

Physical and Biological Oceanographic Observations in Logy Bay, Newfoundland: April - September 1979

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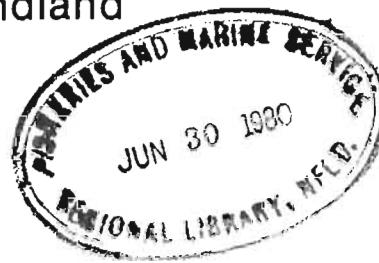
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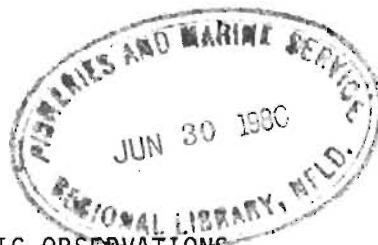
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PHYSICAL AND BIOLOGICAL OCEANOGRAPHIC OBSERVATIONS
IN LOGY BAY, NEWFOUNDLAND: APRIL - SEPTEMBER 1979

by

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This is the second Manuscript Report from the
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ABSTRACT

Kendaris, T. A. 1980. Physical and biological oceanographic observations in Logy Bay, Newfoundland: April - September 1979. Can. MS Rep. Fish. Aquat. Sci. 1569: iv + 60 p.

A program was undertaken to examine the physical and biological oceanography of Logy Bay, Newfoundland, over a 6-month interval beginning in April 1979. Cold, saline waters (0.2°C , 32.6‰) are present throughout the water column in April. Surface waters of intermediate density are observed during May/June. By August, the surface mixed layer has acquired distinct T-S characteristics (15°C , 31.00‰), and extends from surface to bottom near the shoreline. The original more dense water mass that persists year-round at offshore locations below the effects of the atmospheric heating cycle is identified as typical inshore Labrador Current water. Substantial increases in zooplankton concentration are first recorded during August, with inshore neritic copepod species dominating the adult community. Temporal variations suggest possible breeding cycles, and indicate the succession of selected species. Spatial differences reflect the occurrence of certain species exclusively at offshore, deeper water stations. The results demonstrate that there exists two discrete oceanographic environments defined by both physical and biological characteristics: a core of inshore Labrador Current water at depth, and a surface water mass that responds to atmospheric forces.

Keywords: temperature, salinity, sigma-t, zooplankton abundance, species composition, Labrador Current, Newfoundland.

RÉSUMÉ

Kendaris, T. A. 1980. Physical and biological oceanographic observations in Logy Bay, Newfoundland: April - September 1979. Can. MS Rep. Fish. Aquat. Sci. 1569: iv + 60 p.

On a lancé un programme destiné à étudier l'océanographie physique et biologique de la baie Logy (Terre-Neuve), sur une période de six mois commençant en avril 1979. En avril, on trouve des eaux froides et salées (0.2°C ; 32.6‰) dans toute la colonne d'eau. En mai-juin, on observe des eaux superficielles de densité intermédiaire. En août, la couche mixte de surface a acquis des caractéristiques distinctes de température et de salinité (15°C ; 31‰) et s'étend, près du rivage, de la surface au fond. La masse d'eau plus dense qui demeure toute l'année, au large des côtes, à l'abri des effets du cycle thermique atmosphérique, présente les caractéristiques de l'eau du courant côtier du Labrador. C'est en août qu'on commence à noter de fortes augmentations de la concentration du zooplancton, dans lequel les espèces de copépodes nérithiques dominent la communauté adulte. Les variations temporelles semblent indiquer l'existence de cycles de reproduction, et montrent la succession d'espèces particulières. Les différences spatiales révèlent que certaines espèces sont présentes seulement à des stations du large, en eau plus profonde. Les résultats montrent qu'il existe deux milieux océanographiques distincts caractérisés par des éléments physiques et biologiques: un noyau constitué d'eau du courant côtier du Labrador, en profondeur, et une masse d'eau superficielle qui réagit aux forces atmosphériques.

INTRODUCTION

Along the east coast of Newfoundland, the southward flowing Labrador Current is characterized by two prominent streams, one inshore off the Continental Shelf, the other offshore (Sutcliffe et al. 1976). Long-term historical temperature and salinity records from Station 27 (Huyer and Vernay 1975) have provided detailed information concerning the seasonal variation in water column structure of the inshore branch of the Labrador Current. Substantial data have also been collected from locations farther offshore (see, among others, the successive reports referred to in Templeman 1973). However, relatively little work has been directed towards identifying thermohaline conditions in close proximity to the shoreline. Consequently, a program was undertaken to determine the oceanography of Logy Bay ($47^{\circ}38'N$, $52^{\circ}40'W$), where biological research is being carried out by the Marine Sciences Research Laboratory. The results presented in this report are intended to distinguish the physical and biological characteristics of the near-shore neritic environment from those encountered in deeper offshore waters.

METHODS

Vertical profiles of temperature and salinity at six stations in Logy Bay (Fig. 1) were recorded each month from April to September 1979. Cruises during May and August were somewhat abbreviated. Observations were made from the Marine Sciences Research Laboratory vessel, a 6-m Boston Whaler. The relative proximity to land allowed for visual landmarks to be used in identifying station positions.

Temperatures were obtained from a direct reading Martek Model TDC metering system to a precision of $\pm 0.5^{\circ}C$. This system was subsequently replaced for the September cruise by a model MC5/2 Salinity and Temperature Bridge manufactured by Electronic Instruments Limited, which improved the measuring precision to $\pm 0.1^{\circ}C$. Depths were accurately marked directly on the hydrographic wire; wire-angle error was minimal. Nansen bottle casts (without reversing thermometers) obtained salinity samples which were then analyzed using a Plessey Environmental Systems inductive salinometer (model 6230N), providing a precision of ± 0.003 parts per thousand. Density was calculated by a computer program based on Ekman's equation of state.

Vertical zooplankton hauls were simultaneously carried out using a 70 cm diameter net with 210 micron mesh. Each station was sampled to a constant depth from cruise to cruise. All washings were collected and immediately preserved with 5% seawater formalin. Although a flow meter was not utilized in this study, faunal concentration estimates have been presented per vertical (as opposed to a cubic) meter. To facilitate comparison with other works, the relative abundances expressed per vertical meter are equivalent to a range of 140-6147 organisms m^{-3} . Total abundances were determined by the method suggested by Winsor and Walford (1936). Three subsamples of 5 ml were drawn from the randomly mixed original volume and the number of organisms present recorded. Taxonomic identification of the first 100 individuals from a fourth

subsample provided species composition. No attempt was made to classify larval species or fish eggs. Different stages of copepodite development were likewise not distinguished, but rather merely catalogued as copepod larvae. "Les Fiches d'Identification du Zooplankton" (1939 -) was the principal taxonomic reference utilized.

RESULTS AND DISCUSSION

PHYSICAL OCEANOGRAPHY

Appendix I contains complete temperature, salinity and sigma-t records for all six cruises. Profiles of temperature and salinity with depth are presented in Fig. 2a-f. A pattern of elevated water temperatures in response to increased solar radiation as summer progresses is immediately apparent. The waters now observed in Logy Bay were previously those found off the coast of Labrador, and have been transported southward by the inshore Labrador Current.

Station 10 (Fig. 2a), a shallow water location (20-25 m) in close proximity to the shoreline, revealed surface heating in August that extended to the sea bottom, with temperatures exceeding 15°C even at 20 m. The seasonal warming trend was associated with a marked decrease in salinity, resulting from large scale events that originated in Arctic waters. A difference of 2.2 parts per thousand was recorded between April and August, approaching a minimum of 31.01‰. By September, the effects of the summer heating cycle on surface waters had reached a maximum, and temperatures had begun to decrease.

Stations 21 and 22 (Fig. 2b,c) had a thermocline and halocline at 15-20 m by September. A similar decline in salinity to that found inshore was noted. Thus, the seasonal fluctuation in temperature and salinity characteristics at each of these three relatively shallow water stations closely resembled one another.

Stations 33, 34 and 35, less influenced by the coastline or bottom topography, are more representative of the deeper waters found in Logy Bay (Fig. 2d-f). An intense thermocline was established by August, penetrating to a depth of 20-30 m. Moreover, because surface salinities tended to decrease through the summer, a strong halocline developed at approximately the same depth as the thermocline did in August. The composition of this surface summer layer was identical to that of inshore stations, with temperatures ranging from 14 to 16°C and a salinity of 31.1‰. Underlying the base of this relatively low density ($\sigma_t = 23.8$) upper water, temperature and salinity were both narrowly defined over the entire study interval. Fig. 3, which provides computer interpreted temperature and salinity contours at each station, illustrates this situation. Below 30 m, temperature remained within the interval $0.0 \pm 1.4^\circ\text{C}$, salinity was consistently at (or above) 32.2‰, and density was substantially greater than that of near-surface waters, with σ_t values approaching 26.0. The pronounced surface to bottom density gradient indicated a high degree of vertical stability in the water column. Stratification was also observed in the relatively shallow waters of Stations 21 and 22 (see Fig. 4, part c).

A definite thermohaline structure therefore characterizes Logy Bay. Cold, saline waters ($T = 0.2^{\circ}\text{C}$, $S = 32.6^{\circ}/\text{oo}$) with a tightly clustered T-S distribution (see Fig. 4, part a) are present throughout the entire water column in April. A surface mixed layer of intermediate density (24.9 sigma-t units) begins to develop during May and June. By mid-summer (August), these surface waters have acquired distinct T-S characteristics (15°C , $31.00^{\circ}/\text{oo}$, sigma-t = 23.8) and extend from surface to bottom near the shoreline. The original more dense water mass that persists year-round below the effects of the seasonal heating and cooling cycle can be distinguished as typical inshore Labrador Current water, following the core values provided by Kudlo et al. (1976): temperatures between -1.8 and -0.8°C , salinities ranging from 32.9 and $33.1^{\circ}/\text{oo}$.

BIOLOGICAL OCEANOGRAPHY

Zooplankton populations in Logy Bay exhibited distinct seasonal as well as spatial variations. Estimates of total abundance per vertical meter (illustrated in Fig. 5) remained low until August, when approximately five-fold increases were recorded. Copepod larval stages were particularly numerous during May, approaching 60% of all individuals identified at Station 35. By July, however, adult Pseudocalanus minutus and Oithona nana were most frequently encountered. This suggests that a new generation of copepods had developed, occurring concomitantly with the seasonal warming and freshening trend of Logy Bay. Moreover, these modified waters appeared to be suitable for rapid copepod growth and development to maturity, since larvae were once again prominent by September. These copepodites may represent the eventual overwintering phase, although no supporting data exist at present.

Examination of selected species distribution patterns reveals several apparent trends. Fig. 6a-f represent frequency histograms of those species comprising 5% or more of the population by number at each station. Copepods dominated the overall adult community structure, with P. minutus and O. nana the foremost members. Oikopleura dioica, an appendicularian, was first observed in May throughout the study area, and was still abundant in June. By July, however, Fritillaria borealis had entirely replaced this species, only to disappear by August. During this period of succession from O. dioica to F. borealis, a peak in the overall diversity of species was recorded, and one of the dominant zooplankters to emerge was Temora longicornis. The sudden occurrence of this species at a comparatively late stage in the biological summer may indicate a breeding cycle distinct from that of O. nana and/or P. minutus. Indeed, it is also possible that low salinity, high temperature water conditions may be one of the requirements initiating the breeding response in this species, although this has yet to be demonstrated. T. longicornis supplanted O. nana as the dominant representative during September.

Geographical differences in species composition were observed, in addition to those of a seasonal nature. The enhanced percentage composition of T. longicornis was most evident at offshore Stations 33, 34 and 35. Similarly, Calanus finmarchicus and Centropages hamatus were commonly observed only at offshore locations. Since the vertical tows performed at these stations

sampled both above and below the pycnocline, such species as C. finmarchicus and C. hamatus may be primarily associated with the colder, more saline inshore Labrador Current type water found at depth. Consequently this suggests that the relatively deeper waters off Logy Bay constitute a biological (as well as physical) oceanographic environment distinct from that encountered nearer to shore.

The collections obtained from these offshore stations closely resemble zooplankton populations previously determined. According to Vladimirskaia (1965), the shallow waters off Newfoundland commonly harbor such neritic organisms as Pseudocalanus minutus, Temora longicornis and Centropages hamatus. Furthermore, Plekhanova and Ryzhov (1976) stated that in addition to these species, coastal stations in this vicinity were characterized by Fritillaria borealis, Sagitta elegans, Oithona similis, Acartia longiremis and the larvae of such demersal invertebrate taxa as Lamellibranchiata, Polychaeta and Echinodermata, similar to results obtained in this study. (It should be noted that differentiation between O. nana and O. similis was extremely difficult due to the poor physical condition of many of the individuals.)

The results presented have therefore provided a better understanding of zooplankton distributions in a near-shore region. Temporal variations indicated not only possible breeding cycles of several copepod species, but also the succession of certain individual species through the onset of summer. Spatial differences reflected the common occurrence of selected species at offshore, deeper water stations, but their absence inshore. The most significant feature of this study, however, is the demonstration that there exists two discrete oceanographic environments, defined by both physical and biological characteristics: a relatively deep water core, and a surface mixed layer that is modified by atmospheric forces.

ACKNOWLEDGMENTS

It is with pleasure that I am now able to express my appreciation to those individuals who collaborated with me in this research program. I am very grateful to Dr. Ray Thompson, who constantly provided me with encouragement and sound advice. I would also like to sincerely thank Ian Borthwick for his constructive comments upon reading the initial rough draft of this report. My thanks are also extended to the diving crew at the Marine Sciences Research Laboratory who aided in the collection of data. Finally, I appreciate the support I received from Scott Akenhead and John Anderson on behalf of Fisheries and Oceans. This work was financed by an NSERC strategic grant to R. J. Thompson.

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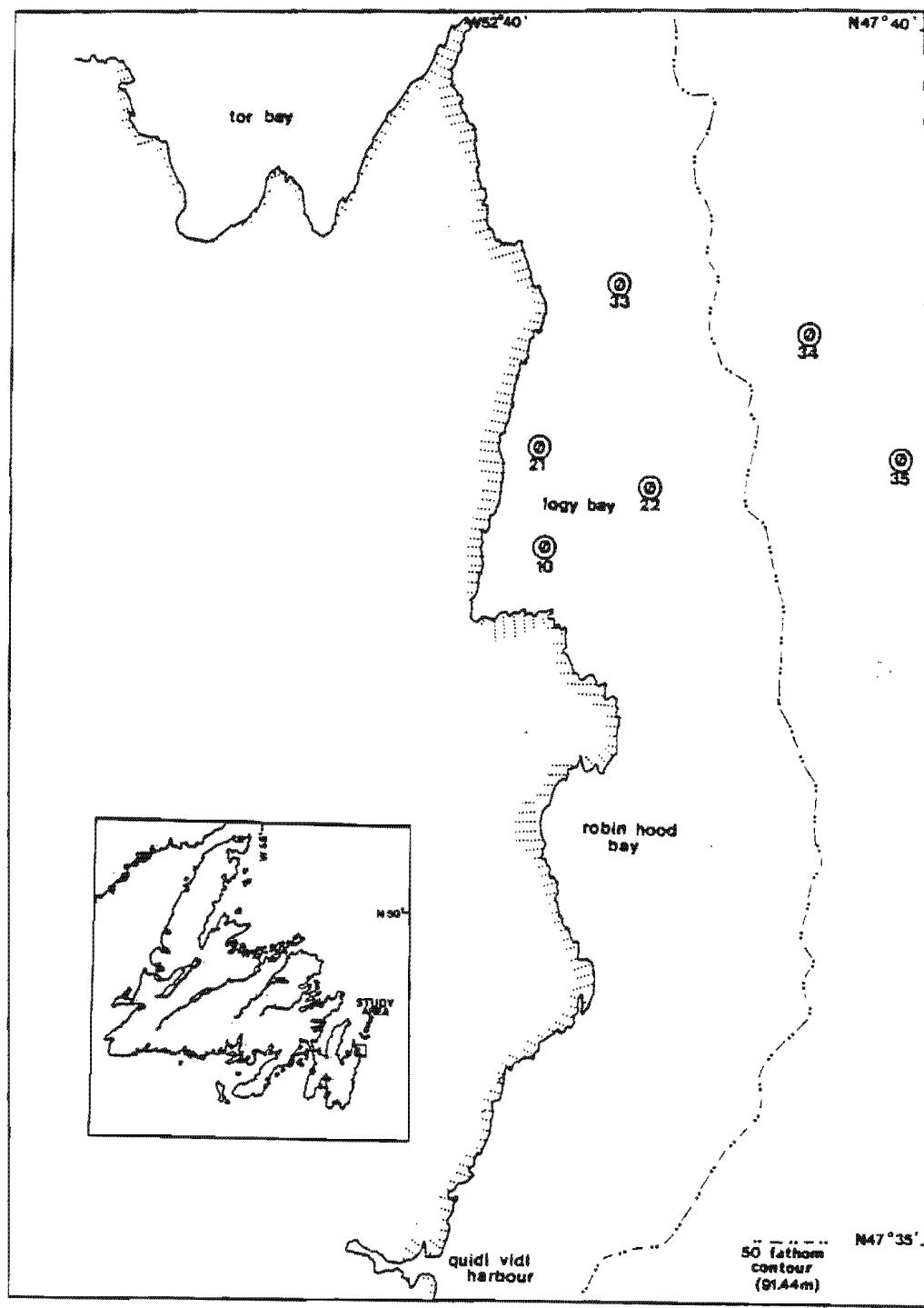


Fig. 1. Logy Bay, Newfoundland, and the positions of the six stations sampled during this study.

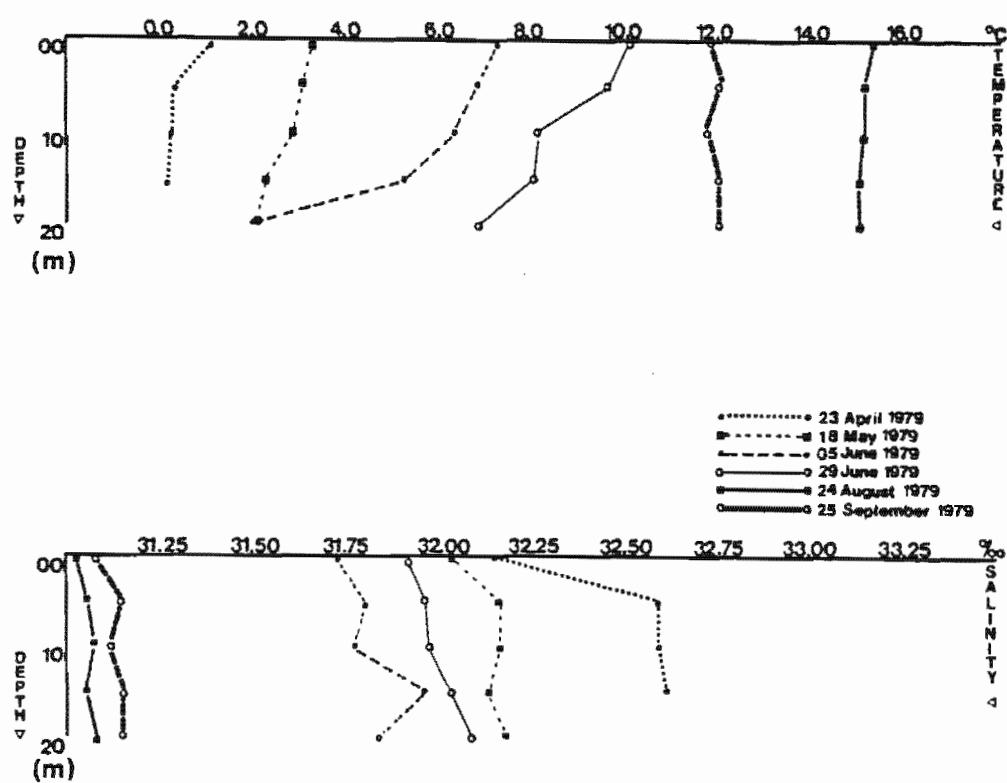


Fig. 2a. Vertical profiles of temperature (above) and salinity (below) at Station 10.

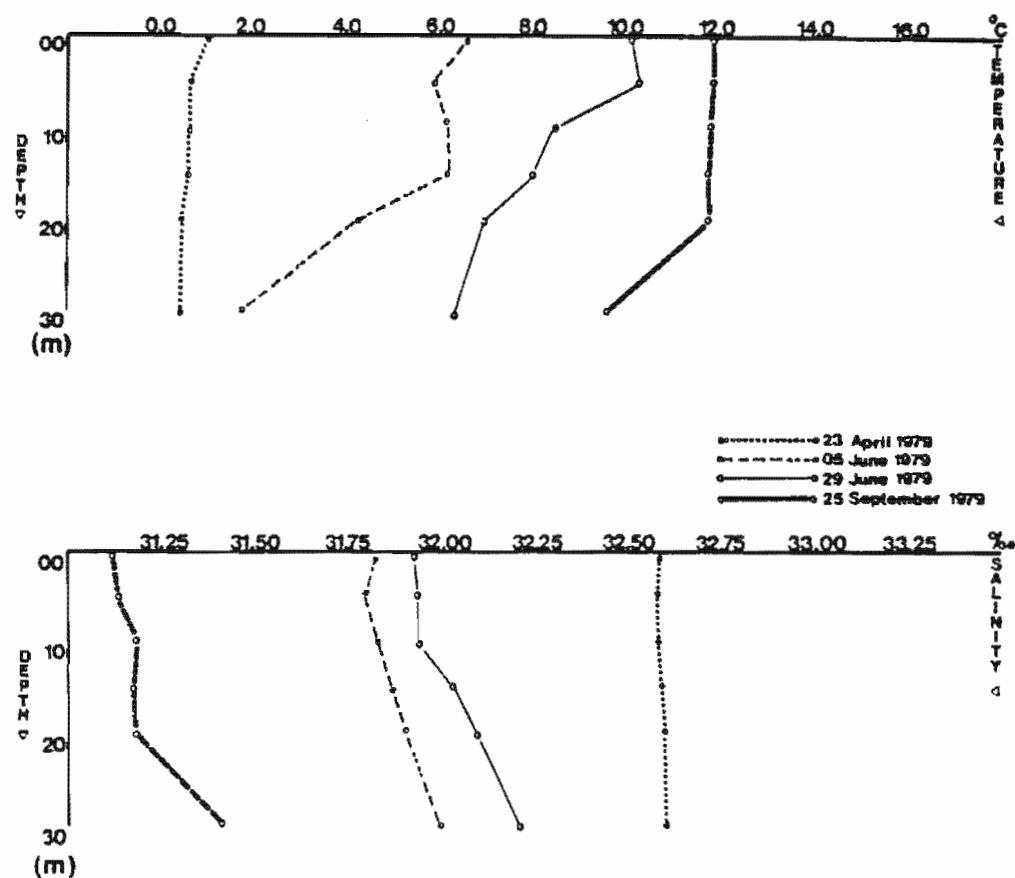


Fig. 2b. Vertical profiles of temperature (above) and salinity (below) at Station 21.

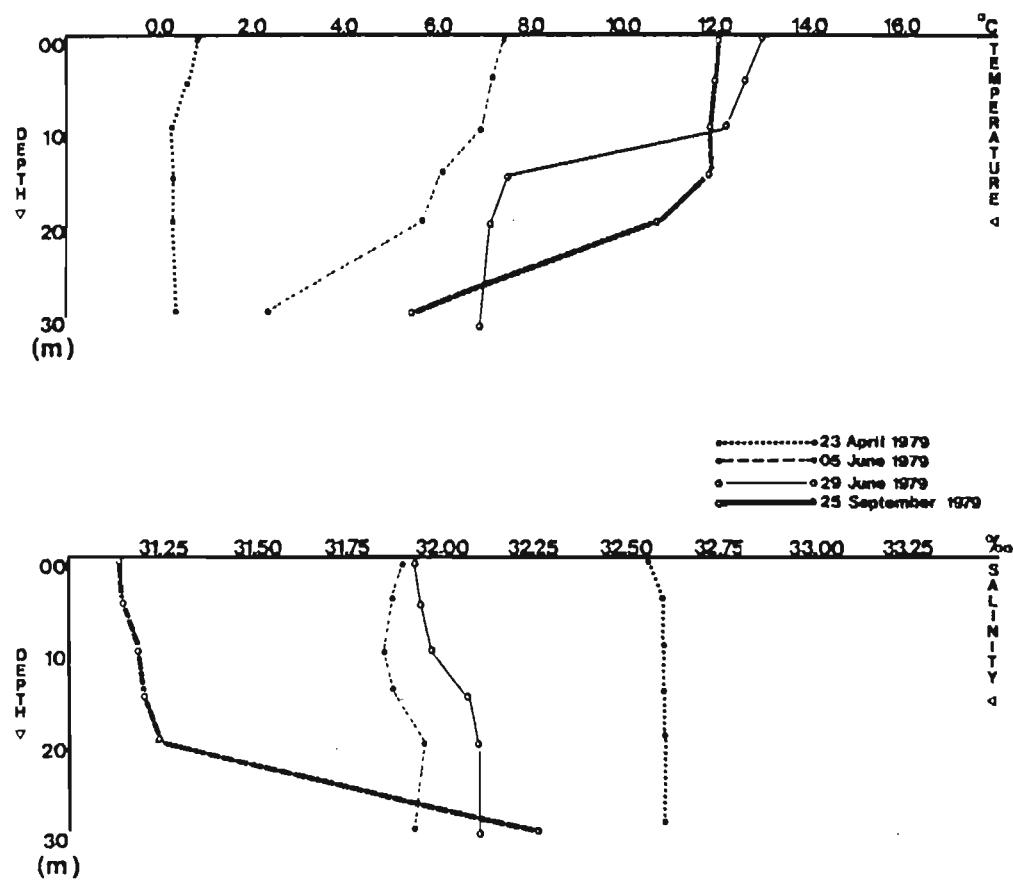


Fig. 2c. Vertical profiles of temperature (above) and salinity (below) at Station 22.

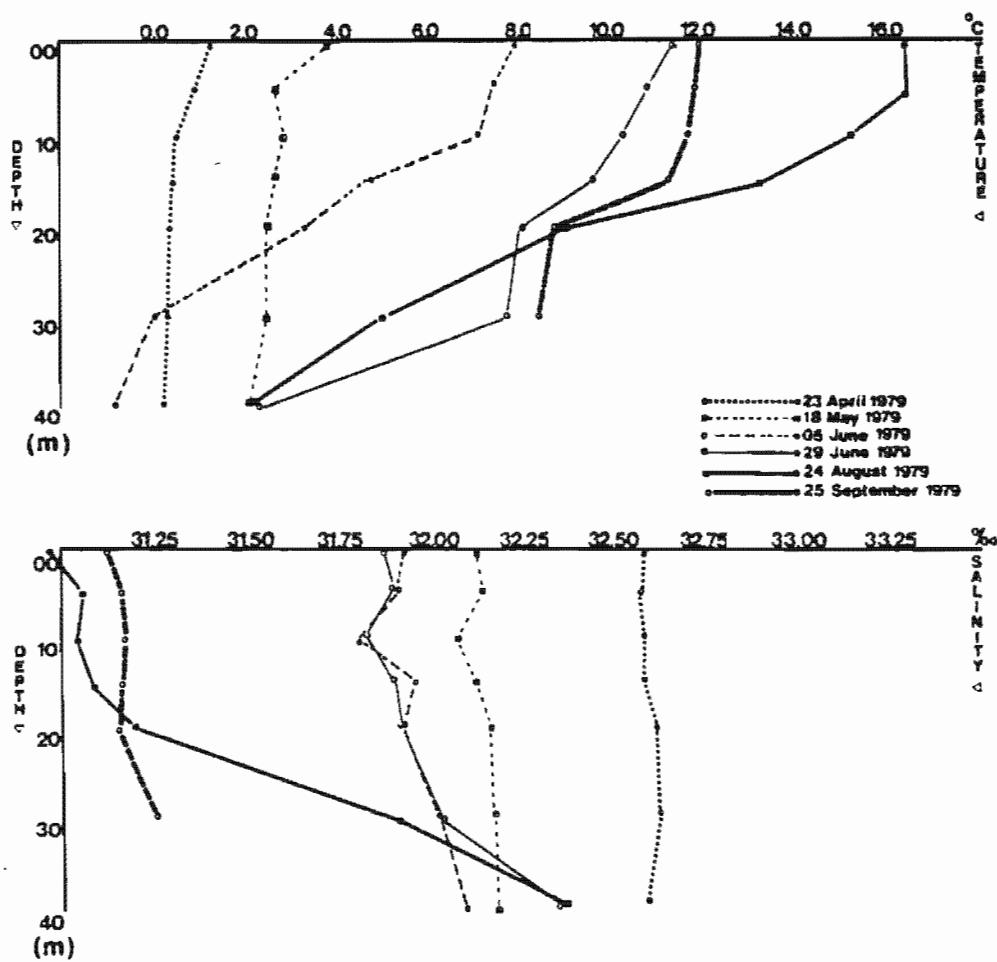


Fig. 2d. Vertical profiles of temperature (above) and salinity (below) at Station 33.

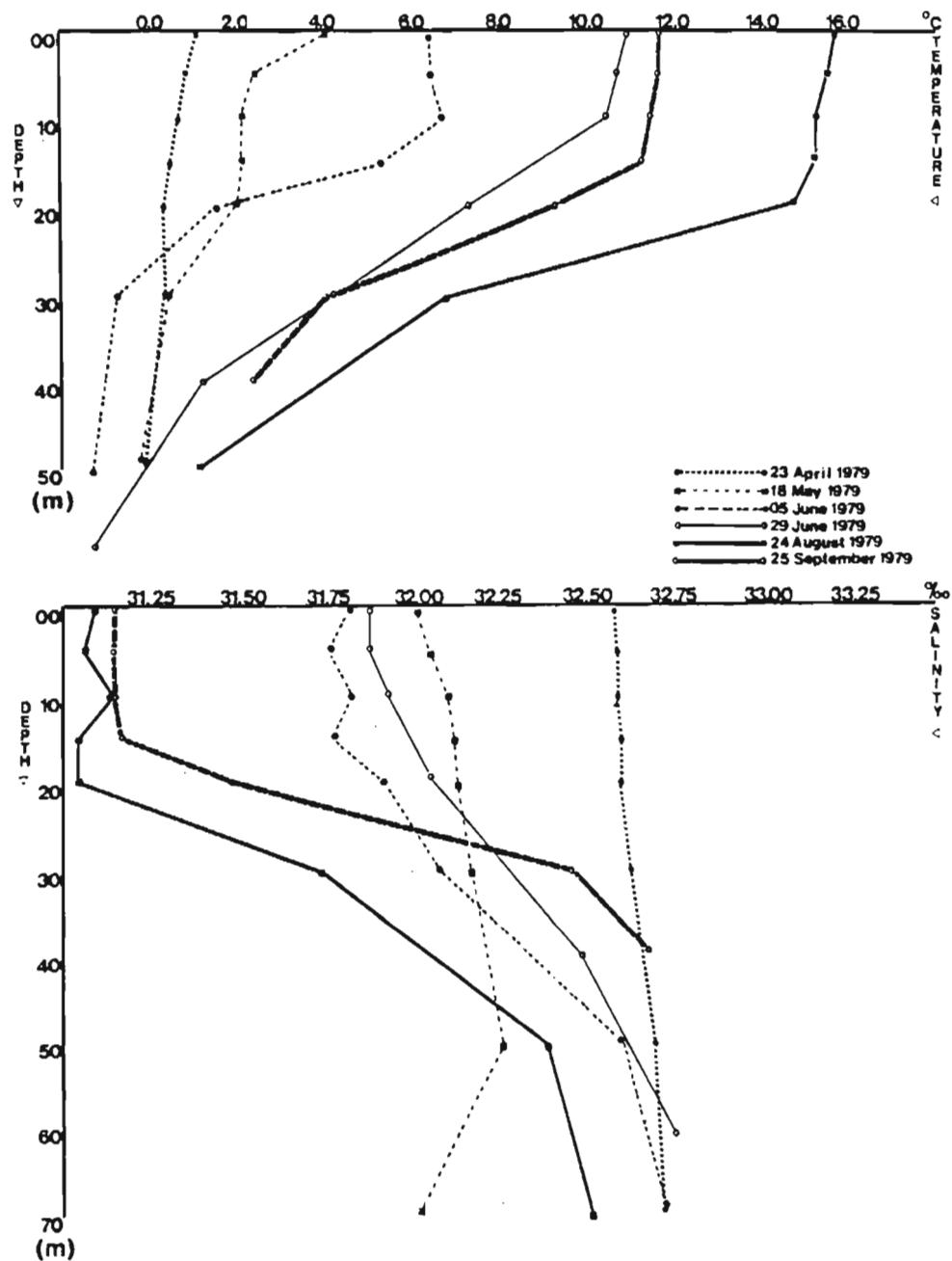


Fig. 2e. Vertical profiles of temperature (above) and salinity (below) at Station 34.

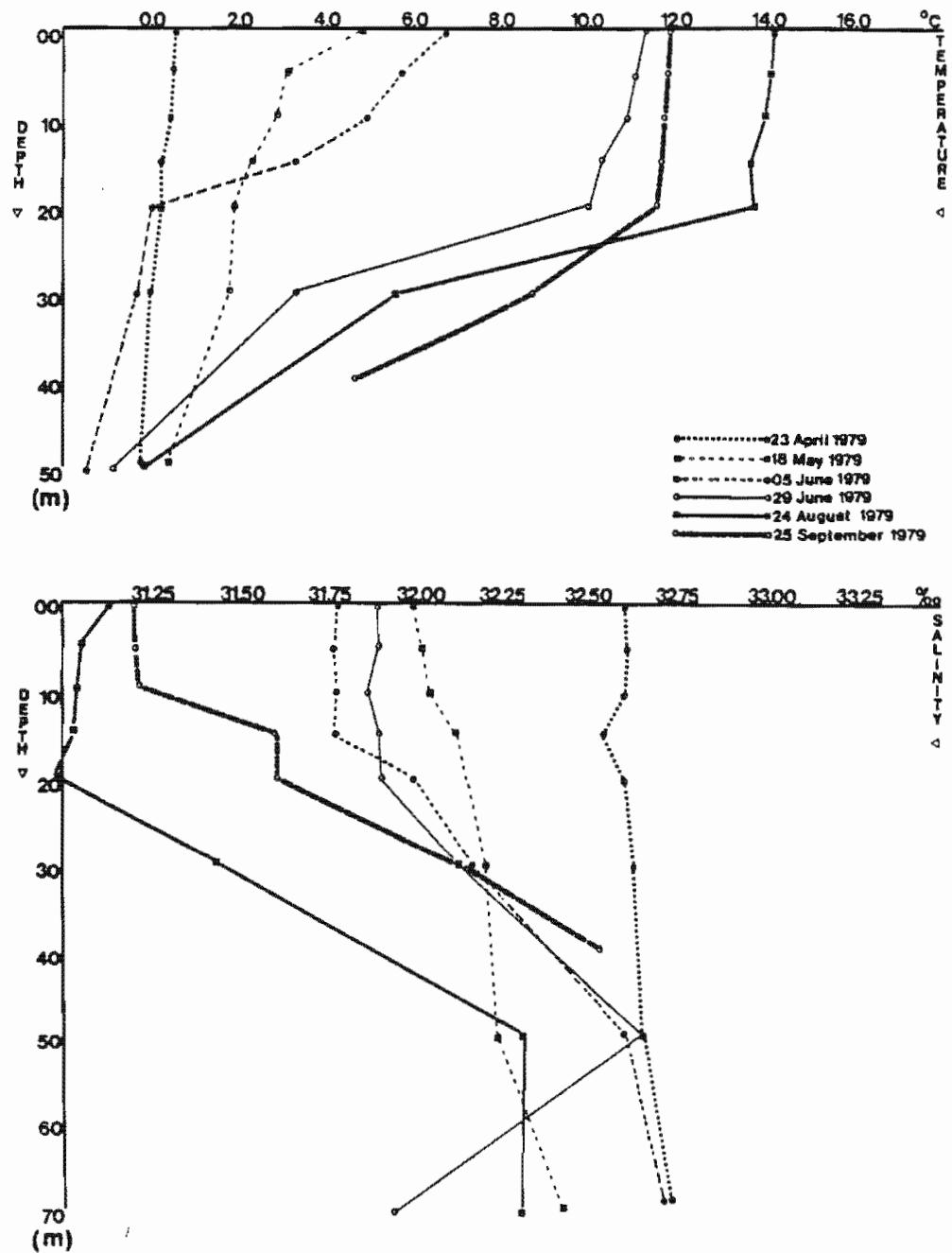


Fig. 2f. Vertical profiles of temperature (above) and salinity (below) at Station 35.

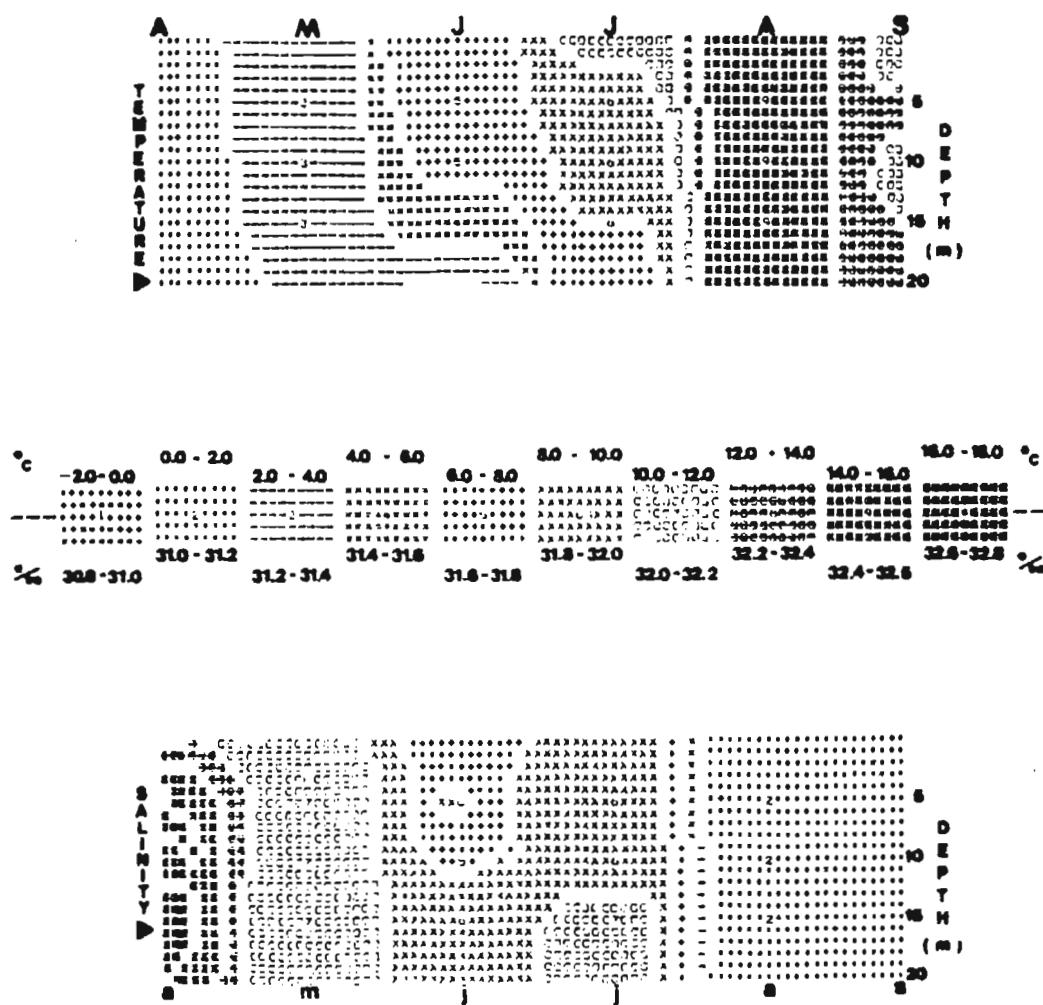


Fig. 3a. Computer interpreted contour diagrams of temperature and salinity at Station 10.

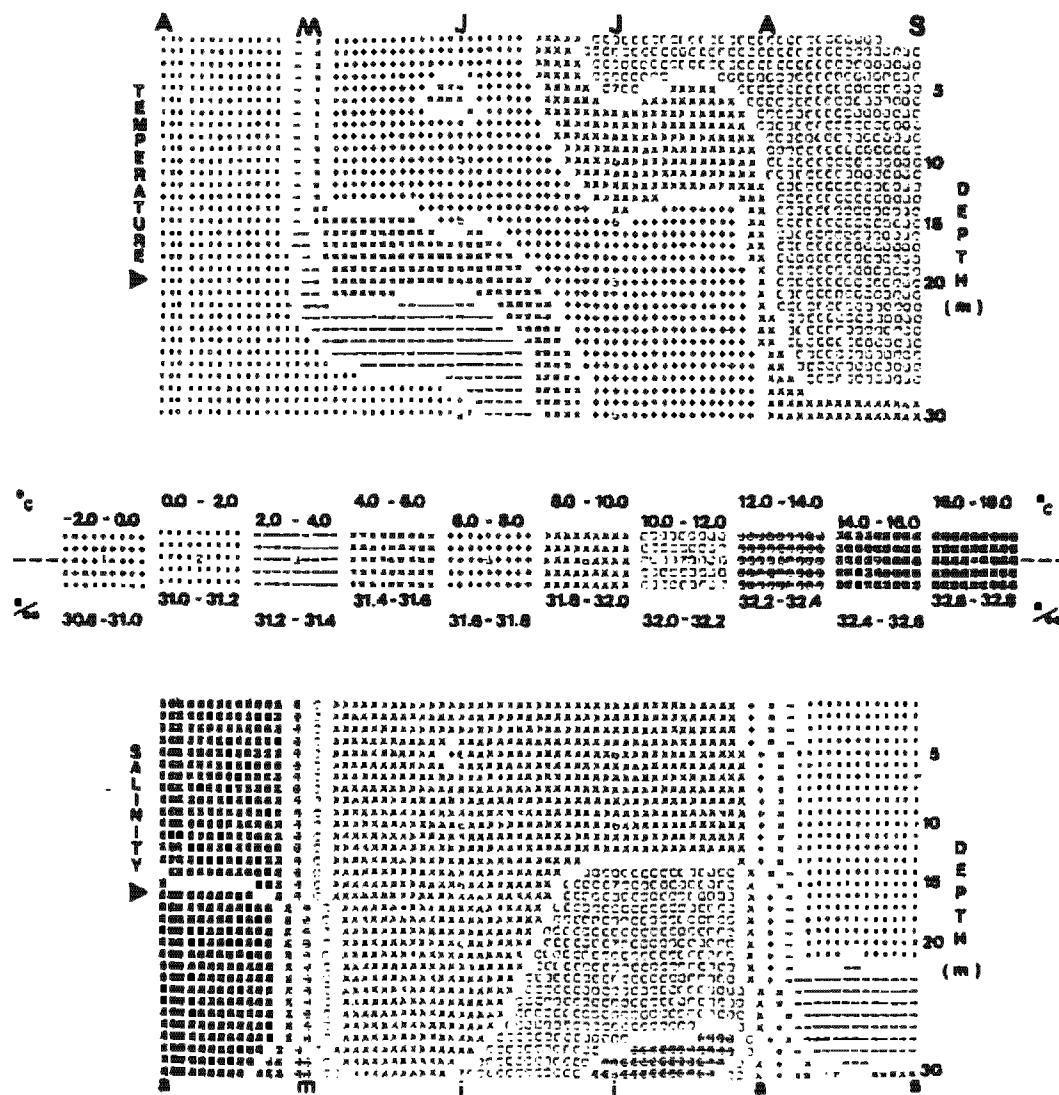


Fig. 3b. Computer interpreted contour diagrams of temperature and salinity at Station 21.

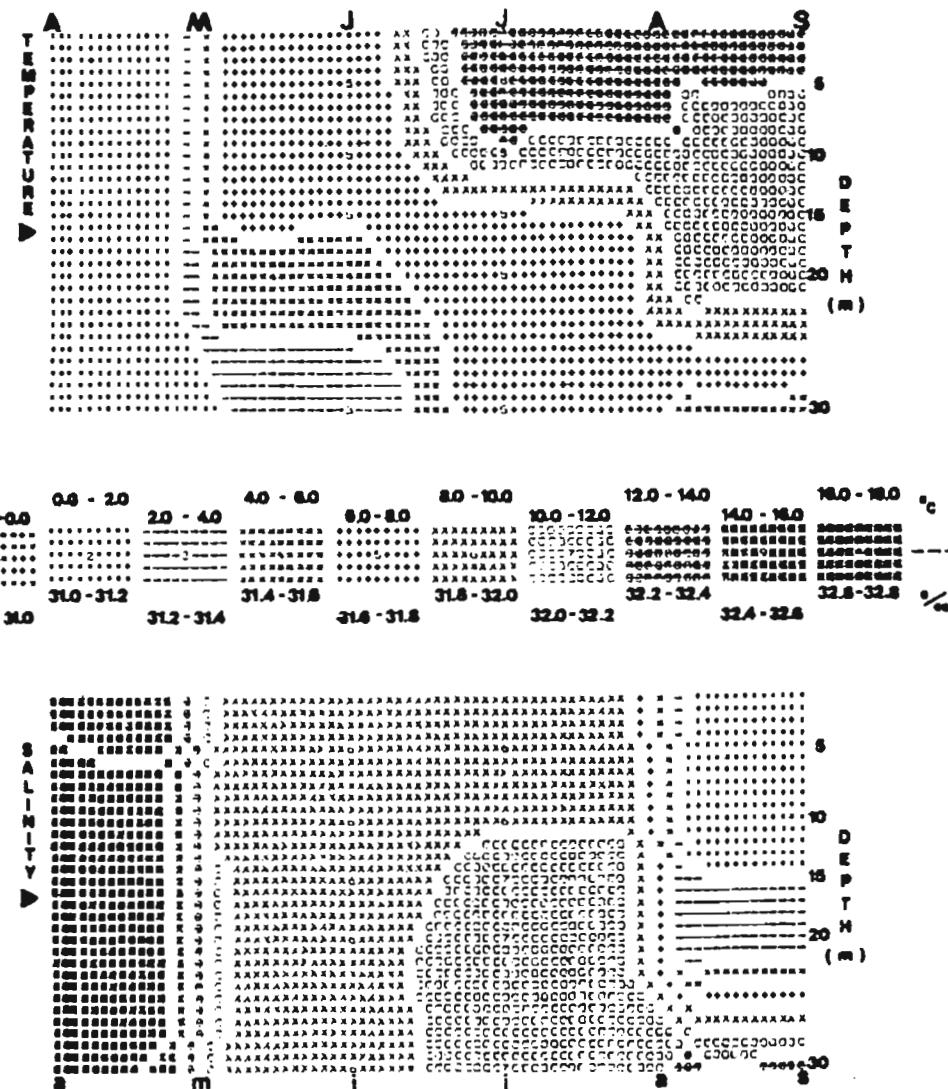


Fig. 3c. Computer interpreted contour diagrams of temperature and salinity at Station 22.

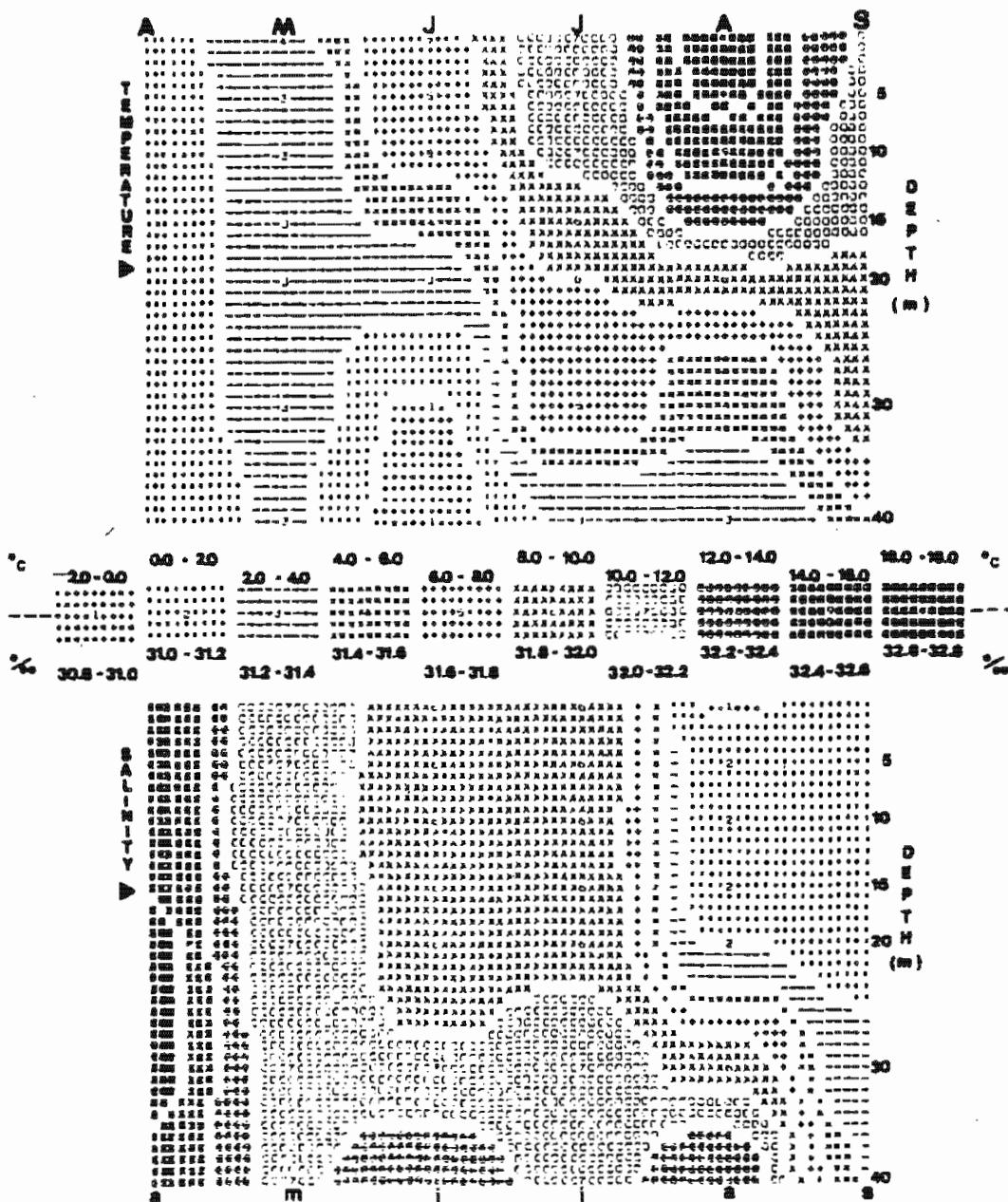


Fig. 3d. Computer interpreted contour diagrams of temperature and salinity at Station 33.

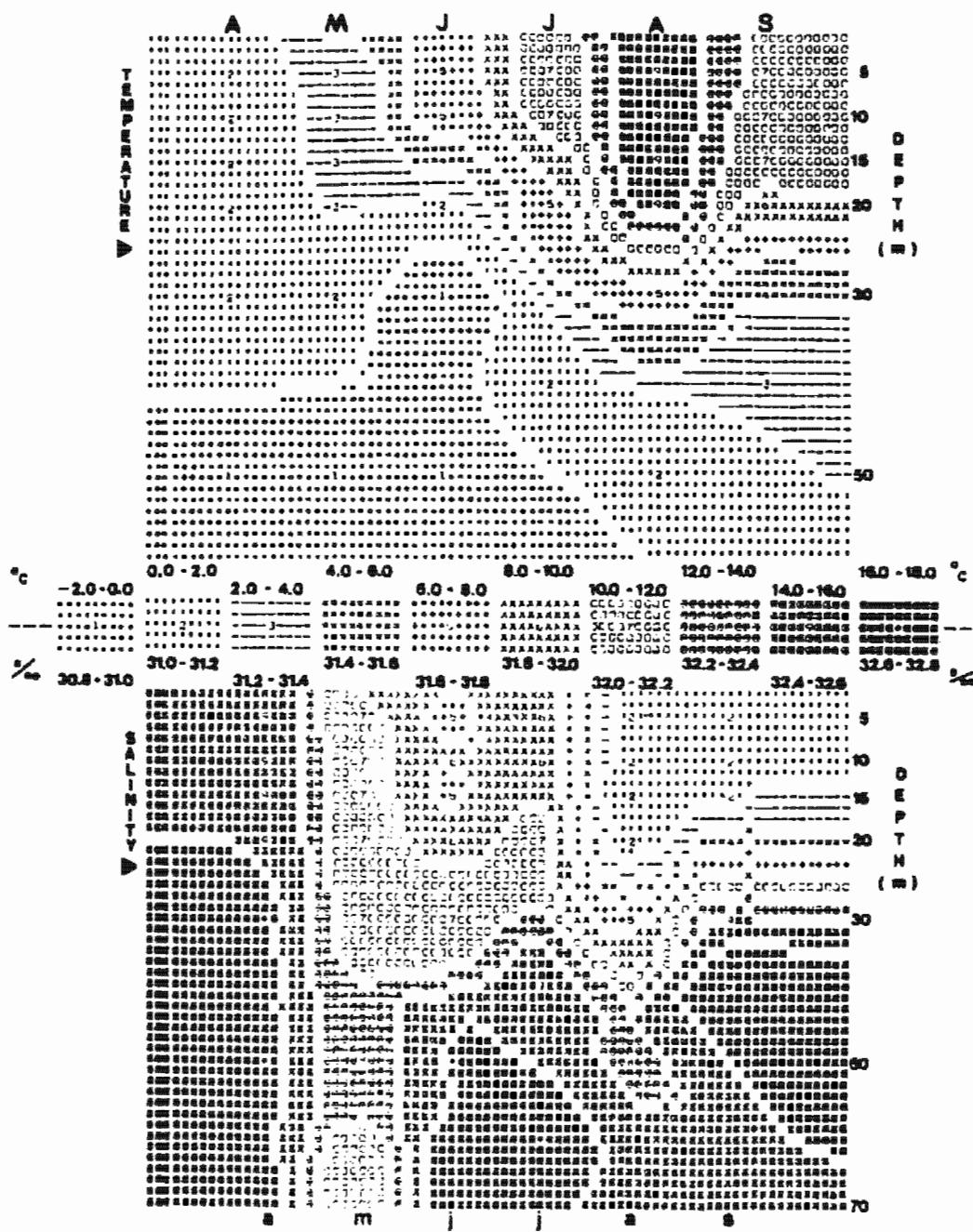


Fig. 3e. Computer interpreted contour diagrams of temperature and salinity at Station 34.

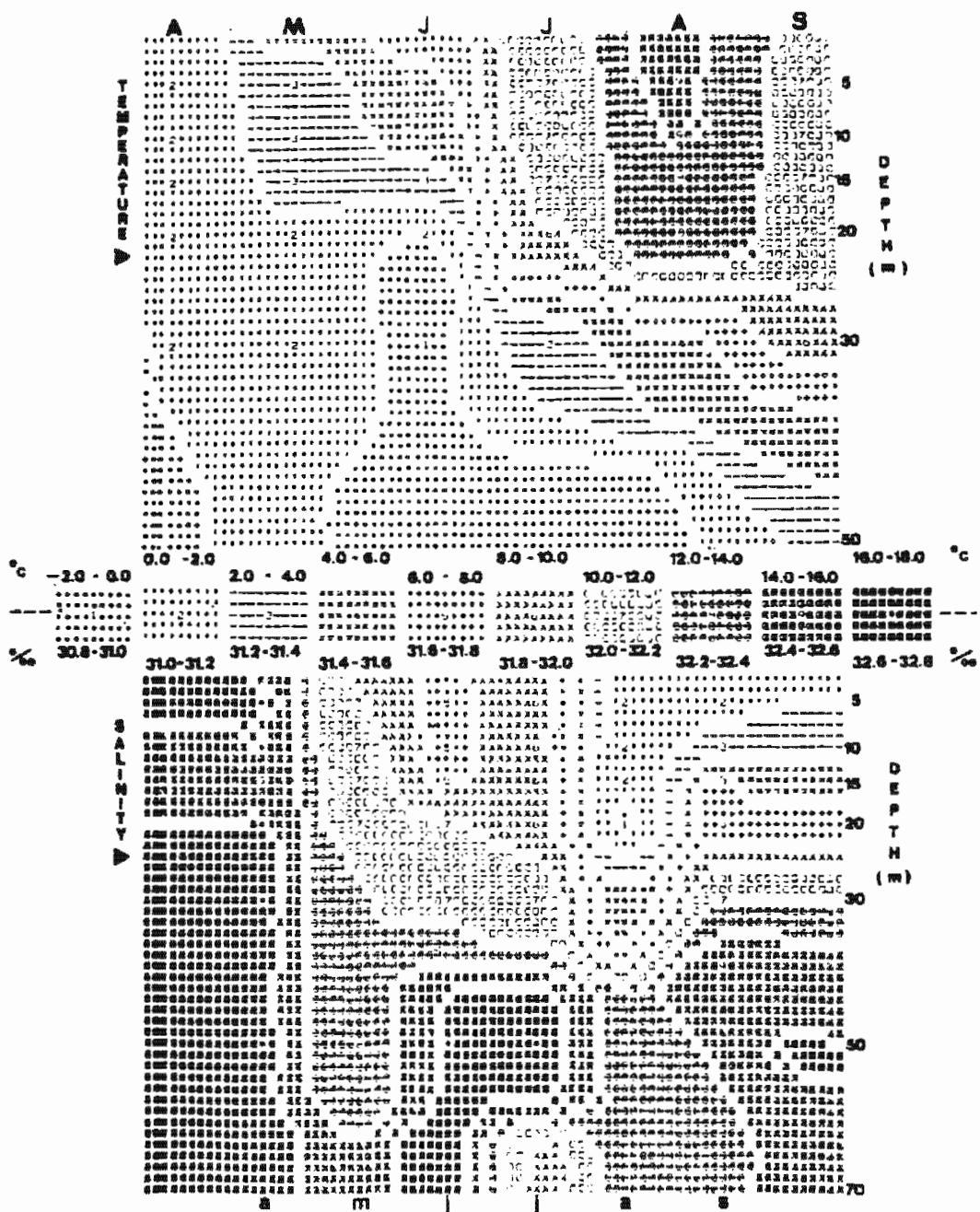


Fig. 3f. Computer interpreted contour diagrams of temperature and salinity at Station 35.

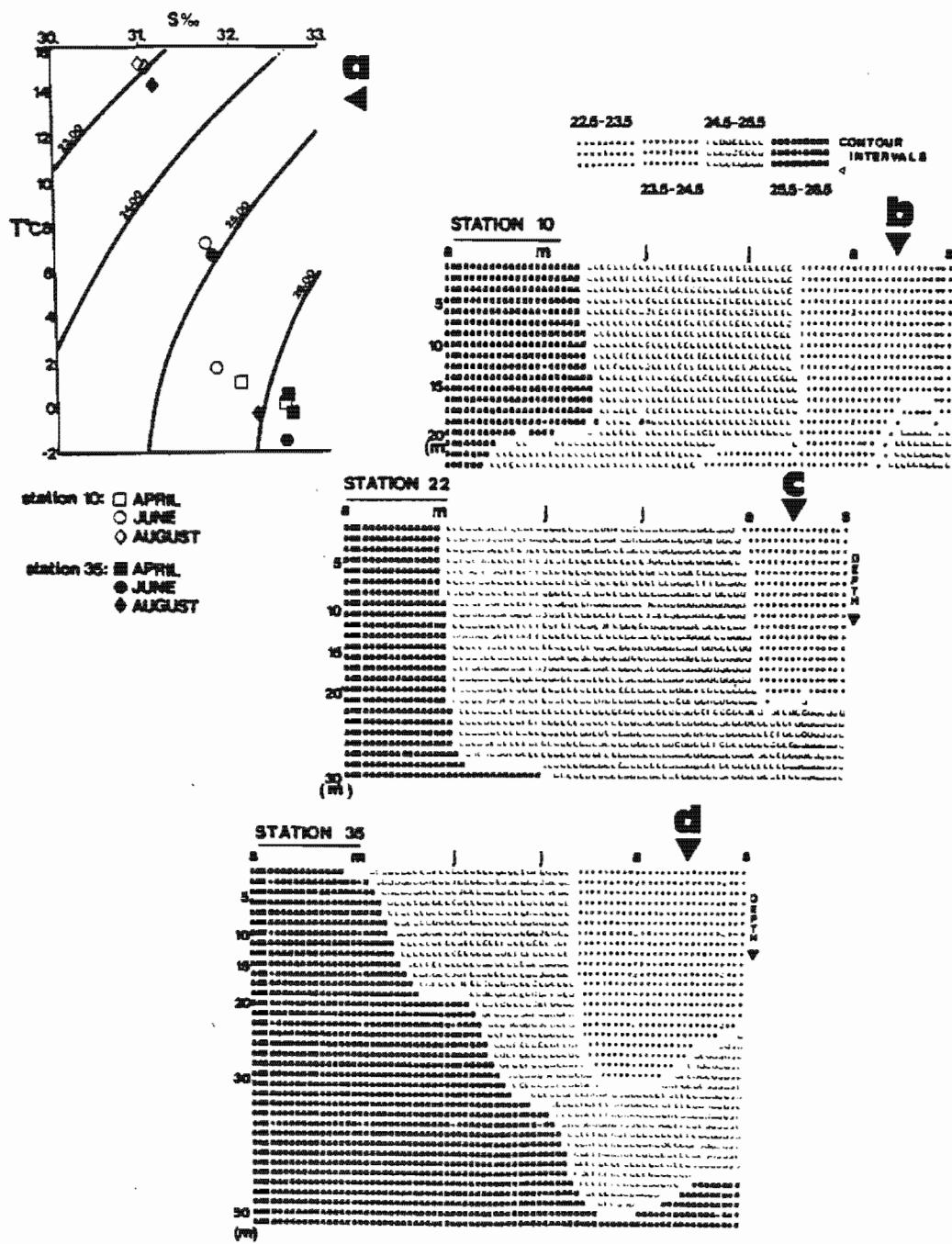


Fig. 4. Density determinations from selected stations. a) T-S diagram with isopleths of sigma-t indicating surface and bottom T-S values (only) from Stations 10 and 35 in April, June and August. Three distinct envelopes are present, with inshore Labrador Current Type Water (at low temperatures and high salinities) and surface coastal water (consisting of high temperature and low salinity); b) Computer interpreted density contours at Station 10; c) Station 22; and d) Station 35. Note the overall seasonal shift in surface densities as well as the intrusion of denser waters at depth at Station 22.

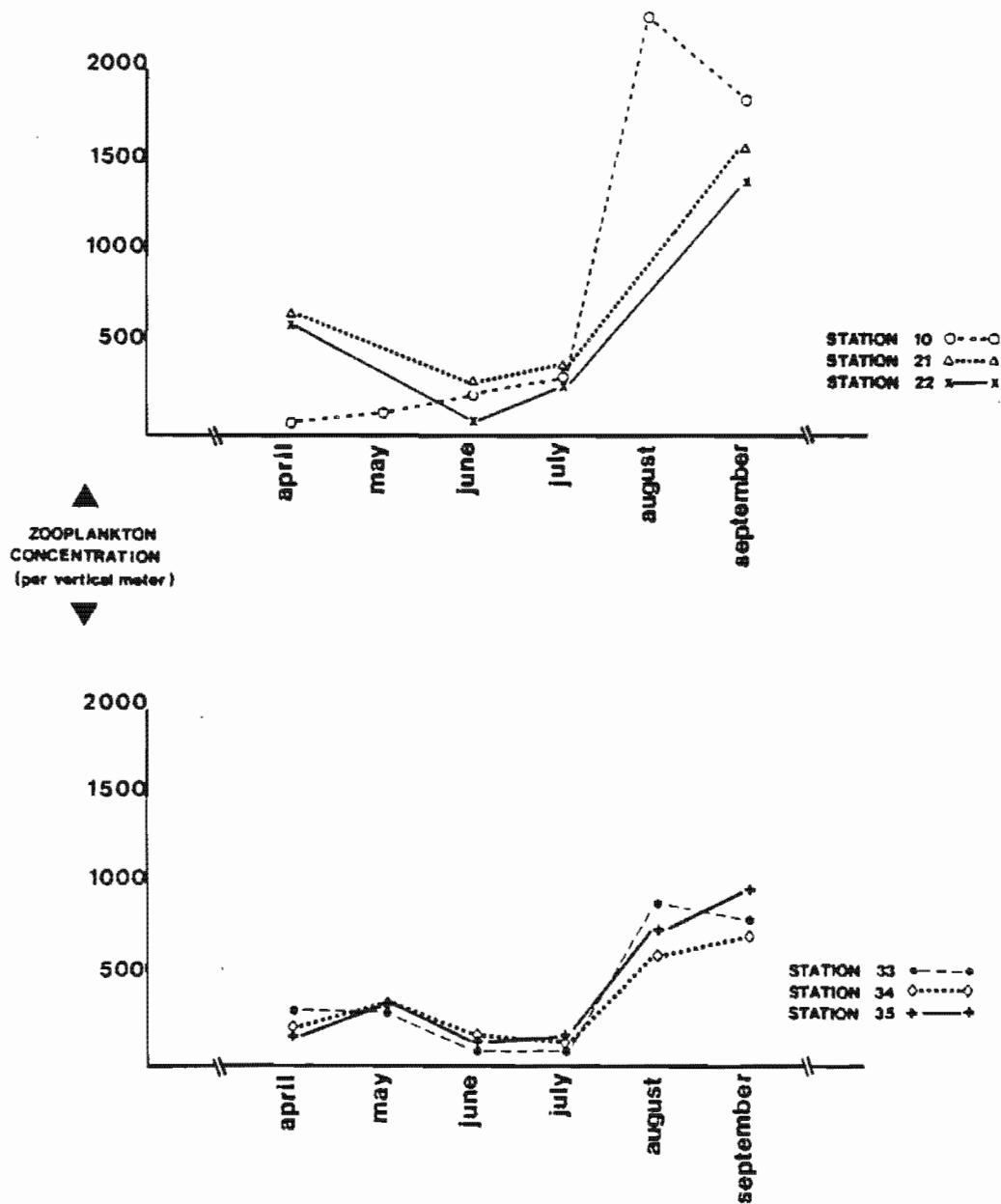


Fig. 5. Estimates of total zooplankton abundance per vertical meter (as defined in text) recorded monthly at each station.

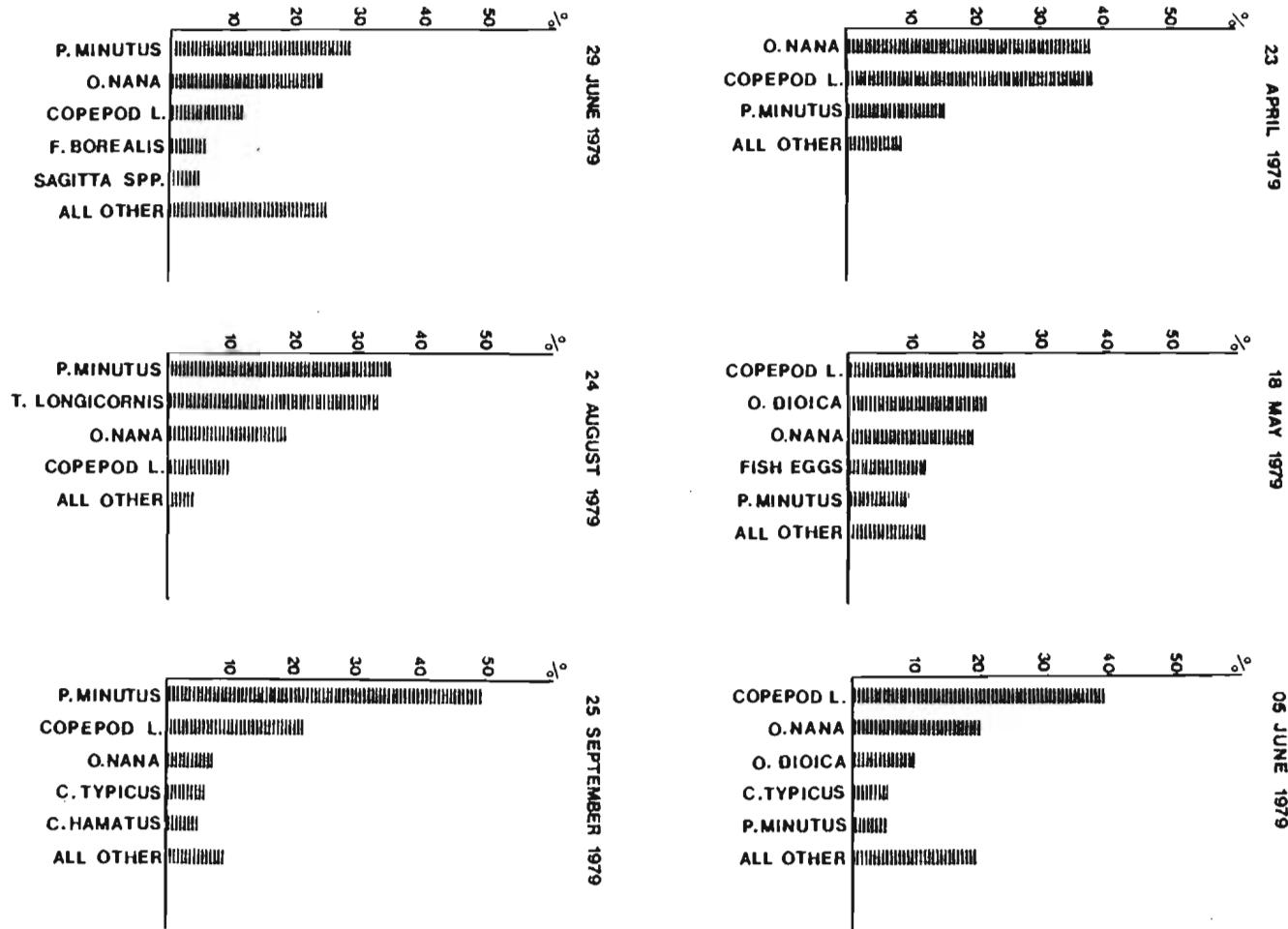


Fig. 6a. Frequency histogram of those individual species constituting 5% or more of the identified population at Station 10.

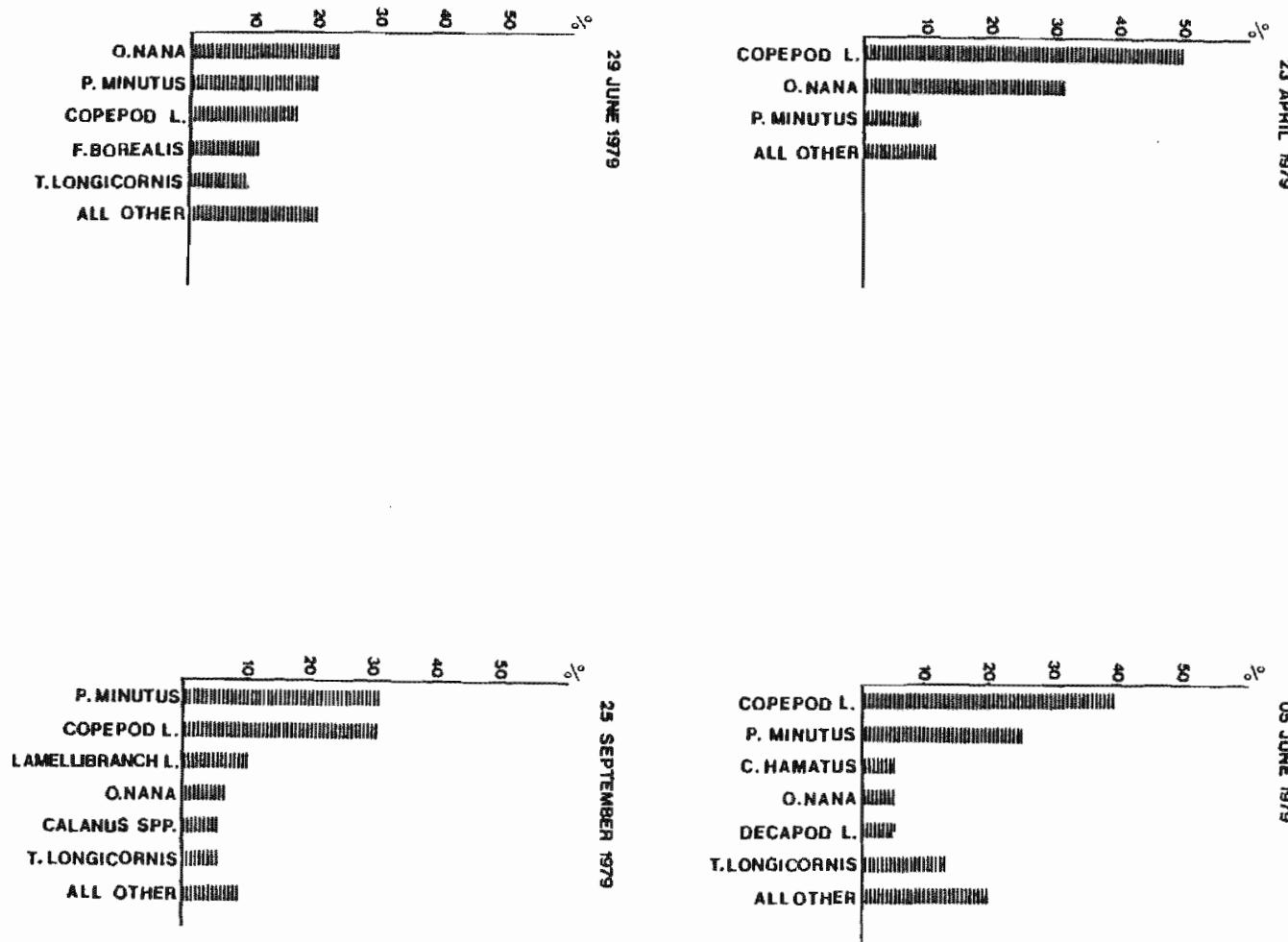


Fig. 6b. Frequency histogram of those individual species constituting 5% or more of the identified population at Station 21.

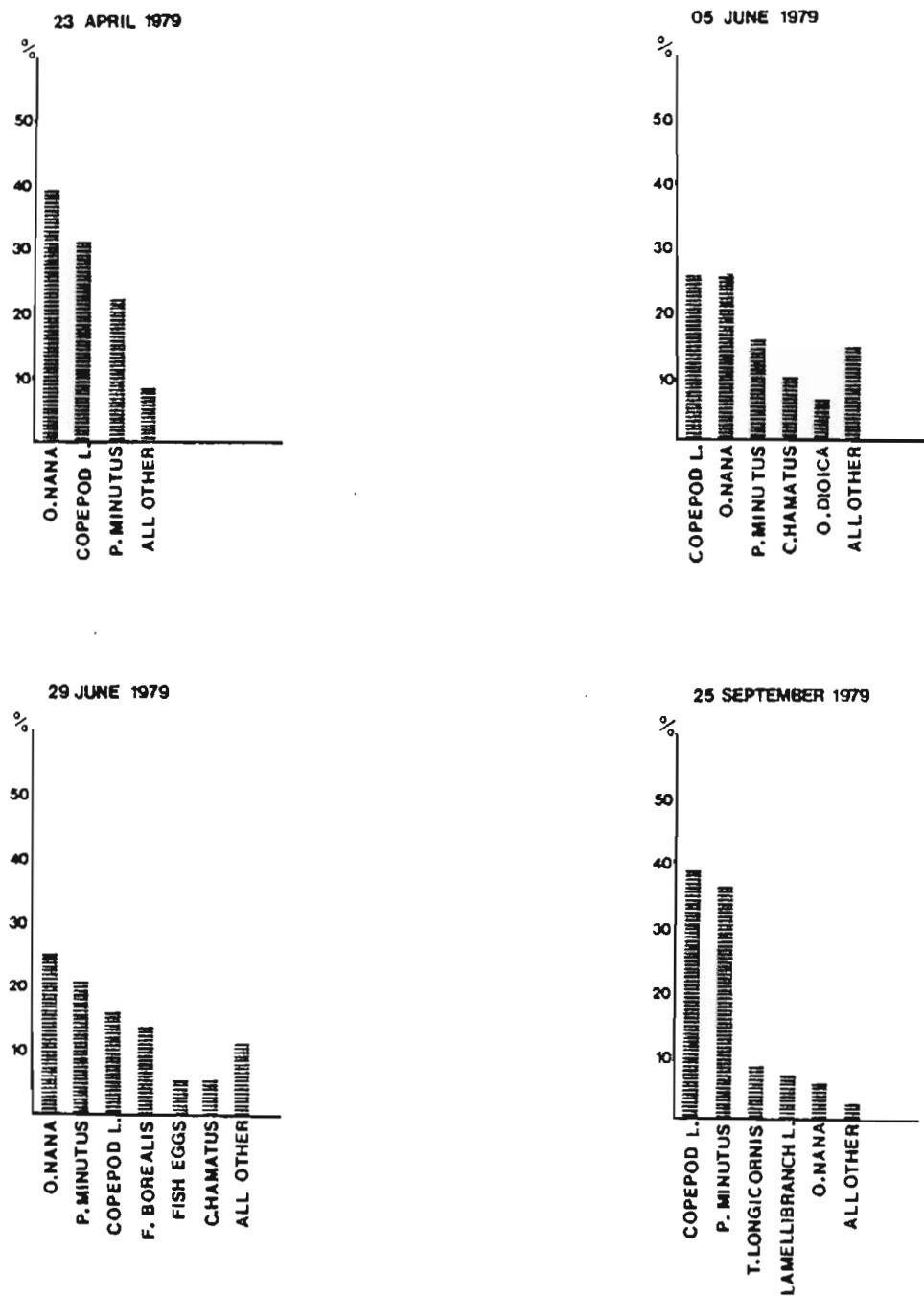


Fig. 6c. Frequency histogram of those individual species constituting 5% or more of the identified population at Station 22.

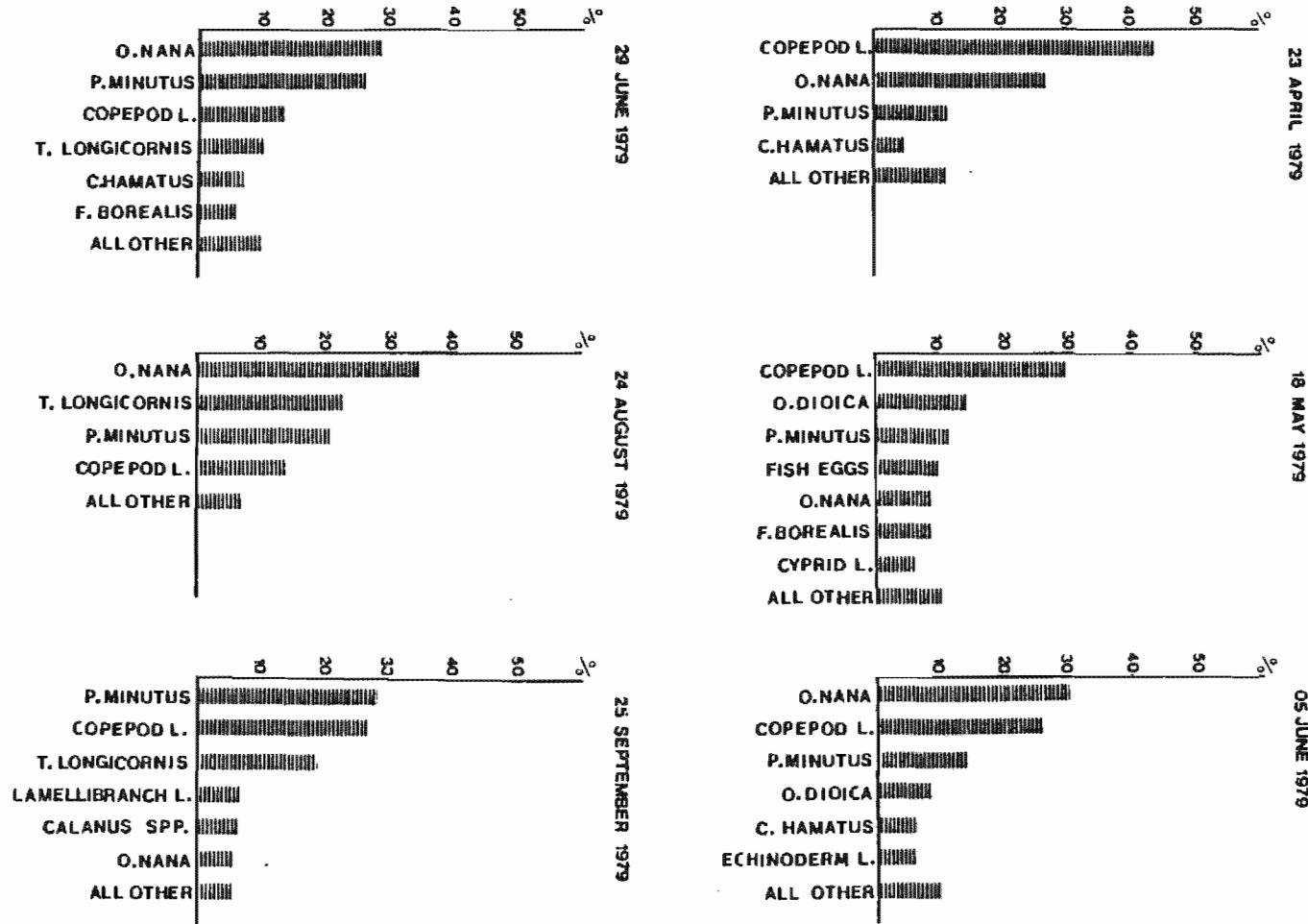


Fig. 6d. Frequency histogram of those individual species constituting 5% or more of the identified population at Station 33.

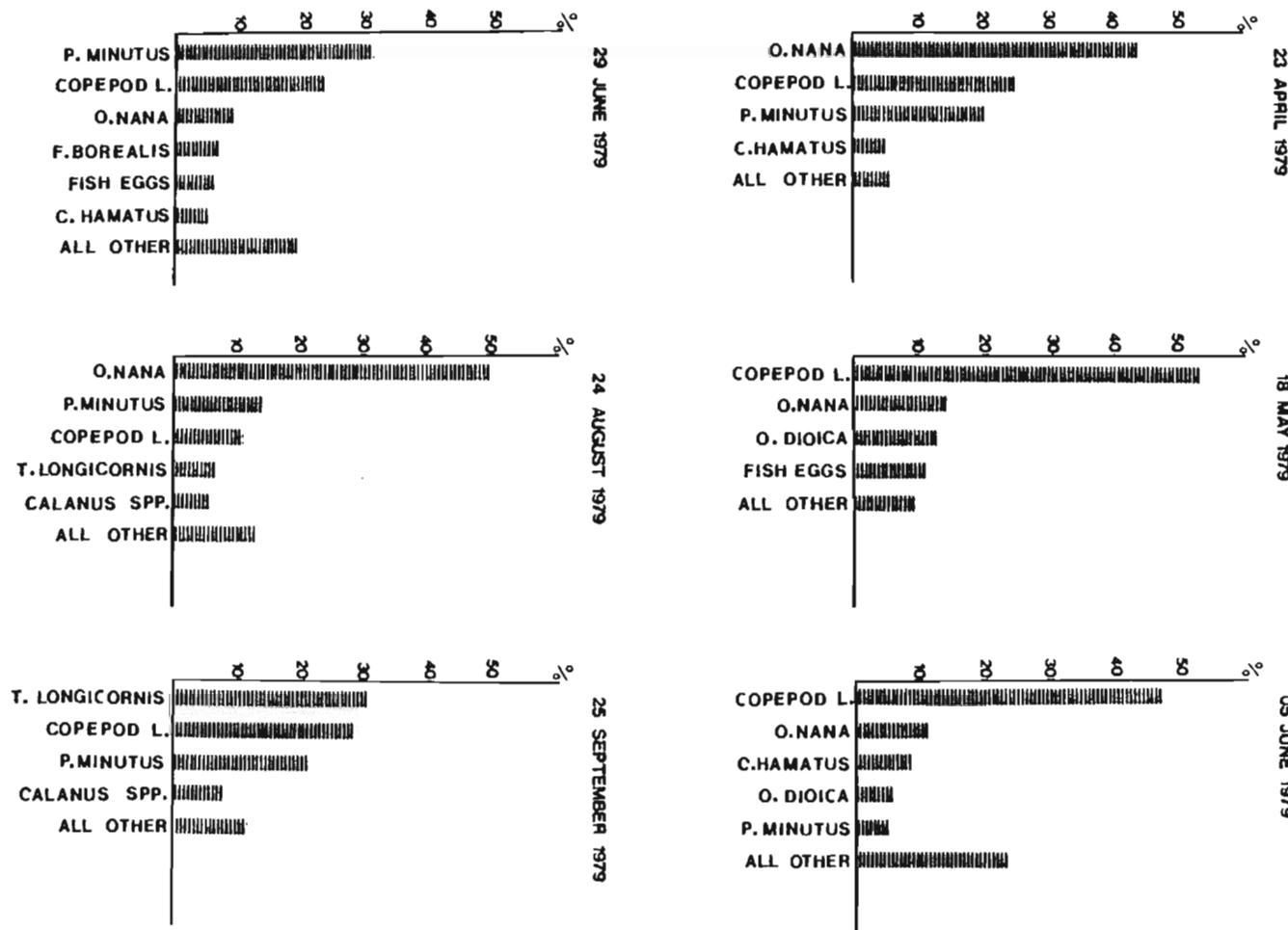


Fig. 6e. Frequency histogram of those individual species constituting 5% or more of the identified population at Station 34.

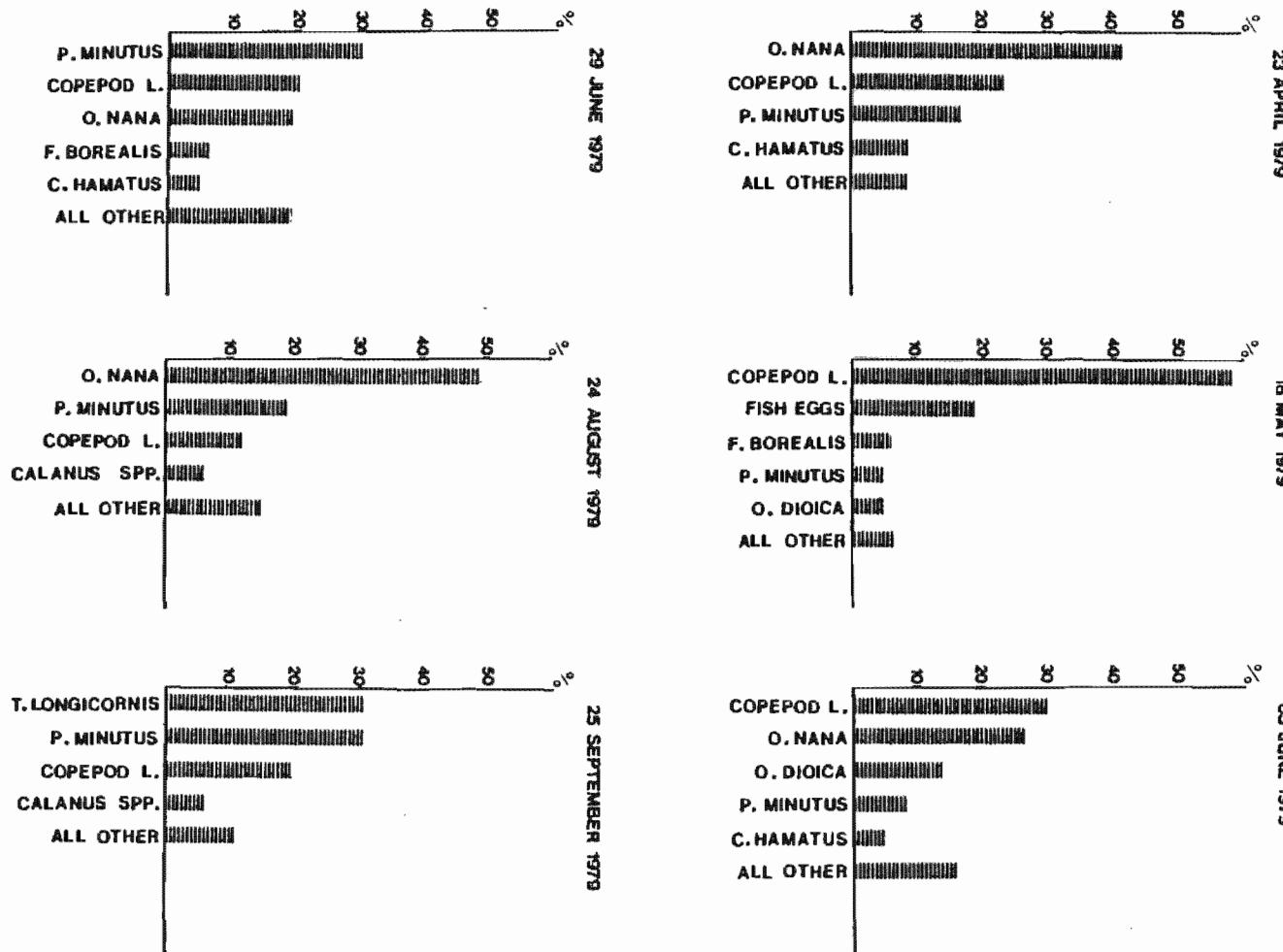


Fig. 6f. Frequency histogram of those individual species constituting 5% or more of the identified population at Station 35.

APPENDIX I

Physical and biological oceanographic data sheets
for each station sampled from the six completed cruises.



CRUISE # 001 - 23 April 1979

Station 10 (1100 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{oo}}$)	density(sigma-t)
0	1.20	32.102	25.78
5	0.35	32.590	26.26
10	0.30	32.593	26.27
15	0.20	32.612	26.30

Zooplankton Total Abundance: 1612
 Maximum Depth of Haul: 30 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	.	38%
Copepod larvae	.	.	.	.	.	.	38
Pseudocalanus minutus	.	.	.	.	.	.	15
Fritillaria borealis	.	.	.	.	.	.	4
Microsetella spp.	.	.	.	.	.	.	2
Calanus finmarchicus/helgolandicus	.	.	.	.	.	.	1
Oikopleura dioica	.	.	.	.	.	.	1
Fish eggs	.	.	.	.	.	.	1

CRUISE # 001 - 23 April 1979
 (continued)

Station 21 (1145 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{o}}$)	density(sigma-t)
0	1.10	32.601	26.19
5	0.65	32.591	26.23
10	0.65	32.591	26.23
15	0.60	32.600	26.24
20	0.45	32.606	26.27
30	0.45	32.613	26.27

Zooplankton Total Abundance: 29,070
 Maximum Depth of Haul: 40 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	49%
Oithona nana	.	.	.	.	.	.	32
Pseudocalanus minutus	.	.	.	.	.	.	8
Fritillaria borealis	.	.	.	.	.	.	3
Sagitta spp.	.	.	.	.	.	.	3
Fish eggs	.	.	.	.	.	.	2
Calanus finmarchicus/helgolandicus	:	.	.	.	.	.	2
Acartia clausi	.	.	.	.	.	.	1

CRUISE # 001 - 23 April 1979
 (continued)

Station 22 (1230 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{o}}$)	density(sigma-t)
0	0.85	32.558	26.18
5	0.65	32.607	26.24
10	0.25	32.608	26.29
15	0.30	32.610	26.29
20	0.30	32.612	26.29
30	0.40	32.615	26.28

Zooplankton Total Abundance: 28,372
 Maximum Depth of Haul: 40 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	.	39%
Copepod larvae	.	.	.	.	.	.	31
Pseudocalanus minutus	.	.	.	.	.	.	22
Calanus finmarchicus/helgolandicus	.	.	.	.	.	.	2
Temora longicornis	.	.	.	.	.	.	1
Acartia discaudata	.	.	.	.	.	.	1
Oikopleura dioica	.	.	.	.	.	.	1
Sagitta spp.	.	.	.	.	.	.	1
Hyperia spp.	.	.	.	.	.	.	1
Fish eggs	.	.	.	.	.	.	1

CRUISE # 001 - 23 April 1979
 (continued)

Station 33 (1400 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{o}}$)	density(sigma-t)
0	1.25	32.591	26.17
5	0.90	32.581	26.20
10	0.50	32.591	26.25
15	0.40	32.589	26.26
20	0.35	32.620	26.29
30	0.30	32.631	26.30
40	0.20	32.589	26.28

Zooplankton Total Abundance: 17,622
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	44%
Oithona nana	:	:	:	:	:	.	27
Pseudocalanus minutus	:	:	:	:	:	.	12
Centropages hamatus	:	:	:	:	:	.	5
Fritillaria borealis	:	:	:	:	:	.	4
Fish eggs	:	:	:	:	:	.	3
Centropages typicus	:	:	:	:	:	.	2
Temora longicornis	:	:	:	:	:	.	2
Sagitta spp.	:	:	:	:	:	.	1

CRUISE # 001 - 23 April 1979
 (continued)

Station 34 (1530 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{o}}$)	density(sigma-t)
0	1.10	32.565	26.16
5	0.80	32.577	26.20
10	0.65	32.584	26.23
15	0.45	32.587	26.25
20	0.30	32.595	26.27
30	0.35	32.619	26.29
50	-0.15	32.690	26.40
70	N/A	32.726	N/A

Zooplankton Total Abundance: 14,938
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	.	44%
Copepod larvae	.	.	.	.	.	.	25
Pseudocalanus minutus	.	.	.	.	.	.	20
Centropages hamatus	.	.	.	.	.	.	5
Fritillaria borealis	.	.	.	.	.	.	3
Calanus finmarchicus/helgolandicus	.	.	.	.	.	.	2
Sagitta spp.	.	.	.	.	.	.	1

CRUISE # 001 - 23 April 1979
 (continued)

Station 35 (1630 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	0.60	32.603	26.25
5	0.55	32.605	26.25
10	0.50	32.600	26.25
15	0.28	32.542	26.23
20	0.30	32.600	26.28
30	0.05	32.627	26.33
50	-0.20	32.662	26.38
70	N/A	32.754	N/A

Zooplankton Total Abundance: 13,122
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	.	42%
Copepod larvae	.	.	.	.	.	.	23
Pseudocalanus minutus	.	.	.	.	.	.	17
Centropages hamatus	.	.	.	.	.	.	9
Centropages typicus	.	.	.	.	.	.	2
Fritillaria borealis	.	.	.	.	.	.	2
Oikopleura dioica	.	.	.	.	.	.	2
Sagitta spp.	.	.	.	.	.	.	1
Fish eggs	.	.	.	.	.	.	1
Calanus finmarchicus/helgolandicus	:					.	1

CRUISE # 002 - 18 May 1979

Station 10 (1115 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{oo}}$)	density(sigma-t)
0	3.30	32.023	25.50
5	3.05	32.162	25.63
10	2.85	32.156	25.65
15	2.25	32.128	25.69
20	2.05	32.182	25.75

Zooplankton Total Abundance: 3300
 Maximum Depth of Haul: 30 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	26%
Oikopleura dioica	.	.	.	.	.	.	22
Oithona nana	.	.	.	.	.	.	19
Fish eggs	.	.	.	.	.	.	12
Pseudocalanus minutus	.	.	.	.	.	.	9
Echinoderm larvae	.	.	.	.	.	.	4
Fritillaria borealis	.	.	.	.	.	.	2
Gastropod larvae	.	.	.	.	.	.	2
Calanus finmarchicus/helgolandicus	.	.	.	.	.	.	1
Centropages typicus	.	.	.	.	.	.	1
Parathemisto spp.	.	.	.	.	.	.	1
Euterpina spp.	.	.	.	.	.	.	1

CRUISE # 002 - 18 May 1979
 (continued)

Station 33 (1200 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	4.00	32.116	25.50
5	2.70	32.140	25.65
10	2.90	32.065	25.57
15	2.70	32.122	25.64
20	2.50	32.155	25.68
30	2.50	32.170	25.70
40	2.10	32.177	25.74

Zooplankton Total Abundance: 15,470
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	30%
Oikopleura dioica	:	:	:	:	:	:	14
Pseudocalanus minutus	:	:	:	:	:	:	12
Fish eggs	:	:	:	:	:	:	10
Oithona nana	:	:	:	:	:	:	9
Fritillaria borealis	:	:	:	:	:	:	9
Cyprid larvae	:	:	:	:	:	:	6
Calanus finmarchicus/helgolandicus	:	:	:	:	:	:	4
Echinoderm larvae	:	:	:	:	:	:	3
Centropages hamatus	:	:	:	:	:	:	2
Temora longicornis	:	:	:	:	:	:	1

CRUISE # 002 - 18 May 1979
 (continued)

Station 34 (1300 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{oo}}$)	density(sigma-t)
0	4.40	31.998	25.37
5	2.50	32.042	25.59
10	2.20	32.092	25.67
15	2.20	32.106	25.68
20	2.10	32.121	25.70
30	0.50	32.159	25.90
50	-0.20	32.248	26.05
70	N/A	32.012	N/A

Zooplankton Total Abundance: 19,360
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	53%
Oithona nana	.	.	.	.	.	.	14
Oikopleura dioica	.	.	.	.	.	.	13
Fish eggs	.	.	.	.	.	.	11
Pseudocalanus minutus	.	.	.	.	.	.	3
Fritillaria borealis	.	.	.	.	.	.	3
Calanus finmarchicus/helgolandicus	.	.	.	.	.	.	2
Centropages hamatus	.	.	.	.	.	.	1

CRUISE # 002 - 18 May 1979
 (continued)

Station 35 (1415 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{o}}$)	density(sigma-t)
0	4.90	31.994	25.32
5	3.10	32.020	25.52
10	2.90	32.037	25.55
15	2.30	32.121	25.68
20	1.90	32.149	25.74
30	1.80	32.206	25.80
50	0.30	32.238	25.99
70	N/A	32.431	N/A

Zooplankton Total Abundance: 19,440
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	58%
Fish eggs	.	.	.	.	.	.	19
Fritillaria borealis	.	.	.	.	.	.	6
Pseudocalanus minutus	.	.	.	.	.	.	5
Oikopleura dioica	.	.	.	.	.	.	5
Cyprid larvae	.	.	.	.	.	.	2
Oithona nana	.	.	.	.	.	.	2
Centropages hamatus	.	.	.	.	.	.	1
Metridia lucens	.	.	.	.	.	.	1
Echinoderm larvae	.	.	.	.	.	.	1

CRUISE # 003 - 05 June 1979

Station 10 (1100 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{o}}$)	density(sigma-t)
0	7.30	31.716	24.89
5	6.80	31.805	25.00
10	6.30	31.770	25.02
15	5.25	31.973	25.27
20	1.80	31.838	25.50

Zooplankton Total Abundance: 5963
 Maximum Depth of Haul: 30 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	39%
Oithona nana	.	.	.	.	.	.	20
Oikopleura dioica	.	.	.	.	.	.	10
Centropages typicus	.	.	.	.	.	.	6
Pseudocalanus minutus	.	.	.	.	.	.	6
Cyprid larvae	.	.	.	.	.	.	4
Centropages hamatus	.	.	.	.	.	.	3
Polychaete larvae	.	.	.	.	.	.	2
Medusae (unidentifiable)	.	.	.	.	.	.	2
Parathemisto spp.	.	.	.	.	.	.	1
Fish eggs	.	.	.	.	.	.	1
Fish larvae	.	.	.	.	.	.	1
Calanus finmarchicus/helgolandicus	.	.	.	.	.	.	1
Temora longicornis	.	.	.	.	.	.	1
Acartia clausi	.	.	.	.	.	.	1
Sagitta spp.	.	.	.	.	.	.	1
Decapod larvae	.	.	.	.	.	.	1

CRUISE # 003 - 05 June 1979
 (continued)

Station 21 (1145 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{oo}}$)	density(sigma-t)
0	6.70	31.829	25.03
5	5.90	31.800	25.08
10	6.20	31.832	25.08
15	6.20	31.870	25.11
20	4.25	31.910	25.32
30	1.70	32.000	25.64

Zooplankton Total Abundance: 10,701
 Maximum Depth of Haul: 40 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	38%
Pseudocalanus minutus	.	.	.	.	.	.	25
Centropages hamatus	.	.	.	.	.	.	6
Oithona nana	.	.	.	.	.	.	6
Cyprid larvae	.	.	.	.	.	.	6
Decapod larvae	.	.	.	.	.	.	6
Oikopleura dioica	.	.	.	.	.	.	3
Calanus finmarchicus/helgolandicus	.	.	.	.	.	.	2
Centropages typicus	.	.	.	.	.	.	2
Fish eggs	.	.	.	.	.	.	2
Metridia lucens	.	.	.	.	.	.	1
Polychaete larvae	.	.	.	.	.	.	1
Gastropod larvae	.	.	.	.	.	.	1
Sagitta spp.	.	.	.	.	.	.	1

CRUISE # 003 - 05 June 1979
 (continued)

Station 22 (1330 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{oo}}$)	density(sigma-t)
0	7.50	31.912	25.03
5	7.20	31.869	25.02
10	7.00	31.847	25.02
15	6.10	31.882	25.12
20	5.70	31.964	25.22
30	2.30	31.927	25.52

Zooplankton Total Abundance: 3197
 Maximum Depth of Haul: 40 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	26%
Oithona nana	.	.	.	.	.	.	26
Pseudocalanus minutus	.	.	.	.	.	.	16
Centropages hamatus	.	.	.	.	.	.	10
Oikopleura dioica	.	.	.	.	.	.	7
Cyprid larvae	.	.	.	.	.	.	3
Echinoderm larvae	.	.	.	.	.	.	3
Fritillaria borealis	.	.	.	.	.	.	3
Temora longicornis	.	.	.	.	.	.	2
Centropages typicus	.	.	.	.	.	.	1
Gastropod larvae	.	.	.	.	.	.	1
Metridia lucens	.	.	.	.	.	.	1
Isias clavipes	.	.	.	.	.	.	1

CRUISE # 003 - 05 June 1979
 (continued)

Station 33 (1415 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	7.90	31.927	25.00
5	7.35	31.910	25.04
10	7.10	31.810	24.98
15	4.60	31.960	25.32
20	3.30	31.928	25.42
30	-0.05	32.023	25.85
40	-0.90	32.360	26.22

Zooplankton Total Abundance: 3960
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	.	30%
Copepod larvae	.	.	.	.	.	.	26
Pseudocalanus minutus	.	.	.	.	.	.	14
Oikopleura dioica	.	.	.	.	.	.	8
Centropages hamatus	.	.	.	.	.	.	6
Echinoderm larvae	.	.	.	.	.	.	6
Centropages typicus	.	.	.	.	.	.	3
Temora longicornis	.	.	.	.	.	.	2
Fritillaria borealis	.	.	.	.	.	.	2
Fish eggs	.	.	.	.	.	.	2
Decapod larvae	.	.	.	.	.	.	1

CRUISE # 003 - 05 June 1979
 (continued)

Station 34 (1530 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	6.40	31.825	25.05
5	6.45	31.761	25.00
10	6.70	31.827	25.03
15	5.30	31.772	25.11
20	1.50	31.920	25.60
30	-0.75	32.077	25.98
50	-1.30	32.602	26.46
70	N/A	32.735	N/A

Zooplankton Total Abundance: 7826
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	47%
Oithona nana	.	.	.	.	.	.	11
Centropages hamatus	.	.	.	.	.	.	8
Oikopleura dioica	.	.	.	.	.	.	6
Pseudocalanus minutus	.	.	.	.	.	.	5
Cyprid larvae	.	.	.	.	.	.	4
Echinoderm larvae	.	.	.	.	.	.	4
Gastropod larvae	.	.	.	.	.	.	3
Fish eggs	.	.	.	.	.	.	3
Metridia lucens	.	.	.	.	.	.	3
Fritillaria borealis	.	.	.	.	.	.	2
Sagitta spp.	.	.	.	.	.	.	1
Decapod larvae	.	.	.	.	.	.	1
Polychaete larvae	.	.	.	.	.	.	1
Centropages typicus	.	.	.	.	.	.	1

CRUISE # 003 - 05 June 1979
 (continued)

STATION 35 (1600 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{oo}}$)	density(sigma-t)
0	6.80	31.783	24.98
5	5.70	31.767	25.07
10	4.95	31.783	25.15
15	3.30	31.771	25.30
20	0.00	32.000	25.83
30	-0.30	32.174	26.00
50	-1.45	32.612	26.49
70	N/A	32.729	N/A

Zooplankton Total Abundance: 7020
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	30%
Oithona nana	.	.	.	.	.	.	27
Oikopleura dioica	.	.	.	.	.	.	14
Pseudocalanus minutus	.	.	.	.	.	.	8
Centropages hamatus	.	.	.	.	.	.	5
Echinoderm larvae	.	.	.	.	.	.	3
Decapod larvae	.	.	.	.	.	.	3
Cyprid larvae	.	.	.	.	.	.	2
Fish eggs	.	.	.	.	.	.	2
Podocoryne spp.	.	.	.	.	.	.	2
Metridia lucens	.	.	.	.	.	.	1
Sagitta spp.	.	.	.	.	.	.	1
Polychaete larvae	.	.	.	.	.	.	1
Centropages typicus	.	.	.	.	.	.	1

CRUISE # 004 - 29 June 1979

Station 10 (0915 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{oo}}$)	density(sigma-t)
0	10.20	31.908	24.81
5	9.75	31.962	24.88
10	8.20	31.967	25.01
15	8.10	32.028	25.07
20	6.90	32.090	25.22

Zooplankton Total Abundance: 8382
 Maximum Depth of Haul: 30 meters
 Zooplankton Species Composition:

Pseudocalanus minutus	.	.	.	.	.	28%
Oithona nana	.	.	.	.	.	24
Copepod larvae	.	.	.	.	.	12
Fritillaria borealis	.	.	.	.	.	6
Sagitta spp.	.	.	.	.	.	5
Temora longicornis	.	.	.	.	.	4
Centropages hamatus	.	.	.	.	.	4
Cyprid larvae	.	.	.	.	.	3
Oikopleura dioica	.	.	.	.	.	3
Medusae (unidentifiable)	.	.	.	.	.	3
Metridia lucens	.	.	.	.	.	2
Decapod larvae	.	.	.	.	.	2
Polychaete larvae	.	.	.	.	.	1
Gastropod larvae	.	.	.	.	.	1
Rathkeea octopunctata	.	.	.	.	.	1
Podocoryne spp.	.	.	.	.	.	1

CRUISE # 004 - 29 June 1979
 (continued)

Station 21 (1115 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	10.10	31.933	24.83
5	10.30	31.938	24.82
10	8.40	31.940	24.97
15	8.00	32.035	25.08
20	6.90	32.099	25.22
30	6.30	32.212	25.37

Zooplankton Total Abundance: 13,694
 Maximum Depth of Haul: 40 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	23%
Pseudocalanus minutus	.	.	.	.	.	20
Copepod larvae	.	.	.	.	.	17
Fritillaria borealis	.	.	.	.	.	11
Temora longicornis	.	.	.	.	.	9
Oikopleura dioica	.	.	.	.	.	4
Fish eggs	.	.	.	.	.	4
Centropages hamatus	.	.	.	.	.	3
Metridia lucens	.	.	.	.	.	2
Rathkeea octopunctata	.	.	.	.	.	1
Calanus finmarchicus/helgolandicus	.	.	.	.	.	1
Decapod larvae	.	.	.	.	.	1
Sagitta spp.	.	.	.	.	.	1
Cyprid larvae	.	.	.	.	.	1
Acartia clausi	.	.	.	.	.	1
Echinoderm larvae	.	.	.	.	.	1

CRUISE # 004 - 29 June 1979
 (continued)

Station 22 (1200 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	13.00	31.907	24.60
5	12.60	31.929	24.65
10	12.20	31.964	24.70
15	7.50	32.060	25.14
20	7.10	32.085	25.20
30	6.90	32.087	25.21

Zooplankton Total Abundance: 10,579
 Maximum Depth of Haul: 40 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	25%
Pseudocalanus minutus	.	.	.	.	.	21
Copepod larvae	.	.	.	.	.	16
Fritillaria borealis	.	.	.	.	.	14
Fish eggs	.	.	.	.	.	6
Centropages hamatus	.	.	.	.	.	6
Oikopleura dioica	.	.	.	.	.	3
Metridia lucens	.	.	.	.	.	2
Centropages typicus	.	.	.	.	.	1
Acartia discaudata	.	.	.	.	.	1
Temora longicornis	.	.	.	.	.	1
Decapod larvae	.	.	.	.	.	1
Polychaete larvae	.	.	.	.	.	1
Cyprid larvae	.	.	.	.	.	1
Echinoderm larvae	.	.	.	.	.	1

CRUISE # 004 - 29 June 1979
 (continued)

Station 33 (1230 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{oo}}$)	density(sigma-t)
0	11.40	31.889	24.70
5	10.80	31.922	24.77
10	10.30	31.843	24.75
15	9.60	31.922	24.86
20	8.00	31.937	25.00
30	7.70	32.039	25.11
40	2.30	32.108	25.67

Zooplankton Total Abundance: 3685
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	28%
Pseudocalanus minutus	.	.	.	.	.	26
Copepod larvae	.	.	.	.	.	13
Temora longicornis	.	.	.	.	.	10
Centropages hamatus	.	.	.	.	.	7
Fritillaria borealis	.	.	.	.	.	6
Acartia clausi	.	.	.	.	.	3
Oikopleura dioica	.	.	.	.	.	3
Calanus finmarchicus/helgolandicus	.	.	.	.	.	1
Centropages typicus	.	.	.	.	.	1
Metridia lucens	.	.	.	.	.	1
Decapod larvae	.	.	.	.	.	1

CRUISE # 004 - 29 June 1979
 (continued)

Station 34 (1430 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{oo}}$)	density(sigma-t)
0	11.00	31.882	24.73
5	10.75	31.882	24.74
10	10.50	31.925	24.80
20	7.30	32.059	25.16
40	1.20	32.480	26.08
60	-1.40	32.737	26.59

Zooplankton Total Abundance: 5796
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Pseudocalanus minutus	.	.	.	.	.	31%
Copepod larvae	.	.	.	.	.	23
Oithona nana	.	.	.	.	.	9
Fritillaria borealis	.	.	.	.	.	7
Fish eggs	.	.	.	.	.	6
Centropages hamatus	.	.	.	.	.	5
Acartia clausi	.	.	.	.	.	4
Oikopleura dioica	.	.	.	.	.	4
Cyprid larvae	.	.	.	.	.	3
Polychaete larvae	.	.	.	.	.	2
Medusae (unidentifiable)	.	.	.	.	.	2
Temora longicornis	.	.	.	.	.	1
Isias clavipes	.	.	.	.	.	1
Metridia lucens	.	.	.	.	.	1
Decapod larvae	.	.	.	.	.	1

CRUISE # 004 - 29 June 1979
 (continued)

Station 35 (1330 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	11.20	31.885	24.71
5	11.00	31.915	24.75
10	10.80	31.852	24.72
15	10.30	31.886	24.78
20	9.90	31.884	24.81
30	3.20	32.130	25.59
50	-0.90	32.683	26.48
70	N/A	31.935	N/A

Zooplankton Total Abundance: 7473
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Pseudocalanus minutus	.	.	.	.	.	30%
Copepod larvae	.	.	.	.	.	20
Oithona nana	.	.	.	.	.	19
Fritillaria borealis	.	.	.	.	.	7
Centropages hamatus	.	.	.	.	.	5
Fish eggs	.	.	.	.	.	4
Oikopleura dioica	.	.	.	.	.	3
Metridia lucens	.	.	.	.	.	2
Decapod larvae	.	.	.	.	.	2
Cyprid larvae	.	.	.	.	.	2
Acartia clausi	.	.	.	.	.	2
Calanus finmarchicus/helgolandicus	.	.	.	.	.	1
Temora longicornis	.	.	.	.	.	1
Echinoderm larvae	.	.	.	.	.	1
Sagitta spp.	.	.	.	.	.	1

CRUISE # 005 - 24 August 1979

Station 10 (1200 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{o}}$)	density(sigma-t)
0	15.40	31.015	23.76
5	15.20	31.045	23.80
10	15.20	31.067	23.82
15	15.10	31.054	23.81
20	15.10	31.083	23.83

Zooplankton Total Abundance: 70,965
 Maximum Depth of Haul: 30 meters
 Zooplankton Species Composition:

Pseudocalanus minutus	.	.	.	.	.	35%
Temora longicornis	.	.	.	.	.	33
Oithona nana	.	.	.	.	.	18
Copepod larvae	.	.	.	.	.	10
Isias clavipes	.	.	.	.	.	1
Calanus finmarchicus/helgolandicus	.	.	.	.	.	1
Acartia clausi	.	.	.	.	.	1
Gastropod larvae	.	.	.	.	.	1

CRUISE # 005 - 24 August 1979
 (continued)

Station 33 (1230 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	16.40	30.965	23.67
5	16.40	31.061	23.74
10	15.10	31.042	23.80
15	13.20	31.076	23.95
20	9.00	31.199	24.35
30	4.85	31.897	25.25
40	2.05	32.374	25.91

Zooplankton Total Abundance: 45,430
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	.	35%
Temora longicornis	:	:	:	:	:	.	23
Pseudocalanus minutus	:	:	:	:	:	.	21
Copepod larvae	:	:	:	:	:	.	14
Acartia clausi	:	:	:	:	.	.	2
Calanus finmarchicus/helgolandicus	:				.	.	2
Centropages hamatus	.	:	:	:	.	.	1
Polychaete larvae	:	:	:	:	.	.	1
Gastropod larvae	:	:	:	:	.	.	1

CRUISE # 005 - 24 August 1979
 (continued)

Station 34 (1445 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	15.90	31.081	23.78
5	15.70	31.054	23.78
10	15.40	31.129	23.85
15	15.40	31.026	23.77
20	14.90	31.031	23.81
30	7.00	31.728	24.92
50	1.10	32.370	26.01
70	N/A	32.517	N/A

Zooplankton Total Abundance: 32,930
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	49%
Pseudocalanus minutus	.	.	.	.	.	14
Copepod larvae	.	.	.	.	.	11
Temora longicornis	.	.	.	.	.	7
Calanus finmarchicus/helgolandicus	.	.	.	.	.	6
Metridia lucens	.	.	.	.	.	3
Centropages typicus	.	.	.	.	.	3
Gastropod larvae	.	.	.	.	.	2
Sagitta spp.	.	.	.	.	.	2
Polychaete larvae	.	.	.	.	.	1
Centropages hamatus	.	.	.	.	.	1
Acartia clausi	.	.	.	.	.	1

CRUISE # 005 - 24 August 1979
 (continued)

Station 35 (1345 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	14.25	31.142	23.93
5	14.20	31.053	23.87
10	14.05	31.038	23.86
15	13.70	31.026	23.88
20	13.80	30.983	23.84
30	5.60	31.438	24.82
50	-0.20	32.318	26.11
70	N/A	32.310	N/A

Zooplankton Total Abundance: 38,700
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Oithona nana	.	.	.	.	.	.	48%
Pseudocalanus minutus	.	.	.	.	.	.	19
Copepod larvae	.	.	.	.	.	.	12
Calanus finmarchicus/helgolandicus	.	.	.	.	.	.	6
Centropages hamatus	.	.	.	.	.	.	4
Gastropod larvae	.	.	.	.	.	.	4
Centropages typicus	.	.	.	.	.	.	3
Temora longicornis	.	.	.	.	.	.	3
Echinoderm larvae	.	.	.	.	.	.	1

CRUISE # 006 - 25 September 1979

Station 10 (1045 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{o}}$)	density(sigma-t)
0	11.78	31.068	24.04
5	12.03	31.150	24.09
10	11.97	31.117	24.08
15	12.00	31.157	24.09
20	12.00	31.162	24.10

Zooplankton Total Abundance: 53,985
 Maximum Depth of Haul: 30 meters
 Zooplankton Species Composition:

Pseudocalanus minutus	.	.	.	.	.	49%
Copepod larvae	.	.	.	.	.	22
Oithona nana	.	.	.	.	.	8
Centropages typicus	.	.	.	.	.	7
Centropages hamatus	.	.	.	.	.	5
Temora longicornis	.	.	.	.	.	4
Decapod larvae	.	.	.	.	.	2
Fritillaria borealis	.	.	.	.	.	1
Podon spp.	.	.	.	.	.	1
Gastropod larvae	.	.	.	.	.	1

CRUISE # 006 - 25 September 1979
 (continued)

Station 21 (1115 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	12.02	31.121	24.06
5	11.95	31.129	24.07
10	11.84	31.175	24.12
15	11.82	31.170	24.12
20	11.82	31.178	24.12
30	9.65	31.416	24.47

Zooplankton Total Abundance: 64,680
 Maximum Depth of Haul: 40 meters
 Zooplankton Species Composition:

Pseudocalanus minutus	.	.	.	.	.	31%
Copepod larvae	.	.	.	.	.	31
Lamellibranch larvae	.	.	.	.	.	10
Oithona nana	.	.	.	.	.	7
Calanus finmarchicus/helgolandicus	.	.	.	.	.	6
Temora longicornis	.	.	.	.	.	6
Sagitta spp.	.	.	.	.	.	2
Fritillaria borealis	.	.	.	.	.	2
Gastropod larvae	.	.	.	.	.	2
Centropages hamatus	.	.	.	.	.	1
Oikopleura dioica	.	.	.	.	.	1
Podocoryne spp.	.	.	.	.	.	1

CRUISE # 006 - 25 September 1979
 (continued)

Station 22 (1145 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	12.10	31.140	24.07
5	12.00	31.136	24.08
10	11.92	31.189	24.12
15	11.90	31.198	24.13
20	10.81	31.238	24.24
30	5.48	31.268	25.48

Zooplankton Total Abundance: 56,210
 Maximum Depth of Haul: 40 meters
 Zooplankton Species Composition:

Copepod larvae	.	.	.	.	.	.	39%
Pseudocalanus minutus	:	:	:	:	:	:	37
Temora longicornis	.	.	.	.	.	.	8
Lamellibranch larvae	.	.	.	.	.	.	7
Oithona nana	.	.	.	.	.	.	6
Metridia lucens	.	.	.	.	.	.	1
Calanus finmarchicus/helgolandicus	:						1
Echinoderm larvae	.	.	.	.	.	.	1

CRUISE # 006 - 25 September 1979
 (continued)

Station 33 (1245 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{o}}$)	density(sigma-t)
0	11.98	31.116	24.06
5	11.92	31.157	24.10
10	11.79	31.169	24.12
15	11.32	31.158	24.14
20	8.81	31.148	24.32
30	8.44	31.247	24.43
40	N/A	31.382	N/A

Zooplankton Total Abundance: 40,320
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Pseudocalanus minutus	.	.	.	.	.	28%
Copepod larvae	.	.	.	.	.	27
Temora longicornis	.	.	.	.	.	19
Lamellibranch larvae	.	.	.	.	.	7
Galanus finmarchicus/helgolandicus	.	.	.	.	.	7
Oithona nana	.	.	.	.	.	6
Centropages typicus	.	.	.	.	.	3
Gastropod larvae	.	.	.	.	.	1
Oikopleura dioica	.	.	.	.	.	1
Metridia lucens	.	.	.	.	.	1

CRUISE # 006 - 25 September 1979
 (continued)

Station 34 (1400 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}/_{\text{oo}}$)	density(sigma-t)
0	11.82	31.158	24.11
5	11.82	31.149	24.10
10	11.60	31.153	24.12
15	11.44	31.167	24.14
20	9.42	31.482	24.53
30	4.31	32.468	25.75
40	2.43	32.692	26.12

Zooplankton Total Abundance: 36,800
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Temora longicornis	.	.	.	.	.	.	31%
Copepod larvae	.	.	.	.	.	.	28
Pseudocalanus minutus	.	.	.	.	.	.	21
Calanus finmarchicus/helgolandicus	.	.	.	.	.	.	8
Oithona nana	.	.	.	.	.	.	3
Podocoryne spp.	.	.	.	.	.	.	2
Echinoderm larvae	.	.	.	.	.	.	2
Centropages hamatus	.	.	.	.	.	.	2
Centropages typicus	.	.	.	.	.	.	1
Lamellibranch larvae	.	.	.	.	.	.	1
Sagitta spp.	.	.	.	.	.	.	1

CRUISE # 006 - 25 September 1979
 (continued)

Station 35 (1530 N.S.T.)

depth(m)	temperature($^{\circ}$ C)	salinity($^{\circ}$ /oo)	density(sigma-t)
0	11.94	31.196	24.13
5	11.91	31.199	24.13
10	11.79	31.207	24.15
15	11.74	31.607	24.46
20	11.61	31.612	24.47
30	8.79	32.127	25.09
40	4.68	32.537	25.77

Zooplankton Total Abundance: 49,800
 Maximum Depth of Haul: 50 meters
 Zooplankton Species Composition:

Temora longicornis	.	.	.	.	.	31%
Pseudocalanus minutus	:	:	:	:	:	31
Copepod larvae	:	:	:	:	:	20
Calanus finmarchicus/helgolandicus	:	:	:	:	:	7
Centropages hamatus	.	.	.	.	.	4
Lamellibranch larvae	:	:	:	:	:	3
Oithona nana	:	:	:	:	:	2
Gastropod larvae	:	:	:	:	:	1
Oikopleura dioica	:	:	:	:	:	1