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Report of Larval Herring Task Force, April 1980

TABLE OF CONTENTS

REPORT OF LARVAL HERRING TASK FORCE, APRIL 1980

Chairman: M. D. Grosslein   Rapporteur: G. Bolz

I. INTRODUCTION

The Task Force met in Woods Hole, Massachusetts, USA from 28 April to 1 May 1980 in response to a recommendation by the ICNAF Standing Committee on Research and Statistics (ICNAF Redbook 1979, pages 101-102) and the Scientific Council of NAFO (NAFO Proc. 1979, page 118), "that a Task Force on the Larval Herring Program be reconstituted to undertake the analysis of the extensive data assembled from the Gulf of Maine - Georges Bank area,...".

The Task Force reviewed the status of the biological and physical data relevant to the question of factors controlling survival of sea herring larvae; and it recommended that the Task Force should meet again in September to consider further documentation (selected papers on herring recruitment and inventories of data) and to present a more complete report on the April 1980 meeting. A preliminary report of the meeting was submitted in June (NAFO SCS Doc. 80/VI/16) with a brief outline of the topics covered. A list of participants was also included in the preliminary report as well as a list of papers suggested for the September 1980 meeting. The agenda for the April meeting is given in NAFO Circular Letter 80/24.

II. OVERVIEW OF LARVAL HERRING PROGRAM

The Chairman presented a very brief overview of the history and development of the ICNAF larval herring program, and noted that results to date are available in a large number of publications, many of which are in the ICNAF document series. A report of the larval herring workshop held at Szczecin, Poland, in June 1977, summarizes status of analysis and field programs through that date (see appendix 2 to this document). Copies of documents submitted at the June 1977 workshop are available from M. Grosslein at NEFC in Woods Hole.

Three recent papers provide summaries of major results through 1979 and also provide reasonably complete bibliographies of relevant papers. Lough and Bolz (1979), NEFC Lab. Ref. Doc. No. 79-60, 230 pp.), describes sampling methods and lists larval herring catch data for .505 mm mesh samples for the Georges Bank - Gulf of Maine area collected from 1968-1978; it is available from the Northeast Fisheries Center, Woods Hole. Evolution of the ICNAF larval herring sampling methods from 1971-1978 is described and length frequencies and catches of larvae (<10 mm and total larvae) are given for all cruises. A second paper (ICNAF Res. Doc. 79/VI/112) provides a preliminary analysis and summary of larval abundance, growth and mortality estimates for the Georges Bank area; it also summarizes comparisons of potential egg production from larval and VPA data, relationship of larval abundance-growth-mortality to recruitment, and dispersal of larvae in relation to EKMAN transport indices. Although results are only preliminary this paper provides a good general picture of the scale of year to year differences observed in all these factors, and the nature of some of the problems we face in making quantitative estimates and drawing valid inferences about the recruitment process in sea herring. The bibliography in 79/VI/112 is quite complete in relation to the topics noted. The third paper is a comprehensive review of the status of herring stocks in the New England region (C. Sindermann 1979, Northeast Fisheries Center, Sandy Hook Laboratory, Highlands, New Jersey, 07732, Tech. Series Rept. 23, 449 pp.). Topics covered in this review include history of the herring fisheries, status of knowledge about stocks, and factors related to recruitment. There are about 800 references in the bibliography and copies of the report are available from the author on request.

A definitive description of the history of the ICNAF larval herring program has yet to be written, including references to all the various working groups, workshops and other meetings which have made contributions to development of the program over nearly the last two decades. The proper place for this description may be as part of a basic inventory report and this option should be considered at the September 1980 meeting. Because of the long time required for processing samples (particularly zooplankton), and new priorities, it is anticipated that at least another two years may be required to complete processing and analysis of all the data. It is hoped that the Task Force can continue its work to help guide and encourage scientists to evaluate and publish all the important information in this unprecedented time series.

III. SPAWNING

A general discussion was held on spawning, with emphasis on spawning locations and current knowledge of factors affecting timing and hatching success. The main spawning areas in the Gulf of Maine - Georges Bank region have been Lurchers, Shoals, Western Gulf of Maine, Jeffreys Ledge, Northeast Georges Bank, and Nantucket Shoals with spawning generally progressing from August to October in the order listed above. It was noted that on Georges Bank the onset of spawning was delayed and length of the spawning season had shortened after 1975. This shift followed the warming trend on Georges Bank during the early 1970's; but it was also coincident with a further decline in the spawning biomass and average age of spawners on Georges Bank, and the spawning on Nantucket Shoals (normally later than on Georges Bank) became relatively more important after 1975. It is very difficult to determine the relative importance of these various factors but the role of temperature is coming under increasing question. The optimum tempterature for herring spawning is stated in the literature as 9.5°C which coincides with the bottom temperatures observed (9.5°-10°C) over 6 years on Jeffreys Ledge. However, bottom temperatures over spawning beds on Northeast Georges Bank (estimated from distribution of <8 mm larvae) are generally higher than this. Some of the egg beds encounter wide temperature fluctuations (from 6°-13°C) with the shifting of a strong temperature front over a single tidal cycle. This contrasts with only a 1°-2°C change over a tidal cycle in the Jeffreys Ledge area. It is possible that the timing of spawning on Northeast Georges may be more closely related to the position of the front relative to the historical beds, and the minimum or maximum temperatures associated with the front, than to the mean temperature. In any case the sampling of temperature in space and time on the standard ICNAF grid is so sparse in relation to the large short-term fluctuations associated with the front, that mean temperature data would not be expected to be closely correlated with spawning time.

A trend toward later spawning after 1974 also occurred in western Gulf of Maine but no specific analysis of timing vs temperature has been done. There are spawning beds all along the coast and spawning normally occurs 2-3 weeks earlier in the north. In addition to the later spawning after 1974 it was noted that there were multiple spawnings whereas in earlier years only one peak in spawning was observed.

Off western Nova Scotia there is normally about a 4-week difference in spawning time between the two major areas, southwest Nova Scotia and off Grand Manan Island, with the earlier spawning occurring off Grand Manan. A trend in spawning times with temperature is not apparent here (although a definitive analysis has yet to be done). Lunar periodicity was suggested as a more important factor but supporting evidence was not available at the meeting. Since records of spawning go back many years it should be possible to evaluate the lunar effect. A summary of the western Nova Scotia studies on larval herring is to be presented at the next meeting of the Task Force.

For comparison purposes it was noted that in the Gulf of St. Lawrence spawning beds are widely spread throughout the area with some sites remaining stable while others are important only from time to time. Based on the mean day or arrival, succession of spring spawning proceeds in an anti-clockwise direction throughout the region with spawners arriving in discrete runs. Autumn runs showed less distinct patterns. Arrival time was correlated with temperature about half the time but it was felt that mean temperature probably would not be a good indicator.

The role of substrate was discussed briefly. It was noted that in the Jeffreys Ledge area eggs were deposited over substrates ranging from boulders to broken shells to sand. About 95% of the eggs spawned in brown algae (attached to rocks and boulders) hatched, whereas those spawned directly on the bottom (without algae) suffered high mortality particularly those on the bottom of the egg mass. On Northeast Georges Bank, the major egg beds are thought to be on pebbly bottom which is free of the algae found off Jeffreys Ledge. A wide variety of substrates and depths appear to be used for spawning off western Nova Scotia. Detailed studies by divers, such as those conducted off Jeffreys Ledge, may be necessary to evaluate the relative importance of different substrates in hatching success and mortality from predation.

IV. LARVAL SAMPLING PROBLEMS

Sources of error in sampling larvae in the field were briefly discussed, with a focus on recent results and additional work required.

Extrusion

It was noted that at 3.5 knots, the standard towing speed for the ICNAF series, there is significant extrusion of herring larvae <12 mm standard length with the .505 mm mesh bongos as compared to the .333 mm nets (Colton, et al. 1980, Can. J. Fish. Squat. Sc. vol. 37, no. 4). No differences were observed between the nets for larger larvae, and skull width vs length measurements also indicate that larvae ≥12 mm would be fully retained in the .505 as well as the .333 nets. This is of particular importance because herring larvae have been lost from some of the .333 samples from the ICNAF time series (through pre-sorting before shipment to the Polish Sorting Center). In such cases it is necessary to use the .505 samples for the standard larval herring estimates of abundance. A correction factor for the .505 nets should be established for herring larvae <12 mm taking account of the shrinkage of larvae due to capture and preservation. Also it was noted that the .505 samples could be processed more quickly because fewer zooplankton were retained and the sample was much cleaner. At 1.5 knots (standard towing speed for MARMAP plankton hauls) there were no significant mesh-size differences in larval herring length frequencies.

Towing speed as well as mesh size influenced catches of zooplankton in the ICNAF series. Significantly greater displacement volumes of zooplankton were caught with .253 mm than with .333 mm mesh nets at 3.5 knots whereas there were no differences in displacement volumes at 1.5 knots (Colton, et al. 1980). However, the smaller and more abundant copepods (e.g., Adult Oithona and Pseudo-Paracalanus spp.) were caught in significantly greater numbers with the .253 mesh and a substantial portion of the food items for larval herring (invertebrate eggs, copepod nauplii, Oithona spp., and Pseudo-Paracalanus spp. copepodites) was not retained by either .253 or .333 mm mesh nets. It was noted that the design of the experiment (making all tows at one station at 1.5 knots, and all tows at the other at 3.5 knots) may have confounded results with between-station differences in zooplankton populations.

Avoidance

A good measure of avoidance of bongo nets by herring larvae is not yet available. The smallest size at which avoidance first becomes significant is not known but day/night differences in catches of larger larvae indicate that avoidance does occur. Graham noted significant avoidance of herring larvae >37 mm in the western Gulf of Maine series and it was suggested that this may be near the upper size limit for mortality estimates. Further analysis of the day/night differences in larval length frequencies should clarify the problem somewhat but it was noted that beyond some (unknown) threshold size some larvae will escape even the hight hauls, and therefore a day/night comparison cannot provide an absolute upper size limit. Inferring avoidance from larval reaction times was suggested but there is no good empirical data upon which to base such an estimate. A series of special sampling studies may be required to provide valid estimates of avoidance. In any case there should be an evaluation of the sensitivity of mortality rate estimates to bias from avoidance. The problem is less severe for relative comparisons between years with standard sampling, but even here variations in growth or size of larvae could confound relative measures of abundance or mortality. However, other sources of error, such as variable dispersal of larvae from inshore spawning grounds like Nantucket Shoals, may be a much larger and unmeasurable source of errors. Thus the relative importance of all sources of error in mortality and abundance estimates must be carefully evaluated before going ahead with an expensive new series of field studies.

Vertical Distribution

Only a few limited studies of vertical distribution of herring larvae have been done in the Georges Bank - Gulf of Maine region. One short series of sampling was done in an aggregation of recently hatched larvae in October 1974 using horizontal tows of small bongos. The larvae had a length frequency mode of 7 mm and were broadly distributed throughout the water column; larger larvae were found nearer the bottom (Lough 1975, ICNAF Res. Doc. 75/50). Vertical sampling was done in 1978 with the opening-closing samplers (MOCNESS) during the patch studies but results are not yet available. The possibility of larvae (and other zooplankton) using vertical movements as a means of retention in an area has often been suggested (North Sea, Georges Bank, etc.) but no confirmation of the hypothesis has yet been achieved. Analyses in progress of vertical and horizontal movements of chaetognaths on Georges Bank during the 1978 patch study, in relation to direct measures of tidal and residual currents, may give some cluse as to a retention mechanism.

Dispersal

So far only two papers have treated dispersal of herring larvae in the Georges Bank area in more than a cursory way. Bumpus (1976, ICNAF Res. Bull. 12) showed that net drift of larvae was generally southwest over Georges Bank which is consistent with mean advection. Lough et al. 1979 (ICNAF Res. Doc. 79/VI/112) examined changes in distribution from cruise to cruise in relation to EKMAN transport indices but no clear relationship emerged, possibly because the average interval (3 weeks) between ICNAF surveys was too long to observe effects of major wind events, and no special sampling was done immediately before and after major storms. Also it is quite possible that actual wind driven currents at depth on Georges Bank do not closely follow the theoretical EKMAN pattern. Nevertheless it was noted that over the entire ICNAF series (except for December 1975) herring larvae were largely restricted inside the 100 m depth contour on Georges Bank, throughout the period September-February. Very few larvae were observed outside this zone, either on the southern side of the Bank or off the northern edge. This suggests that massive losses of larvae may not be common. In December 1975 there appeared to have been transport of larvae north into the Gulf of Maine; but by February 1976 the larvae were back on Georges Bank in their usual distribution pattern. The possibility was noted that warm core eddies (derived from Gulf Stream meanders) impinging on southern Georges may entrain herring larvae. However, no evidence of such an event has been recorded yet; satellite pictures of rings didn't become available until late in 1975, the last year when there was a substantial population of herring larvae on Georges Bank. Also, after 1974 there was very little sampling in the central and western Gulf of Maine (except for Graham's inshore work) and there never was much sampling west of Nantucket Shoals; therefore, dispersal into these areas was not monitored after 1974 by ICNAF surveys. Some information is available from MARMAP cruises since 1975 but these did not cover the whole area regularly until 1977.

Drift of larvae from the southwest Nova Scotia spawning areas is typically northeast and into the Bay of Fundy, whereas larvae spawned off Grand Manan drift west. A thorough analysis of hydrographic and sea bed drifter data vs larval drift has not been completed for this area.

Sampling Variability

Analysis of the Bay of Fundy larval surveys by R. O'Boyle, M. Sinclair, and D. Iles, showed a much smaller variance in larval abundance estimates than for the Georges Bank surveys. A summary is presented here and the final paper is to be completed later.

Ichthyoplankton surveys to determine larval herring abundance have been run simultaneously in the Bay of Fundy (4X) and on Georges Bank (5Ze) since the early 1970's. The sampling intensity of these two surveys is markedly different. The station densities for the 4X and 5Ze surveys are approximately 51 and 269 sq. n. mi per station, respectively. For the 1972-75 period, the individual within year coefficients of variation for the 5Ze survey were almost double that of the 4X survey.

Both surveys were examined for their capability of predicting spawning production potential. The effect of calculation procedure (Saville, Sette, and Ahlstrom, Simpson, AM & GM means, etc.) on larval abundance estimates was first determined. For the Bay of Fundy survey, it was found that the geometric mean of station by station data produced the best correlation with the equivalent VPA production estimates. It was noted that as more corrections were applied to the larval abundance estimates, this correlation got worse. The procedure to generate the best VPA/egg production correlation in the 5Ze survey was that of Sette and Ahlstrom. However, it was noted that the Y-intercept method also provided acceptable results. For this survey, application of correction factors (back calculating from larvae to eggs) did increase survey prediction capability.

The coefficients of variation of the VPA/larval estimate ratios for the 5Ze survey were almost five times those of the 4X survey. To see if the latter survey could mimic the former survey's results, varying percentages of stations were chosen randomly from the grid and new abundance estimates calculated. It was found that the coefficient of variation of the VPA/larval estimate ratio remained below 40% until 10% of the stations were picked. The correlation coefficient of the VPA/larval abundance relationships dropped below 0.7 to 40% of the stations.

From the analysis, it is apparent that considerable attention has to be paid to the definition of station density for larval surveys for which the primary aim is to estimate spawning stock size. It was noted, however, that the larval herring data was consistent with the general pattern of results from sampling highly contagious distributions, i.e., there is a decline in precision per unit increase in sampling intensity. Also the frequency as well as station density of surveys must be taken into account, and this is difficult to do in a quantitative way without accurate knowledge of currents and actual dispersal of larvae. Finally it was noted that care must be taken when using only the level of correlation as a criterion for selection among a number of different correction factors applied to egg and larval abundance estimates. The best approach is to give greatest weight to those assumptions for which the best biological basis can be established (and for which actual data exist).

V. PLANKTON SAMPLE AND DATA PROCESSING

Sorting Procedures

Sorting protocols for ichthyoplankton (including herring larvae) and zooplankton used at the Polish Sorting Center were described briefly by R. Marak. These protocols are the same for both the ICNAF and MARMAP series and are outlined in appendix 1. The question was raised as to the accuracy of length frequency sampling of larvae - a subsample of 100 larvae picked out individually by sorters is used for estimating length frequency at the Sorting Center. The possibility of selection bias by sorters with this method is of concern as well as the precision of multi-model length frequencies. The chairman agreed to report on evaluations of these methods at the September meeting. The use of image analyzers (Narragansett) and digitizers (St. Andrews) for measuring larvae or zooplankton was noted.

George Bolz gave a preliminary report on the status of comparisons between .333 and .505 bongo samples from the ICNAF time series. In a number of cases the .333 samples had been pre-sorted for herring larvae before shipment to the Polish Sorting Center and the larval herring catches for these samples cannot be re-constituted. In such cases the .505 samples must be used for herring larvae. Bolz agreed to prepare a summary list of the exact status of each cruise in the ICNAF series for the September meeting.

Iles reported briefly on sorting protocols used at St. Andrews. The methods for fish larvae are basically similar to those used at the Polish Sorting Center except that larvae are selected by splitting samples rather than picking individuals by hand. Zooplankton samples are sorted by scientists in universities, each using his own methods, depending upon objectives. A summary report of the available data will be prepared for the next meeting of the Task Force.

Available Data Products

J. Goulet briefly reviewed the standard data products available for the ICNAF and MARMAP series. They include the following:

Station Activity Summaries	(ind. cruises)
Station Location Maps	(" ")
Cruise Track Maps	(" ")
Net Tow Data-haul factors	(" ")
Larval Length Summaries	(" ")
Zooplankton Volume Summaries	(" ")
Data Status Reports	(all cruises)
Selected Taxa Locations	(entire data base)

Most of these outputs for the 1971-1976 ICNAF surveys (.505 samples, herring larvae) were distributed to participants at the June 1977 workshop on ICNAF larval herring studies, Szczecin, Poland (see appendix 2). The standard summaries for .333 samples were completed in 1979 but as noted above, the evolution is still in progress as to which .333 samples cannot be used for larval herring length frequencies. In the meantime a general summary of the sampling methods and larval herring catch data for the .505 mm samples has been prepared for the entire ICNAF time series by Lough and Bolz (Northeast Fisheries Center, Lab. Ref. 79-60, 230 pp.). This report lists length frequency and abundance for each cruise, plots of distribution of catches (numbers /10 m^2/haul) for each cruise by two size categories, and plots of cruise tracks. It was noted that it may be desirable to publish a similar data report based on the .333 samples (to the extent possible) depending on the decision of the Task Force as to the utility of such a voluminous document.

VI. ZOOPLANKTON VS LARVAL FEEDING

R. Cohen presented a brief statement on the status of studies of larval herring gut contents and condition factors, and on zooplankton data from the ICNAF series. Work is still in progress on larval food habits during three complete spawning seasons and on subsamples (of stations from Georges Bank grid) of zooplankton data from .333 samples for the corresponding three years. A small subset of .165 mm samples has also been processed. An inventory of these data is given in Table VI-1, and a listing of mean abundance of all zooplankton species (including ichthyoplankton) taken with .505 mm mesh for the February 1976 cruise is shown in Table VI-2.

There appears to be a good correlation between larval gut contents and the .165 mesh samples as to species dominance. Centropages spp. was most abundant in one year and Pseudocalanus spp. and Calanus minutus were dominant in the other year. No day/night differences in gut contents were observed. A partial report on these data may be ready in time for the September meeting.

VII. LARVAL GROWTH AND MORTALITY

R. Lough reviewed the status of growth and mortality estimates for larval herring in the Georges Bank - Nantucket Shoals area. Preliminary estimates based on .505 mm samples were presented in ICNAF Res. Doc. 79/VI/112 but these are now under revision following better estimates of growth and the availability of the .333 mm sample data. A growth model using a Gompertz equation and otolith-based age data was described for herring larvae and a paper on growth will be presented at the September meeting. Also an attempt will be made to update the larval herring mortality estimates.

There was a general discussion of various ideas about the nature of larval growth and its relation to mortality. In particular the possibility of density-dependent growth was considered and the manner in which estimates of mortality would be affected by different assumptions regarding dependence of mortality on size or overwinter growth rates. Graham indicated that his studies in western Gulf of Maine support the notion that winter is a critical period for herring larvae, since spring abundance of larvae was correlated

Table VI-1. Inventory of larval herring gut analysis and zooplankton data base.

Vessel & Cruise	Code	Dates	Larval herring gut content & measurements	Data Summaries: Computer Files	Data Summaries: Analyses, Charts, Tables	Zooplankton .053	Zooplankton .165	Summaries: Computer Files	Summaries: Anal. Charts Tables	.333	.505	Data Summaries: Computer Files	Data Summaries: Anal. Charts Tables
1. Alb IV 73-09	6	04-20 Dec.								X		X	
2. Alb IV 74-02	5	11-22 Feb.								X		X	
3. Cryos 74-04	55	07-24 Sept.	X	X	X		X	X		X		X	
4. Wieczno 74-01	54	27 Sept-18 Oct					X	X		X		X	
5. Prognoz 74-01	17	18-30 Oct.	X	X	X					X		X	
6. A. Dohrn 74-01	53	16-23 Nov.	X	X	X		X	X		X		X	
7. Alb IV 74-13	4	04-19 Dec	X	X	X		X	X		X		X	
8. Alb IV 75-02	3	12-22 Feb	X	X	X	X	X	X		X	X	X	
9. Alb IV 75-05	49	13-22 May					X	X					
10. Bel. 75-02	52	25 Sept-08 Oct	X	X	X		X	X		X		X	
11. Bel. 75-03	51	17-30 Oct	X	X	X		X	X		X		X	
12. A. Dohrn 75-187	50	01-18 Nov	X	X	X		X	X		X		X	
13. Alb IV 75-14	2	05-17 Dec.	X	X	X		X	X		X		X	
14. Alb. IV 76-01	1	10-25 Feb.	X	X	X		X	X		X		X	
15. Wieczno 76-01	28	10 Apr-03 May	X										
16. Wieczno 76-03	31	14 Oct-03 Nov.	X	X			X	X					
17. A. Dohrn 76-02	32	15-29 Nov	X	X			X	X					
18. Researc. 76-01	33	27 Nov-11 Dec	X	X			X	X		X		X	
19 Mt. Mitch 77-01	34	13-34 Feb.	X	X			X	X		X		X	
20. A. Dohrn 77-01	35	15-21 Mar	X										

Table VI-2. Relative abundance of zooplankton on Georges Bank during February 1976 (ALBATROSS IV 76-01, 61-cm bongos, 0.505-mm mesh).

			Abundance[3]				Dispersion		
	Mean Rank[1]	Dominance[2]	Range	Mean/1,000M[3]	Variance	Standard Deviation	c.v. (s/x̄)	$s^2/\bar{x}$	Frequency of Occurrence
Centropages typicus	12.70	10/20	22-35,311	11,265	$9.5x10^7$	9,760	0.87	8,456.00	20/20
Sagitta elegans	11.65	7/20	0-46,048	9,222	$1.7x10^8$	13,114	1.42	18,648.00	19/20
Calanus finmarchicus	11.28	5/20	22-31,390	7,441	$6.8x10^7$	8,245	1.11	9,136.60	20/20
Metridia lucens	9.55	8/20	0-32,690	7,564	$1.6x10^8$	12,542	1.66	20,793.64	18/20
Pseudocalanus minutus	9.50	1/20	0-13,261	3,210	$1.7x10^7$	4,105	1.28	5,249.70	18/20
Limacina retroversa	8.60	1/20	80- 6,443	1,938	$4.2x10^6$	2,041	1.05	2,148.28	20/20
Centropages hamatus	5.58	1/20	0-14,029	2,178	$2.5x10^7$	4,978	2.29	11,377.60	11/20
Hyperiidea	4.88	0/20	0- 3,188	672	$9.3x10^5$	965	1.44	1,385.95	15/20
Gammaridea	4.68	0/20	0- 3,428	388	$5.3x10^5$	760	1.96	1,490.99	13/20
Crustacean larvae	4.48	0/20	0- 1,845	316	$2.8x10^5$	533	1.68	897.20	11/20
Candacia armata	4.40	0/20	0- 1,968	337	$2.5x10^5$	504	1.50	753.69	13/20
Unidentified calanoida	4.15	0/20	0- 1,841	373	$2.3x10^5$	484	1.30	626.60	15/20
Ammodytes dubius	3.90	0/20	0- 3,665	555	$1.2x10^6$	1,097	1.98	2,168.06	12/20
Neomysis americana	3.58	3/20	0-31,817	3,450	$7.4x10^7$	8,607	2.49	21,471.65	5/20
Vertebrate eggs (fish eggs)	2.72	0/20	0- 5,142	483	$1.4x10^6$	1,194	2.47	2,953.44	8/20
Polychaeta	2.50	0/20	0-10,517	684	$5.5x10^6$	2,340	3.42	7,996.80	8/20
Cumacea	1.72	0/20	0- 2,744	177	$3.7x10^5$	610	3.44	2,100.13	5/20
Unidentified Bivalvia larvae	1.68	0/20	0- 1,074	117	$8.4x10^4$	290	2.48	721.14	4/20
Meganyctiphanes norvegica	1.40	0/20	0- 824	61	$3.5x10^4$	187	3.05	569.16	4/20
Thysanoessa spp.	1.32	0/20	0- 477	49	$1.7x10^4$	131	2.70	352.30	4/20
Nannocalanus minor	1.10	0/20	0- 1,161	71	$6.8x10^4$	260	3.67	955.01	3/20
Euchaeta norvegica	0.88	0/20	0- 253	27	$4.9x10^3$	71	2.64	185.75	3/20
Centropages spp.	0.78	0/20	0- 637	45	$2.1x10^4$	146	3.23	472.40	3/20
Unidentified Harpacticoida	0.75	0/20	0- 457	47	$1.2x10^4$	109	2.31	252.30	5/20
Thaliacea (salps)	0.72	0/20	0- 338	17	$5.7x10^3$	76	4.47	338.00	1/20
Eucalanus attenuatus	0.70	0/20	0- 536	36	$1.5x10^4$	123	3.40	419.97	3/20
Porifera	0.70	0/20	0- 108	41	$1.9x10^4$	139	3.41	472.51	3/20
Acartia spp.	0.65	0/20	0- 184	19	$2.5x10^3$	50	2.59	130.28	3/20
Clupea harengus	0.60	0/20	0- 128	17	$9.9x10^2$	31	1.88	59.30	12/20
Rhincalanus nasutus	0.55	0/20	0- 536	27	$1.4x10^4$	120	4.47	536.00	1/20
Unidentified Cyclopoida	0.48	0/20	0- 123	12	$1.1x10^3$	33	2.77	91.90	3/20
Pteropoda sp.	0.48	0/20	0- 119	9	$8.3x10^2$	29	3.29	94.83	2/20
Rhincalanus cornutus	0.42	0/20	0- 357	18	$6.4x10^3$	80	4.47	357.00	1/20
Undinula vulgaris	0.30	0/20	0- 56	3	$1.6x10^2$	13	4.47	56.00	1/20
Tortanus discaudatus	0.25	0/20	0- 119	15	$1.4x10^3$	37	2.47	90.93	3/20
Temora longicornis	0.20	0/20	0- 89	4	$4.0x10^2$	20	4.47	89.00	1/20
Echinoderm larvae	0.20	0/20	0- 89	4	$4.0x10^2$	20	4.47	89.00	1/20
Rhynchocoela	0.20	0/20	0- 89	4	$4.0x10^2$	20	4.47	89.00	1/20
Unidentified fish larvae	0.18	0/20	0- 184	9	$1.7x10^3$	41	4.47	184.00	1/20
Sipunculid	0.15	0/20	0- 22	1	$2.4x10^1$	5	4.47	22.00	1/20
Crangon septemspinosa	0.12	0/20	0- 28	1	$3.9x10^1$	6	4.47	0.11	1/20
Caprellidea	0.10	0/20	0- 40	2	$8.0x10^1$	9	4.47	40.00	1/20
Anguilla rostrata	0.05	0/20	0- 1	<1	$5.0x10^{-2}$	0.22	4.47	1.00	1/20

[1]Species or taxonomic groups were ranked within each sample on the basis of numbers of individuals. Ranks for each species or taxonomic group were averaged over the 20 station samples. Highest density sample was assigned highest rank.

[2]Proportion of samples in which the species was among those making up 50 percent of the individuals.

[3]Range and mean of numbers of individuals per 1,000 M^3 of water in samples in which the species was found.

with subsequent recruitment to the sardine fisheries at least during the 1960's when spawning patterns were normal. Participants were urged to document the evidence for their hypotheses to help the Task Force sort out fact from speculation.

VIII. SPAWNING STOCK, LARVAL PRODUCTION, RECRUITMENT

Preliminary estimates of spawning stock size for Georges Bank - Nantucket Shoals were reported in ICNAF Res. Doc. 79/VI/112, based on back calculations from initial larval abundance estimates and assumptions about early stage larval mortality and hatching success. From 1972 to 1975 the larval production curves for Georges Bank - Nantucket Shoals combined, seemed to bear some resemblance to the VPA estimates of spawning stock, but prior to 1972 and after 1975 the larval production appeared to be inversely related to the spawning stock size. It was noted that there might not be a direct relation between egg production and spawning stock size, e.g., the USSR data suggests that egg production declined more rapidly than the spawning stock during the 1960's. A number of other sources of error might account for a lack of correlation but so far there has not been a definitive evaluation of the relative likelihood of error between the VPA and the back-calculated estimates of spawning stock. Major shifts occurred in the relative importance of Nantucket Shoals vs Georges Bank in larval production (see Figure VIII-1) but these were not consistent with available information on spawning stock size until 1977 and 1978 when no larval production on Georges Bank coincided with evidence of no spawning on the bank. Improved estimates of spawning stock and larval abundance estimates are now in progress and revised estimates are to be presented at the September meeting.

Spring abundance of larvae in coastal waters of the western Gulf of Maine was correlated with strength of year classes recruiting to the juvenile herring fisheries during the 1960's, but the correlation broke down in the 1970's. Graham noted however that taking account of overwinter mortality, timing of spawning (late spawning apparently enhances overwinter survival) and larval condition,together with larval abundance, can provide a useful prediction of year class strength. Documentation of this approach was planned for the next meeting.

It was noted that although Grand Manan historically had a large spawning stock until the turn of the century, in recent times the spawning stock in southwest Nova Scotia has been about 30 times as large as that off Grand Manan Island. Differences in potential retention areas for larvae were suggested as a possible factor but there is no evidence of a change in circulation to account for such an effect. In fact upwelling off Lurcher's Shoals would be expected to enhance survival potential on the average. Also it was noted that large losses of herring due to organisms causing paralytic shellfish poisoning have been observed off Grand Manan.

IX. PHYSICAL-CHEMICAL DATA

R. Wright briefly reviewed the physical-chemical observations taken on ICNAF larval herring cruises, and preliminary results related to circulation and larval dispersal. Figure X-1 shows the distribution in time of the physical-chemical data from the 1971-1977 ICNAF Larval Herring Cruises. Note that late winter coverage did not begin until 1973 and that parameters other than temperature were not routinely measured until the 1975 season. An inventory of data on nutrients, chlorophyll, and primary production measurements is to be presented at the September meeting.

Auxiliary data are available from biennial groundfish survey cruises (XBTs and surface salinity only), monthly SOOP runs across the Gulf of Maine (XBTs and surface salinity), and, since the fall of 1977, MARMAP I cruises 6-8 times yearly. In addition, from 1978 through 1980 an extensive current measurement program has been carried in the Georges Bank region by NMFS, WHOI, BIO, U.S. Geological Survey, and EG&G Inc. Such a program is not likely to be repeated.

Fig. VIII-1.

LARVAL HERRING INITIAL PRODUCTION ESTIMATES (>10MM LENGTH) GEORGES BANK (GB) AND NANTUCKET SHOALS (NS)[1/]

SEASON	AREA	NO. LARVAE X 10^{-11} SETTE AND AHLSTROM METHOD		SAVILLE METHOD
1968	GB & NS	-		15.4
1969	GB & NS	-		4.2
1970	GB & NS	-		55.9
1971	GB	48.5	(96%)*	
	NS	2.2	(4%)	
	GB & NS	50.7		27.2
1972	GB	18.9	(14%)	
	NS	110.7	(86%)	
	GB & NS	129.5		38.3
1973	GB	253.7	(56%)*	
	NS	200.2	(44%)	
	GB & NS	453.8		334.0
1974	GB	281.7	(86%)*	
	NS	44.9	(14%)	
	GB & NS	326.6		201.5
1975	GB	43.8	(34%)	
	NS	86.7	(66%)	
	GB & NS	130.5		88.7
1976	GB	0.5	(100%)*	
	NS	0.0	(0%)	
	GB & NS	0.5		0.14
1977	GB	0.04	(<1%)	
	NS	25.8	(99%)	
	GB & NS	25.9		19.1

1/ Condensed from Table 7, ICNAF RES. DOC. 79/VI/112.

Station spacing during the ICNAF cruises was adequate for general description of the distribution of variables and interannual differences, but not for examining details of features such as oceanic fronts nor short period fluctuations. Information on circulation is limited to inferences from distribution plots.

Preliminary review of the data has revealed some interesting features: persistent "cold" spots on the Northeast Peak of Georges and east of Cape Cod; breakdown of the shelf-slope front at the southeast corner of the bank; an unusually large influx of Slope Water in 1976 leading to high salinities on the bank in early 1977. Comparison with ichthyoplankton distributions may provide some insights into dispersal.

However, to begin to understand the mechanisms through which environmental variations affect larval survival, it will be necessary to construct and test specific hypotheses through intensive studies of small and meso-scale interactions such as the 1978 Larval Herring Patch Study. Further broad scale monitoring will be of limited value unless it is augmented by the results of such programs.

Two general analyses using the physical-chemical data from these cruises have been proposed:

1. A review of the general physical environment of the study region during the period covered, with discussion of interannual variations and their relation to meteorological developments.

2. A summary, based on current meter data as well as hydrography, of the evidence for the existence and persistence of the so-called Georges Bank gyre and the degree to which cataclysmic events like storms and warm-core rings may remove coastal water from the bank.

M. Ingham (Atlantic Environmental Group, Narragansett, RI) outlined other sources of oceanographic and meteorological data which are relevant to the larval herring problem. Average monthly wind stress and EKMAN transport indices are available by 3° and 5° grids from 1946 to present; however, the EKMAN indices should be calibrated by experiment at sea before attempting to apply rigorous analysis to the Georges Bank area. Surface weather observations are also available from coastal weather stations (1949 to present). Nantucket Island weather station is closest to Georges Bank and weather observations are available for every 3 hours daily from 1965-1977. Monthly average sea surface temperatures from shipboard are listed from 1946-1975 and monthly average temperatures at NOS tidal stations. Also XBT data are available from ships of opportunity from 1971 on. Finally, continuous plankton recorder runs are available in the Georges Bank - Gulf of Maine area along three transects.

W. Chamberlin (AEG) noted the importance of the position of the slope front and the occurrence of Gulf Stream eddies (warm core rings) to exchanges with shelf water. These features can be followed by sea surface temperature maps from satellite pictures and good imagery is available for the Georges Bank area at least since 1973. Estimated losses of shelf water from satellite imagery should be attempted and compared with larval dispersal and mortality indices.

J. Gagnon (MEDS) described the nature of the international oceanographic data files maintained by MEDS with particular reference to the ICNAF area. He noted that a catalogue of oceanographic data was under preparation for the Georges Bank area and would be completed in time for the September meeting. Sample computer listings for BT, CTD, and Nansen observations were handed out to participants.

X. DATA REPORTS ON ICNAF TIME SERIES

The possible value of data reports and/or atlases of both biological and physical-chemical data from the ICNAF larval herring program was discussed. There was general agreement that at least an inventory of all the types of data should be published for the entire series. However, the cost and effort of preparing a large atlas or data report is so large that a clear need should be identified for the specific outputs before the cost can be justified.

MEDS agreed to prepare a draft inventory of the physical-chemical data for the series and NEFC agreed to do the same for the biological data. The possible advantages of a combined inventory were considered.

It was noted that a comprehensive data report on larval herring catches (.505 mm mesh samples) had already been completed by the Northeast Fisheries Center in Woods Hole (Laboratory Ref. Doc. 79-60, 230 pp.). Such a document would be of value to anyone doing detailed studies on distribution and abundance of larvae; but in spite of its large size the document shows only two size categories in its distributional plots and the adequacy of these plots would depend on the exact questions being investigated. A data report in sufficient detail to meet all possible levels of refinement desired, would be out of the question. Thus there was a general consensus that the bulk of the data should be stored in a computer providing it is readily accessible. It was agreed to consider the problem further at the next meeting.

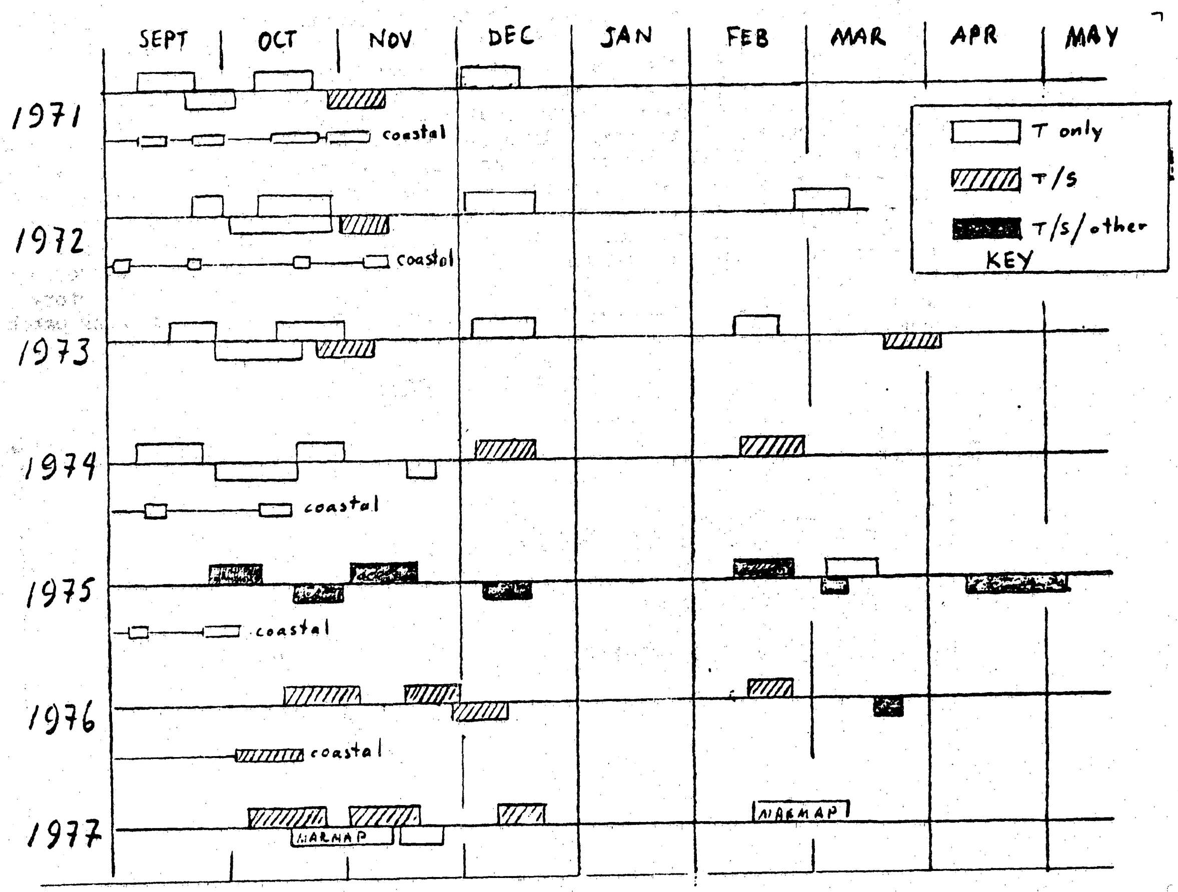

Figure X-1 Sampling of physical-chemical data in Georges Bank area during 1971-1977.

XI. PATCH STUDIES

Georges Bank

R. Trites summarized the physical oceanographic experiments conducted on the 1978 patch study on Georges Bank. He noted that residual currents decreased with depth from about 1 Kt near the surface to only 1/5 Kt near the bottom at 55 m. Tidal currents also decreased with depth but to a lesser extent. Also he reported a strong frontal zone along the northern edge of Georges Bank just north of historic herring spawning beds. The front oscillated back and forth with tidal cycles resulting in temperature variations as much as 6°C (6-12°C) over intervals of only a few hours.

R. Schlitz commented further on results of NEFC current meter data. Six current meter moorings were set along two longitude lines at water depths varying between 50-250 m, for varying periods up to a maximum of eight weeks. For about three weeks, data were recorded simultaneously at all six sites. The well-defined semidiurnal tidal ellipses on the bank were generally about four times larger than those over deeper water off the bank. The major and minor axes of the ellipses on the bank were about 18 km by 10 km during spring and 10 km by 6 km during neap tides. Residual currents, which diminished with depth, varied around eastward at all sites on the bank. A summary of the performance and data collected by each instrument and the residual currents are presented in a report on the patch study by Wright and Lough (ICES, C.M.

1979/L:36). At the northeastern mooring mean currents were north of east indicating the possibility of upwelling caused by divergence. Highest values (9-25 km/day) were recorded in the northernmost moorings and lowest values (2-5 km/day) in the shallow water where the column was vertically well mixed. The current meter records were consistent with other oceanographic data, which reveal the existence of a marked, eastward flowing jet positioned along the boundary between the vertically well mixed bankwater and the stratified water north of the bank. Linear shear of 1.2 cm/sec/10 m for the residual current (Figure XI-1). was observed at mooring 6 for three consecutive current meters on the array. All the meters were therefore outside the boundary regimes. The mid-depth linear shear was confirmed on at mooring 1 (1.9 m/sec/10 m) for the instruments at 30, 40, and 75 m. Temperature records from the current meters indicate that the front remained north of the southern moorings but occasionally crossed the positions of the middle moorings. An inventory of all the physical oceanographic data collected during the Georges Bank patch study was prepared by A. Allen.

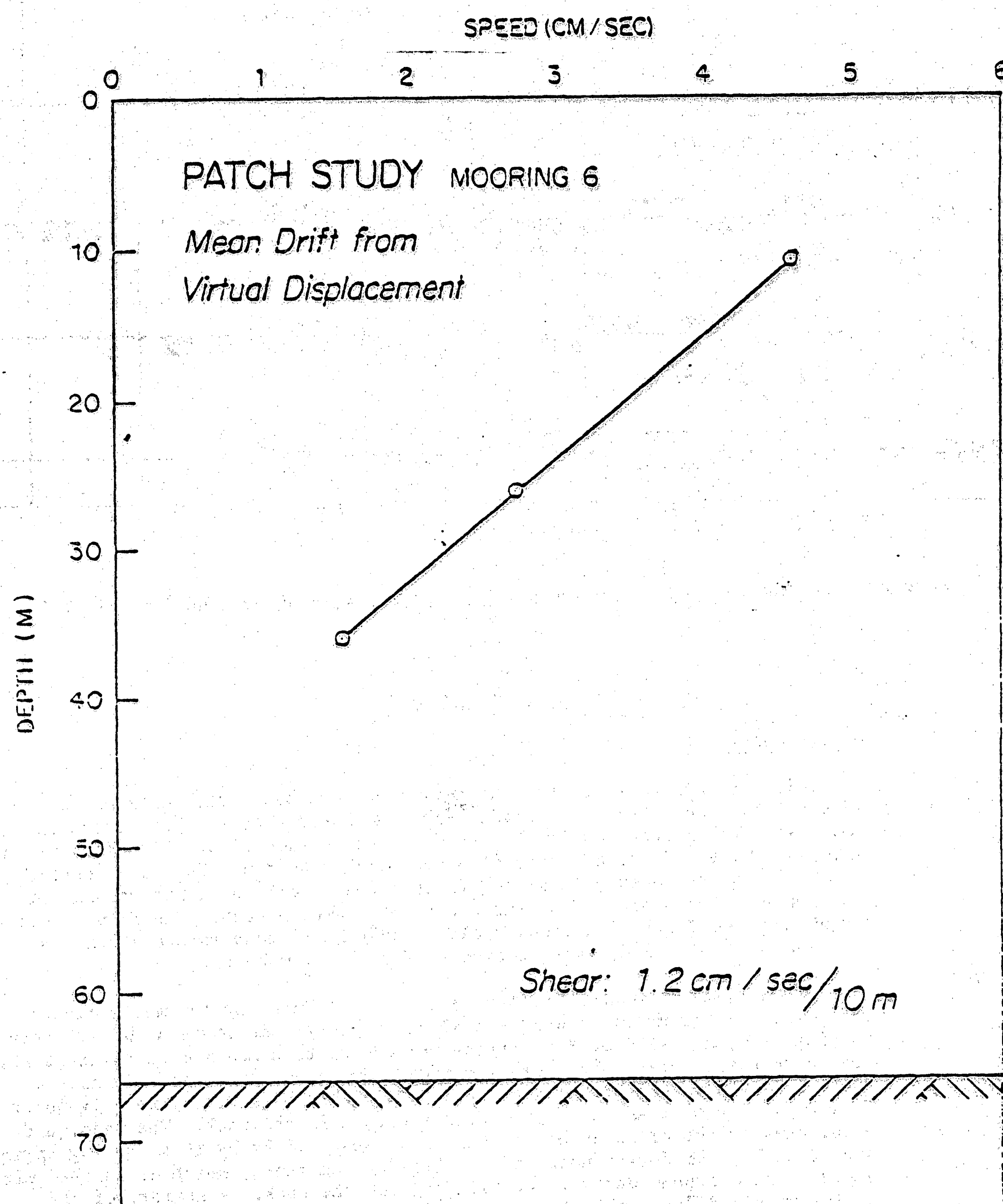

Figure XI-1. Mean residual speeds for current meter data at mooring 6 during the Patch Study.

T. Whitledge and M. Dagg (Brookhaven National Laboratory, Long Island) outlined their October 1978 studies of phytoplankton production and zooplankton grazing on Georges Bank (Figure XI-2). These studies were part of a continuing series on plankton production dynamics on the New England Shelf but an attempt was made to synchronize the 1978 study with the patch study. Results will be forthcoming in future reports by Brookhaven.

North Sea

H. Hill presented a summary of the methods and general results of the plaice egg and larval patch study program in the North Sea. Intensive high speed surveys have been used successfully in monitoring the production, drift and fate of plaice larvae up until they move into estuarine areas.

XII. HYPOTHESES ABOUT RECRUITMENT

A general discussion was held on how to approach the problem of testing hypotheses about factors controlling recruitment in sea herring. A matrix of hypotheses and relevant biological and physical factors developed for the Flemish Cap program (ICNAF Res. Doc. 78/VI/80) was used to facilitate discussion. There was general agreement on the need for such a framework to provide a checklist and an aid to thinking, but a wide variety of opinion was expressed as to the feasibility or virtue of attempting to deal with such a large matrix for distinguishing cause and effect. Since multiple factors may very well be involved the question was raised as to how the affects of any single factor could be distinguished or how any one hypothesis could ever be tested. Given multiple factors it may only be possible to monitor characteristics of the recruitment process for a long time in hopes some insight may be achieved; but there is uncertainty as to what should be monitored since it is not possible to monitor everything with precision.

In spite of the obvious difficulty of the recruitment problem some members of the group agreed that it may be possible to narrow down the range of possible factors and to evaluate the relative importance of certain factors by means of a comprehensive synthesis and critique of available data and hypotheses. Grosslein and O'Boyle agreed to try to prepare such a synthesis in time for the September meeting.

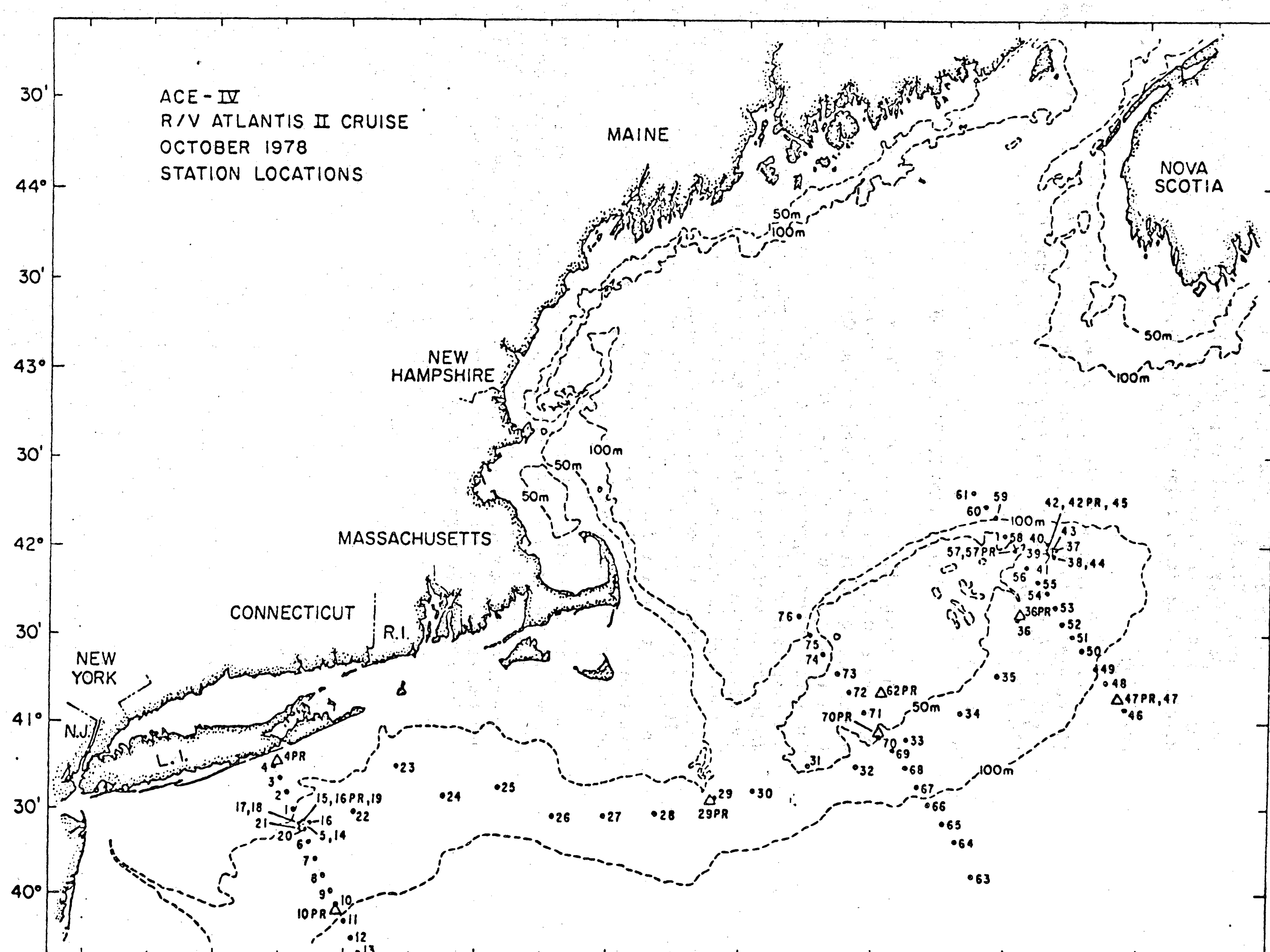

Figure XI-2. Stations occupied by Brookhaven National Laboratory.

Appendix 1

SORTING PROTOCOL FOR MARMAP ICHTHYOPLANKTON SERIES
(Extracted and abbreviated from MARMAP Survey I Manual)

(Steps 1, 2, 3 are the same for zooplankton analysis if done separately.)

1. Sample is poured into tray -- any tar and plastic contaminants are removed and placed in jars -- tar is weighed and amount recorded on Zooplankton Volume Log for transcription to IOC/WMO IGOSS Log. Plastics are identified and logged as described in MARMAP Survey I Manual.

2. Remove all non-plankton organisms. The names and quantities (number or volume) are recorded on the Zooplankton Volume Log. Place organisms in jar and label.

3. All planktonic organisms greater than 2.5 cm are removed from sample, volumized, identified to lowest taxonomic level, measured, vialed and recorded on ZIW. This log should be stapled to ZIW with data on organisms less than 2.5 cm.

4. Displacement volume is determined and recorded on Zooplankton Volume Log.

5. Total sample is sorted for fish eggs and larvae by one sorter-identifier. A recheck (2 additional scans) is made of the sorting disk to ensure all fish eggs and larvae have been removed.

6. Each dish of sorted organisms is checked for final identification by senior staff members.

7. The contents of each dish are enumerated and/or measured and entered on the MARMAP Plankton Sorters Worksheet.
   a. Total number of heads and tails
   b. Total number of disintegrated larvae
   c. Total number of eggs
   d. Total number of larvae.

8. A random selection of sorted samples (about 10%) are reexamined by a sorter other than the original sorter for the presence of any eggs or larvae. If any are found they are entered on an additional work sheet which is attached to the original.

9. Identified larvae are measured (standard length) to the nearest 0.1 mm. All specimens of a species, up to 100 are measured from any sample. If there is doubt that these data are not representative of the size frequency distribution of the total specimens then more measurements are made. Head and tail sections may possibly be identified and these data are recorded separately from whole specimens.

10. The above data -- name, bionumeric code, and length are entered on the Ichthyoplankton Data Record -- Larvae.

11. Each group of organisms is placed in one or more vials. Labels are placed in and on the cap of each vial and the vial capped.

12. The vials of each station are arranged in numerical order in small cardboard boxes with vial dividers and distributed for further analysis or archiving.

SORTING PROTOCOL FOR MARMAP ZOOPLANKTON SERIES

(Extracted and abbreviated from MARMAP Survey I Manual)

(Steps 1, 2, 3 are the same for ichthyoplankton analysis if done separately).

1. Sample is poured into tray -- any tar and plastic contaminants are removed and placed in jars -- tar is weighed and amount recorded on Zooplankton Volume Log for transcription to IOC/WMO IGOSS Log. Plastics are identified and logged as described in MARMAP Survey I Manual.

2. Remove all non-plankton organisms. The names and quantities (number or volume) are recorded on the Zooplankton Volume Log. Place organisms in jar and label.

3. All planktonic organisms greater than 2.5 cm are removed from sample, volumized, identified to lowest taxonomic level, measured, vialed and recorded on ZIW. This log should be stapled to ZIW with data on organisms less than 2.5 cm.

4. Aliquot sample for ½ archive and ¼ dry weight and jar.

5. Continue aliquoting to approximately 500 organisms noting final split (1/32, 1/64, etc.).

6. Identify all organisms to lowest level possible (a ten minute limit on "rare" species is reasonable). Count total of each species.

7. Dominant species (those whose total number equal 10% of the aliquoted samples) are vialed separately (1 species per vial). All other (those under 10%) are placed in one vial.

8. All information is entered on ZIW sheets by species including name, code number, developmental stages (052-000, etc.), vial number and total number of each species.

APPENDIX 2

Report of a workshop on Georges Bank larval herring studies, Szczecin, Poland, 20-23 June, 1977.

by M. D. Grosslein (Chairman); W. G. Smith (Rapporteur)

I. INTRODUCTION

A workshop was held in Szczecin from 20-23 June, 1977, to review status of the larval herring studies on Georges Bank. The principal purpose of the meeting was to review progress ofthe sorting and data processing, and to discuss analysis of the time series of ICNAF surveys from 1971 to 1976. In addition, plans for possible future research on larval herring were also discussed but commitments of vessels or scientists were not considered.

This workshop represented a continuation of the work begun in 1974 by the ICNAF Environmental Working Group, which had focused attention on the Georges Bank larval herring studies as well as the need for similar work on Flemish Cap. The third and final meeting of the Environmental Working Group was held in Szczecin in April 1976 and its report was presented in ICNAF Summ. Doc. 76/VI/36. Shortly thereafter at the 1976 annual ICNAF meeting the Environmental Working Group was terminated and its functions reverted back to the parent Environmental Subcommittee of STACRES. With the withdrawal of USA from ICNAF in December 1976 it was no longer possible for the Northeast Fisheries Center or for the Task Force Leader of the larval herring surveys (M.D. Grosslein, USA) to have a functional role within ICNAF. However, it was essential to continue the scientific work related to the larval herring, particularly the processing and analysis of the backlog of the 1971-76 time series which represents an extremely valuable data base for both biological and physical characteristics of Georges Bank. Thus, the present workshop was organized outside the official framework of ICNAF.

Participants in the workshop included scientists from Poland, USSR, Federal Republic of Germany, German Democratic Republic, and USA (see list of participants, Annex 1). Discussions were organized around a preliminary agenda (see Annex 2) which was generally followed except for a few additions which are noted in the text of this report. It was agreed that the chairman should write up a summary of the discussions (aided by notes from the Rapporteur) and circulate these to all participants for comments before preparing a final report. Also it was agreed that all written documentation presented at the workshop should be referenced in the final report; a list of all papers or handouts is given in Annex 3.

The first day of the meetings was held at the Fisheries Central Board, and subsequent sessions were held at the Sorting Center where participants had an opportunity to observe sorting procedures first hand and to talk with members of the Center Staff. Formal meetings with all participants were held from 20-22 June, and informal discussions on future work were held on 23 June involving a few participants and including the chairman. The following report is arranged about in the same order as the attached agenda, although some of the discussions actually occurred in a different order.

II. LARVAL HERRING SURVEYS - OCT. '76 TO MARCH '77

M. Grosslein presented a brief progress report on the most recent surveys (attachment #4). Seven larval herring cruises were conducted between October '76 and March 1977, by USA, Poland, Federal Republic of Germany and USSR, using standard ICNAF sampling protocol with Bongo and neuston nets. Nutrients and primary productivity were obtained on five of these seven cruises. In addition, night plankton hauls were made in March and early April on R/V Goerlitz by the German Democratic Republic during the juvenile herring trawl survey. The 1976 larval herring production on Georges Bank was the lowest observed to date, with winter '76-77 densities of larvae about on order of magnitude lower than those observed during the three previous winters.

III. STATUS OF ICNAF LARVAL HERRING DATA BASE - '71 TO PRESENT

A. Scope of ichthyoplankton and zooplankton data base.

R. G. Lough outlined the scope of the ICNAF larval herring time series. A total of 49 cruises were conducted since 1971, on which basic sampling at each standard station consisted of paired 60 cm Bongo hauls (.505 mm and .333 mm mesh), temperature profiles, and usually salinity samples at selected depths (at least surface). During the first two years (1971 and 1972) sampling extended from September to December. Beginning in March 1973 the Federal Republic of Germany began night sampling of larval herring with Bongos and neuston nets concurrent with their daytime trawling for juvenile herring.

In February 1974 the US began the February series of cruises which provided overwinter mortality estimates.

In the autumn of 1974, paired 20 cm Bongos with smaller mesh sizes (.253 mm and .053 mm) were added to the standard 60 cm Bongo array; in 1975 and thereafter the 20 cm Bongos used .253 mm and .165 mm mesh. Also in the autumn of 1974, O_2 measurements were added to the hydrographic sampling on a fairly regular basis. Beginning in 1975 sampling expanded further to include nutrients, chlorophyll and primary production, and at the same time the area of coverage was restricted tothe Georges Bank-Nantucket Shoals region to allow more intensive sampling of this area on each cruise. Status of hydrographic nutrients and primary productivity data is reviewed in a later section.

So far, sorting has been mostly on the .505 mm and .333 mm samples. The .505 samples have been sorted chiefly for larval herring by the various participating countries and not by the Sorting Center at Szczecin. Information on other constituents of the .505 samples (other fish larvae and zooplankton) as well as total zooplankton biomass has been obtained on some cruises, but only larval herring were sorted for the entire series of .505 samples. The Sorting Center has concentrated on the .333 mm mesh samples which were supposed to have been untouched and shipped to Szczecin; the status of processing these samples is presented below.

Analysis to date has been restricted largely to the .505 series and to the length frequency and distribution of herring larvae. Preliminary estimates of larval production were made at previous ICNAF meetings (1972-75) for each year 1971 to 1974 by pooling results of cruises within each year, but no overall synthesis of the .505 series has yet been made. This June the US completed entry and quality control of the .505 larval herring data series, and standard data listings were presented at this meeting for 31 cruises covering the Georges Bank area (see below for details).

B. Standard Computer Outputs, larval herring .505 mesh.

R. G. Lough presented standard computer outputs for the basic time series of 31 cruises which cover the Georges Bank area, September through February, 1971 to date. These outputs included individual station sample records, station and cruise plots and the .505 mesh larval herring catch data (number per 10 m^2 by 1 mm and 5 mm size classes) for each station (see Table 1).

App. Table 1. Standard Computer Outputs (Larval herring .505 mesh)

ESSEL	CRUISE[1] NUMBER	LENGTH CONVEN-TION[2]	NET TOW DATA	STATION ACTIVITIES SUMMARY	STATION POSITION PLOT	CRUISE TRACK PLOT	LARVAL FISH SUMMARY HERRING LARVAE No./$10m^2$	
							1 mm size classes	5 mm size classes
Albatross IV	71-07	SL'	+	+	+	-	+	+
	72-09	SL'	+	+	+	-	+	+
	*73-09	SL'	+	+	+	-	+	+
	*74-13	SL'	+	+	+	-	+	+
	*74-02	SL'	+	+	+	-	+	+
	*75-02	SL'	+	+	+	-	+	+
	*75-14	SL'	+	+	+	+	+	+
	*76-01	SL'	+	+	+	+	+	+
Anton Dohrn	*72-01	TL	+	+	+	-	+	+
	*74-01	SL	+	+	+	-	+	+
	*75-187	SL	+	+	+	+	+	+
	76-02	SL'	+	+	+	+	+	+
Cryos	*72-01	SL(SL'?)	+	+	+	-	+	+
	*72-02	SL(SL'?)	+	+	+	-	+	+
Belogorsk	*73-01	SL(TL?)	+	+	+	-	+	+
	*75-02[3]	SL	+	+	+	+	+	+
	*75-03[3]	SL	+	+	+	+	+	+
Cryos	71-01	TL' ?	+	+	+	-	+	+
	*73-01	TL'	+	+	+	-	+	+
	*74-04	SL'	+	+	+	-	+	+
Delaware II	*71-04	SL'	+	+	+	-	+	+
Mt. Mitchell	77-01	SL'	+	+	+	+	+	+
Prognoz	*74-01	SL(TL?)	+	+	+	-	+	+
Researcher	76-01	SL'	+	+	+	+	+	+
Viandra	71-01	SL	+	+	+	-	+	+
Walther Herwig	*71-01	SL	+	+	+	-	+	+
	*73-43	SL	+	+	+	-	+	+
Wieczno	*72-01	TL'	+	+	+	-	+	+
	*73-40	SL	+	+	+	-	+	+
	*74-01	SL	+	+	+	-	+	+
	76-03	SL'	+	+	+	+	+	+

? indicates insufficient data available

1 as of July, 1977, .333 mesh samples sorted for total ichthyoplankton for cruises with asterisk(*).

2 SL = standard length to mm below; SL' = std. length to nearest mm;
TL = total length to mm below; TL' = tot. length to nearest mm.

3 0.333 mm mesh larval herring data outputs.

Workshop participants examined these outputs and copies of all outputs were made available to representatives from the laboratories at Gdynia, Szczecin, Kiel, and Kaliningrad. Outputs of the .505 series are also to be supplied at a later date to the laboratories at St. Pierre and Rostock. The suitability of the format and content of these outputs were discussed, and suggestions for improvements were requested. Dr. Schnack noted that the length measurement convention should be included on the output (e.g. standard length to the mm below). In fact the length measurements for the .505 series were not standardized and there was still some doubt about the exact convention used on USSR data. Participants are asked to confirm conventions indicated in Table 1. G. Joakimsson raised the question as to the exact length measurement procedures used at the Sorting Center and this matter is treated later in this report.

It should be noted that cruise tracks were not plotted for most surveys (see Table 1) because the data were taken chiefly from ICNAF larval herring data summary sheets which did not include time and date of each station; however, the tracks are available in ICNAF research documents for individual cruises (see bibliography, Annex 3). In addition it was noted that other data were also missing from some stations on some cruises, namely, flowmeter readings or maximum depth of tow, etc., and in some instances numbers of herring larvae by 1 mm or 5 mm size classes. It is desirable that these missing records be sent to Woods Hole so that the computer file can be completed. Time and date of each station are necessary in order that the computer can plot cruise tracks, or make separate plots of stations occupied during short periods within a given cruise. The basic station data will also apply to the .333 mesh samples, and therefore it is important to complete the computer file insofar as possible prior to production of standard computer outputs for the .333 mesh series. Representatives at the workshop from each country with cruises shown in Table 1 were asked to provide the missing data in the near future. The most convenient way would be to record the missing data on the computer output sheets for the .505 series, namely, the station activities summary and the larval herring summary sheets, and copies of these sheets with corrections should be sent to Woods Hole in the near future (c/o Dr. R. G. Lough).

There is one problem of inconsistency in the numbering of stations between the ICNAF and MARMAP protocols; the ICNAF series has used standard station numbers whereas the MARMAP series used consecutive station numbers. Scientists outside the US have become used to the ICNAF system, and since they have no direct access to the computer find it much more convenient to plot and analyze new results in terms of standard stations. The question arose whether it would be feasible to prepare a station index for each cruise listing both the ICNAF and MARMAP station numbers. It is not practical to generate computer plots of cruise tracks with standard station numbers, and neither is it feasible to predict and produce on the computer all the possible plots (species, size categories, space-time constraints, etc) which someone might want to have in the future. For these and other reasons a number of the scientists said they would probably continue to use the ICNAF standard station system for some time for those studies which they can do by hand plotting and analysis. L. Ejysmont noted that he had a listing of the occurrence of fish larvae (all species) on a station by station basis for each cruise. A number of people indicated an interest in having access to this list and it was suggested that the Sorting Center prepare and maintain a reference collection list which could be made available on request. Ejysmont agreed to do this but noted that it would be some time before the list could be completed for cruises sorted to date.

C. Status of Sorting and Computer Processing .333 mm Samples

L. Ejysmont briefly reviewed the sorting status of the .333 samples. All but eight of the 31 cruises have been sorted for total ichthyoplankton (Table 1). Of these eight cruises, four are from the 1976 spawning season (ANTON DOHRN 76-02, MT. MITCHELL 77-01, RESEARCHER 76-01, WIECZNO 76-03) and it was decided they should get top priority at the Sorting Center. Second priority was assigned to the remaining three cruises (ALBATROSS IV 71-07, 72-09 and VIANDRA 71-01); the .333 mm samples from CRYOS 71-01 were destroyed. Some larvae had already been removed in Kaliningrad from .333 samples of VIANDRA 71-01, and Dr. Ejysmont noted that he needed either the actual specimens or the records of what had been removed from these samples (for each individual station) before he could complete this cruise. It was estimated that the sorting of all remaining seven cruises for total ichthyoplankton (about 600 samples, .333 mesh) would be completed by December, 1977. None of the ichthyoplankton data for .333 mm samples has been entered into the computer as yet, and much of the coding of OPSCAN forms remains to be done for sorted cruises. It is now expected that standard computer outputs for the .333 species (total ichthyoplankton) will be available by early summer, 1978.

G. Joakimmsson noted that the 1971 surveys were not comparable to the subsequent surveys because of the following factors on some or all of the 1971 cruises:

1. Nonstandard plankton nets - .300 mm mesh instead of .333 mm mesh nets, .500 mm mesh vs. .505 mm mesh, and lack of cylinder extension on Bongo nets (present on subsequent nets).
2. Nets towed directly behind vessel in the wake instead of off the side of vessel.
3. Step-oblique tow to 200 m instead of a continuous oblique to 100 m maximum depth.
4. Faster retrieval rates.
5. Different station grid and some positions doubtful.

While the above differences preclude strictly quantitative comparisons between 1971 and subsequent years, it was noted that qualitative comparisons of distribution and relative abundance of larvae and zooplankton will still be valuable. Thus, it was decided to finish sorting the .333 samples from the 1971 cruises listed in Table 1, after completion of the 1976 samples.

With respect to zooplankton sorting of .333 samples, progress has been very much slower than for ichthyoplankton because of the much greater sorting time per sample and because so far only about one fourth of the Sorting Center Staff is trained for sorting zooplankton. Of the 31 cruises shown in Table 1 only two were completed at the time of the workshop (ALBATROSS IV 75-02 and BELOGORSK 75-02), and a third was nearly complete (BELOGORSK 75-03). In view of the clear need for accelerating the sorting of zooplankton, a special workshop is scheduled for August, 1977, to develop ways of drastically reducing sorting time for zooplankton. The five zooplankton sorters from SZCZECIN will go to Narragansett to work with USA scientists on this problem. In the meantime whatever portion of the Center's effort is directed toward zooplankton; first priority should be given to analysis of the December to February period in the 1973 1973-75 seasons because differential growth and overwinter mortality of herring larvae was observed in those years and because .333 mesh samples in these months are more likely to provide a quantitative index of the abundance of the larger food organisms for herring larvae; the .333 mm mesh is too large to provide quantitative measures of abundance of all larval food organisms during the October cruises and probably November as well. Second priority should be given to the fall cruises of the 1974 and 1975 spawning season. In addition to the differential larval growth and mortality in those years, fine mesh samples also are available for subsequent analysis of relative abundance of some smaller zooplankton than are retained by the .333 mesh. Third priority is given to the most recent cruises, December, 1976 and February, 1977. The list of cruises incorporating these priorities is given in Table 2.

App. Table 2. List of cruises in order of priority for Sorting Center, .333 mm samples for zooplankton (Georges Bank and Nantucket Shoals only).

1.	Albatross IV	75-14
2.	"	76-01
3.	"	74-13
	"	75-02 (completed)
4.	"	74-02
5.	"	73-09
	Belogorsk	75-02 (completed)
	"	75-03 (nearly completed)
6.	Anton Dohrn	75-187
7.	" "	74-01
8.	Prognoz	74-01
9.	Wieczno	74-01
10.	Cryos	74-01
11.	Mt. Mitchell	77-01
12.	Researcher	76-01

Discussion occurred at several points during the workshop on the problem of sorting priorities between ichthyoplankton and zooplankton for the ICNAF .333 mm samples. There was general consensus that the Sorting Center should continue to give first priority to sorting total ichthyoplankton until the present backlog was finished (by December 1977), and that it would be desirable to keep up with ichthyoplankton from standard larval herring surveys which are planned for the next two years as well as some portion of the larval patch studies which are also scheduled. However, at the beginning of next year (1978) it would clearly seem desirable to bring the ratio of zooplankton to ichthyoplankton sorters more into balance at the Center. This could be done and still keep up with the ichthyoplankton from the projected standard larval herring surveys on Georges Bank, but perhaps not all other parts of the ICNAF ichthyoplankton backlog (Gulf of Maine region and March-April cruises) or the patch study samples. There will be a better basis for evaluating priorities in 1978 after considering results of the August 1977 workshop and extent of the task of converting ichthyo - to zooplankton sorters.

D. Phytoplankton.

Stefan Grimm presented a brief report on phytoplankton studies for the Georges Bank area by Zofia Ringer of Gdynia. Dr. Ringer has analyzed species composition of phytoplankton samples taken on Georges Bank during larval herring cruises in April 1976 (12 stations), October 1976 (10 stations), and April 1977 (12 stations). Most of the analyses to date have been based on net samples (50 micron mesh?) and therefore are only qualitative. Quantitative samples (from water samples) were also taken but processing of these had not been completed. A written report (in Polish) on the methods and results for the April '76 cruise, as well as some notes on work accomplished to date on the other cruises, were given to the chairman. They were subsequently translated and are appended here as attachments #6 and #7. Inquiries about these preliminary results should be addressed to Dr. Ringer.

Seasonal and geographic (Georges Bank vs Nantucket Shoals) variations in phytoplankton were observed but the dominant forms were for the most part typical of this region based on earlier studies, and included Bacillariophyceae (89 species), Dinoflagellates (23 species), and Silicoflagellateae, Pyrocystae and Cyanophyceae (15 species). However, in spring 1977 a bloom of toxic bluegreen algae (Gleocapsa) was observed to a depth of 50 m coincident with the absence of phytoplankton in the region of the Argo Merchant oil spill on Nantucket Shoals. Also damaged or dead phytoplankton cells were observed at some stations.

There followed a general discussion of the need for more comprehensive work on phytoplankton. It was noted that Dr. Ringer was interested in continuing her work on Georges Bank but as yet could not predict how many samples she could process in a year. Identifying and counting phytoplankton cells is a laborious task and Dr. Ringer will be able to document the time requirements of her methods in her next report. Dr. Gruzov reported that some work was in progress on Georges

Bank phytoplankton in Dr. Noskov's laboratory at Kaliningrad, and also that there was some expertise in phytoplankton in his own laboratory. It was agreed that the US and USSR scientists would explore the possibility of expanding their studies of the abundance and species composition of phytoplankton communities for the Georges Bank area. The possibility was discussed of automating most of the task of counting cells with an electronic instrument. Such techniques and instruments exist but apparently are not now available in any of the laboratories represented at the workshop; it was recommended that this approach be investigated.

E. Hydrography.

M. Grosslein presented a brief report on the status of the hydrographic and primary production data base for the ICNAF time series (see attachment #4). With regard to the basic hydrographic data, temperature-salinity-oxygen records for all years and countries have been compiled in Woods Hole but not yet integrated into a single computer file. This job is to be completed this summer after which analysis of the time series can proceed more rapidly. At present there are plans for the Marine Environmental Data Service of Canada to produce a hydrographic atlas series for the larval herring cruises. This atlas would include whatever plots of temperature and salinity were considered important for comparison with larval distributions.

Nutrients, chlorophyll and primary production measures have been collected since 1975 and some preliminary data reports have been completed. These reports have not yet been issued because there is some concern about possible bias in some of the data. Possible bias in nutrient samples may have arisen from use of unfiltered water samples and from prolonged storage in some cases. With respect to primary production, the recent levels were very much higher than those reported in the literature and the possibility of differences in technique is being evaluated. These analyses are still in the preliminary stage and the first summary report is not expected until June 1978 (see status of processing and analysis in Table 2, attachment #4).

IV. RESULTS OF ANALYSIS

A. Summary of previous work.

A very brief overview of the results of the larval herring time series was given by R. Lough. Larval production was low in 1971 and 1972, high in 1973 and 1974, intermediate in 1975, and extremely low in 1976. The spawning-hatching period has become later each autumn during the period 1971-76. Estimates of larval growth and mortality during three winters (i.e. comparisons of December and February cruises) have indicated a possible inverse relationship between the two parameters.

A list of references on herring larvae in the Northwest Atlantic compiled by R. Lough is given in attachment #5. This list supposedly contains all the known papers derived from the ICNAF larval herring series. If there are additional papers please write to Dr. Lough so that the reference list may be completed.

B. New Results.

R. Lough presented a preliminary report (attachment #8) on age and growth measurements of larval herring based on analysis of otoliths. A good correlation was found between larval length and otolith growth increments, and the regression indicated that otolith ring formation began at a larval length of about 7 mm, the size of herring larvae at time of yolk sac absorption. The data were consistent with the assumption that each otolith growth increment represents one day, and after adjustment for the period from hatching to yolk sac absorption, there was a close relationship between larval length and age (in days). Growth rate estimates based on these data were comparable to those observed for larval herring in other areas. Also there may be a possibility of distinguishing between larvae spawned at different places in the Gulf of Maine region on the basis of careful analysis of their otoliths.

A report (attachment #9) on zooplankton composition, abundance and distribution on Georges Bank during February 1975 and 1976 was summarized by R. Lough. Samples from twenty stations (.505 mm mesh) on each February cruise were sorted for all major taxonomic groups and total displacement volumes were obtained. Zooplankton volumes were higher and more uniformly dispersed in '76 than in '75, and the mean density of zooplankters was also higher in '76. Copepods and chaetognaths were the two most abundant groups in both years and both were more abundant in February '76 than in February '75. Species diversity (Simpson and Shannon-Weaver Indices) was basically similar between the two years, and stations with greatest diversity occurred near the center of Georges Bank in both years. The most abundant larval fish in both years was Ammodytes dubius. Larval herring distribution and abundance was similar in both years but it was noted that growth was greater (and mortality lower) in '76 than in '75. A brief discussion took place on the possible relationship between the observed zooplankton abundance and larval herring growth and mortality. A question was raised as to the possibility of Sagitta predation on herring larvae, but it was pointed out that the larvae were too large at this time of year to be consumed by Sagitta. Also it was noted that the .505 mm mesh samples did not contain the smaller size groups of zooplankton which are important as food of smaller larvae and therefore these data may not provide a definitive relationship between food abundance and larval growth. The principal purpose of the paper was simply to document distribution and relative abundance of the larger forms of major zooplankton groups in mid-winter, a time when larval mortality may be critical, and it was agreed that this was a very useful first look at the winter zooplankton community.

A second preliminary zooplankton study (attachment #10) on fine mesh (.165 mm mesh) samples was reviewed by Lough. Four stations from an ICNAF survey were sorted and numbers of each life stage of each copepod species were recorded; in addition length frequencies of various stages of the dominant species, Pseudocalanus minutus, were documented. As would be expected, total numbers of zooplankton per m^3 were very much higher in the fine mesh than in the larger mesh (.505) samples. Also it was noted that all copepodite stages of P. minutus except $C_7$1 were fully represented in the samples. Several interesting features of the size frequencies of the various stages of P. minutus were indicated in the paper and it was clear that useful quantitative measures of larval food abundance could be obtained from .165 mm mesh samples providing samples were screened for clogging. Discussion focused on the time and labor involved in processing fine mesh material. Lough indicated that it took about 7 man-days to sort one sample, and this included identifying and counting all zooplankton species from an aliquot, and measuring all stages of Pseudocalanus minutus. Sherman noted the need to explore ways of reducing the processing time by automating such processing with particle size counters and subsampling stations.

Another study was reported by Lough which compared vertical distribution of recently hatched herring larvae on Georges Bank and Jeffreys Ledge, and described the respective zooplankton communities with particular reference to prey and predator organisms (attachment #11). Vertical series of 20-cm Bongos with .333 and .053 mm mesh were towed simultaneously every two hours at one location in each area where high concentrations of early stage herring larvae were found.

Considering the entire vertical range of larval herring, surface to bottom, there was no significant night/day difference in distribution. However, surface night/day ratios were fairly high suggesting some migratory activity there. Chaetognaths which were collected only at the Georges Bank station, exhibited the classical diurnal migratory pattern seen in other studies which substantiates the validity of the sampling relative to larval herring. Unfortunately no larvae had any food in their gut and this could not be attributed to the method of sampling or preservation. Examination of the fine mesh samples indicates two general types of copepods: "Type A" was teardrop shaped, and "Type B" was shaped more like a copepodite with a cephalosome and urosome. "Type A" included Oithona, Centropages and Acartia species; "Type B" included Pseudocalanus, Paracalanus and early stage Calanus species. Prey organisms of suitable size (<.25 mm body width) for small herring larvae were several times as abundant in Georges Bank samples as in those from Jeffreys Ledge. There was some discussion of the usefulness of vertical distribution studies. It was noted that while general diel migration patterns of a given species may be consistent from one area to another, there still was a need for studies in each local area when trying to relate dispersal to circulation. A new opening-closing sampler will be available in October 1977 for larval herring studies, and it is to be used in the Georges Bank patch study.

Sherman gave a short verbal report on some recent US studies of extrusion using standard 20 cm Bongos (.253 and .333 mm mesh) at 3.5 and 1.5 knots. More larger herring larvae were retained at the higher speed but condition of larvae was better at the slower speed, and in particular a larger proportion had gut contents. Major prey items for recently hatched larvae (copepod eggs and early copepodite stages) were not retained by either mesh and therefore it is obvious that the .333 mm mesh samples in the ICNAF series will have very limited value for indicating abundance of prey for young larvae. Nevertheless the .333 series will be valuable for the larger stages and species, and also Sherman noted the availability of zooplankton biomass indices for a 5-year series of spring and fall groundfish cruises. Although the data are not yet published they are available on request. There was general consensus in the group that quantitative feeding studies in the field would require the high sampling intensity such as provided in the patch study mode, and that net sampling should be supplemented by plankton pump data.

Reference was made to the report on the two USSR larval herring surveys in September and October 1975, which was recently issued as ICNAF Research Document 77/VI/43. Also, a USSR paper on the relation between water temperature and spawning time of sea herring was issued in 1977 as ICNAF Res. Doc. 77/VI/42, and generally confirmed the recent delayed spawning times associated with higher autumn temperatures.

Finally, S. Grimm reported briefly on larval herring growth and mortality estimates derived from comparison of length frequencies of larvae caught in April '76 with those caught in February 1976 (attachment #12). He found that growth and mortality rates were roughly comparable to the levels observed from December 1975 to February 1976, after adjustments for escapement of larger larvae in the April samples. Growth of smaller larvae from February to April was approximately 4-5 mm per month which is similar to the average growth rate of herring larvae in the Georges Bank area based on Lough's work. Similarly mortality rates observed in the spring (Feb. to April) were roughly comparable to those observed in the winter (Dec. to Feb.). In view of these results it was suggested that sampling in March and April even with Bongos at 3.5 knots could provide useful relative measures of growth and mortality. However, somewhat larger gear would be required to avoid escapement of the larger larvae especially in April.

V. HYPOTHESES ON FACTORS CONTROLLING YEAR CLASS SUCCESS

Major hypotheses about factors controlling year-class success were briefly reviewed, and the status of the relevant data base on testability of the hypotheses was discussed.

The relationship of time and location of spawning to hydrographic factors was mentioned. In addition to the expected further analysis of the ICNAF hydrographic and plankton data series participants were asked to check on potential information on timing and location of spawning from commercial fishery records. The question of dispersal of larvae (or alternatively the concept of retention on Georges Bank) was reviewed and it was noted that while general patterns and very large anomalies could be detected with the ICNAF time series, definitive work would require more detailed short-term studies of circulation and larval distribution such as is planned in the patch study.

On the matter of stock-recruitment relationships it was noted that there was little expectation we could learn much about this complex problem with such a short time series, and in fact some felt that the best chance for insight into the effects of spawning stock size on recruitment would be learn what mechanisms controlled survival in the very early life stages. This is basically the reasoning which the ICNAF Environmental Working Group had been following, and there was consensus among workshop participants that this is still a valid rationale.

So far there has been no correlation between numbers of early stage larvae produced and year class success, but there is some indication that overwinter mortality might be critical. Even so,studies of autumn growth and feeding conditions are considered important because size and condition of larvae may be the key to their overwinter survival.

There was general agreement that the density distribution of food organisms was a critical aspect for study and there was considerable discussion about how far we might be able to go with the data base available in the ICNAF time series. Admittedly the .333 mm mesh samples are limited in that the smaller zooplankton forms are missing. However, some useful insight into species composition and timing of reproduction can be learned from examination of adult and subadult stages. Even the .165 mm mesh samples may not be adequate for truly quantitative studies but some felt that it was too early to drop that series until we had an analysis of the two contrasting years of larval growth. This work should be further along by the time of the next meeting and the question can be reexamined again. Another technique such as the Hardy-type continuous plankton recorder was suggested as a way to study food organisms during the September-October period, concurrently during standard larval herring sampling. Lough thought that in situ studies at sea with electronic counter-sizer instruments might be the best hope for future larval food studies if only because of the enormous labor involved in processing fine mesh samples. Nevertheless the group felt that the present line of research on monitoring growth and mortality throughout the first six months should be continued, while the various approaches for studying food density are evaluated.

The relation of larval survival to density of competitors and/or predators was discussed and it was emphasized that intensive food habit studies would be required. Woods Hole is planning to study gut contents of *Ammodytes* larvae which is a likely competitor of herring larvae. Professor Popiel noted that there was evidence for a competitive relationship between *Ammodytes* and herring larvae in the North Sea. Dr. Schnack indicated that Sagitta probably was an important competitor of herring and also an occasional predator although preferring other zooplankton. Lough indicated there were very few herring larvae in Sagitta stomachs and felt they were not an important predator especially in late fall and winter when herring larvae were large relative to Sagitta. There was some question as to the value of examining Sagitta stomachs but some felt it was too early to discount this approach.

Other possible predators include small pelagic fishes and gelatinous forms such as siphonophores in midwater, amphipods near the bottom, and sea birds near the surface. Pelagic predators of larger larvae could be investigated with midwater trawls and such studies have been recommended by ICNAF. However, resources have not yet been available for a systematic approach to this problem.

VI. FUTURE WORK

A. 1977 and 1978 Field Studies.

Monitoring larval herring production on Georges Bank is expected to continue in 1977 and 1978, with participation by USA, USSR, Federal Republic of Germany and the German Democratic Republic. In addition, plans are now well underway for a preliminary larval herring patch study in 1977 and a full scale patch study in 1978. US and Canadian vessels are scheduled to provide the basic ship support for the patch studies but participation by scientists from other countries is strongly encouraged. For further details of the patch study plans see pp. 3 and 4 of attachment #4.

Sherman presented a brief review of US plans for implementing the MARMAP program which is parallel and complementary to the larval herring studies. The MARMAP program represents a broad scale ecosystem monitoring effort involving 6 surveys a year and 200 stations per survey over the entire shelf from Cape Hatteras to western Nova Scotia. On each survey data are collected on the biomass and composition of zooplankton, primary productivity, nutrients and hydrography. The US and USSR are jointly conducting these surveys in 1977 and 1978. Results of these broader scale surveys ultimately are to be integrated with finer scale studies such as the larval herring series and the patch study to provide a more comprehensive picture of the plankton communities. Still another US program is PULSE which will begin in 1978 and which will emphasize monitoring state of the marine environment relative to chemical pollutant loading at selected locations within the MARMAP survey area. Finally he noted the establishment of a Task Force at NEFC to prepare an energy budget for Georges Bank and to begin modeling studies of energy flow within the Georges Bank ecosystem.

B. Sorting Center

The priorities for the Sorting Center in 1977 are presented in Section III, pp. 8-11. However, in addition to streamlining the process of sorting zooplankton (via special workshop at Narragansett in August 1977) it probably will be necessary to reduce the workload of sorting zooplankton by subsampling. That is, initially it may be desirable to sort only a subsample of about 50% of the samples from each cruise to get a first look at the nature of the zooplankton data from the .333 mm samples. In addition, it was suggested that for the first level sorting it would probably be sufficient to count and measure only dominant taxa and species, and do a complete sort on only a small number of samples. These problems will be reviewed following the August workshop on sorting, and progress will be documented in a report of the workshop to be circulated in autumn 1977. By the time of the next larval herring workshop (September 1978) a significant portion of the zooplankton will have been sorted and analyzed and we can evaluate the subsampling procedures further.

With regard to ichthyoplankton G. Joakimsson and D. Schnack questioned whether the general rule of measuring 100 fish larvae per species per sample was sufficient to provide accurate measures of length frequency. They pointed out that when there was a fairly wide length range of larvae and especially when there were two or more modes then 100 larvae was not an adequate sample. In addition there was general concern about the possibility of bias in selecting fish larvae for measurement from the sample as well as the variation of measuring techniques among different sorters. It was agreed that the best way to select larvae for measurement was to use some mechanical means for dividing a sample into aliquots; e.g. a sorting dish with compartments, and then measure all larvae in a randomly selected compartment. There was general agreement that some such procedure should be implemented at the Sorting Center. Further a small working group was set up (Gunnar Joakimsson, R. Lough, L. Ejysmont) to study the nature of variability of larval measurements by different sorters as well as the sample size; the group is to maintain contact with the Task Force Leader and the advisory committee (for the Sorting Center) by correspondence and document its findings at the next larval herring workshop.

C. Processing of Samples Outside the Sorting Center.

The US will continue work on the .165 mm mesh samples as well as the gut contents of larval herring, *Ammodytes* and possibly *Sagitta*. Gunnar Joakimsson will continue his work on Bongo and neuston samples from the series of March cruises by FRG; also he plans to compare length frequencies of larval herring taken in November on FRG vessels from .505 and .333 mm mesh samples and also relative selectivity of these two meshes for ichthyoplankton in general.

D. Data Listings, Analyses and Reports for 1978.

Further work on distribution and abundance of ichthyoplankton can be done most efficiently after completion of the basic computer listings and it was agreed that the US should continue to develop basic computer listings along the lines of those submitted at this workshop, and that it was desirable to make the listings for the .333 samples available to participating scientists as soon as possible (first outputs expected by Jan. '78). Possible summary data for zooplankton was briefly discussed in relation to a list of outputs (attachment #13).

Scientists from several countries are interested in looking at some of the same questions regarding dispersal, growth and mortality of larvae, and the chairman noted that there is no problem with more than one person analyzing the same data providing there is a coordinator to insure that unnecessary duplication is avoided. For the time being the Task Force Leader (M. Grosslein) is to serve in that role and scientists should keep him informed of their plans and progress. It should be noted also that a basic data report on distribution and abundance of ichthyoplankton from the ICNAF time series is planned in the form of an Atlas. The Atlas could have multiple authorship including appropriate representatives from the participating countries, but in any case the basic larval data would be published in standard form for the entire series.

A similar Atlas or combination with the ichthyoplankton Atlas is under consideration for publishing the associated hydrographic data. The group agreed to proceed with the US plan to get the entire hydrographic series into MEDS as soon as possible, and to explore possible formats for summarizing the hydrographic data. While this project is in progress individual investigators should feel free to request specific parts of the data base if they have an immediate need for it. Several scientists indicated an interest in looking at the problem of dispersal in relation to hydrographic features, but noted that they needed results of all cruises before they could do any significant analysis.

A symposium on larval fish is scheduled for spring 1979 in Woods Hole and it was noted that investigators may wish to present some of their work on Georges Bank larval herring at that symposium. It was suggested that scientists inform the Task Force Leader of the title and subject of any papers they plan to present so that undesirable duplication is avoided.

E. Next Meeting of the Larval Herring Workshop.

In view of the large volume of data processing still to be done on the larval herring series it was suggested that the next larval herring workshop be held in September 1978 just prior to the Patch Study. Confirmation of the time and place will be made by late spring 1978.

ANNEX 1

List of Participants at Workshop on
Georges Bank larval herring studies,
Szczecin, 20-23 June, 1977.

Name	Institute
Andrzej Paciorkowski	Sea Fisheries Institute, Gdynia, Poland
Stefan Grimm	" " " " "
Prof. Popiel	" " " " "
Norbert Schultz	Sea Fisheries Institute, Rostock, GDR
Kurt Lambert	" " " " "
Gunnar Joakimsson	Institut fur Meereskunde, Kiel, FRG
Dietrich Schnack	Institut fur Hydrobiologie und Fischeserwissenschaft, Hamburg, FRG
W.G. Smith	NEFC, Sandy Hook, N.J. USA
Robert R. Marak	MARMAP Field Group, Narragansett, R.I., USA
R. Gregory Lough	NMFS, Northeast Fisheries Center, Woods Hole, Mass., USA
M. Grosslein	NMFS, Northeast Fisheries Center, Woods Hole, Mass., USA
Vjacheslav Sushin	AtlantNIRO, Kalingrad, USSR
Lev Gruzov	AtlantNIRO, Kalingrad, USSR
Janusz Rozak	ZSOP, Szczecin, Poland
Leonard Ejsymont (and various members of Staff of Secretary Center)	ZSOP, Szczecin, Poland
Ken Sherman	NMFS, Narragansett, R.I., USA

ANNEX 2

Tentative Agenda - Larval Herring Workshop
Szczecin - June 18-23, 1977

I. Introduction - Ejysmont.

II. Review larval herring surveys, Sept. '76-March '77 - Grosslein.

III. Status of ICNAF larval herring data base - 1971 to present.

A. Ichthyoplankton and zooplankton.
1. Outline scope of plankton time series - Lough.
2. Status of sorting - Ejysmont.
3. Computer processing - Marak, Lough.
4. Standard computer outputs, larval herring 0.505 mesh - Lough.

B. Phytoplankton - Grimm?

C. Hydrography - Grosslein.

IV. Results of Analysis.

A. Brief summary previous reports - Grosslein. Lit. Ref. - Lough.

B. New results.
1. Larval age and growth studies - Lough.
2. Zooplankton composition selected cruises - Sherman, Lough.
3. Oct. 1974 vertical studies - Lough.
4. Ichthyoplankton extrusion studies, 1.5 vs. 3.5 knots - Sherman.
5. P. minutus from fine mesh samples - Lough.
6. Zooplankton biomass indices - Sherman, et al.
7. Other items.

V. General discussion on testable hypotheses relative to factors controlling year class success.

A. Time and location of spawning.

B. Larval production proportional to stock size.

C. Over-winter larval mortality and subsequent year class success related to larval growth rate.

D. Larval growth rate dependent on density distribution of food.

E. Larval survival related todensity of competitors and/or predators (zooplankton).

F. Larval dispersal off the Banks.

VI. Future work.

A. Proposed Surveys, 1977 and 1978 - Grosslein.

B. Oct. '78 Patch Study - Lough.

C. Sorting protocols and priorities, 0.333 mm and fine mesh samples - Sherman, Ejysmont.

D. Larval gut contents - Lough.

E. Basic data listings, summary reports for 0.333 mesh ICNAF time series - Grosslein, Sherman.

F. Hydrography and productivity studies - Grosslein.

G. Papers for 1979 "larval fish" symposium in Woods Hole.

H. Other items.

ANNEX 3

List of papers and handouts presented

at Workshop on larval herring studies,

Szczecin, 20-23 June, 1977.

Attachment #1. List of Participants.

Attachment #2. Agenda.

Attachment #3. List of papers and handouts.

Attachment #4. Grosslein, M.D. Progress Report on the ICNAF larval herring surveys. Northeast Fisheries Center, Woods Hole. Handout, 8 pp.

Attachment #5. Lough, R.G. 1977. References to herring larvae (Clupea harengus) in the Northwestern Atlantic. Northeast Fisheries Center, Woods Hole, USA. Handout, 8 pp.

Attachment #6. Ringer, Zofia. 1977. Phytoplankton in waters of Nantucket Shoals and Georges Bank, April 10-24, 1976. SEA FISHERIES INSTITUTE (MIR), Gydnia, Poland. Laboratory Report. 8 pp.

Attachment #7. Ringer,Zofia. Further information on phytoplankton collections from Nantucket Shoals and Georges Bank in 1976 and 1977.

Attachment #8. Rosenberg, A.A. and R.G. Lough. 1977. A preliminary report on the age and growth of larval herring (Clupea harengus) from daily growth increments in otoliths. Northeast Fisheries Center, Woods Hole, USA. Manuscript. 17 pp.

Attachment #9. Dubé, G.P., R.G. Lough and R.E. Cohen. 1977. Zooplankton composition, abundance and distribution on Georges Bank during February 1975 and 1976. Northeast Fisheries Center, Woods Hole, USA. Manuscript. 39 pp.

Attachment #10. Davis, Cabell. 1977. Preliminary analysis of ICNAF .165 mm mesh plankton samples with special reference to the copepod Pseudocalanus minutus. Northeast Fisheries Center, Woods Hole, USA. Manuscript. 5 pp.

Attachment #11. Lough, R.G. and R.E. Cohen. 1977. Further analysis on the vertical distribution of recently-hatched herring larvae and their prey organisms on Georges Bank and Jeffrey's Ledge. Northeast Fisheries Center, Woods Hole, USA. Manuscript. 27 pp.

Attachment #12. Grimm, Stefan. 1977. Distribution, abundance, growth and mortality of herring larvae on Nantucket Shoals and Georges Bank during spring, 1976. SEA FISHERIES INSTITUTE (MIR), Gydnia, Poland. Laboratory Report.

Attachment #13. Anonymous. Suggested Outputs for zooplankton data. One page.

Lough, R.G. 1977. Overview of larval herring studies - ICNAF time series. Northeast Fisheries Center, Woods Hole. Handout, 1 page.

MARMAP. 1977. Basic computer listings for 31 cruises (see Table 1). Handout at Workshop only.