LABEL	CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	0.	49	2.4	2.4	2.4
	5.	2	.1	.1	2.4
	6.	8	.4	.4	2.8
	7.	19	.9	.9	3.7
	8.	8	.4	.4	4.1
	9.	4	.2	.2	4.3
	10.	26	1.2	1.2	5.6
	11.	52	2.5	2.5	8.1
	12.	58	2.8	2.8	10.8
	13.	112	5.4	5.4	16.2
	14.	124	5.9	5.9	22.2
	15.	173	8.3	8.3	30.5
	16.	258	12.4	12.4	42.8
	17.	301	14.4	14.4	57.3
	18.	282	13.5	13.5	70.8

19.	222	10.6	10.6	81.4
20.	135	6.5	6.5	87.9
21.	97	4.7	4.7	92.6
22.	51	2.4	2.4	95.0
23.	42	2.0	2.0	97.0
24.	28	1.3	1.3	98.4
25.	22	1.1	1.1	99.4
26.	5	.2	.2	99.7
27.	7	.3	.3	100.0
	------	------	------	
TOTAL	2085	100.0	100.0	

VALID CASES = 2085 MISSING CASES = 0

*** FREQUENCIES INTEGER WORKSPACE = 705 WORDS ***

*** TRANSPACE SIZE = 1298 WORDS

SAVE FILE DC/RC7514S

THE 53 SAVED VARIABLES ARE:

SEQNUM	SUBFILE	CASWGT	CRU	STAT	HAUL	DATE	TIME	LAT	LONG	GEAR	MESH
PREDCODE	SPECNUMB	PREDWGT	PREDLEN	STDLEN	PREDSKUL	MAXIL	PREDEYE	PREDHEAD	PREDBODY	PECTARAL	PREDCOND
PREDIS	GUTFLAG	PREYPOS	RECTYP	PREYCODE	STAGE	PREYSEX	PREYCOND	PREYLEN	PREYWID	PREYFLG	PPL
TT	LL	P	PPW	PL	WGT	DRYW	MOUTHGAP	EYEHEAD	BODYSTDL	WGTLEN1	WGTLEN2
NPREDSKU	NMAXIL	NPREDHEA	NPREDBOD	NPREDEYE							

THE SUBFILES ARE...

NAME	N OF CASES
RC7514S	2085

FINISH

161 COMMAND RECORDS READ.

```
13:27 AUG 03,'79 ID=068D
JOB 723,2260,7. FILE=JMRET, ID=16, LINE=D
LIMIT (TIME,7),(CORE,20),(LO,20),(UO,20),(9T,1)
LIMIT (ACCOUNT)
MESSAGE READ SVC7.
ASSIGN F:DICT,(FILE,DICT,345),(IN)
ASSIGN F:MSTRFILE,(DEVICE,9T),(IN),(SN,SVC7),(TRIES,10)
ASSIGN F:NONREPT,(FILE,YR7475),(OUT),(SAVE)
RETRIEVE
SORT VERSION  F03WH0: JUN 4 79
SEQUENTIAL
RECORDS IN TOURNAMENT:          364
NUMBER OF MERGE BUFFERS:         12
INTERMEDIATE BUFFER SIZE:      3588
RECORDS INPUT:                    3
RECORDS OUTPUT:                   3
```

```
0001 A      HERRGUT              S U E
0001 C 01 YEAR       EQ =74,=75,                                              AND
0001 C 02 CRU        EQ =  3,=  4,= 17,= 53,= 55,                             END
CODE GENERATION COMPLETE
MANAGE RETRIEVAL PHASE COMPLETE
PCL
LIST YR7475
ORG    GRAN     REC    LAST MODIFIED     NAME
 C      432    7074   13130   3 AUG 79  YR7475
.. 1 FILES LISTED
END
PCL PROCESSING TERMINATED
EOD
```

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*** SIGMA SPSS **** RELEASE 7.0 *** 04/13/78 PAGE 1

RUN NAME SCATTERGRAM PLOTS LARVAL CONDITION FACTORS (80NGB)
FILE NAME HERRING PREY
GET FILE OC/RC75025

THE NUMBER OF ACTIVE VARIABLES RETRIEVED IS 51

THE SUBFILES ARE...

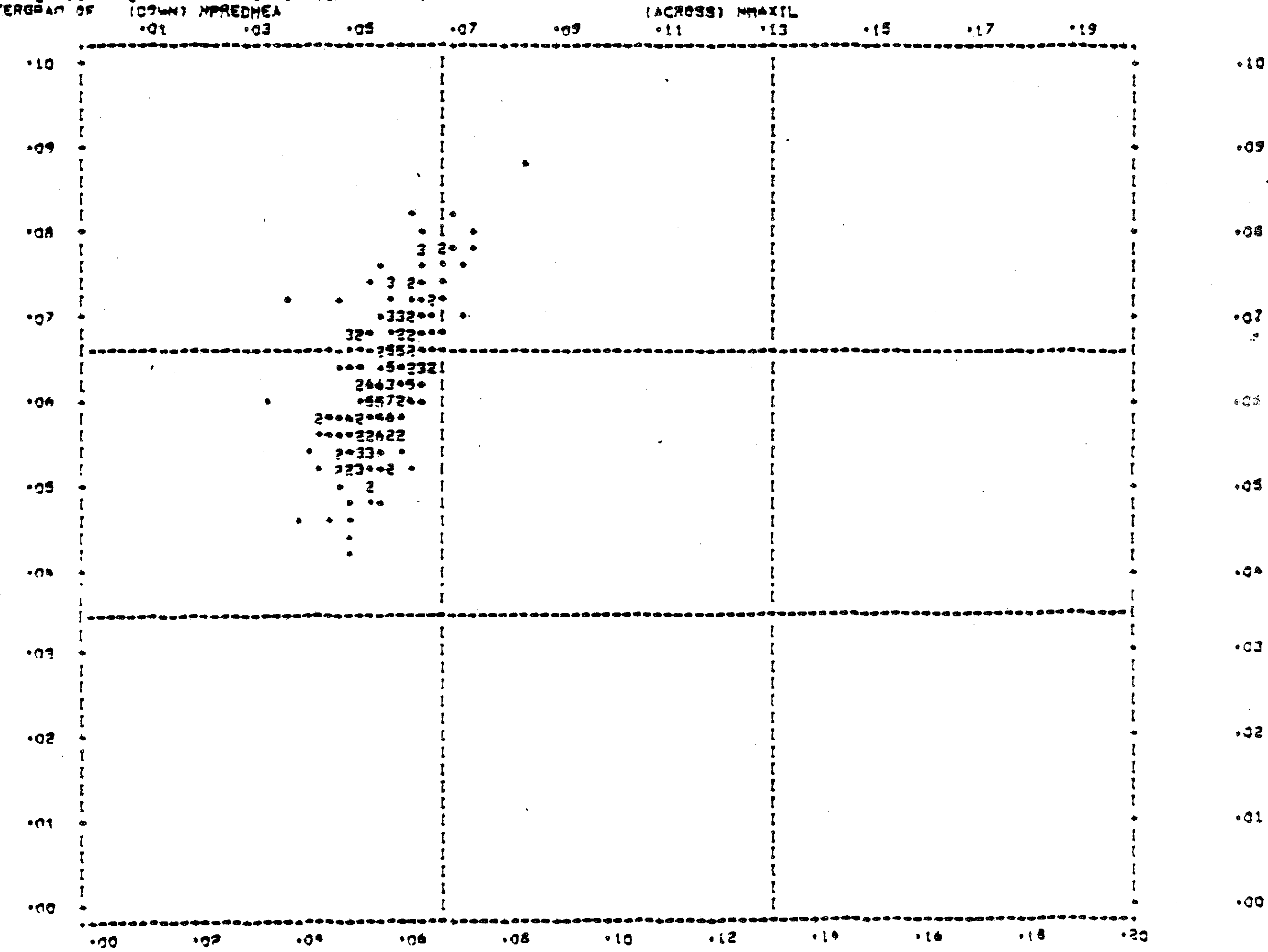
NAME N OF CASES

RC75025 1815

SELECT IF (GUTFLAG EQ 0 AND GEAR EQ 1 AND PREDEYE LT 3)
SCATTERGRAM NPREDHEAD(0,.1) WITH NMAXIL(0,.2)/
NPREDHEAD(0,.1) WITH NPREDBODY(0,.1)/
NPREDHEAD(0,.1) WITH EYEHEAD(0,3)/
NPREDHEAD(0,.1) WITH PECTORAL(80,180)/
NPREDHEAD(0,.1) WITH NPREDEYE(0,.1)/
NPREDHEAD(0,.1) WITH NPREDSKUL(0,.2)/
STATISTICS ALL

SCATTERGRAM PLOTS LARVAL CONDITION FACTORS (80NGB) 04/13/78 PAGE 2

FILE RC75025 (CREATION DATE: 04/12/78) PREY
SCATTERGRAM OF (DOWN) NPREDHEA (ACROSS) NMAXIL



STATISTICS..
CORRELATION (R)- .60992
R SQUARED - .37200
SIGNIFICANCE - .00001
STD ERR OF EST - .00635
INTERCEPT (A) - .02040
SLOPE (B) - .73756

PLOTTED VALUES- 221 EXCLUDED VALUES-0 MISSING VALUES- 16

*** SIGMA SPSS ---- RELEASE 7.0 *** 01/15/79 PAGE 1

```
RUN NAME          DESCRIPTIVE STATISTICS
FILE NAME          HERRING PREY
GET FILE          RC75148
```

THE NUMBER OF ACTIVE VARIABLES RETRIEVED IS 53

THE SUBFILES ARE...

NAME	N OF CASES
RC75148	2085

```
SELECT IF            (GEAR EQ 1)
CONDESCRIPTIVE          STOLEN,PREDSKUL,MAXIL,
                     PREDEYE,PREDHEAD,PREDBODY,
                     PECTORAL,PREYLEN,PREYWID
OPTIONS                4
STATISTICS             1,2,5,6,9,10,11
```

- -

FILE RC75148 (CREATION DATE: 08/07/78) PREY

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VARIABLE STOLEN LARVAL LENGTH

MEAN	= 16.55203	STD ERR	= .9211040E-01	STD DEV	= 4.205928
VARIANCE	= 17.68983	RANGE	= 27.00000	MINIMUM	= .0000000
MAXIMUM	= 27.00000				

VALID CASES = 2085 MISSING CASES = 0

VARIABLE PREDSKUL WIDTH

MEAN	= 1.125412	STD ERR	= .4616782E-02	STD DEV	= .2040284
VARIANCE	= .4162759E-01	RANGE	= 1.900000	MINIMUM	= .5000000
MAXIMUM	= 2.400000				

VALID CASES = 1953 MISSING CASES = 132

VARIABLE MAXIL MAXILLARY LENGTH

MEAN	= 1.463408	STD ERR	= .2040352E-01	STD DEV	= .8896031
VARIANCE	= .7913937	RANGE	= 4.280000	MINIMUM	= .4200000
MAXIMUM	= 4.700000				

VALID CASES = 1901 MISSING CASES = 184

VARIABLE PREDEYE

MEAN	= .7001705	STD ERR	= .4439358E-02	STD DEV	= .1520440
VARIANCE	= .2311738E-01	RANGE	= 1.039999	MINIMUM	= .3600000
MAXIMUM	= 1.400000				

VALID CASES = 1173 MISSING CASES = 912

VARIABLE PREDHEAD

STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES- XEROX VERSION 6.02 09/29/77 PAGE 1

RUN NAME CROSSTABS FEEDING LARVAE OVER 24 HOURS (BONGO)
FILE NAME HERRING PREY
GET FILE DC/RC75145

FILE RC75145 HAS 45 VARIABLES

THE SUBFILES ARE...

NAME N OF CASES

RC75145 2085

SELECT IF (PREYFLG EQ 1 AND GEAR EQ 1)
CROSSTABS VARIABLES=TT(1,12)/LL(0,10)/
TABLES=LL BY TT
STATISTICS ALL
OPTIONS 7

CROSSTABS FEEDING LARVAE OVER 24 HOURS 100 09/29/77 PAGE 2

FILE RC75145 (CREATION DATE 09/29/77) PREY

* * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * * * * * * * * * * * * * *
LL LARVAL SIZE CLASS BY TT TIME GMT
* PAGE 1 OF 1

LL	TT COUNT ROW PCT COL PCT TOT PCT	0000-020 0 1	0201-040 0 2	0401-060 0 3	1001-120 0 6	1201-140 0 7	1401-160 0 8	1601-180 0 9	1801-200 0 10	2001-220 0 11	2201-240 0 12	ROW TOTAL
LENGTH MISSING	0	3 42.86 4.35 .85	0 .00 .00 .00	0 .00 .00 .00	0 .00 .00 .00	3 42.86 6.52 .85	0 .00 .00 .00	0 .00 .00 .00	0 .00 .00 .00	1 14.29 .90 .28	0 .00 .00 .00	7 1.97
10-14	2	4 7.84 5.80 1.13	0 .00 .00 .00	0 .00 .00 .00	0 .00 .00 .00	1 1.96 2.17 .28	2 3.92 33.33 .56	4 7.84 40.00 1.13	7 13.73 16.28 1.97	24 47.06 21.62 6.76	9 17.65 13.43 2.54	51 14.37
15-19	3	45 19.15 65.22 12.68	0 .00 .00 .00	1 .43 100.00 .28	1 .43 100.00 .28	32 13.62 69.57 9.01	2 .85 33.88 .56	6 2.55 60.00 1.69	32 13.62 74.42 9.01	82 34.89 73.87 23.10	34 14.47 50.75 9.58	235 66.20
20-24	4	16 27.59 23.19 4.51	1 1.72 100.00 .28	0 .00 .00 .00	0 .00 .00 .00	9 15.52 19.57 2.54	2 3.45 33.33 .56	0 .00 .00 .00	4 6.90 9.30 1.19	4 6.90 3.60 1.13	22 37.93 32.84 6.20	58 16.34
25-29	5	1 25.00 1.45 .28	0 .00 .00 .00	0 .00 .00 .00	0 .00 .00 .00	1 25.00 2.17 .28	0 .00 .00 .00	0 .00 .00 .00	0 .00 .00 .00	0 .00 .00 .00	2 50.00 2.99 .56	4 1.13
	COLUMN TOTAL	69 19.44	1 .28	1 .28	1 .28	46 12.96	6 1.69	10 2.82	43 12.11	111 31.27	67 18.87	355 100.00

STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES - [illegible] VERSION 6.02 11/21/77 PAGE 1

```
RUN NAME      BREAKDOWN LARVAL PREY (SIZE DISTRIBUTIONS)
                (BONGO)
FILE NAME     HERRING PREY
GET FILE        DC/RC75145

FILE RC75145 HAS 45 VARIABLES

THE SUBFILES ARE...

NAME      N OF CASES

RC75145        2085

SELECT IF       (PREYCODE NE 9 AND GEAR EQ 1)
BREAKDOWN         TABLES=PREYLEN,PREYWID BY PREYCODE
                  BY STAGE BY PREYSEX
```

BREAKDOWN LARVAL PREY (SIZE DISTRIBUTIONS) 11/21/77 PAGE 2

FILE RC75145 (CREATION DATE = 11/21/77) PREY

- - - - - - - - - - DESCRIPTION OF SUBPOPULATIONS - - - - - - - - - -

```
CRITERION VAR. PREYLEN      PREY LENGTH
BROKEN DOWN BY PREYCODE     PREY CODE
            BY STAGE
            BY PREYSEX      PREY SEX
```

- -

VARIABLE	CODE	VALUE LABEL	SUM	MEAN	STD DEV	VARIANCE	N
FOR ENTIRE POPULATION			389.0900	.6905516	.1704069	.2903798E-01	(563)
PREYCODE	100.	COPEPODA	28.25000	.5330189	.1402686	.1967529E-01	(53)
STAGE	0.	ADULT	21.52000	.5663158	.1249522	.1561305E-01	(38)
PREYSEX	0.		21.52000	.5663158	.1249522	.1561305E-01	(38)
STAGE	50.	INVERT EGG	.1600000	.1600000	.0000000	.0000000	(1)
PREYSEX	0.		.1600000	.1600000	.0000000	.0000000	(1)
STAGE	52.	COPEPODITE	6.570000	.4692857	.1262738	.1594557E-01	(14)
PREYSEX	3.	IMMATURE	6.570000	.4692857	.1262738	.1594557E-01	(14)
PREYCODE	101.	CALANUS F.	1.240000	.3100000	.8246202E-01	.6799998E-02	(4)
STAGE	13.	NAUPLIUS	1.240000	.3100000	.8246202E-01	.6799998E-02	(4)
PREYSEX	3.	IMMATURE	1.240000	.3100000	.8246202E-01	.6799998E-02	(4)
PREYCODE	102.	PSEUDOCALANUS M.	41.62000	[illegible]	[illegible]	[illegible]	(49)
STAGE	0.	ADULT	24.30000	[illegible]	[illegible]	[illegible]	(33)
PREYSEX	0.		10.00000	[illegible]	[illegible]	[illegible]	(12)
PREYSEX	1.	MALE	2.440000	[illegible]	[illegible]	[illegible]	(3)
PREYSEX	2.	FEMALE	21.86000	[illegible]	[illegible]	[illegible]	(24)
STAGE	52.	COPEPODITE	2.320000	[illegible]	[illegible]	[illegible]	(10)
PREYSEX	1.	MALE	4.600000	.7666667	[illegible]	[illegible]	(6)
PREYSEX	3.	IMMATURE	3.720000	[illegible]	[illegible]	.1066662E-01	(4)

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```
*** SIGMA  SPSS  ----  RELEASE 7.0  ***                                                04/12/78     PAGE 1

            RUN NAME               DISCRIMINANT ANALYSIS (BONGOS)
            FILE NAME         HERRING PREY
            OFT FILE           DC/RC75145

      THE NUMBER OF ACTIVE VARIABLES RETRIEVED IS 51

      THE SUBFILES ARE,...

      NAME      N OF CASES

      RC75145        2085

            VALUE LABELS              GUTFLAG(0)NONFEEDING (1)FEEDING
            SELECT IF              (RECTYP EQ 1 AND GEAR EQ 1 AND PREDEYE LT 3)
            DISCRIMINANT                GROUPS=GUTFLAG(0,1)/VARIABLES=
                                  PREDLEN,NPREDSKUL,NMAXIL,NPREDHEAD,
                                  NPREDBODY,PECTORAL,EYEHEAD,NPREDEYE/
                                  ANALYSIS=PREDLEN,NPREDSKUL,NMAXIL,
                                  NPREDHEAD,NPREDBODY,PECTORAL,
                                   EYEHEAD,NPREDEYE/
                                  METHOD=DIRECT/FUNCTIONS=2/
            OPTIONS                  5,7,10,14,15,17,18,19
            STATISTICS               1,2,3,4,5,6,9

*** WARNING! UNIMPLEMENTED FEATURES ...
*** OPTIONS 13 TO 19  AND  STATISTICS 7 AND 8.
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

DISCRIMINANT ANALYSIS (BONGOS)                                                         04/12/78     PAGE 2

FILE   RC75145  (CREATION DATE= 04/12/78)   PREY


GROUP COUNTS

           GROUP    0  GROUP    1   TOTAL
             NONFEEDI    FEEDING
             NG

COUNT        319.0000    195.0000    514.0000


MEANS

           GROUP    0  GROUP    1   TOTAL
             NONFEEDI    FEEDING
             NG

PREDLEN      18.2208     18.3405     18.2661
NPREDSKU       .0641       .0645       .0642
NMAXIL         .0873       .0841       .0861
NPREDHEA       .0523       .0522       .0522
NPREDBOD       .0400       .0388       .0395
PECTORAL    151.6771    147.3487    150.0350
EYEHEAD        .7297       .7252       .7279
NPREDEYE       .0374       .0373       .0374
```

STANDARD DEVIATIONS

	GROUP 0 NONFEEDING	GROUP 1 FEEDING	TOTAL
PREDLEN	2.8864	2.7172	2.8217
NPREDSKU	.0080	.0068	.0076
NMAXIL	.0448	.0438	.0444
NPREDHEA	.0083	.0083	.0083
NPREDBOD	.0070	.0064	.0068
PECTORAL	14.0849	17.3122	15.5160
EYEHEAD	.1206	.1023	.1141
NPREDEYE	.0048	.0042	.0046

WILKS' LAMBDA (U-STATISTIC) AND
UNIVARIATE F-RATIO WITH 1 AND 512 DEGREES OF FREEDOM

VARIABLE	WILKS' LAMBDA	F	F PROBABILITY
PREDLEN	.9991	.4862	.4859
NPREDSKU	.9929	3.6368	.0270
NMAXIL	.9986	.7178	.5417
NPREDHEA	.9959	2.0901	.0809
NPREDBOD	.9895	5.41[illegible]6	.0001
PECTORAL	.7816	9.5957	.0000
EYEHEAD	.9951	2.52[illegible]9	.0147
NPREDEYE	.9951	2.5206	.0107

WITHIN GROUPS COVARIANCE MATRIX

	PREDLEN	NPREDSKU	NMAXIL	NPREDHEA	NPREDBOD	PECTORAL	EYEHEAD	NPREDEYE
PREDLEN	7.9700							
NPREDSKU	-.0067	.0001						
NMAXIL	.0304	-.0001	.0020					
NPREDHEA	.0054	-.0000	.0002	.0001				
NPREDBOD	-.0003	.0000	-.0002	-.0000	.0000			
PECTORAL	7.4492	-.0350	.3351	.0649	-.0348	236.7715		
EYEHEAD	-.0533	.0003	-.0015	-.0007	.0002	-.7675	.0130	
NPREDEYE	.0011	.0000	.0000	.0000	.0000	.0065	.0002	.0000

WITHIN GROUPS CORRELATION MATRIX

	PREDLEN	NPREDSKU	NMAXIL	NPREDHEA	NPREDBOD	PECTORAL	EYEHEAD	NPREDEYE
PREDLEN	1.0000							
NPREDSKU	-.3121	1.0000						
NMAXIL	.2425	-.2490	1.0000					
NPREDHEA	.2299	-.1342	.4566	1.0000				
NPREDBOD	-.0167	.3673	-.5649	-.1283	1.0000			
PECTORAL	.1715	-.3014	.4901	.5078	-.3328	1.0000		
EYEHEAD	-.1657	.3236	-.2934	-.6812	.2550	-.4377	1.0000	
NPREDEYE	.0826	.2385	.1899	.3457	.1869	.0923	.4183	1.0000

TOTAL COVARIANCE MATRIX

	PREDLEN	NPREDSKU	NMAXIL	NPREDHEA	NPREDBOD	PECTORAL	EYEHEAD	NPREDEYE
PREDLEN	7.9620							
NPREDSKU	-.0066	.0001						
NMAXIL	.0303	-.0001	.0020					
NPREDHEA	.0054	-.0000	.0002	.0001				
NPREDBOD	-.0003	.0000	-.0002	-.0000	.0000			
PECTORAL	7.3314	-.0349	.3380	.0653	-.0332	240.7388		
EYEHEAD	-.0525	.0003	-.0015	-.0006	.0002	-.7554	.0130	
NPREDEYE	.0011	.0000	.0000	.0000	.0000	.0068	.0002	.0000

FILE RC75145 (CREATION DATE) 04/12/78) PREY

- D I S C R I M I N A N T   A N A L Y S I S -

ANALYSIS NUMBER 1

SOLUTION METHOD - DIRECT.

PRIOR PROBABILITIES -

GROUP 0 NONFEEDING	GROUP 1 FEEDING
.50000	.50000

DISCRIM. FUNCTION	EIGEN VALUE	REL. %	CANON CORR	FUNCTIONS DERIVED	WILKS' LAMBDA	CHI SQUARE	DF	SIG.
				0	.81190	105.854	8	.000
1	.23171	100.00	.4337					

REMAINING COMPUTATIONS WILL BE BASED ON 1 DISCRIMINANT FUNCTION(S)

STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS

	FUNC 1
PREDLEN	-.06142
NPREDSKU	-.06792
NMAXIL	-.06409
NPREDHEA	-4.50537
NPREDBOD	-.31282
PECTORAL	-.43168
EYEHEAD	-4.86334
NPREDEYE	3.58703

CENTROIDS OF GROUPS IN REDUCED SPACE

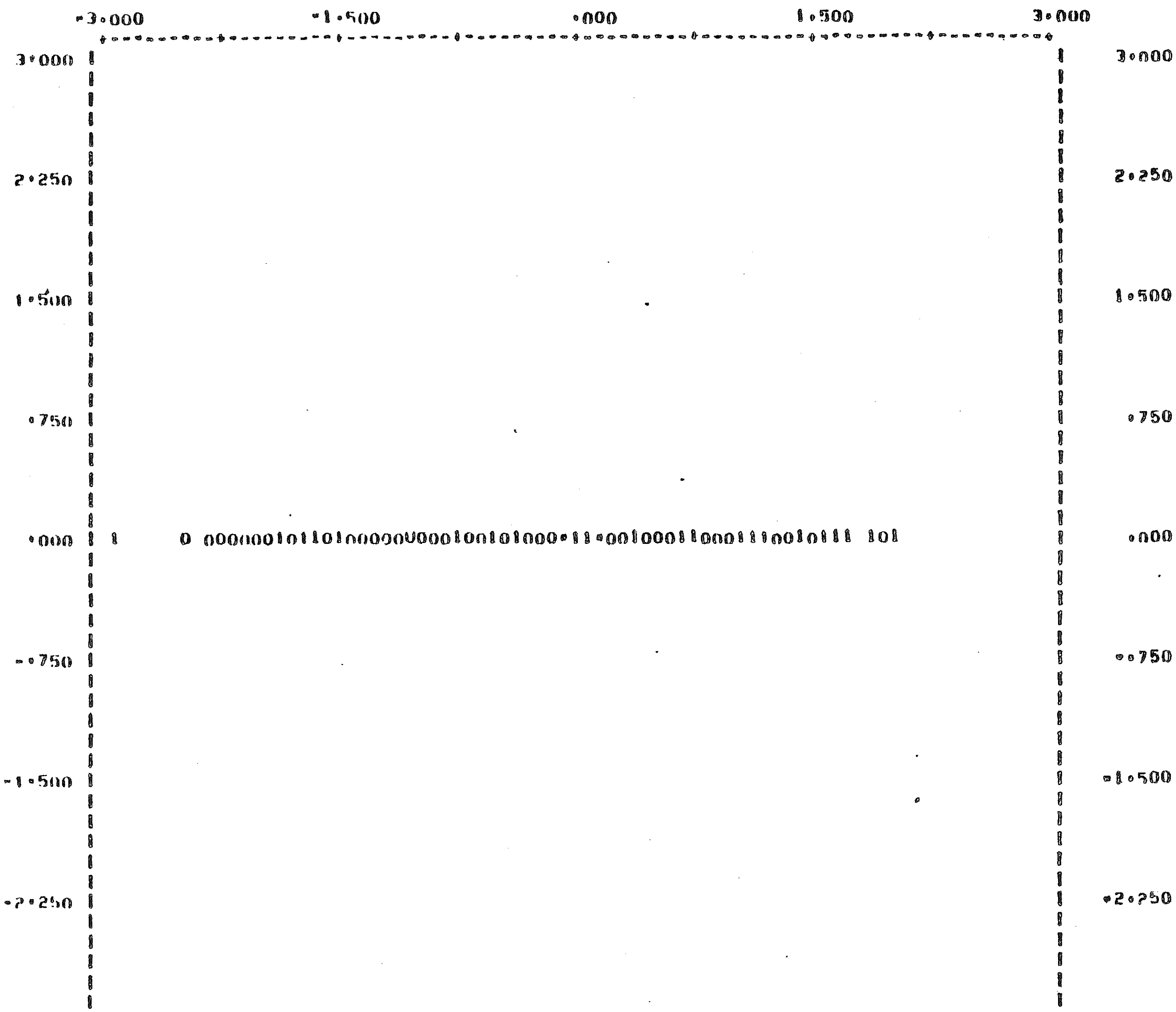
	FUNC 1
GROUP 0 NONFEEDING	-.10617
GROUP 1 FEEDING	.16754

DIRECTORY OF PLOT SYMBOLS -

DIRECTORY OF PLOT SYMBOLS -

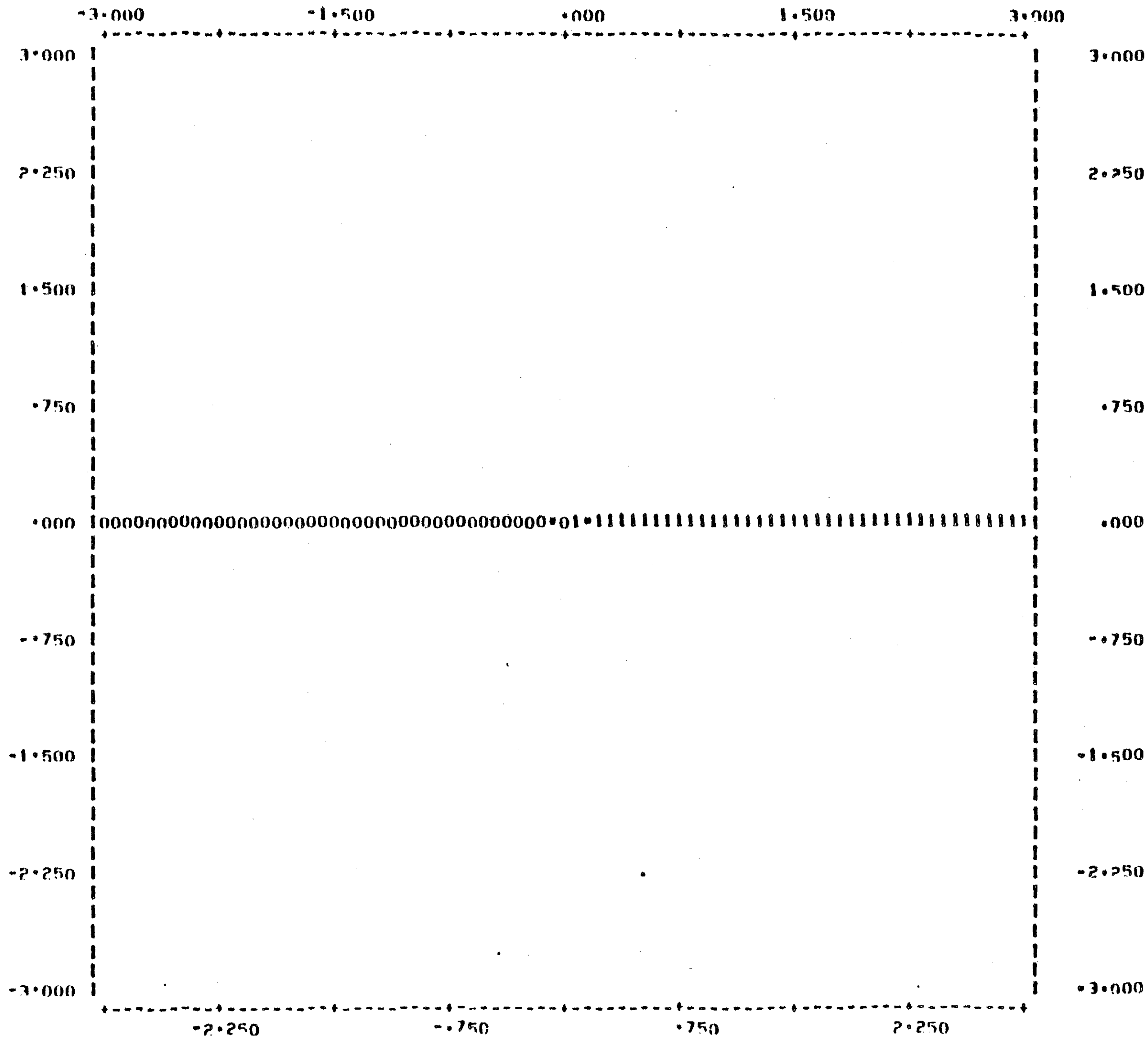
SYMBOL	GROUP	LABEL
0	0	NONFEEDING
1	1	FEEDING
U		ALL UNGROUPED CASES
*		CENTROIDS

PLOT OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). * INDICATES A GROUP CENTROID.



-2.250 -.750 .750 2.250

TERRITORIAL MAP OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). * INDICATES A GROUP CENTROID.



PREDICTION RESULTS -

ACTUAL GROUP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP GP. 0	GP. 1
GROUP 0 NONFEEDING	319.	145. 45.5%	174. 54.5%
GROUP 1 FEEDING	195.	73. 37.4%	122. 62.6%
UNGROUPED CASES	14.	6. 42.9%	8. 57.1%

PERCENT OF GROUPED CASES CORRECTLY CLASSIFIED: 51.95%
'DISCRIMINANT' WORKSPACE = 1346 WORDS
*** TRANSPACE SIZE = 21 WORDS

FINISH

15 COMMAND RECORDS READ.

*** SIGMA SPSS ---- RELEASE 7.0 ***   04/12/78   PAGE 1

```
        RUN NAME        PREDATOR STATISTICS (BONGO)  FACTOR ANALYSIS
        FILE NAME       HERRING PREY
        GET FILE          DC/RC75145
```

THE NUMBER OF ACTIVE VARIABLES RETRIEVED IS 51

THE SUBFILES ARE...

NAME	N OF CASES
RC75145	2085

```
        SELECT IF                 (GEAR EQ 1 AND PREDEYE LT 3)
        FACTOR          VARIABLES=PREDLEN,NPREDSKUL,NMAXIL,
                        NPREDHEAD,NPREDBODY,PECTORAL,
                          NPREDEYE,EYEHEAD/
                          TYPE=PA1/
                         NFACTORS=2/
                         ROTATE=OBLIQUE/
        STATISTICS       ALL
```

PREDATOR STATISTICS (BONGO) FACTOR ANALYSIS   04/12/78   PAGE 2

1.VARIABLE LIST

VARIABLES..	LABELS..
PREDLEN	
NPREDSKU	
NMAXIL	
NPREDHEA	
NPREDBOD	
PECTORAL	
NPREDEYE	
EYEHEAD	

FILE RC75145 (CREATION DATE: 04/12/78) PREY

VARIABLE	MEAN	STANDARD DEV	CASES
PREDLEN	18.2643	2.8085	528
NPREDSKU	.0643	.0075	528
NMAXIL	.0854	.0442	528
NPREDHEA	.0522	.0083	528
NPREDBOD	.0396	.0068	528
PECTORAL	149.9432	15.4783	528
NPREDEYE	.0873	.0046	528
EYEHEAD	.7271	.1143	528

FILE RC75145 (CREATION DATE: 04/12/78) PREY

CORRELATION COEFFICIENTS..

	PREDLEN	NPREDSKU	NMAXIL	NPREDHEA	NPREDBOD	PECTORAL	NPREDEYE	EYEHEAD
PREDLEN	1.00000	-.29781	.23874	.22206	-.00784	.16214	.08241	-.15591
NPREDSKU	-.29781	1.00000	-.24919	-.12814	.36970	-.30007	.24253	.32601
NMAXIL	.23874	-.24919	1.00000	.44629	-.55978	.48395	.19298	-.27731
NPREDHEA	.22206	-.12814	.44629	1.00000	-.12072	.49100	.34631	-.68241
NPREDBOD	-.00784	.36970	-.55978	-.12072	1.00000	-.31073	.18650	.25125
PECTORAL	.16214	-.30007	.48395	.49100	-.31073	1.00000	.09659	-.41131
NPREDEYE	.08241	.24253	.19298	.34631	.18650	.09659	1.00000	.42546
EYEHEAD	-.15591	.32601	-.27731	-.68241	.25125	-.41131	.42546	1.00000

FILE HC75145 (CREATION DATE = 04/12/78) PREY

VARIABLE	EST COMMUNALITY	FACTOR	EIGENVALUE	PCT OF VAR	CUM PCT
PREDLEN	1.00000	1	2.93198	36.6	36.6
NPREDSKU	1.00000	2	1.54956	19.4	56.0
NMAXIL	1.00000	3	1.11445	13.9	70.0
NPREDHEA	1.00000	4	1.02234	12.8	82.7
NPREDBOD	1.00000	5	.59550	7.4	90.2
PECTORAL	1.00000	6	.48569	6.1	96.2
NPREDEYE	1.00000	7	.28600	3.6	99.8
EYEHEAD	1.00000	8	.01445	.2	100.0

FILE HC75145 (CREATION DATE = 04/12/78) PREY

FACTOR MATRIX USING PRINCIPAL FACTOR, NO ITERATIONS

	FACTOR 1	FACTOR 2
PREDLEN	.38162	.14516
NPREDSKU	-.55397	.42959
NMAXIL	.74019	.22739
NPREDHEA	.72563	.44219
NPREDBOD	-.58249	.31885
PECTORAL	.73442	.16552
NPREDEYE	-.02463	.93758
EYEHEAD	-.72506	.29766

VARIABLE	COMMUNALITY
PREDLEN	.16671
NPREDSKU	.49131
NMAXIL	.59958
NPREDHEA	.72207
NPREDBOD	.44096
PECTORAL	.56676
NPREDEYE	.87967
EYEHEAD	.61431

FILE HC75145 (CREATION DATE = 04/12/78) PREY

DELTA = .00
FILE HC75145 (CREATION DATE = 04/12/78) PREY
ROTATION FOR DIRECT OBLIMIN LOADINGS

CRITERION

0	1.937932
1	1.869482
2	1.733754
3	1.607636
4	1.519160
5	1.470454
6	1.447722
7	1.438055
8	1.434133
9	1.432562
10	1.431946
11	1.431693
12	1.431571
13	1.431552
14	1.431520
15	1.431501

FILE RC7514S (CREATION DATE = 04/12/78) PREY

AFTER ROTATION WITH KAISER NORMALIZATION

FACTOR PATTERN

	FACTOR 1	FACTOR 2
PREDLEN	.40494	-.01425
NPREDSKU	-.20762	.62563
NMAXIL	.75327	-.07881
NPREDHEA	.86862	.12992
NPREDMOD	-.29727	.53236
PECTORAL	.71172	-.13478
NPREDEYE	.53285	.89715
EYEHEAD	-.42893	.56891

FACTOR CORRELATIONS

	FACTOR 1	FACTOR 2
FACTOR 1	1.00000	-.21855
FACTOR 2	-.21855	1.00000

FACTOR STRUCTURE

	FACTOR 1	FACTOR 2
PREDLEN	.40306	-.10275
NPREDSKU	-.34436	.67101
NMAXIL	[illegible]	[illegible]

NPREDHEA	.84022	-.05992
NPREDMOD	-.41362	.59733
PECTORAL	.74122	-.29053
NPREDEYE	.33678	.78069
EYEHEAD	-.55327	.66265

FILE RC75145 (CREATION DATE 04/12/78) PREY

FACTOR SCORE COEFFICIENTS

	FACTOR 1	FACTOR 2
PREDLEN	.15628	.00096
NPREDSKU	-.06684	.33541
NMAXIL	.28958	-.02663
NPREDHEA	.33467	.08924
NPREDMOD	-.10351	.28291
PECTORAL	.27241	-.05804
NPREDEYE	.22531	.49891
EYEHEAD	-.15364	.29984

*** FACTOR WORKSPACE = 357 WORDS ***

*** TRANSPACE SIZE = 21 WORDS

FINISH

12 COMMAND RECORDS READ.

Table 1. Cryos 74-04, 9/7-9/24/74, mean length and width of larval herring prey items by 5-mm larval length class.

CRUISE Cryos 74-04 GEAR 61 cm Bongo MESH .333 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	262	14	28	2.0	16	10					
10-14	35	1	1	1.0	1						
15-19	7	0									
20-24											
25-29											
30-39											
> 40											
LENGTH MISSING	8	1	1	1.0							
TOTAL	312	16	29	1.81	17	10					

Appendix 3

Table 16. Cryos 74-04, 9/7-9/24/74, abundance of larval herring prey items by 5-mm larval length class.

N = copepod nauplius C = copepodite A = adult copepod

CRUISE Cryos 74-04 GEAR 61 cm Bongo MESH .333 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	262	14	11-N		1-N	8-N							8-N	
10-14	35	1											1-N	
15-19	7	0												
20-24														
25-29														
30-39														
>40														
LENGTH MISSING	8	1											1-N	
TOTAL	312	16	11-N		1-N	8-N							10-N	

Table 31. Cryos 74-04, 9/7-9/24/74, diel distribution of feeding larval herring by 5-mm length class.

TIME (GMT) CRUISE Cryos 74-04 GEAR 61 cm Bongo MESH .333 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				8					2	4			14
10-14				1					0	0			1
15-19													
20-24													
25-29													
30-39													
>40													
LENGTH MISSING				0					1	0			1
TOTAL				9					3	4			16

☐ = Day ▥ = Twilight ▣ = Night

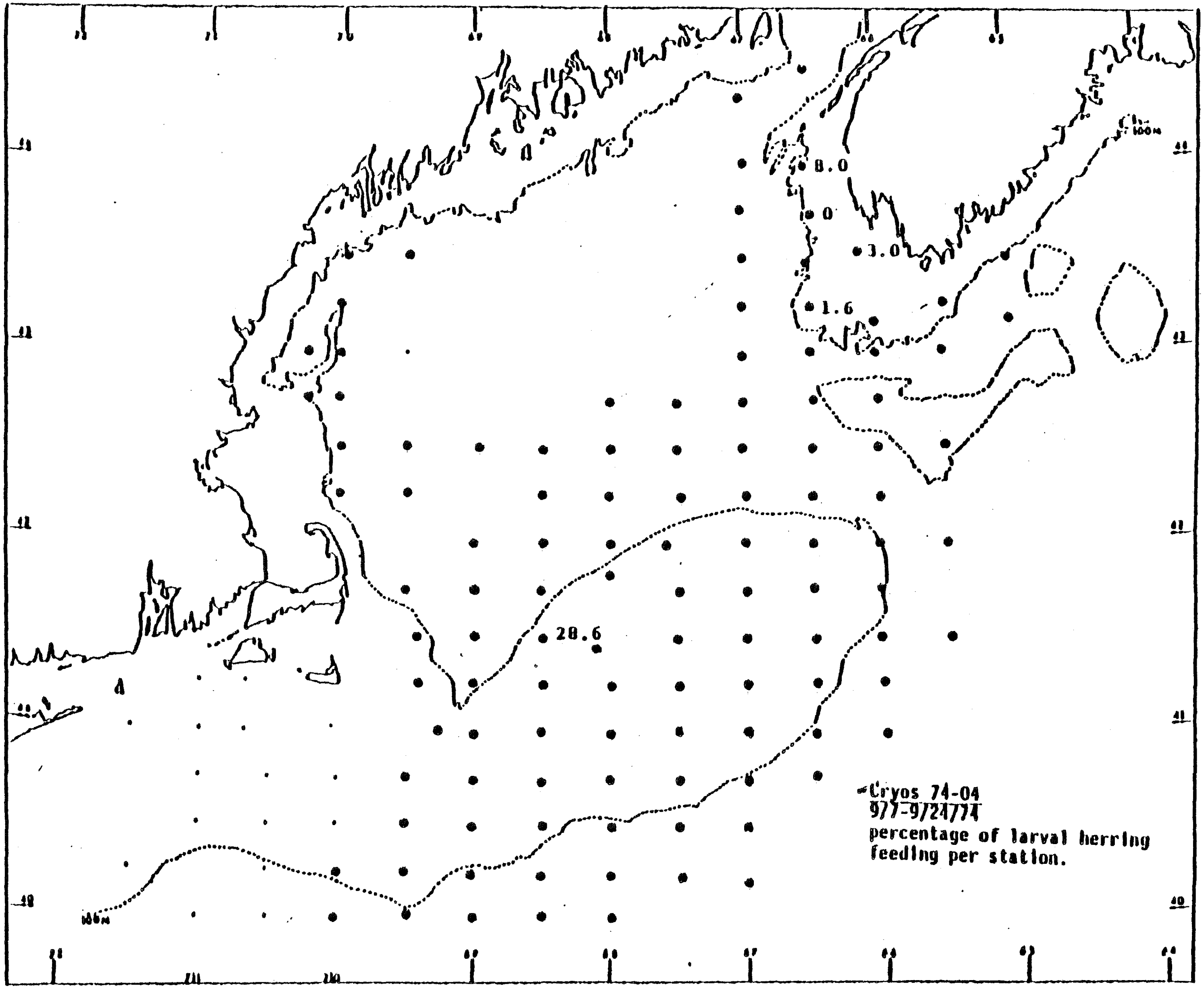
Table 46. Cryos 74-04, 9/7-9/24/74, mean value of larval herring condition factor measurements by 5-mm length class.

MEAN VALUES OF CONDITION FACTOR MEASUREMENTS - LARVAL GUT CONTENTS SP [illegible]

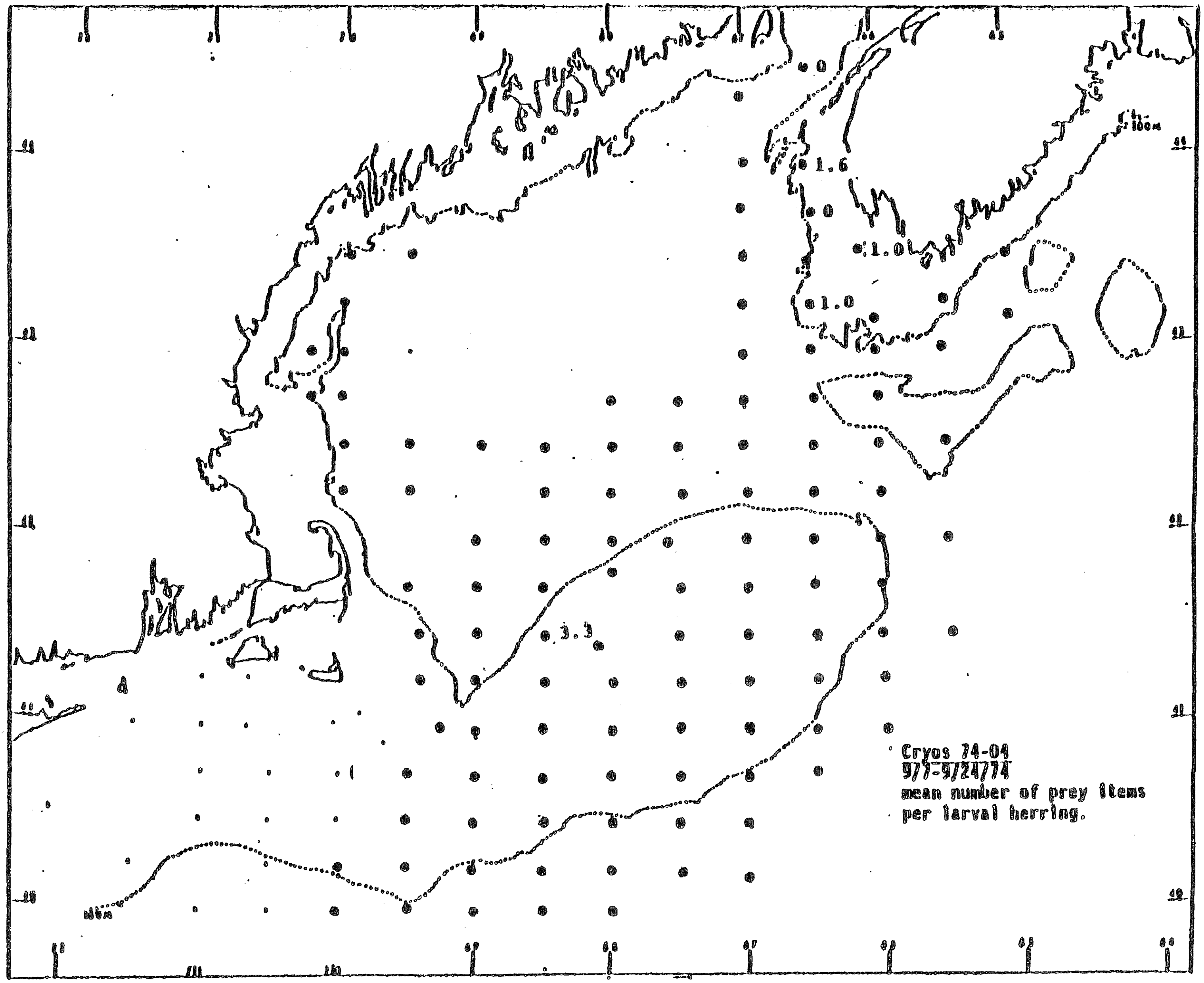
CRUISE Cryos 74-04 GEAR 61 cm Bongo MESH .333 mm

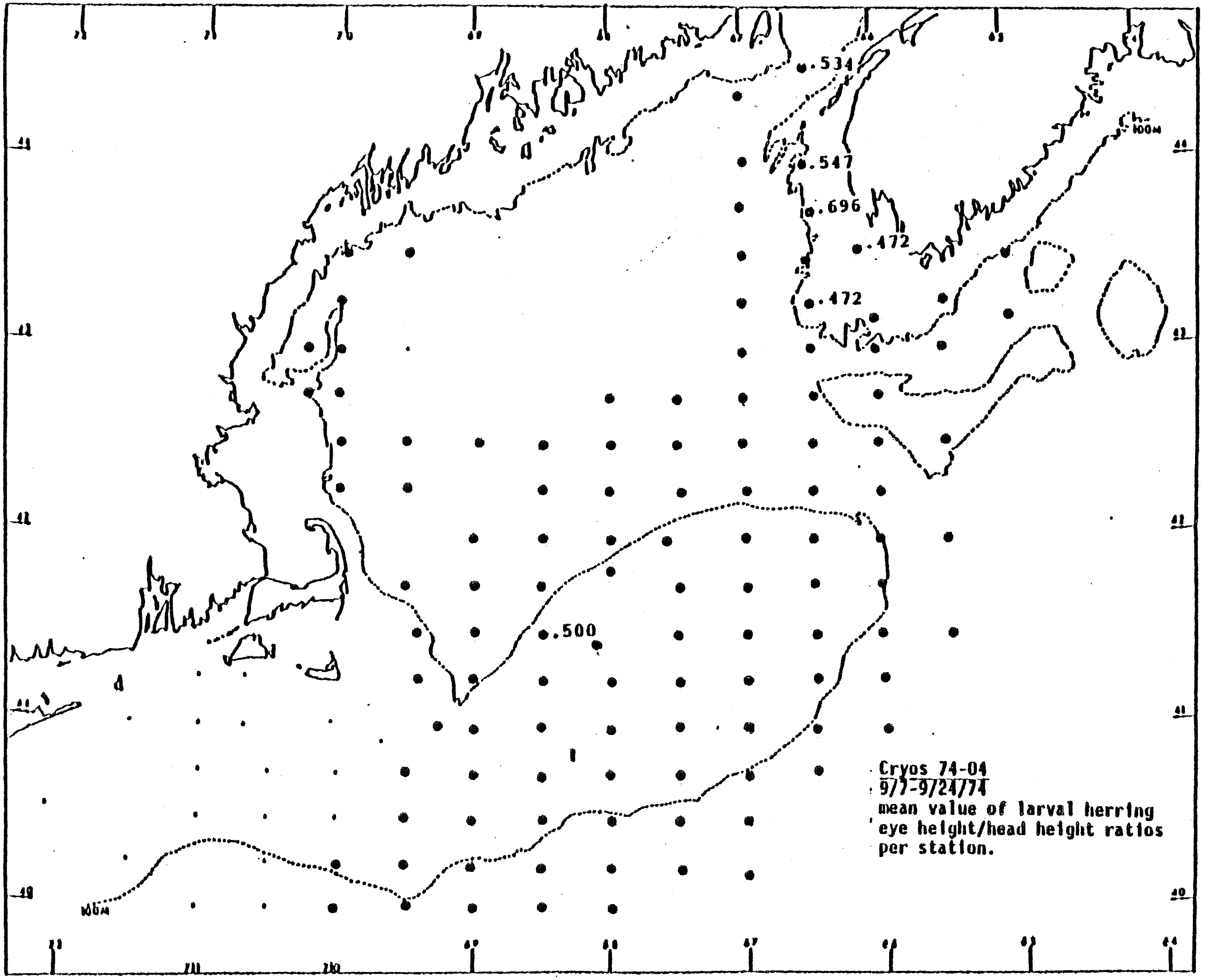
STD LENGTH (MM)	NUMBER LARVAE ANALYZED	SKULL WIDTH (MM)			MOUTH GAPE (MM)			MAXILLARY LENGTH (MM)			EYE HEIGHT (MM)			HEAD HEIGHT (MM)			EYE/HEAD HEIGHT RATIO			BODY HEIGHT (MM)			PECTORAL ANGLE (°)			BODY HEIGHT/STD LENGTH RATIO			WEIGHT (MG)X[illegible]/STD LENGTH (MM)3		
		NO	$\bar{X}$	CL	NO	$\bar{X}$	CL	NO	$\bar{X}$	CL	NO	$\bar{X}$	CL	NO	$\bar{X}$	CL	NO	$\bar{X}$	CL	NO	$\bar{X}$	CL	NO	$\bar{X}$	CL	NO	$\bar{X}$	CL	NO	$\bar{X}$	CL
<10	262	174	.456	± .012	36	.614	± .035	36	.434	± .025	78	.261	± .011	184	.473	± .009	76	.520	± .019	235	.318	.029	122	129.8	± 1.15	235	.050	± .006	262	.043	.00
10-14	35	31	.633	± .043	20	.827	± .047	20	.584	± .033	17	.368	± .039	27	.652	± .029	16	.546	± .054	33	.459	.034	28	132.1	± 2.48	33	.038	± .002	35	.116	± .00
15-19	7	6	.947	± .102	7	1.19	± .154	7	.840	± .109	6	.553	± .077	7	.903	± .060	6	.621	± .096	7	.680	.123	7	141.3	± 7.08	7	.040	± .004	7	.203	± .0[illegible]
20-24																															
25-29																															
30-39																															
40																															
LENGTH MISSED	8	2	.455	± 1.33	1	.382		1	.270					2	.475	± 1.08				8	.313	± .067	2	128.[illegible]	± 19.1						
TOTAL	312	213	.495	± .018	64	.740	± .054	64	.523	± .038	101	.296	± .019	220	.508	± .015	98	.530	± .018	283	.343	± .026	159	130.7	± 1.07	275	.048	± .005	304	.05[illegible]	± .00[illegible]

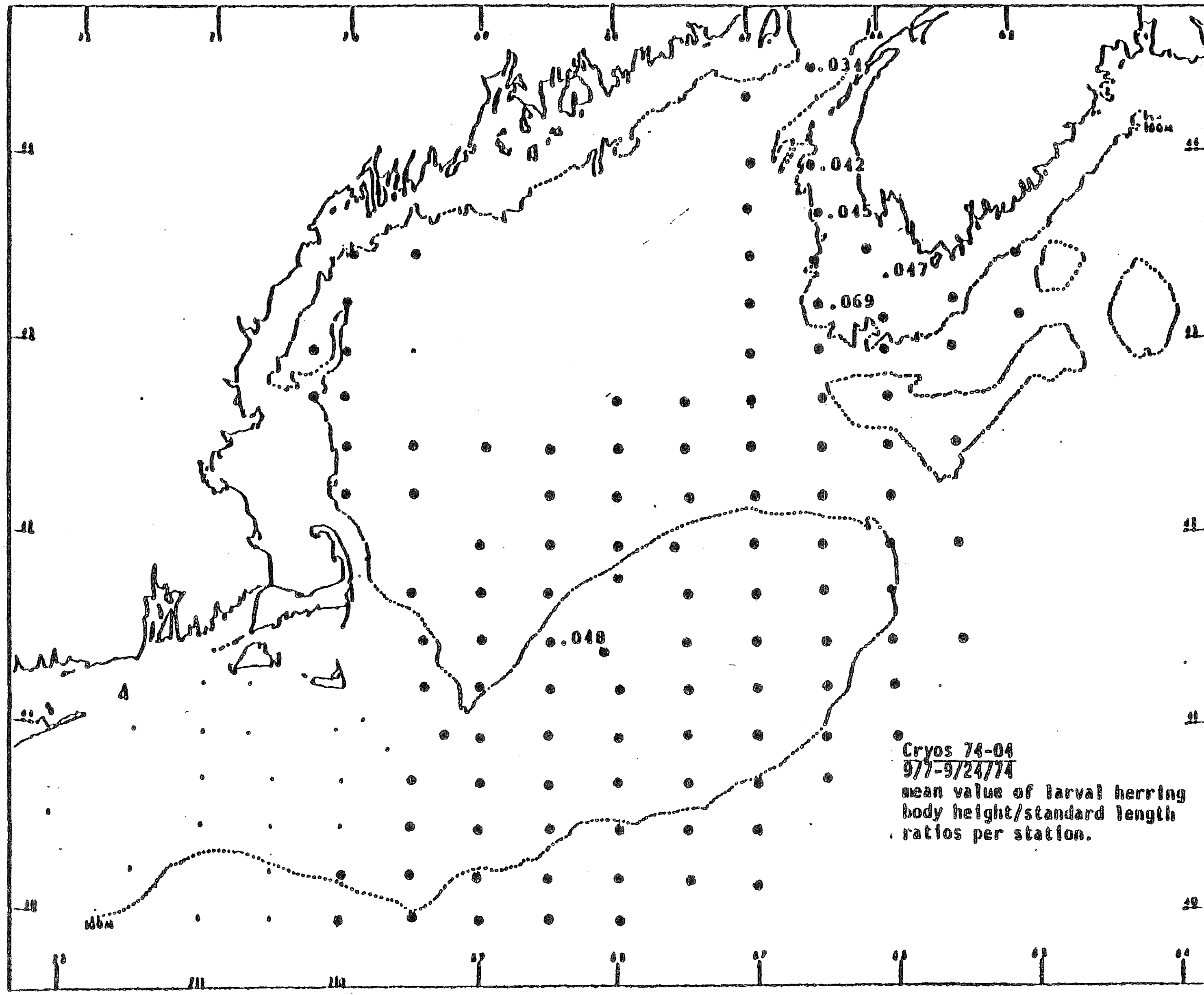
NOTE: CL = 95% confidence limits.



Cryos 74-04
9/7-9/24/74
percentage of larval herring feeding per station.


0
1.6
0
1.0
1.0
3.3
100m
Cryos 74-04
9/?-9/24/74
mean number of prey items
per larval herring.


.534
.547
.696
.472
.472
.500
100M
Cryos 74-04
9/7-9/24/74
mean value of larval herring
eye height/head height ratios
per station.


.034
.042
.045
.047
.069
.048
100m
Cryos 74-04
9/7-9/24/74
mean value of larval herring
body height/standard length
ratios per station.

Sample Graphs