FILE COPY

LABORATORY REFERENCE DOCUMENT NO. 82-26

RAPID SHIPBOARD IDENTIFICATION AND ENUMERATION OF ZOOPLANKTON SAMPLES*

by

R. Gregory Lough and David C. Potter

☑ APPROVED FOR DISTRIBUTION

(APPROVING OFFICIAL)

14 Sept '82

(DATE)

National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole, Massachusetts 02543

*MARMAP Contribution MED/NEFC 82-53

ABSTRACT

A method is described to make routine, quantitative analysis of plankton-net samples at sea using silhouette photography techniques coupled with a microfiche reader, an electronic digitizer, and a small personal computer. More than 90% of the organisms can be identified to species level and life stage, and a subsample enumerated within 20 minutes after collection by this method. Coefficients of variation estimated for the dominant taxa were usually in the range of 13-57%, comparable to conventional sorting methods. Advantages and disadvantages of this methodology are discussed.

INTRODUCTION

Biologists working on planktonic populations at sea have been hampered by not being able to make real-time decisions in their sampling program because of the difficulties in identifying and enumerating zooplankton samples on a moving ship. Settled plankton volume can be readily obtained at sea or, an eye-order-of-magnitude estimate can be made if the species of interest is easily seen in the sample. Electronic particle size analyzers are now in field use (Pugh, 1978; Herman and Dauphinee, 1980) but they don't always discriminate the species or life stages under study. If conditions are sufficiently stable, standard sorting methods of subsampling and microscopic examination of preserved samples can be employed which are tedious and time consuming. But for the most part, the ship's inherent movement and vibration make it virtually impossible to carryout any routine microscopic identification required for decision making in an experimental program.

Recently, silhouette photography has been employed by Ortner et al., (1979) and Edgerton (1981) to identify live zooplankton collected at sea, as well as to look at their fine-scale patchiness using an *in situ* silhouette camera system (Ortner et al., 1981). In brief, a shadow image of captured zooplankton is made on fine-grain positive film by exposure to an electronic flash of short-pulse duration. The resulting negative of the plankton silhouettes is sufficiently detailed that it can be viewed directly or enlarged, depending on the size of the organism, and

identified to species level in many cases. This simple but elegant technique has now made it possible for rapid and routine identification of zooplankton samples at sea for ready analysis that normally would be a time consuming process ashore after the cruise. At the Northeast Fisheries Center (NEFC), we have successfully employed silhouette photography techniques at sea since 1978 to identify and track fish egg and larval concentrations to determine their dispersal and fine-scale distribution in relation to their zooplankton food organisms (Lough, 1979; Lough and Laurence, 1981). We report here the development of our shipboard processing methods that permit the complete enumeration of a plankton net sample, including size frequency analysis, within 20 minutes after collecting.

METHODS

Zooplankton samples are routinely collected on the northeast continental shelf as part of NEFC's MARMAP program (Sherman, 1980). Paired large (61 cm) and small (20 cm) bongo samplers are used with nets of 0.505- and 0.333-mm mesh on the large bongos, and 0.253- (or 0.053-) and 0.165-mm mesh on the small bongo (Posgay and Marak, 1980). Oblique hauls are made to a maximum depth of 200 m and, depending on the depth to bottom, a large bongo net filters between 100- and 1000 m^3 of water which results in a typical settled plankton volume between 20- and 1000 ml. A flow chart of the shipboard processing procedure for quantitative analysis of the plankton sample is shown in Table 1.

The unpreserved plankton sample is first put into a large, wide-mouth container (gallon) which has been marked on the side to known volumes. The seawater level is typically brought up to the 3000 ml mark, stirred to a homogeneous suspension, and a 100-ml aliquot is taken with a plastic dipper. At this point in the sample processing, one may choose to make a second aliquot of greater dilution for identifying the more abundant, smaller organisms. Through a few preliminary trials the appropriate aliquot can be estimated for the organisms of interest. Generally, we try to end up with a subsample of 100-200 organisms in the final count, which is usually sufficient to enumerate the three to six dominant copepods found in the region. The aliquots are put into pint jars, appropriately labeled, for transfer to the ship's darkroom.

In the darkroom with safety lights on, an Eastman Kodak fine-grain positive film 7302 is placed in a lucite box (8" x 10" x 5") specially constructed to match the dimensions of the film (see Figure 1). The plankton aliquot is poured on top of the film, being careful to use just enough rinse water to completely cover the bottom (ca. 1 cm). The box is placed on a gimbaled framework to stabilize the sample against excessive ship's motion, and when the sample appears to be randomly distributed on the film, the film is exposed by an electronic flash of short duration (3x10-6 sec.) from a xenon bulb (EG&G, Inc., Fx6A). The flashbulb is located on the ceiling about 1 m from the film. The exposed positive is then developed according to film instructions, adjusting development time to produce the sharpest negative.

Upon drying, the developed negative is ready for viewing by transmitted light to identify, count, and measure the species of zooplankton from their silhouettes. In the first stage of enumeration, the negative is placed on a translucent electronic measuring tablet atop a lightbox which is part of a digital image analyzer system (Carl Zeiss MOP3). Total silhouette counts and length measurements are made by the identifier on the large or less numerous taxa such as fish eggs and larvae, chaetognaths, euphausiids, etc., using the opto-electronic pen. The taxa point counts and length measurements are stored in the console microprocessor and a printed record is kept of the tallies and length-frequency summaries. Data from the MOP3 system also can be interfaced directly with the larger computer. Identifiers find it helpful to overlay the negative with a clear acetate sheet marked off with about 30 squares to systematize the counting and protect the negative from ink tracings. Also, a magnifying lamp of 5-10x may be used if necessary.

The second level of enumeration for the smaller, more abundant zooplankton requires the examination of a smaller portion of the silhouette negative under higher magnification. We have found a microfiche reader to be an excellent at-sea tool for this purpose. Our reader is a Bell & Howell (ABR-1010) molded plastic unit with dual lenses. An assortment of lens magnifications are available but we find the 29x to be adequate for routine identification. The standard reader fiche/jacket carriage is 4"x6", so that for convenience in viewing and storage, a representative subsample of the 8"x10" negative is cut out using

a 4"x6" template. The cut negative is inserted into the reader jacket carriage and a smaller acetate-marked square (1.5"x1.5") is positioned on the negative that represents 1/32 of the original negative. The organisms within the 1/32 square are identified and counted on the screen by following parallel lines marked within the square. An acetate millimeter scale made at the same magnification being viewed is used by the identifier to make measurements on organisms directly on the reader screen for routine length frequencies, as well as to aid in the separation of species or stage of development based on size. The zooplankton counts are recorded on a counter array and tallied on a log sheet (Table 2) prior to computer entry. A more efficient way of entering the data directly into the computer is being developed by the use of a special sorting log sheet that can be overlaid on the electronic grid tablet.

The zooplankton data is processed by a small personal computer, a Commodore PET 2001 Series (32K memory) linked to a Dual Drive Floppy Disk Model 2040, a Tractor Printer Model 2022, and a WATANABE DIGIPLOT plotter Model WX4671. The plankton counts are standardized to number per m3 and m2 and the taxa are printed in abundance tables and distributional plots, as well as various length-frequency summaries and plots.

A preliminary estimate of the precision of the silhouette subsampling method used at sea was made by a series of repeated counts on the two levels of subsampling. The second level of subsampling also was compared to a series of repeated counts made using the standard Folsom plankton splitter method (McEwan et

al., 1954; Longhurst and Seibert, 1967). In the first experiment, 12 individual 100-ml aliquots, representing 1/30th of the sample, were taken with replacement, a silhouette photo made, and the following taxa were tallied from each total silhouette: Sagitta elegans, Gadid eggs, Gadid larvae, and Ammodytes sp. larvae. Subsampling variability was estimated for each taxa by calculating the arithmetic mean, standard deviation, coefficient of variation, standard error of the mean, and 95% limits of the mean (Snedecor and Cochran, 1967). In the second experiment, eight separate silhouette counts were made on 1/32 subsamples from one total silhouette which represented a 1/30th aliquot of the plankton sample. Then, using the Folsom plankton splitter, the same initial 1/30th aliquot was split to 1/32 subsamples, and eight of these were enumerated using a stereomicroscope in the conventional manner. Thus, each of the eight subsamples from the two methods represented 1/960th of the original plankton sample. Zooplankton identified from the subsamples was standardized to number per m3. Standard statistical measures of sample variability were again calculated for comparison.

RESULTS

A total of 375 plankton samples were identified and enumerated by the silhouette photography method on a spring 1981 ALBATROSS IV cruise over 11 days of sampling. Mesh size of the samples processed included 0.333-, 0.165-, and 0.064-mm aperture. An example plot of Gadid eggs collected from the initial bongo

grid survey (stations five miles apart) on southeast Georges Bank is shown in Figure 2. Two technicians around the clock were required to accomplish this level of real-time sample processing. One technician usually is responsible for making the initial sample aliquots and developing the silhouettes; the other performs the species identifications, counts, measurements, and production of standard computer listings and plots. In practice, a single plankton sample takes about 20 minutes to process from the time it enters the wet lab to the production of a standard species list. Total processing time depends on the net mesh size used, the volume of plankton collected, the level of identification required and, of course, the skill of the identifier. Our MOCNESS, electronically-controlled opening/closing net (Wiebe et al., 1976) collects nine samples in one haul which have to be processed in batch mode, assembly-line fashion.

The silhouette photographs made during the cruise on live plankton samples are exceptionally sharp and detailed, compared to preserved samples, which greatly facilitates identification (Figure 3). Dead, opaque specimens often obscure some important structural detail on the silhouette. The dominant copepods on Georges Bank are Calanus finmarchicus, Pseudocalanus sp., Paracalanus parvus, Centropages typicus, C. hamatus, and Oithona similis (Bigelow, 1926; Sherman and Jones, 1980; Cohen and Lough, 1982; Davis, 1982). These copepods can usually be identified to species, sex, and copepodid stage from the silhouettes with reasonable certainity. However, Pseudocalanus and Paracalanus cannot be readily separated from their silhouettes, but their

population peaks occur in May-June and September-October, respectively, which tends to reduce the problem. Also, the sex of adult Pseudocalanus is often questionable because the fifth leg is not usually visible. Most of the copepod nauplii are lumped, but those of Calanus, and Centropages and some others can be identified from their silhouettes. Fish eggs and larvae cannot usually be identified to species level on the basis of their silhouettes alone as they are opaque and pigmentation markings are important characteristics for separation. An experienced technician familiar with the fauna can tentatively identify most (90%) of the organisms found in the sample silhouettes to species level. After some quality-control checking on the plankton samples back in the laboratory, tentative identifications can be confirmed or at least the proportion of species within an assigned taxa can be estimated.

The sample variability experiments are presented in Tables 3 and 4. Total silhouette counts from the 12 replicate 1/30th aliquots are shown as actual counts as well as standardized for the four taxa. The subsample counts were normally distributed and therefore did not require a transformation. The coefficient of variation increased with the fewer numbers of organisms counted; 75-107% for a mean of 1-2 Gadid and Ammodytes sp. larvae, but only 13% and 21% for Sagitta elegans and Gadid eggs having means of 91 and 49, respectively. The 95% confidence limits are quite small for the more abundant taxa, so that the factor of four contouring of the Gadid eggs used in Figure 2 is appropriate.

Further subsampling (1/32) of a total silhouette for copepod enumeration (Table 4) showed a similar range in the coefficients of variation (27-87%) for the dominant taxa, which decreased with an increase in the mean number of individuals ranging from 46 to 672 per m3. The total copepod category represents the dominants plus the less common taxa found in the sample. The same taxa enumerated by the Folsom splitter always had somewhat higher means than those estimated from the silhouette method, and their coefficients of variation were smaller (17-49%). A t-test comparing the means for each taxa indicated significant differences at the 1% level, except for Pseudocalanus sp. adults. No reason is apparent for these differences between the two methods unless it is related to the fact that fewer organisms were usually counted in the silhouette subsamples. The silhouette estimates may be improved by including a second 1/32 square to increase the number of organisms actually counted in the subsample. In either case, the 95% confidence limits are estimated to fall within approximately half to double that of the mean for the more abundant taxa. The 95% limits for a single net haul has been previously found to usually exceed half or double the observed value regardless of the type of net, haul, or organism (Wiebe and Holland, 1968; Wiebe et al., 1973).

DISCUSSION

Rather sophisticated computer-processing of zooplankton samples is being developed using image formation devices and pattern recognition techniques (Jeffries et al., 1980). So far the larger

zooplankton species can be accurately identified to group, such as copepods, chaetognaths, euphausiids, based on repeatable morphometric relations. Present drawbacks to electronic identification besides the inability to discriminate to species level, are the sample preparation time (24+ minutes), which may involve pre-sieving to remove smaller organisms and detritus, and the fact that the organisms or their silhouettes must be spatially separated for viewing so that discrete images can be perceived by the vidicon monitor. Once the sample preparation is complete, however, processing by the processor-controlled vidicon system is extremely rapid.

The silhouette subsampling and processing method used at sea as described in this paper represents a stand-alone, in-hand decision making system that allows the operator to decide on proper orientation of the organism and focus on important but subtle detail necessary to identify it down to species and even stage of development. Small organisms collected by fine mesh nets also can be processed by this method. Sample preparation is minimal so that processing time is reduced to about 20 minutes total. Also, this system is relatively inexpensive and a variety of the components are available to suit the needs of the investigator. Another advantage of being able to process live zooplankton at sea is to make more accurate biomass measures since shrinkage of many zooplankton is considerable in preservative. In spite of these advantages, the crucial factor in this method of processing zooplankton samples is the technician skilled in plankton identification.

ACKNOWLEDGEMENTS

We owe special thanks to Dr. Harold Edgerton for his many consultations (with D.C.P.) regarding the silhouette photography method and loan of equipment. Randolph Goodlett identified all the zooplankton used in the study. Harold Merry originally suggested the idea of using a microfiche reader to enlarge the silhouettes.

REFERENCES CITED

Bigelow, H.B. 1926. Plankton of the offshore waters of the Gulf of Maine. Bull. U.S. Bur. Fish. 40(Part II): 1-509.

Cohen, R.E., and R.G. Lough. 1982. Zooplankton distribution and abundance in the Georges Bank-Nantucket Shoals area during the autumn-winter larval Atlantic herring surveys (1973-1977). NEFC Woods Hole Lab Ref. No. 82-12. 533 p.

Davis, C.S. 1982. Processes controlling zooplankton abundance on Georges Bank. Boston University Ph.D. Thesis. 198 p.

Edgerton, H.E. 1981. Electronic flash sources and films for plankton photography. J. Biol. Photography 49: 25-26.

Herman, A.W., and T.M. Dauphinee. 1980. Continuous and rapid profiling of zooplankton with an electronic counter mounted on a 'Batfish' vehicle. Deep-Sea Res. 27: 79-96.

Jeffries, H.P., K. Sherman, R. Maurer, and C. Katsinis. 1980. Computer processing of zooplankton samples. In V.C. Kennedy (ed.), Estuarine perpectives, p. 303-316. Academic Press, New York.

Longhurst, A.R., and D.L.R. Seibert. 1967. Skill in the use of Folsom's plankton splitter. Limnol. Oceanogr. 12: 344-335.

Lough, R.G. 1979. Larval herring patch study. ICNAF Res. Doc. 79/VI/116. 4 p.

Lough, R.G., G.C. Laurence. 1981. Larval haddock and cod survival studies on Georges Bank. ICES Larval Fish Working Group Report, Lowestoft, Suffolk, U.K. July 1-3, 1981. 17 p.

McEwan, C.F., M.W. Johnson, and T.R. Folsom. 1954. A statistical analysis of the performance of the Folsom plankton sample splitter, based upon test observations. Arch. Meterol. Geophys. Bioklimatol. Ser. A 7: 502-527.

Ortner, P.B., L.C. Hill, and H.E. Edgerton. 1981. In-situ silhouette photography of Gulf Stream zooplankton. Deep-sea Res. 28A: 1569-1576.

Ortner, P.B., S.R. Cummings, R.P. Aftring, and H.E. Edgerton. 1979. Silhouette photography of oceanic zooplankton. Nature 277: 50-51.

Posgay, J.A., and R.R. Marak. 1980. The MARMAP bongo zooplankton samples. J. Northw. Atl. Fish. Sci. 1: 91-99.

Pugh, P.R. 1978. The application of particle counting to an understanding of the small-scale distribution of plankton. In J.H. Steele (ed.), Spatial pattern in plankton communities. p. 111-129. NATO Conference Series IV, Volume 3. Plenum Press, New York.

Sherman, K. 1980. MARMAP, a fisheries ecosystem study in the Northwest Atlantic: Fluctuations in ichthyoplankton-zooplankton components and their potential impact on the system. In F.P. Diemer, F.J. Vernberg, D.Z. Mirkes (eds.), Advanced concepts in ocean measurements for marine biology, p. 9-37, Belle W. Baruch Institute for Marine Biology and Coastal Research. Univ. South Carolina Press, Columbia.

Sherman, K., and C. Jones. 1980. The zooplankton component of a Northwest Atlantic ecosystem. ICES C.M. 1980/L:67.

Snednecor, G.W., and W.G. Cochran. 1967. Statistical methods. 6th ed. Iowa State University Press, Ames, Iowa. 593 p.

Wiebe, P.H., G.D. Grice, and E. Hoagland. 1973. Acid-iron waste as a factor affecting the distribution and abundance of zooplankton in the New Bight II. Spatial variations in the field and implications for monitoring studies. Estuarine Coastal Mar. Sci. 1: 51-64.

Wiebe, P.H., K.H. Burt, S.H. Boyd, and A.W. Morton. 1976. A multiple opening/closing net and environmental sensing system for sampling zooplankton. J. Mar. Res. 34: 313-326.

Wiebe, P. H., and W.R. Holland. 1968. Plankton patchiness: effects of repeated net tows. Liminol. Oceanogr. 13: 315-321.

Table 1. Flow chart for quantitative, shipboard zooplankton sample processing based on silhouette photography.

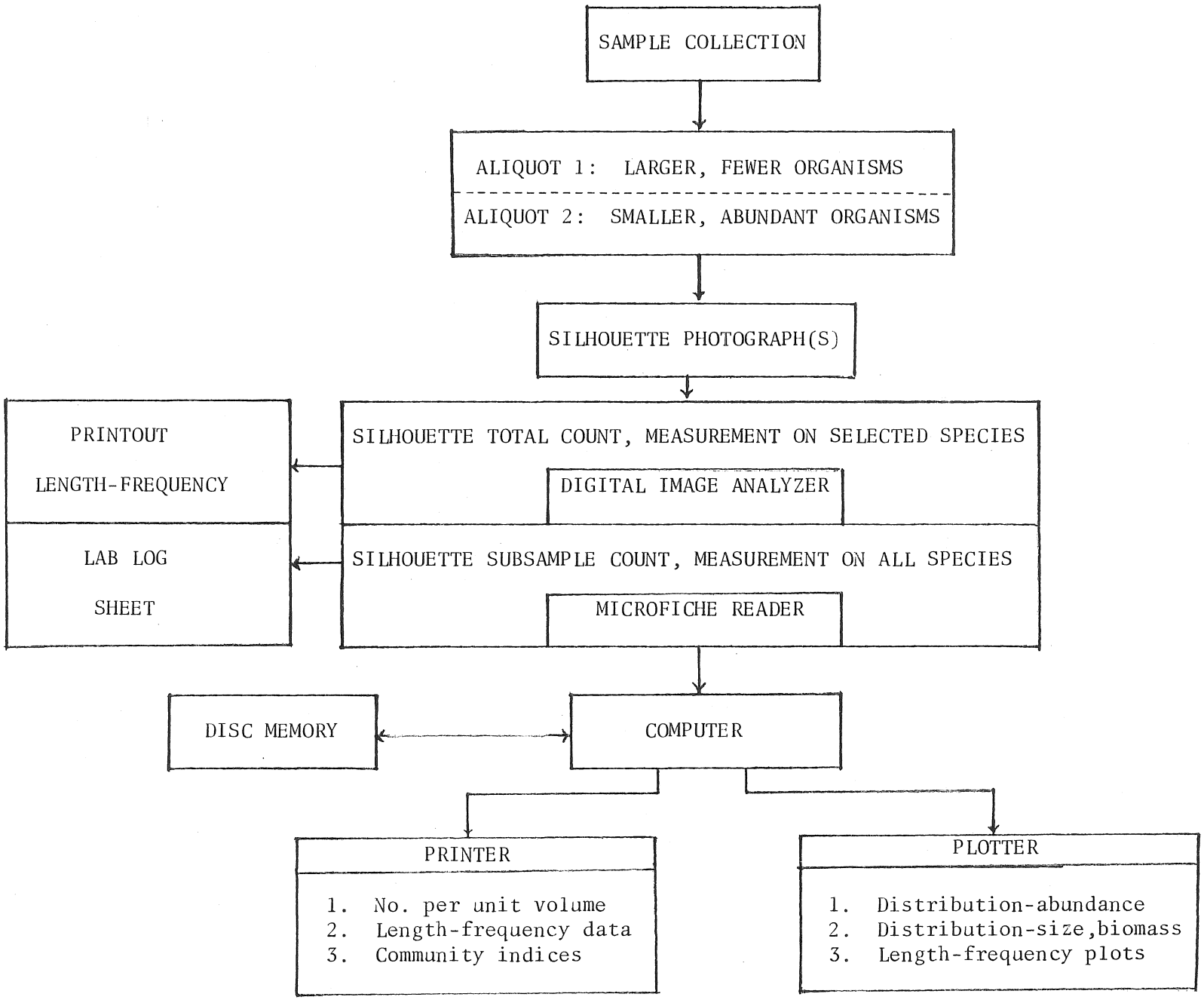

Table 2. Example of zooplankton sorting log used at sea to record taxa identified from silhouette photographs.

Haul 213

ALBATROSS IV 81-05 STATION 64 DATE 27-V-81

TIME 1314-1321 LAT. 41°07′ LONG. 67°35′ GEAR MOC 1 MESH 333 NET 6

~~TEMP.~~ VOL. FIL. 251.9 m³ DEPTH 10-15m SPLIT 1/60 · 1/32

COPEPODA	CI	CII	CIII	CIV	CV	F	M	T	ZOOPLANKTON	
ACARTIA							2	2	HYDROIDS	13
C. FINMAR.		2	5	13	8	1		29	CARIDEAN ZOEA	
C. HAMATUS					1		1	2	CRANGON ZOEA	
PSEUDOCAL.				23	80	140	11	254	PAGURUS ZOEA	2
METRIDIA									CRAB ZOEA	
PARACALANUS									BARNACLE NAUP.	
TEMORA						1	1	2	BARNACLE CYPR.	
PLEUROMA.									CHAETOGNATH SP.	6
HARPACTIC.									FISH EGG	1
OITHONA									FISH LARVAE	
UNIDENT.								4	POLYCHAETE TRO.	
C. TYPICUS			3	9	6	9	1	28	POLYCHAETE LAR.	
PSEUDO PARA NAUP.									HYPERIID AMPHI.	
CALANUS NAUP.									ISOPODA	
PSEUDO-PARA C.									BIVALVIA	
OITHONA NAUP.									LARVACEAN	
CENTRO. NAUP.									CLADOCERAN	
									GASTROPODA	
									HYDROMEDUSAE	
									ECHINOD LARV.	

Table 3. Total silhouette enumeration of four taxa from station 46 bongo-net sample (0.333-mm mesh) and some standard statistical measures of subsampling variability based on 12 1/30th aliquotes.

TAXA	SUBSAMPLE 1	2	3	4	5	6	7	8	9	10	11	12	Mean	Std Dev.	Coef.Var (%)	Std Error	95%CL (% of Mean)
								SILHOUETTE COUNT									
Sagitta elegans[1]	100	84	66	87	106	105	95	86	86	103	92	81	90.9	11.7	13	3.4	42.3-55.3 (87-113)
Gadid eggs	49	50	73	47	52	32	50	57	53	41	41	41	48.8	10.2	21	3.0	83.5-98.3 (92-108)
Gadid larvae	3	4	1	1	2	0	3	1	1	0	2	1	1.6	1.2	75	0.4	0.8-2.4 (50-153)
Ammodytes sp. larvae	1	5	0	0	1	2	2	1	2	0	0	4	1.5	1.6	107	0.5	0.5-2.5 (33-167)
								STANDARDIZED NO./M^3									
Sagitta elegans	20	16.8	13.2	17.8	21.2	21.0	19.0	17.2	17.2	20.6	18.4	16.2	18.2	2.3	13	0.7	8.5-11.1 (87-113)
Gadid eggs	9.8	10	14.6	9.4	10.4	6.4	10	11.4	10.6	8.2	8.2	8.2	9.8	2.1	21	0.6	16.7-19.7 (92-108)
Gadid larvae	0.6	0.8	0.2	0.2	0.4	0	0.6	0.2	0.2	0	0.4	0.2	0.3	0.3	78	0.1	0.2-0.5 (67-167)
Ammodytes sp. larvae	0.2	1.0	0	0	0.2	0.4	0.4	0.2	0.2	0	0	0.8	0.3	0.3	114	0.9	0.1-0.5 (33-167)

[1] Length-frequency distribution made from one silhouette subsample: $\bar{X}$= 17.7 mm, S.D.= 6.3, N= 96, Range= 4-26 mm.

Table 4. Enumeration of dominant copepod taxa (no./m^3) from station 56 bongo-net sample (0.333-mm mesh) based on eight replicate counts of the silhouette photograph method (1/960th aliquote) and standard plankton splitting method 1/960th aliquote). Some standard statistical measures of subsampling variability are provided.

TAXA	SUBSAMPLE 1	2	3	4	5	6	7	8	Mean	Std.Dev.	Coef.Var. (%)	Std Error	95%CL (% Mean)
					SILHOUETTE SUBSAMPLE NO./M^3								
Calanus finmarchicus copepodite	387	658	371	390	682	572	481	377	490	131	27	46	384-596 (78-122)
Pseudocalanus sp. copepodite	37	37	43	30	140	43	6	30	46	40	87	14	14-78 (30-170)
Pseudocalanus sp. adult	30	85	85	18	104	55	30	37	56	32	57	11	30-82 (54-146)
Total copepods	511	877	591	505	1,029	779	597	487	672	200	30	71	509-835 (76-124)
(Total copepods in subsample)	(84)	(144)	(97)	(83)	(169)	(128)	(98)	(82)	(110)	(33)			
					SPLITTER SUBSAMPLE NO./M^3								
Calanus finmarchicus copepodite	554	554	572	554	548	627	499	846	594	108	18	88	506-682 (85-115)
Pseudocalanus sp. copepodite	43	146	85	30	91	79	61	55	74	36	49	13	45-103 (61-139)
Pseudocalanus sp. adult	49	37	73	37	67	61	37	61	53	15	28	5	41-65 (77-123)
Total copepods	689	871	853	676	743	798	615	1023	784	131	17	46	677-891 (86-114)
(Total copepods in subsample)	(123)	(143)	(140)	(111)	(131)	(148)	(111)	(179)	(136)	(22)			

Figure 1. Top left: view of shipboard darkroom centered on silhouette sample box on gimbaled platform. Top right: MOP 3 Digital Image Analyzer System with electronic measuring tablet mounted on a light box. Bottom left: Microfiche reader and counter array used for identification and enumeration of plankton silhouettes. Bottom right: Commodore PET computer showing main console, disk storage unit, and printer.

Figure 2. Example distribution plot of gadid eggs (no./$100m^3$) on the southeast part of Georges Bank made in realtime using the silhouette photography method of enumeration. Plankton samples were collected at each station by double-oblique bongo hauls (61-cm mouth diameter, 0.333-mm mesh net) on the ALBATROSS IV, cruise 81-03, 16-18 April 1981. The heavy contour lines (factor of 4) are based on sample variability estimates.

Figure 3. Enlarged silhouette photograph of a 0.333-mm mesh bongo-net sample collected on the southeast part of Georges Bank, May 1982. A: *Sagitta elegans* (14.3 mm), B: *Calanus finmarchicus* adult female (2.7 mm), C: *C. finmarchicus* copepodid IV, D: *C. finmarchicus* copepodid III, E: *C. finmarchicus* copepodid II, F: *Pseudocalanus* sp. adult female, G: *Acartia* sp., H: hydroid.

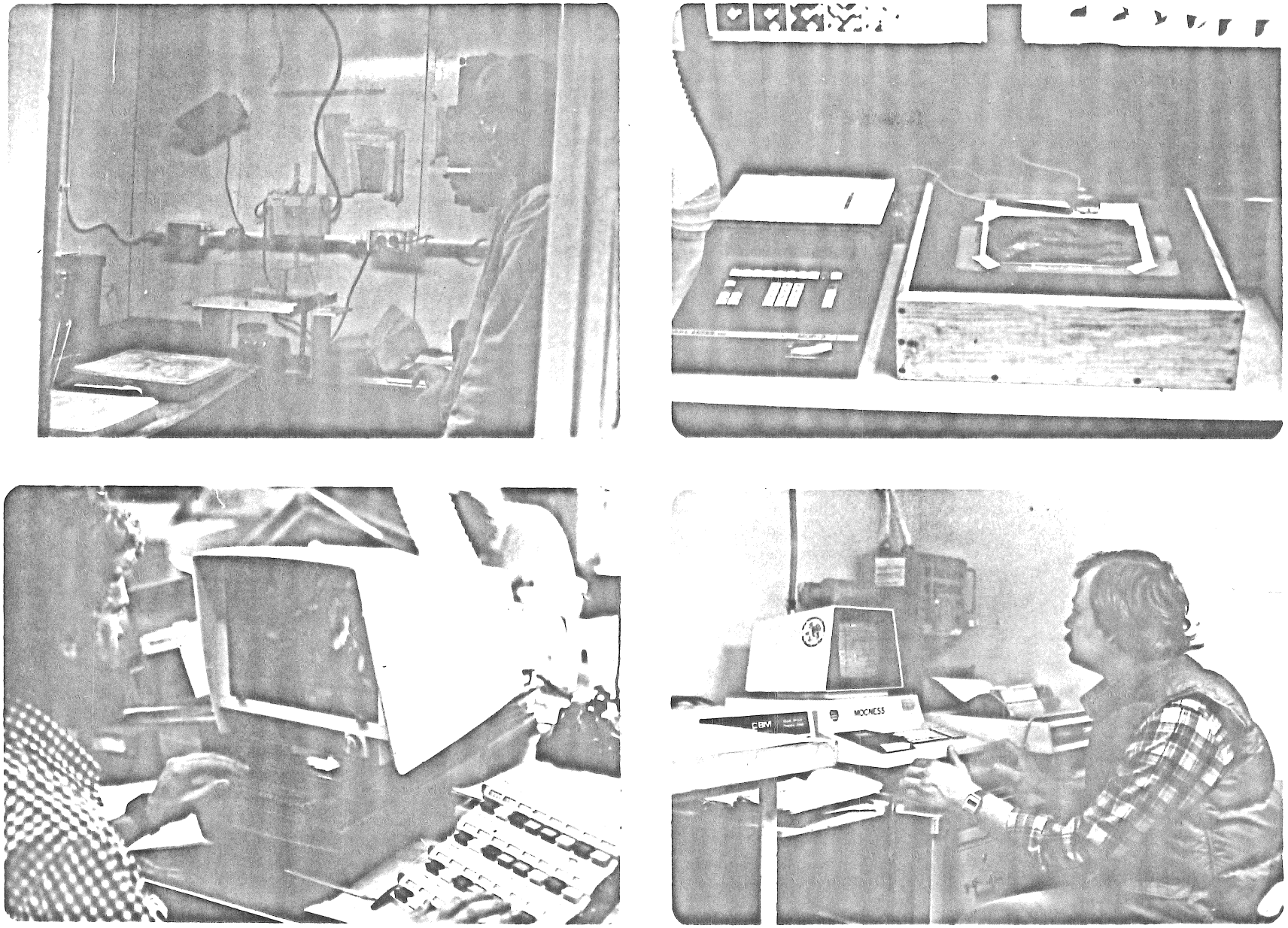

Figure 1

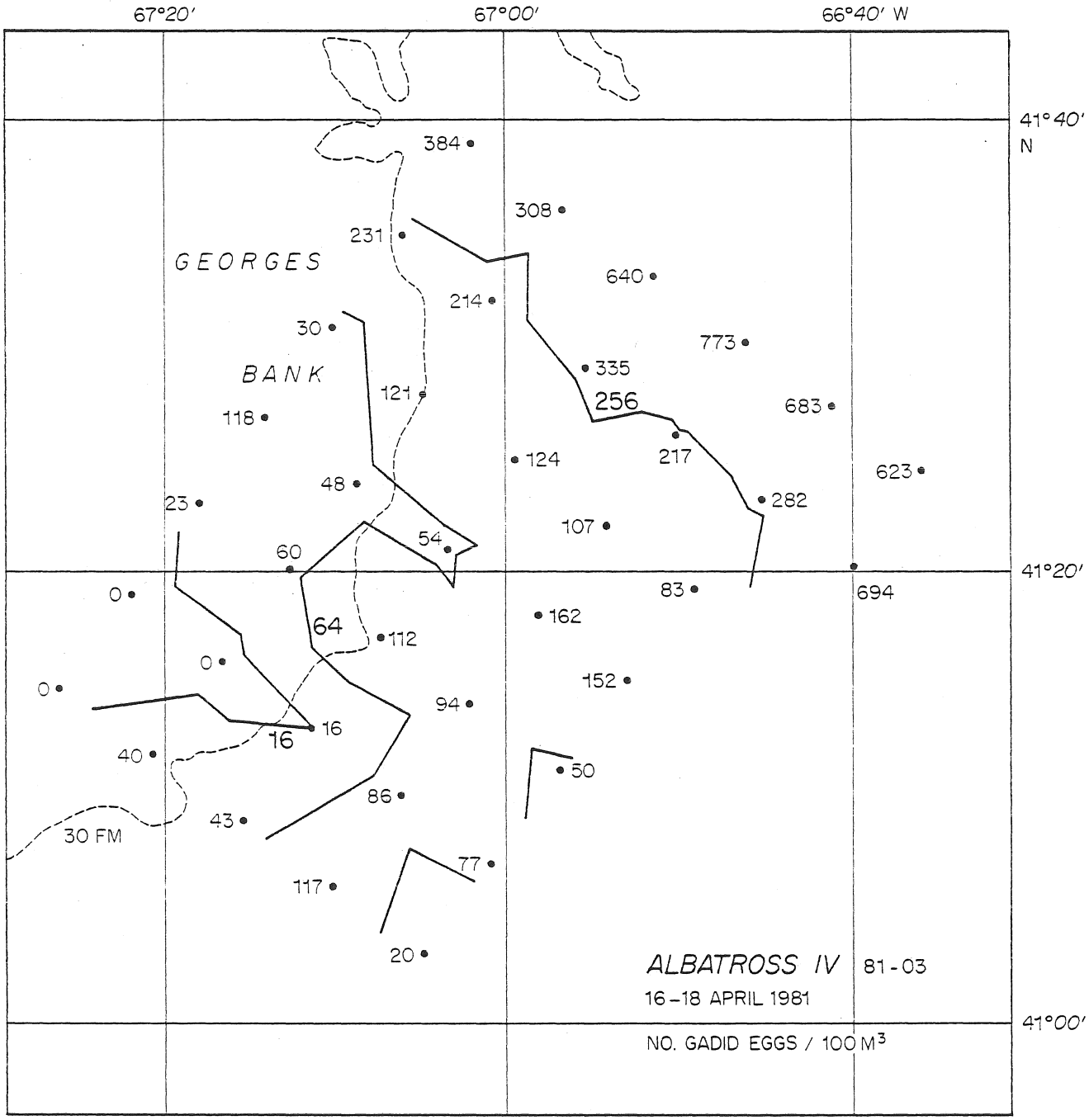
67°20′
67°00′
66°40′ W
41°40′ N
41°20′
41°00′
GEORGES
BANK
384
308
231
640
214
30
773
335
256
121
683
118
217
124
623
48
282
23
107
54
60
83
694
0
162
64
112
0
152
0
94
16
16
40
50
86
43
30 FM
77
117
20
ALBATROSS IV
81-03
16–18 APRIL 1981
NO. GADID EGGS / 100 M³

FIGURE 2

Figure 3