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# ENVIRONMENTAL ASSESSMENT OF THE SOUTHEASTERN BERING SEA: ZOOPLANKTON AND MICRONEKTON

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## I. SUMMARY

The unobtrusive pelagic fauna of the southeastern Bering Sea has been studied to determine species composition, distributions in time and space, and dependencies on "critical" habitat that may be impacted by the development of offshore oil in outer Bristol Bay and the St. George Basin areas. An abundant and diverse fauna was encountered which showed close affinities with pelagic assemblages described for the north Pacific Ocean south of the Aleutian chain and Alaska Peninsula.

The distributional data obtained in this study, coupled with an understanding of the biology of the dominant species, is used to assess the relationship between the adjacent oceanic watermass and that overlying the shelf and slope. Evidence is presented that suggests water shallower than about 80 m is isolated biologically from the rest of the shelf environment. Recent physical oceanographic information is discussed as it relates to this observation.

The results of this investigation complement the extensive work of Japanese and Soviet scientists by presenting data on the seasonality of the zooplankton and micronekton communities occurring in the slope and shelf regimes.

The influence of the seasonal ice pack is discussed and notions concerning the overall productivity of the region developed.

## II. INTRODUCTION

This report is a synthesis of the many detailed observations obtained during the late spring, summer, and fall of 1975, and early spring of 1976 in the open water and near-ice zone of the southeastern Bering Sea. As previously noted (Appendices I, II), this study represents only a portion of a much larger attempt to characterize the biota associated with, or adjacent to, the waters of Alaska's continental shelves. Outer Bristol Bay and the St. George Basin area were both considered potential sites for offshore petroleum development and as such warranted careful examinations of community composition and descriptions of seasonality. Since most species found in these waters (excluding sea birds and marine mammals) pass through an early planktonic life history stage, an understanding of the ecology of this complex assemblage was thought to be of great importance in assessing the possible effect of offshore industrial development.

## 2.1 The Goal of Zooplankton and Micronekton Studies

The major objective of this study was to characterize the species composition and standing stock of the pelagic fauna of the southeastern Bering Sea in the approximate size range 0.3-50 mm using collections obtained by standard oceanographic means augmented occasionally by acoustic remote sensing. A field design was conceived which generated measures of variability associated with sampling a single location, with samples taken from relatively large spatial regimes, and with samples acquired at various times of the year. Within this framework the following specific tasks were addressed:

1. Determine seasonal density distributions and environmental requirements of principal species of zooplankton, micronekton, and ichthyoplankton;
2. Determine relationships of zooplankton and micronekton to the edge of the seasonal ice pack in the Bering Sea;

3. Identify and characterize critical factors in the planktonic stages of fish and shellfish species;

4. Describe the food dependencies of common species of dielly-migrating mesopelagic fishes;

5. Identify pathways of matter and energy transfer between primary producers and consumers;

6. Summarize the existing literature and unpublished data on the transfer of organic matter through the lower levels of the pelagic food web in the northern north Pacific Ocean and Bering Sea.

Tasks 1, 3 and 4, and to a limited extent 2, are described in this final report. Task 6 is submitted as the 1977 annual report, and the remainder of task 2, to include work accomplished in Norton Sound and in the southeastern Chukchi Sea, will appear in the final report of the project, September 1978. Task 5 was curtailed by budget restrictions to the FY78 proposal which eliminated any continuing field work for that period.

## 2.2 Status of Knowledge

Cooney (1976) reviewed the literature pertaining to zooplankton and micronekton in the Bering Sea (see Appendix I). The bulk of this information was available as reports and papers of the faculty of fisheries of Hokkaido University, and the Fisheries Agency of Japan from studies dating back to 1953. Most investigations were carried out during the late spring, and summer periods which cover the biologically productive times of the year but contain little or no information pertaining to levels of overwintering stocks or relationships to the seasonal ice pack. Work funded by NOAA specifically to study ichthyoplankton of the eastern Bering Sea (K. Waldron and I?. Favorite;

RU 380) is adding *valuable* information, particularly during the early spring season when the reproductive processes of many fin-fish species occurs in this region. A large, multi-disciplinary ecosystem study, PROBES (Processes and Resources of the Bering Sea Shelf) is currently in its third field season examining the relationships between numerous oceanographic variables and the' overall productivity of the outer shelf region south of the Pribilof Islands. The walleye pollock, *Theragra chalcogramma*, is serving as an ecosystem tracer for this project since in its life history the species integrates many processes occurring both in the pelagic realm and near the sea bed.

Notions presented by Motoda and Minoda (1974) concerning regional aspects of animal plankton communities as reflective of broad hydrographic regimes are probably quite representative of the large scale features of the Bering Sea and northern Pacific Ocean for the ice free periods of the year, but continuity with season is lacking. The literature is very sparse regarding the possible effects of seasonal ice on resident populations at lower trophic levels, particularly during the late fall and winter. The field work funded for this study and the subsequent synthesis of the information collected is expected to contribute significantly to the overall understanding of animal plankton ecology in this northern sea. Our observation in November and March will provide initial insight into the biological problems of overwintering and recruitment which are characteristic of seasonally fluctuating high latitude populations. Coupled with studies of other environmental factors incorporated in the breadth of the overall OCS investigation in the southeast Bering Sea, our results will *also* contribute some of the detail necessary to enable the Department of Interior to respond in a timely manner to the development schedule planned for this region.

## III. RESEARCH OBJECTIVES

The achievement of a predictive understanding of the occurrence and seasonal abundance of natural populations of animal plankton and micro-nekton is only vaguely possible after the major components of the variance structure of a system have been described at some arbitrary level of precision. In high-latitude marine ecosystems, a very strong seasonal source of variation is always present and usually modified locally by hydrographic processes unique to a region. Overlying this strong seasonal signal are additional sources of variability which include both non-random diel displacements and ontogenetic migrations, and smaller-scale random patchiness associated with weather influences or internal advective processes. Since by definition plankters are weak swimmers, their overall distributions most often mirror the dynamics of physical fields of motion modified by temperature and salinity gradients which place biological constraints (i.e. upper and lower tolerance limits) on survival. It is within this complex association of variables that collections are obtained which in themselves are used to describe the framework of the system's structure. Because of the dynamic nature of the pelagic regime, both biologically and physically, a strict interpretation of time and space patterns is limited to a statistical evaluation of observations in which the precision of the methodology is most often "sample size" dependent. Quantitative plankton investigations have been notorious for the amount of work involved in the field, in sample processing, and in interpretation of results. This project was no exception.

My research objectives were these:

1. To inventory and quantitatively census the numerically dominant or otherwise obvious species;

2. To describe, within an appropriate statistical design, spatial and seasonal distributions;

3. To examine relationships that might exist between the various populations and existing hydrographic and/or biochemical parameters.

These objectives were viewed as realistic within the context of the extended study as planned by NOAA. Within this framework of collection, several smaller scale experiments were planned which would provide a basis for evaluating the function of some of the major species. Unfortunately, the field aspects of the program were terminated before any meaningful process studies could be initiated at the primary consumer level.

These research objectives were fulfilled in part and now form the basis for evaluating the project goals (tasks) as previously stated (see section 2.1).

## IV. STUDY AREA AND CRUISES

This report describes results from four cruises which visited the southeast Bering Sea in May-June 1975, in August 1975, in November 1975, and in March-April 1976:

1. NOAA Ship *Discoverer*, cruise 808; 1975
2. NOAA Ship *Discovers,* cruise 810; 1975
3. NOAA Ship *Miller Freeman*, cruise 815; 1975
4. NOAA Ship Surveyor, cruise SU 1 and 2; 1976

The area of study included the open ocean, outer shelf, central shelf, and northern coastal regimes of the southeastern Bering Sea as depicted in Figure 1. Although some samples were obtained north of Nunivak Island, most

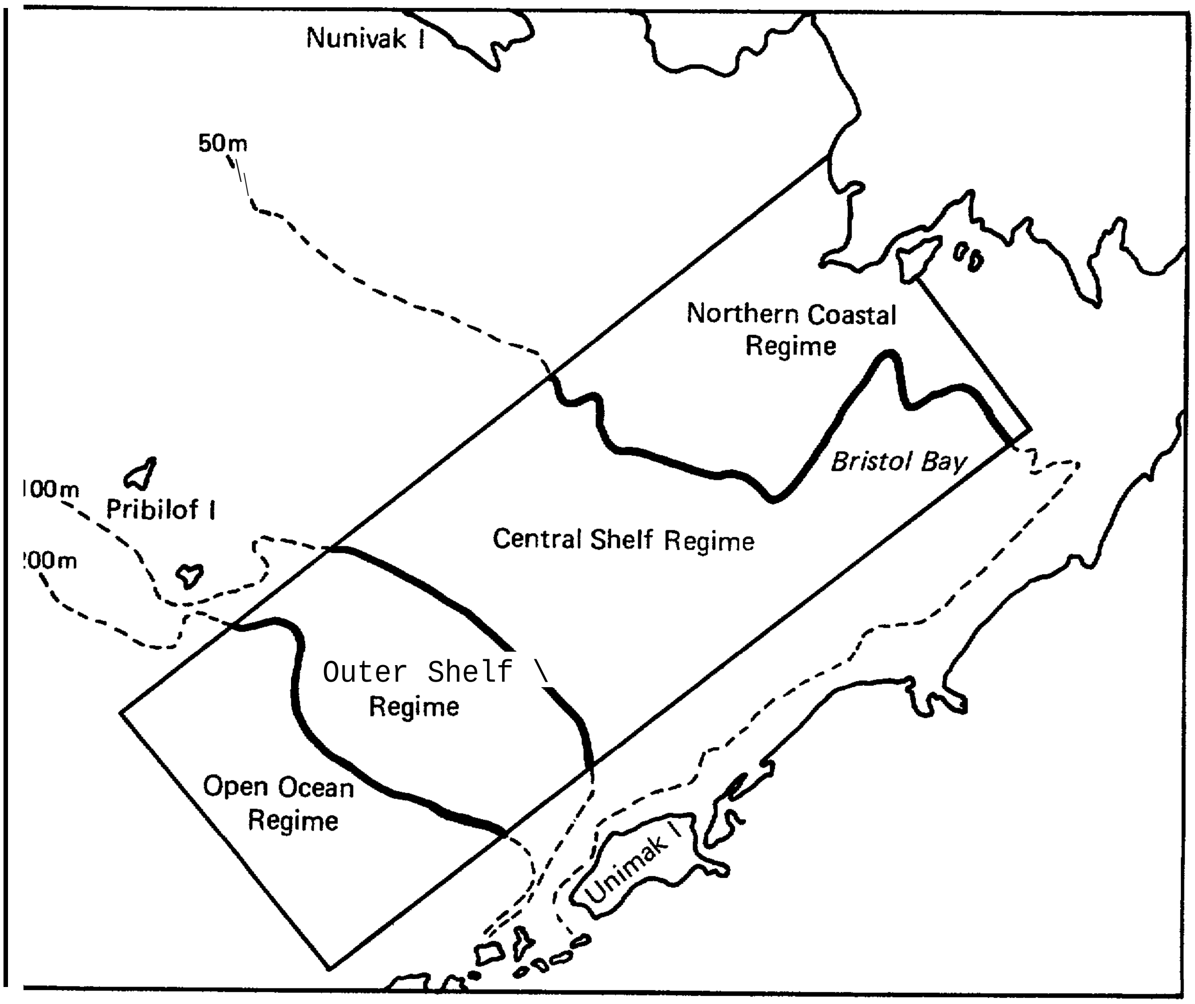


Figure 1. The area of study and its division into bathymetric regimes.

information reported here is for the open water and near-ice region of the shelf between Unimak Pass and the Pribilof Islands extending landward through Bristol Bay to Cape Newenham. Observations taken further to the north in association with the seasonal ice-pack will be reported in September 1978, as part of the project final report. Sampling frequency and location have been previously reported for this area (Appendices I, II).

## V. METHODS AND SOURCES OF DATA

The field program was designed to test hypotheses and to estimate levels of variability using the statistical procedures of Analysis of Variance. This technique objectively evaluates the additive effects of major factors and their interactions relative to a background of variability associated with a combination of natural patchiness and error introduced by equipment and analytical technique. The procedure is widely used in plankton field research and affords a methodology whereby limited resources are most efficiently allocated within complex temporal and spatial sampling programs.

Using results from the analysis of data collected in the northern Gulf of Alaska (Cooney, 1975) I proposed to stratify the research area into several discrete regimes by depth, and to periodically visit these regimes (cruises) sampling each randomly with nets and trawls of appropriate dimension to representatively collect the numerically dominant zooplankton and micronekton species.

For purposes of analysis, the original plan of eight regimes and multiple cruises per year was revised by pooling to four subareas and four cruises within the period May 1975-April 1976 (Fig. 1). I attempted to obtain 10 observations per regime each cruise since previous analyses of within-area variance predicted that differences in population abundance of about one-half order of magnitude (i.e. factor of 5.0) or more could be discerned with this level of effort. The resulting matrix became unbalanced with missing observations due to ice conditions encountered during the early spring of 1976.

A fixed split plot model of Analysis of Variance was used to examine the main effect of cruise and regime, and their interaction on distributions of numerically dominant species or composites. As mentioned, four regimes were identified: 1) open ocean (depths greater than 200 m): 2) outer shelf (depth between 100 and 200 m); 3) central shelf (depths between 50 and 100 m); and 4) northern coastal (depths shallower than 50 m). Because the seasonal ice pack prevented sampling the northern coastal area during the spring of 1976, the analysis was performed on two configurations of the data: 1) four cruises and three spatial regimes (omitting the northern coastal in 1976); and 2) three cruises and four regimes (omitting the entire spring black 1976).

Counts of organisms per unit area of sea surface were transformed to base ten logarithms, an acceptable technique that tends to normalize the variance and adjust data sets in which the main effects are suspected of being proportional rather than additive. All analyses were conducted on transformed data.

Field collections were obtained using a l-m net (0.333-mm Nitex) fished vertically from the seabed or from 200 m to the surface, if deeper, at each oceanographic station. The relative simplicity and reproducibility of this operation were factors considered in selecting the methodology. The major advantages of the vertically integrated collection include knowing the depth increment sampled from simple wire metering, avoiding difficulties in positioning a net to fish horizontally layered populations which may migrate dielly in the water column, and the small volume of catch to be processed and preserved. The disadvantages are with the small actual volumes filtered (∿80$^3$ in a 100 tow) and the relatively slow retrieval speed of the net (∿1 m/see). The amount of water filtered, 160 m$^3$ per tow from 200 m to the surface, was adequate for the common species but exceedingly marginal or completely inappropriate to sample the rarer members of the plankton community such as fish eggs and larvae. Since this study proposed to deal quantitatively with the numerically dominant or otherwise obvious organisms, the disadvantages were considered of second-order importance.

The l-m vertical net towing was augmented with occasional samples obtained from a small mid-water trawl (2-m NIO version of the Tucker trawl; l/8-inch knotless nylon). The trawl was lowered with the vessel underway (2-3 m/see), fished to depth as determined by wire length monitored with a mechanical time-depth recorder, and then retrieved. Volumes filtered were measured with a flowmeter hung in the mouth of the trawl.

All samples were preserved in 10% buffered seawater and returned to the University of Alaska Marine Sorting Center for processing. Identification and enumeration of taxa was performed on sub-samples obtained using a Stempel pipet; between 100 and 300 animals were routinely counted per sub-sample. In addition, a *fraction* of the original sample *was* dried to constant weight and reported for each station using the method of Lovegrove (1966).

Collections of larger organisms taken with the NIO trawl were searched for the obvious taxa and then subsampled using a mechanical splitter described by Cooney (1971). Again, between 100 and 300 were enumerated.

It is realized that subsampling introduces a component of error into estimates of number per catch. However, the magnitude of the variability involved is minor compared with that encountered in repeatedly sampling a water column at sea (Cooney, 1971). In my view, the inability to consistently census the rarer animals in these collections was vastly offset by the gain in precision afforded by rapidly processing large numbers of samples for the dominant members of the community.

A high-frequency recording echosounder was used at some stations at sea to profile the vertical distributions of larger organisms (pelagic fishes) and layers of micronekton (euphausiids, amphipods) that were acoustically visible at 105 kHz. Initially it was hoped that direct samples, particularly from the mid-water trawling, could be used to identify the scatterers and thus provide a means of interpreting sonic phenomena that could be measured continuously along transects within the regimes. An inability to accurately position the net at depth or to tow a transducer routinely while underway curtailed this approach. Several acoustic observations were obtained in the ice-related work and will be reported in support of that study, September 1978.

## VI. RESULTS

The findings reported here represent a synthesis of data collected specifically to examine the time-space distribution patterns of zooplankton and micronekton occurring in the open water and edge-zone of the southeastern Bering Sea, May 1975-April 1976. Details of underice distributions will be available in the Final Report of Project, September 1978.

## 6.1 The Zooplankton and Micronekton Community

During the course of the investigation, 167 species and 6 composite taxa were sorted from l-m net samples. Of these, only 21 species were designated as numerically common at most locations and seasons (Table I). Likewise, 161 species and 4 composite taxa are reported for 2-m NIO trawl samples taken at the same time and at many of the same locations (Table II). Only 18 of these species were consistently numerically common. Although these two gear types sampled different size classes and consequently taxa due to mesh size selectivity, 9 species of the common groups were shared.

The l-m net samples were dominated by copepods (41 species; 8 common) while the midwater trawl took more "jellyfishes", amphipods, and finfishes. Euphausiids, annelids, and molluscs appeared in roughly similar proportions by gear type. In cases where the life history stages varied greatly in size (i.e. euphausiids), the l-m net most representatively sampled the juveniles while the trawl took the adults in greater number.

## 6.2 Distribution Patterns

Thirty-three categories including 23 species, 9 genera or larger composites, and total dry weight were examined statistically to determine if patterns of abundance related to season or regime were discernible within the variance structure of the collection. In the formal analysis of variance

TABLE I

ZOOPLANKTON AND MICRONEKTON SAMPLED WITH A 1-M NET IN THE SOUTHEASTERN BERING SEA; MAY 1975-APRIL 1976

| Taxa | Common | Rare |
|---|---|---|
| Cnidaria | | |
| Hydrozoa | | |
| *Aequorea forskalea* | | X |
| *Perigonimus yoldia-arcticae* | | X |
| *P. multicirratus* | | X |
| *P. breviconis* | | X |
| *Calycopsis nematophora* | | X |
| Bougainvillea *superciliaris* | | X |
| *Corymorpha flammea* | | X |
| *Tubularia prolifer* | | X |
| *Coryne tubulosa* | | X |
| *C. principes* | X | |
| *Obelia longissima* | | X |
| *Ptychogena lactea* | | X |
| *Eirene indicans* | | X |
| *Aglanthe digitale* | X | |
| *Aegina* roses | | X |
| *Dimophyes arctica* | | X |
| Scyphozoa | | |
| *Periphylla hyacinthina* | | X |
| *Chrysaora helova* | | X |
| Ctenophora | | |
| *Beroe* spp. | | X |
| Annelida | | |
| Polychaeta | | |
| *Hesperone complanata* | | X |
| *Eteone* longs | | X |
| *Lopadorrhynchus* sp. | | X |
| *Pelagobia longicirrata* | | X |
| *Typhloscolex muelleri* | X | |
| *Tomopteris septentrionalis* | | X |
| *Laonice cirrata* | | X |
| *Glycera capitata* | | X |
| *Lumbrinereis* sp. | | X |
| *Scoloplos armiger* | | X |
| *Pelagobia longicirrata* | | X |
| *Capitella capitata* | | X |
| *Maldane sarsi* | | X |
| *Terebellides stroemii* | | X |

TABLE I

CONTINUED

| Taxa | Common | Rare |
| --- | --- | --- |
| Mollusca | | |
| Gastropod | | |
| *Euclio* sp. | | X |
| *Limacina helicina* | X | |
| *Blione limacina* | X | |
| *Gonatus fabricii* | | X |
| Crustacea | | |
| Cladocera | | |
| *podon* sp. | | X |
| *Evadne* sp. | | X |
| Ostracoda | | |
| *Conchoecia alata minor* | | X |
| *Conchoecia borealis* var. *antipoda* | | X |
| C. *borealis* var. *maxima* | | X |
| *C. curta* | | X |
| *c. pseudoalata* | | X |
| *C. pseudodiscophora* | | X |
| *c. skogsbergi* | | X |
| Copepoda | | |
| Harpacticoida | | |
| *Microsetella* roses | | X |
| *Bradya* sp. | | X |
| *Ectinosome* sp. | | X |
| *Tisbe* sp. | | X |
| Calanoida | | |
| *Calanus cristatus* | X | |
| *C. glacialis* | | X |
| *C. marshallae* | X | |
| c. *plumchrus* | X | |
| *Eucalanus bungii bungii* | X | |
| *Microcalanus* spp. | | X |
| *Pseudocalanus* spp. | X | |
| *Aetideus pacificus* | | X |
| *A.* sp. | | X |
| *Bradyidius saanichi* | | X |
| *Chiridius gracilis* | | X |
| *Gaetanus intermedius* | | X |
| *Gaidius variabilis* | | X |
| *Euchaeta elongata* | | X |
| *Haloptilus pseudooxycephalus* | | X |
| *Xanthocalanus kurilensis* | | X |
| *x.* Sp. | | X |

TABLE I

CONTINUED

| Taxa | Common | Rare |
|---|---|---|
| Calanoid (cent'd) | | |
| *Racovitzanus antarcticus* | | X |
| *Spinocalanus* sp. | | X |
| *Scolecithricella minor* | | X |
| *S. ovata* | | X |
| *Eurytemora herdmani* | | X |
| *E. pacifica* | | X |
| *Metridia lucens* | | |
| *M. okhotensis* | | X |
| *Pleuromamma scutullata* | | X |
| *Centropages abdominalis* | | X |
| *Lucicutia* sp. | | X |
| *Heterorhabdus compactus* | | X |
| *H.* sp. | | X |
| *Candacia columbiae* | | X |
| *Acartia longiremis* | X | |
| *A. tumida* | | X |
| *Lucicutia ovaliformis* | | X |
| Cyclopoida | | |
| *Oithona similis* | X | |
| *O. spinirostris* | | X |
| *Onceae* borealis | | X |
| Nebaliacea | | |
| *Nebalia* sp. | | X |
| Mysidacea | | |
| *Eucopia* sp. | | X |
| *Acanthomysis nephrophthalma* | | X |
| *A.* dybowskii | | X |
| *A. pseudomacropsis* | | X |
| *A. stelleri* | | X |
| *Boreomysis knicaidi* | | X |
| *Holmesiella anomala* | | X |
| *Neomysis rayii* | | X |
| *Pseudomma truncatum* | | X |
| Cumacea | | |
| *Lamprops quadriplicata typica* | | X |
| *Leucon nasica orientalis* | | X |
| *L. fulvus* | | X |
| *L.* sp. | | X |
| *Eudorella pacifica* | | X |
| *Eudorellopsis deformis* | | X |
| *Diastylis bidentata* | | X |
| *D. alaskensis* | | X |

TABLE I

CONTINUED

| Taxa | Common | Rare |
|---|---|---|
| Amphipoda | | |
| *Argissa hamatipes* | | X |
| *Corophium* sp. | | X |
| *Guernea* sp. | | X |
| *Rhachotropis natator* | | X |
| *Pontoporeia femorata* | | X |
| *Photis* sp. | | X |
| *Ischyrocerus commensalis* | | X |
| *I.* spp. | | X |
| *Protomedia* sp. | | X |
| Anonyx *lilljeborgi* | | X |
| *Eusirella multicalceola* | | X |
| *Cyclocaris guilelmi* | | X |
| *Cyphocaris challengeri* | | X |
| *C. anonyx* | | X |
| *Koroga megalops* | | X |
| *Lepidepedcreum kasatka* | | X |
| *L. comatum* | | X |
| *Orchomene lepidula* | | X |
| *O. nugax* | | X |
| *Melphidippa* sp. | | X |
| *Bathymedon obtusifrons* | | X |
| *B. nanseni* | | X |
| *Monoculodes diamesus* | | X |
| *M. packardi* | | X |
| *M. zernovi* | | X |
| *Westwoodilla coecula* | | X |
| *Paraphoxus* sp. | | X |
| *Stenopleustes glaber* | | X |
| *Dulichia* sp. | | X |
| *Melphidippa* sp. | | X |
| *Metopa alderi* | | X |
| *Stenula* sp. | | X |
| *Scina* borealis | | X |
| *Hyperia medusarum* | | X |
| *Hyperoche medusarum* | | X |
| *Parathimisto libellula* | X | |
| *P. pacifica* | X | |
| *Primno macropa* | | X |
| Euphausiacea | | |
| *Euphausia pacifica* | | X |
| *Thysanoessa inermis* | X | |
| *T. longipes* | X | |
| *T. raschii* | X | |
| *T. spinifera* | | X |

TABLE I

CONTINUED

| Taxa | Common | Rare |
|---|---|---|
| Decapoda | | |
| *Pandalus borealis* | | X |
| *P.* Sp. | | X |
| *Eualus macilenta* | | X |
| *Paracrangon echinata* | | X |
| *Paralithodes camtschatica* | | X |
| *Chionoecetes* spp. | | X |
| *Hyas* spp. | | X |
| *Telmessus cheiragonus* | | X |
| *Erimacrus isenbeckii* | | X |
| Chaetognatha | | |
| *Eukrohnia hamata* | X | |
| *E. bathypelagica* | | X |
| *Sagitta elegans* | X | |
| Chordata | | |
| Larvacea | | |
| *Fritillaria borealis* | | X |
| *Oikopleura* spp. | X | |
| Teleostei | | |
| *Clupea harengus pallasi* | | X |
| *Mallotus villosus* | | X |
| *Bathylagus pacificus* | | X |
| *B. stilbius schmidti* | | X |
| *Stenobrachius leucopsarus* | | X |
| *Theragra chalcogramma* | | X |
| *Sebastes* spp. | | X |
| *Liparis* spp. | | X |
| *Nectoliparis pelagicus* | | X |
| *Atheresthes stomias* | | X |
| *Hippoglossoides elassodon* | | X |

TABLE 11

ZOOPLANKTON AND MICRONEKTON SAMPLED WITH A 2-M NIO TRAWL IN THE SOUTHEASTERN BERING SEA; MAY 1975-APRIL 1976

| Taxa | Common | Rare |
|---|---|---|
| Cnidaria | | |
| Hydrozoa | | |
| *Aglantha digitale* | X | |
| *Perigonimus brevironis* | | X |
| *Perigonimus c.f. P. yoldia arcticea* | | X |
| *Perigonimus multicirratus* | | X |
| *Calycopsis nematophora* | | X |
| *Bougainvillea superciliaris* | | X |
| *Rathkea jaschnowi* | | X |
| *Corymorpha flammea* | | X |
| *Coryne principes* | X | |
| *Ptychogena lactea* | | X |
| *Eirene indicans* | | X |
| *Aegina rosea* | | X |
| *Aequores forskalea* | | X |
| *Pantachogan haeckeli* | | X |
| *Melicertum campanula* | | X |
| *Botrynema burcei* | | X |
| *Halicreas minimum* | | X |
| *Crossota brunnea* | | X |
| Scyphozoa | | |
| *Periphylla hyacinthina* | | X |
| *Atolla wyvillei* | | X |
| *Chrysaora melanaster* | X | |
| *Chrysaora helvola* | | X |
| *Cyanea capillata* | X | |
| *Phacellophora camtschatica* | | X |
| *Aurelia limbata* | | X |
| Siphonophora | | |
| *Dimophyes arctica* | | X |
| *Vogtia serrata* | | X |
| *Ramosia vitiazi* | | X |
| *Rosacea plicata* | | X |
| Chaetognatha | | |
| *Sagitta elegans* | | X |
| *Eukrohnia* spp. | | X |
| *Sagitta scrippsae* | | X |
| Mollusca | | |
| *Galiteuthis armata* | | X |
| *Chiroteuthis veranyi* | | X |
| *Gonatus fabricii* | | X |
| *Gonatus magister* | | X |
| *Gonatopsis* sp. | | X |

TABLE II

CONTINUED

| Taxa | Common | Rare |
|---|---|---|
| *Clione limacina* | | X |
| *Limacina heliciana* | | X |
| Annelida | | |
| Polychaeta | | |
| *Tomopteris septentrionalis* | | X |
| *Hesperone complanata* | | X |
| *Chaetozone setosa* | | X |
| *Krohnia excellata* | | X |
| *Lopadorrhynchidae* spp. | | X |
| *Antinoella sarsi* | | X |
| *Nereis pelagica* | | X |
| Crustacea | | |
| Copepoda | | |
| *Calanus cristatus* | X | |
| *Eucalanus bungii bungii* | X | |
| *Euchaeta elongata* | | X |
| *Pachyptilus pacificus* | | X |
| *Candacia columbiae* | | X |
| Euphausiacea | | |
| *Euphausia pacifica* | | X |
| *Tessarabrachion oculatus* | | X |
| *Thysanoessa raschii* | X | |
| *Thysanoessa inermis* | X | |
| *Thysanoessa spinifera* | | X |
| *Thysanoessa longipes* | X | |
| Isopoda | | |
| *Ilyarachna* sp. | | X |
| *Synidotea bicuspida* | | X |
| Mysidacea | | |
| *Acanthomysis stelleri* | | X |
| *Acanthomysis dybowskii* | | X |
| *Pseudomma truncatum* | | X |
| *Neomysis rayii* | | X |
| *Neomysis czerniawskii* | | X |
| *Holmesiella anomala* | | X |
| *Eucopia* sp. | | X |
| *Boreomysis kincaidi* | | X |
| *Boreomysis californica* | | X |

TABLE II

CONTINUED

| Taxa | Common | Rare |
|---|---|---|
| **Cumacea** | | |
| *Diastylis bidentata* | X | |
| *D. alaskensis* | | X |
| *Leucon quadriplicata typica* | | X |
| **Amphipoda** | | |
| Hyperiidea | | |
| *Parathemisto pacifica* | X | |
| *Parathemisto libellula* | X | |
| *Hyperia medusarum* | | X |
| *Hyperia springera* | | X |
| *Hyperoche medusarum* | | X |
| *Primno macropa* | | X |
| *Phronima sedentaria* | | X |
| *Hyperia galba* | | X |
| *Paraphronima crassipes* | | X |
| *Scina* borealis | | X |
| *Scina rattrayi* | | X |
| *Archoeoscina steenstrupi* | | X |
| *Parathemisto japonica* | | X |
| **Gammaridea** | | |
| *Anonyx nugax* | | X |
| *Cyphocaris challengeri* | | X |
| *Byblis gaimardi* | | X |
| *Protomedia* sp. | | X |
| *Metopa alderi* | | X |
| *Monoculodes zernovi* | | X |
| *Ampelisca macrocephala* | | X |
| *Westwoodilla coecula* | X | |
| *Dulichia unispina* | | X |
| *Pontoporeia femorata* | | X |
| *Bulichia arctica* | | X |
| *Melitoides makarovi* | | X |
| *Rhachotropis oculata* | | X |
| *Pleustes panopla* | | X |
| *Monoculoides diamesus* | | X |
| *Rhachotropis natator* | | X |
| *Priscillina armata* | | X |
| *Eusirella multicalceola* | | X |
| *Parandania boecki* | | X |
| *Anonyx compactus* | | X |
| *Stenopleustes glaber* | | X |
| *Melita dentata* | | X |
| *Paramphithoe polyacantha polyacantha* | | X |
| *Monoculopsis longicornis* | | X |
| *Anisogammarus macginitiei* | | X |

TABLE II

CONTINUED

| Taxa | Common | Rare |
|---|---|---|
| Gamrnaridea (cent'd) | | |
| *Hippomdeon kuri licus* | | X |
| *Orchomene* c. *f.* *O. lipedula* | | X |
| *Pontogenia ivanovi* | | X |
| *Atylus bruggeni* | | X |
| *Atylus col lingi* | | X |
| *Socarnes bidenticulatus* | | X |
| *Ischerocerus anguipes* | | X |
| *Melphidippa goesi* | | X |
| *Cyclocaris guilelmi* | | X |
| Decapoda | | |
| *Pasiphaea pacifica* | | X |
| *Cancer* sp. | | X |
| *Crangon dalli* | | X |
| *Argis lar* | | X |
| *Hymenadora frontalis* | | X |
| *Eualus macilenta* | | X |
| *Eualus stonyei* | | X |
| *Pandalus goniurus* | | X |
| *Pandalus* borealis | | X |
| *Sergestes similis* | | X |
| *Chionoecetes* spp. | X | |
| *Erimacrus isenbecki* | | X |
| *Erimacrus isenbecki* | | X |
| *Telmessus cheirigonus* | | X |
| *Telmessue cheirigonus* | | X |
| *Paralithodes camtschatica* | | X |
| *Paralithodes camtschatica* | | X |
| *Hyas* sp. | | X |
| *Pandalus montagui tridens* | | X |
| *Pandalopsis* spp. | | X |
| Chordata | | |
| **Cyclostomata** | | |
| *Lampetra tridentatus* | | X |
| **Teleostei** | | |
| *Mallotus villosus* | X | |
| *Lycodes palearis* | | X |
| *Lumpenus maculatus* | | X |
| *Reinharditius hippoglossoides* | X | |
| Lips.ris *herschelinus* | | X |
| *Agonus acipenserinus* | | X |
| *Theragra chalcogramma* | | X |
| *Liparis dennyi* | | X |

TABLE II

CONTINUED

| Taxa | Common | Rare |
|---|---|---|
| **Teleostei** (cent'd) | | |
| *Clupea harengus pallasi* | | X |
| *Lumpenus medius* | | X |
| *Artediellus pacificus* | | X |
| *Stenobrachius leucopsarus* | X | |
| *Bathylagus pacificus* | | X |
| *Bathylagus alascanus* | | X |
| *Ptilichthys goodei* | | X |
| *Stenobrachius nannochir* | | X |
| *Nectoliparis pelagicus* | | X |
| *Bathylagus stilbius schmidti* | X | |
| *Hippoglossus stenolepis* | | X |
| *Malacocottus zonurus* | | X |
| *Hemilepidotus* sp. | | X |
| *Chauliodus macouni* | | X |
| *Bathymaster signatus* | | X |
| *Triglops pingeli* | | X |
| *Ammodytes hexapterus* | | X |

considering three cruises and four regimes, a significant cruise effect ($P<0.05$) is evident for 22 categories, a regime effect is apparent for 25 categories, and the interaction of these factors is significant for 10 taxa (Table III). When four cruises and three regimes are examined using the same analysis, 24 categories exhibit a significant cruise effect, 28 show regime effects, and the interaction term is apparent for 14 (Table IV). The results of this statistical treatment demonstrate that seasonal and spatial fluctuations occur in the distribution of most common species or composites, and that for some the time-space distributions are very complex.

To examine the nature of these distributions, depictions of mean standing stock by cruise were drawn for each category (Figs. 2-33). When these distributions were further sorted by regime, several general distributions emerged (Table V).

Sixteen categories were usually found in greatest abundance in the open ocean regime seaward of the shelf break. This group includes the ecologically important interzonal copepods *Calanus cristatus*, *Calanus plumchrus*, and *Eucalanus b. bungii*, the pteropods *Clione limacina* and *Limacina helicina*, the chaetognath *Eukrohnia hamata*, the euphausiid *Thysanoessa longipes*, and the amphipod *Parathemisto pacifica*.

The copepod *Oithona spinirostris*, the euphausiid *Thysanoessa inermis*, and spider crab (Majiidae) larvae, mostly *Chionoecetes* spp., selected the outer shelf regime, while the central shelf water mass favored the copepods *Calanus glacialis*, *Calanus marshallae*, and *Pseudocalanus* spp., the amphipod *Parathemisto libellula*, the euphausiid *Thysanoessa raschii* and the arrow worm *Sagitta elegans*.

## TABLE III

ANALYSIS OF VARIANCE FOR THREE CRUISES AND FOUR REGIMES
IN THE SOUTHEAST BERING SEA
MAY 1975 - NOVEMBER 1975

| Taxonomic Category | Source of Variation | | | | | |
|---|---|---|---|---|---|---|
| | Cruise [1] | | Regime [2] | | Interaction | |
| | F [3] | df | F | df | F | df |
| **Cnidaria** | | | | | | |
| Hydrozoa | | | | | | |
| *Aglantha digitale* | ** | 2,87 | * | 3,87 | NS | 6,87 |
| *Dimophyes arctica* | NS | 2,39 | ** | 3,39 | NS | 6,39 |
| **Mollusca** | | | | | | |
| Pteropoda | | | | | | |
| *Clione limacina* | ** | 2,59 | ** | 3,59 | NS | 6,59 |
| *Limacina helicina* | ** | 2,81 | ** | 3,81 | ** | 6,81 |
| **Crustacea** | | | | | | |
| **Ostracoda** | | | | | | |
| *Conchoecia* spp. | NS | 2,47 | ** | 3,47 | NS | 6,47 |
| **Copepoda** | | | | | | |
| *Acartia longiremis* | ** | 2,91 | ** | 3,91 | ** | 6,91 |
| *Calanus cristatus* | * | 2,24 | ** | 3,24 | NS | 6,24 |
| *C. glacialis* | ** | 2,29 | NS | 3,29 | NS | 6,29 |
| *C. marshallae* | ** | 2,91 | ** | 3,91 | NS | 6,91 |
| *C. plumchrus* | NS | 2,66 | ** | 3,66 | NS | 6,66 |
| *C.* spp. (juveniles) | ** | 2,83 | NS | 3,83 | * | 6,83 |
| *Eucalanus b. bungii* | ** | 2,50 | ** | 3,50 | ** | 6,50 |
| *Metridia lucens* | NS | 2,81 | ** | 3,81 | NS | 6,81 |
| *Oithona similis* | ** | 2,91 | ** | 3,91 | ** | 6,91 |
| *O. spinirostrus* | NS | 2,42 | ** | 3,48 | NS | 6,48 |
| *Pseudocalanus* spp. | ** | 2,91 | NS | 3,91 | NS | 6,91 |
| Nauplii (composite) | ** | 2,76 | ** | 3,76 | k* | 6,76 |
| **Amphipoda** | | | | | | |
| *Parathemisto libellula* | * | 2,65 | ** | 3,65 | * | 6,65 |
| *P. pacifica* | ** | 2,66 | ** | 3,66 | NS | 6,66 |
| **Euphausiacea** | | | | | | |
| *Thysanoessa inermis* | ** | 2,59 | ** | 3,59 | NS | 6,59 |
| *T. longipes* | NS | 2,51 | ** | 3,51 | NS | 6,51 |
| *T. raschii* | ** | 2,63 | ** | 3,63 | ** | 6,63 |
| *T. spinifera* | NS | 2,43 | NS | 3,43 | NS | 6,43 |
| *T.* spp. (juveniles) | NS | 2,32 | NS | 3,32 | NS | 6,32 |
| *T.* spp. (eggs and larvae) | ** | 2,91 | NS | 3,91 | NS | 6,91 |

TABLE III

CONTINUED

| Taxonomic Category | Source of Variation: Cruise[1] F[3] | df | Regime[2] F | df | Interaction F | df |
|---|---|---|---|---|---|---|
| **Crustacea** (cent'd) | | | | | | |
| **Decapoda** | | | | | | |
| **Majiidae** (composite) | ** | 2,77 | * | 3,77 | ** | 6,77 |
| **Chaetognatha** | | | | | | |
| *Eukrohnia hamata* | NS | 2,58 | ** | 3,58 | NS | 6,58 |
| *Sagitta elegans* | ** | 2,91 | ** | 3,91 | NS | 6,91 |
| Composite (juveniles) | * | 2,91 | ** | 3,91 | NS | 6,91 |
| **Chordata** | | | | | | |
| **Larvacea** | | | | | | |
| *Oikopleura* spp. | * | 2,73 | ** | 3,73 | NS | 6,73 |
| Composite | NS | 2,67 | NS | 3,67 | NS | 6,67 |
| **Teleostei** | | | | | | |
| *Theragra chalcogramma* | | | | | | |
| DRY WEIGHT (composite) | * | 2,91 | * | 3,91 | * | 6,91 |

[1] May-June 1975; August 1975; October-November 1976.

[2] Open ocean,· Outer shelf; Central shelf; Northern coastal.

[3] * = $P \leq 0.05$; ** = $P \leq 0.01$; NS = $P > 0.05$

TABLE IV

ANALYSIS OF VARIANCE FOR FOUR CRUISES AND THREE REGIMES
IN THE SOUTHEAST BERING SEA
MAY 1975 - APRIL 1976

| Taxonomic Category | Source of Variation | | | | | |
|---|---|---|---|---|---|---|
| | Cruise[1] | | Regime[2] | | Interaction | |
| | F[3] | df | F | df | F | df |
| **Cnidaria** | | | | | | |
| Hydrozoa | | | | | | |
| *Aglantha digitale* | ** | 3,89 | NS | 2,89 | * | 6,89 |
| *Dimophyes arctica* | NS | 3,66 | ** | 2,66 | * | 6,66 |
| **Mollusca** | | | | | | |
| Pteropoda | | | | | | |
| *Clione limacina* | ** | 3,86 | * | 2,86 | NS | 6,86 |
| *Limacina helicina* | ** | 3,93 | ** | 2,93 | ** | 6,93 |
| **Crustacea** | | | | | | |
| Ostracoda | | | | | | |
| *Conchoecia* spp. | NS | 3,57 | ** | 2,57 | NS | 6,57 |
| Copepoda | | | | | | |
| *Acartia longiremis* | ** | 3,93 | ** | 2,93 | ** | 6,93 |
| *Calanus cristatus* | ** | 3,51 | ** | 2,51 | * | 6,51 |
| *C. glacialis* | ** | 3,32 | NS | 2,32 | NS | 6,32 |
| *C. marshallae* | ** | 3,93 | ** | 2,93 | NS | 6,93 |
| *C. plumchrus* | NS | 3,93 | ** | 2,93 | NS | 6,93 |
| *C.* spp. (juveniles) | ** | 3,93 | ** | 2,93 | ** | 6,93 |
| *Eucalanus b. bungii* | ** | 3,77 | ** | 2,77 | ** | 6,77 |
| *Metridia lucens* | NS | 3,93 | ** | 2,93 | NS | 6,93 |
| *Oithona similis* | ** | 3,93 | NS | 2,93 | ** | 6,93 |
| *O. spinirostrus* | NS | 3,65 | ** | 2,65 | NS | 6,65 |
| *Pseudocalanus* spp. | ** | 3,93 | ** | 2,93 | NS | 6,93 |
| Nauplii (composite) | ** | 3,78 | ** | 2,78 | ** | 6,78 |
| Amphipoda | | | | | | |
| *Parathemisto libellula* | * | 3,60 | ** | 2,60 | NS | 6,60 |
| *P. pacifica* | ** | 3,93 | ** | 2,93 | NS | 6,93 |
| Euphausiacea | | | | | | |
| *Thysanoessa inermis* | ** | 3,86 | ** | 2,86 | NS | 6,86 |
| *T. longipes* | NS | 3,75 | ** | 2,75 | NS | 6,75 |
| *T. raschii* | ** | 3,67 | ** | 2,67 | ** | 6,67 |
| *T. spinifera* | NS | 3,60 | NS | 2,60 | NS | 6,60 |
| *T.* spp. (juveniles) | ** | 3,43 | NS | 2,43 | NS | 6,43 |
| *T.* spp, (eggs and larvae) | ** | 3,93 | ** | 2,93 | NS | 6,93 |

TABLE IV

CONTINUED

| Taxonomic Category | Cruise [1] F [3] | df | Regime [2] F | df | Interaction F | df |
|---|---|---|---|---|---|---|
| Crustacea (cent'd) | | | | | | |
| Decapoda | | | | | | |
| Majiidae (composite) | ** | 3,87 | * | 2,87 | ** | 6,87 |
| Chaetognatha | | | | | | |
| *Eukrohnia hamata* | NS | 3,86 | ** | 2,86 | NS | 6,86 |
| *Sagitta elegans* | ** | 3,93 | ** | 2,93 | NS | 6,93 |
| Composite (juveniles) | * | 3,93 | ** | 2,93 | NS | 6,93 |
| Chordata | | | | | | |
| Larvacea | | | | | | |
| *Oikopleura* spp. | * | 3,93 | ** | 2,93 | NS | 6,93 |
| Composite | NS | 3,76 | ** | 2,76 | * | 6,76 |
| Teleostei | | | | | | |
| *Theragra chalcogramma* | ** | 3,17 | * | 2,17 | ** | 6,17 |
| DRY WEIGHT (composite) | * | 3,93 | * | 2,93 | * | 6,93 |

Source of Variation: Cruise, Regime, Interaction.

[1] May-June 1975; August 1975; October-November 1975; March-April 1976.

[2] Open ocean; Outer shelf; Central shelf

[3] * = $P \leq 0.05$; ** = $P \leq 0.01$; NS = $P > 0.05$

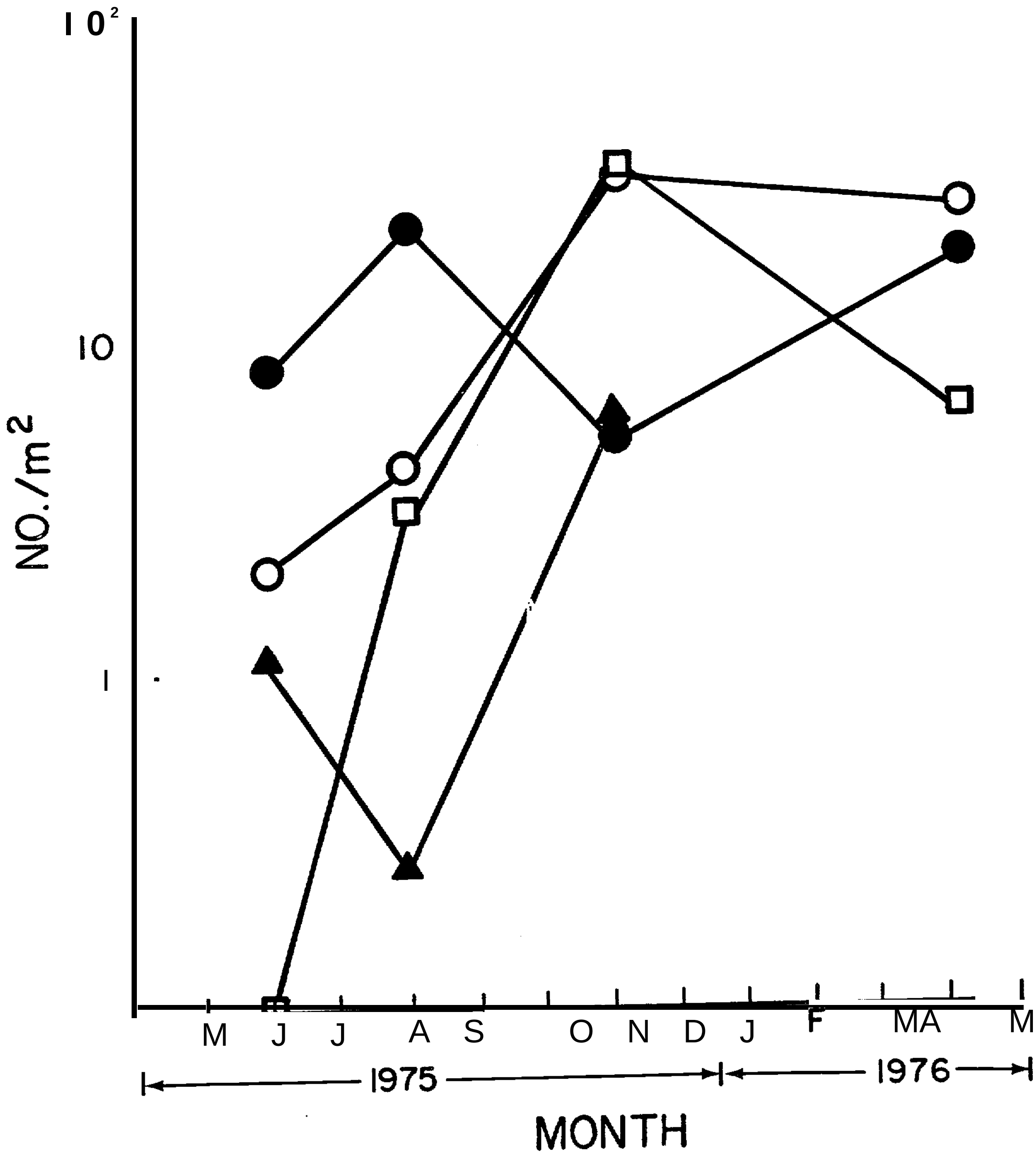


Figure 2. The average abundance of the hydrozoan, *Aglantha digitale*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regimes; squares the outer shelf; open circles the central shelf; and triangles the northern coastal regime.

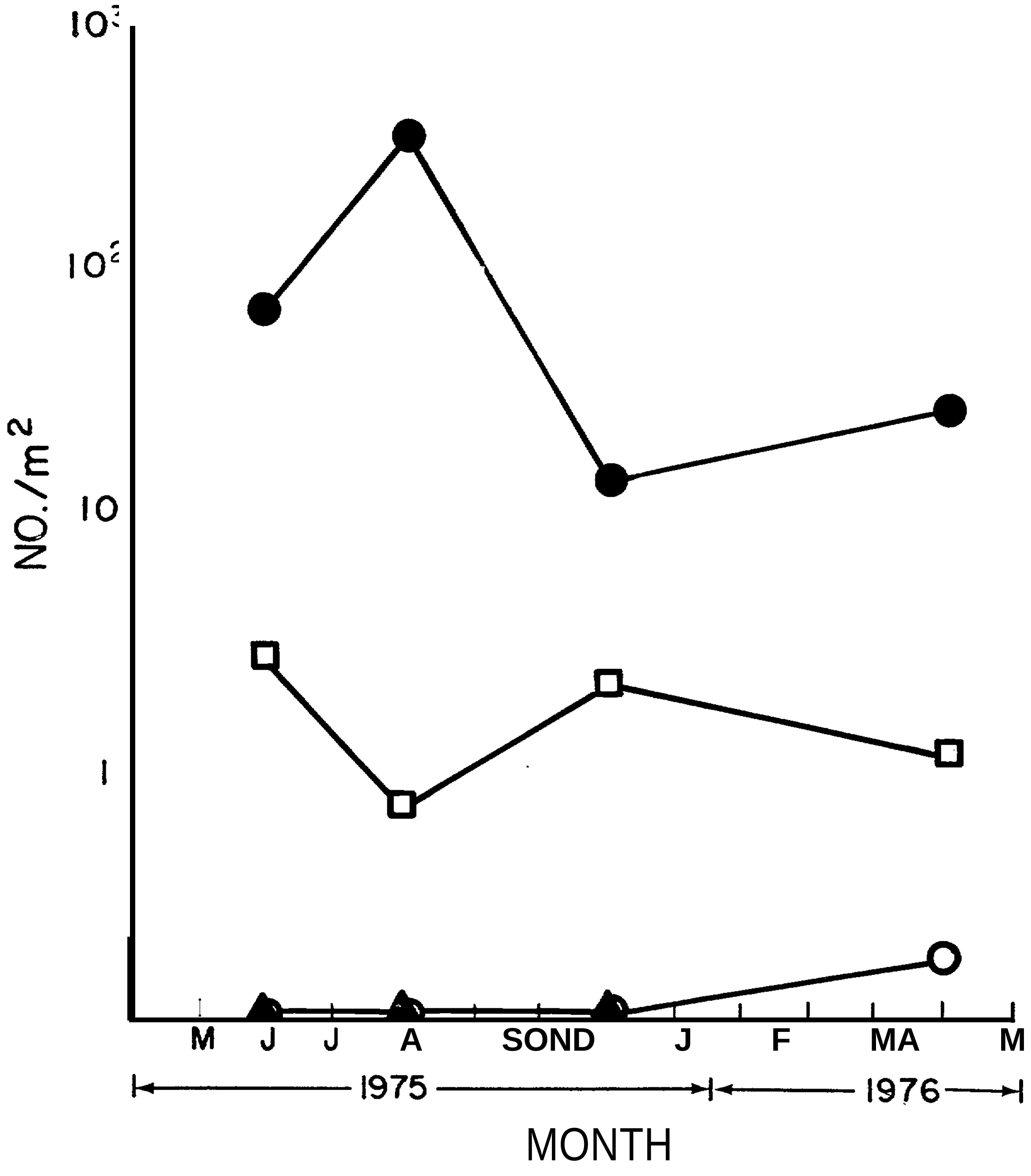


Figure 3. The average abundance of the hydrozoan, *Dimophyes arctica*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles the central shelf; and triangles, the northern coastal regime.

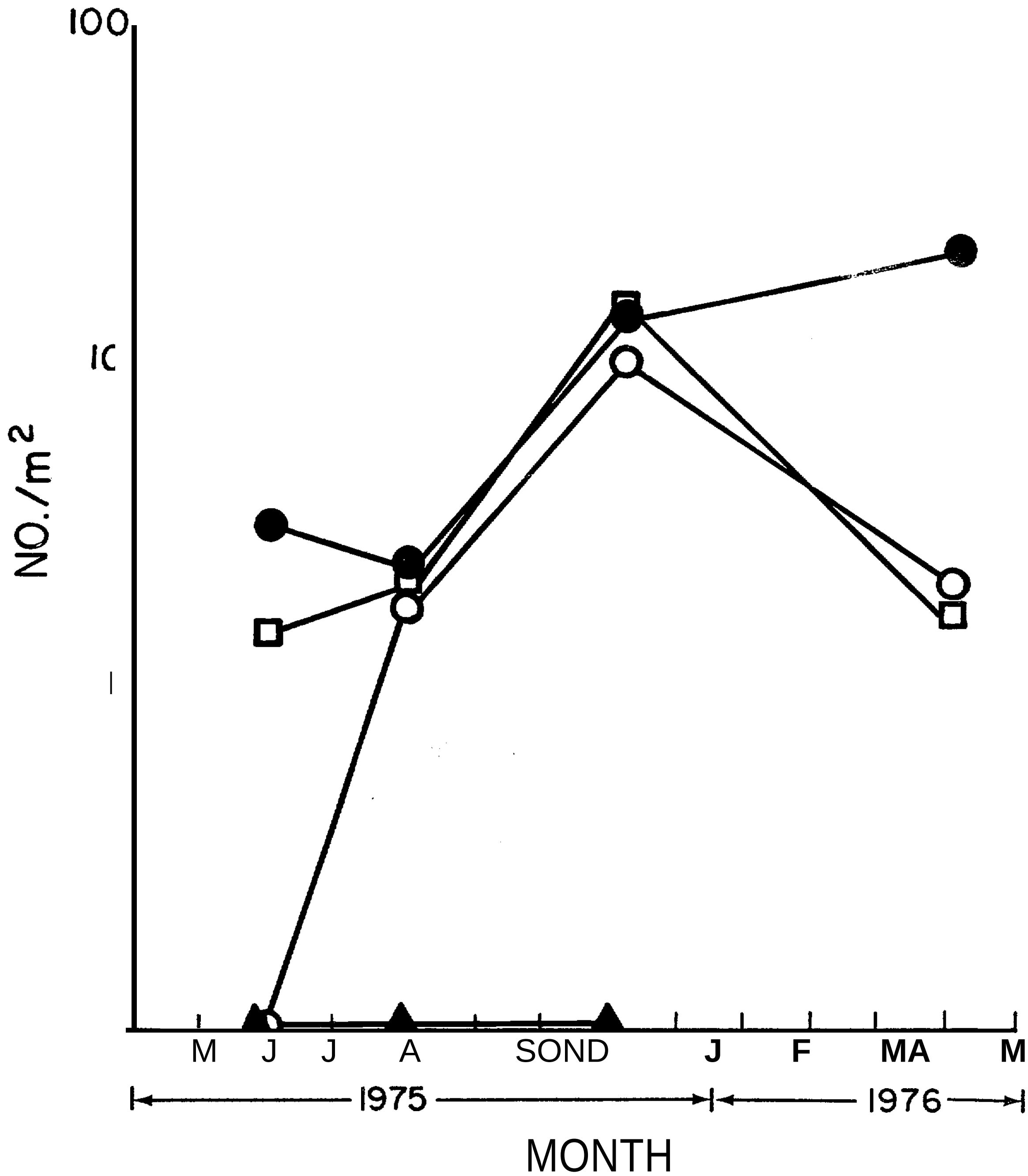


Figure 4. The average abundance of the pteropod, *Clione limacina*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

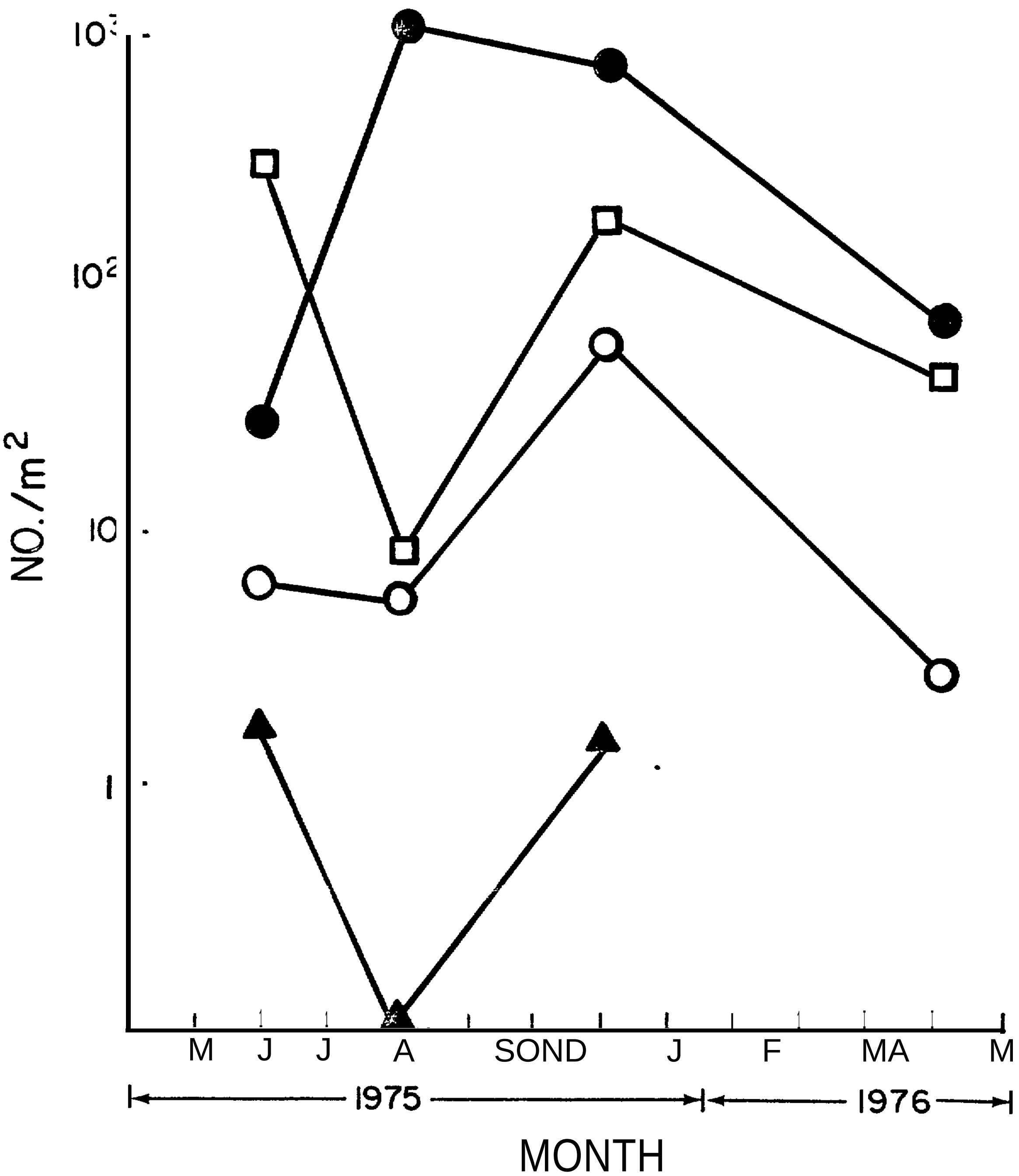


Figure 5. The average abundance of the pteropod, *Limacina helicina*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

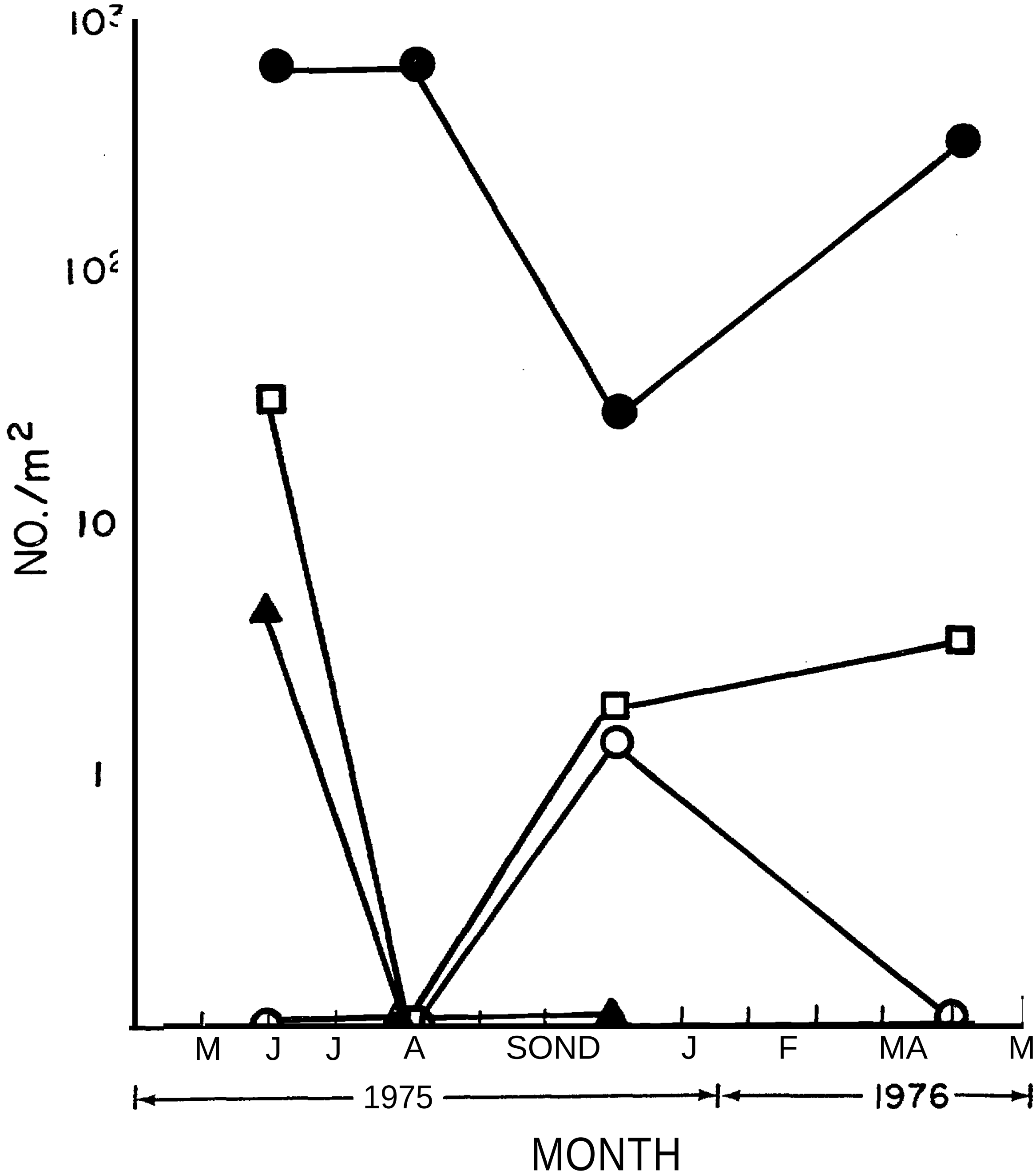


Figure 6. The average abundance of ostracods, *Conchoecia* spp., in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

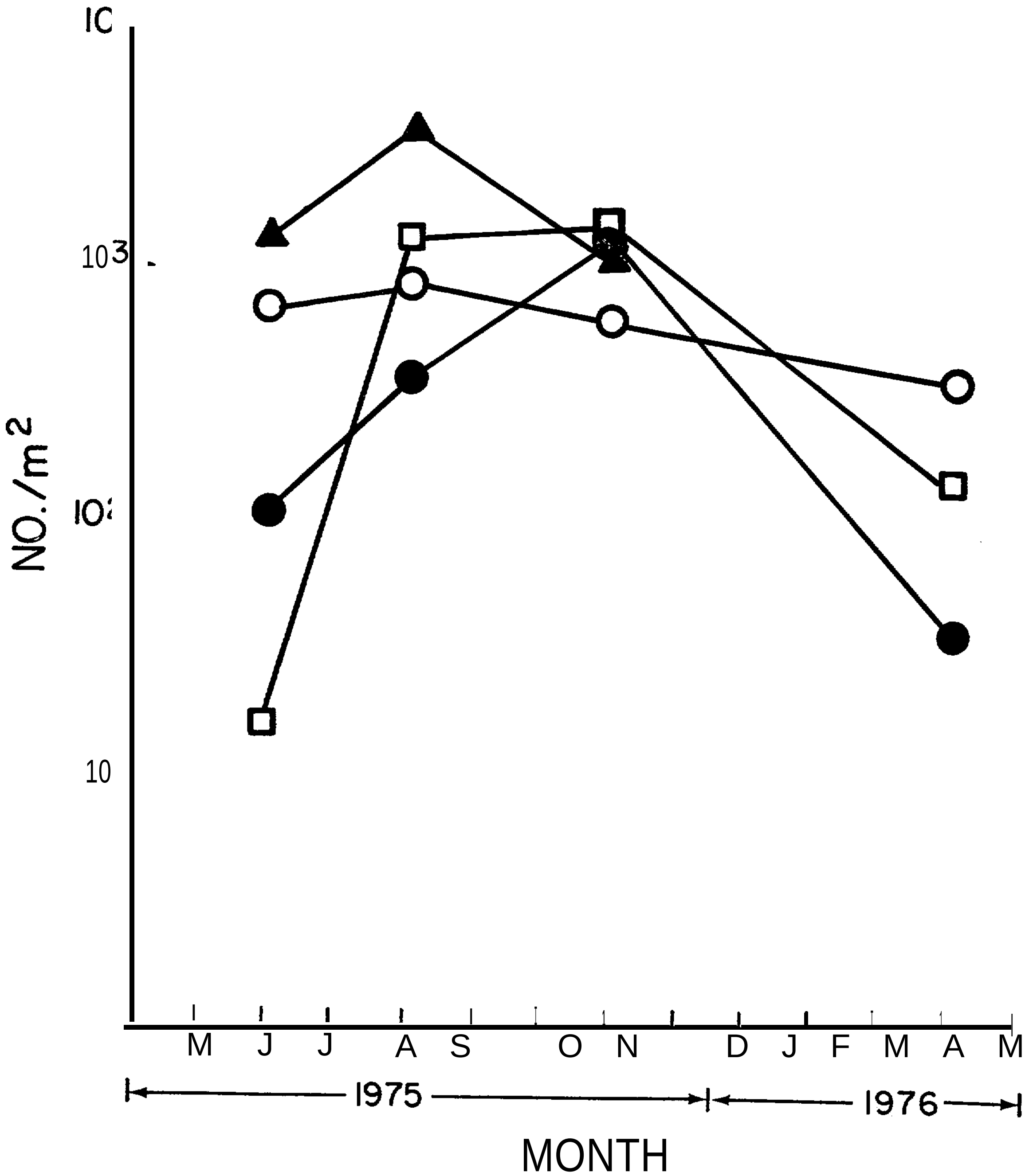


Figure 7. The average abundance of the copepod, *Acartia longiremis*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

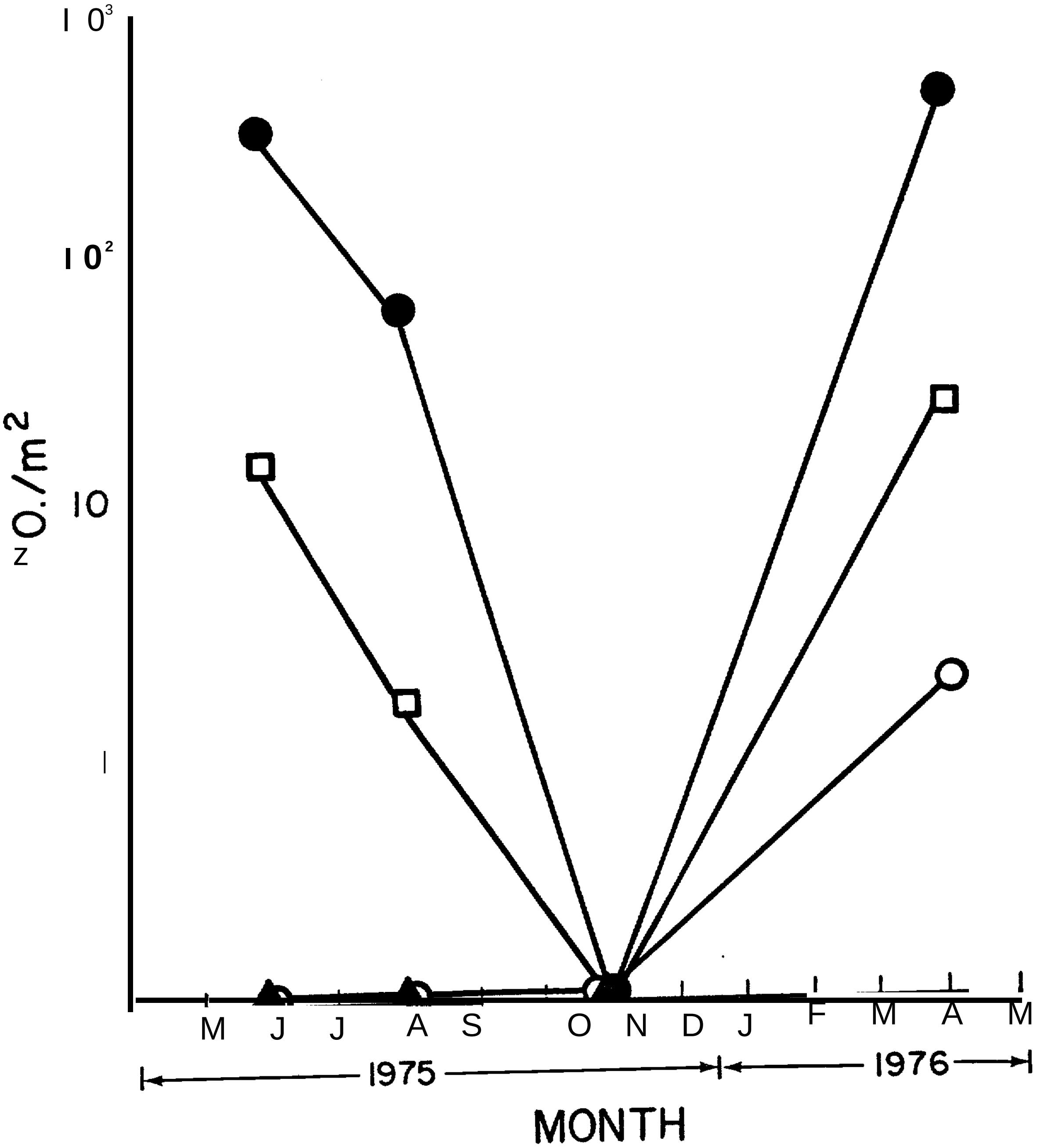


Figure 8. The average abundance of the copepod, *Calanus cristatus*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime,

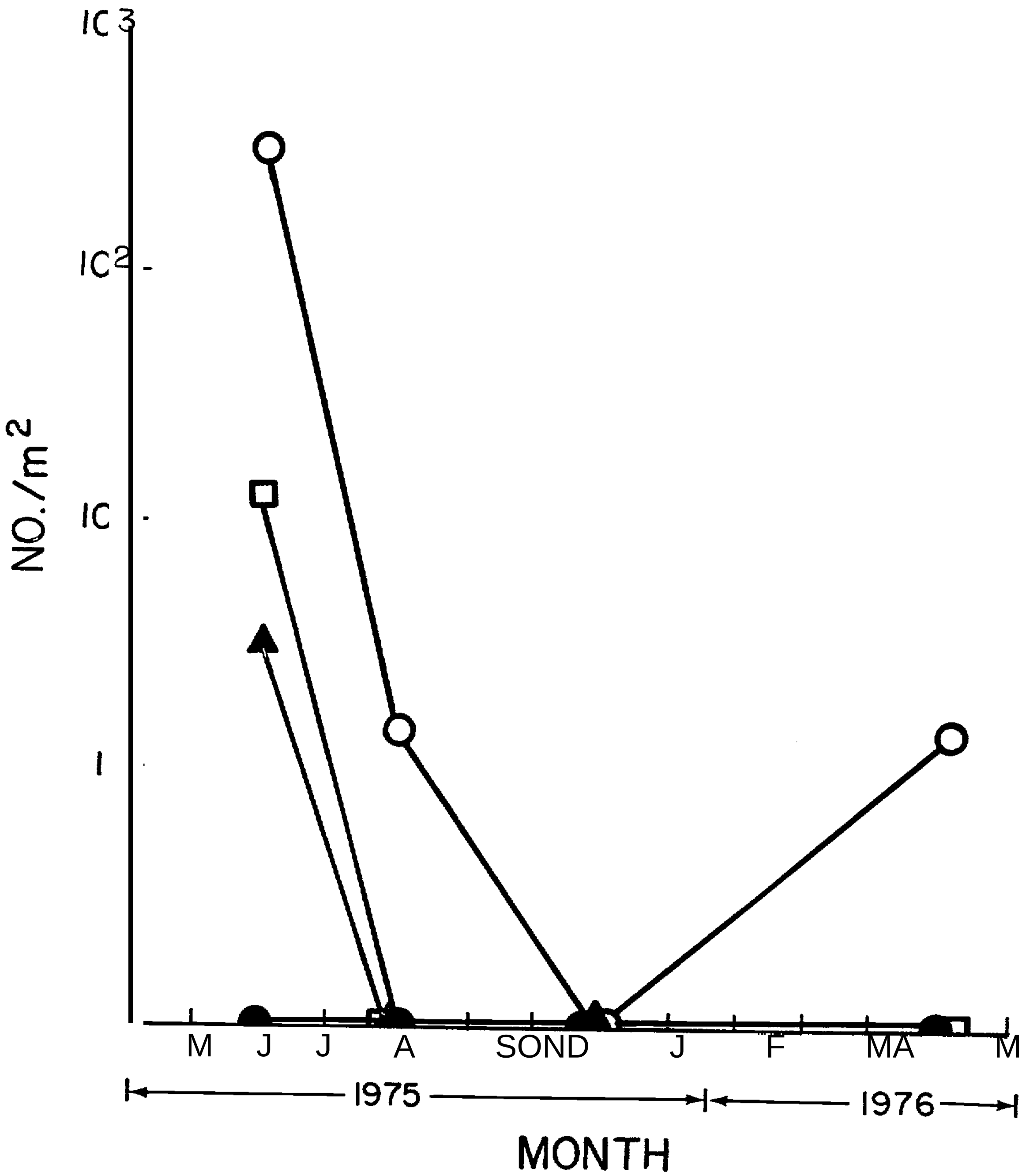


Figure 9. The average abundance of the copepod, *Calanus glacialis*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

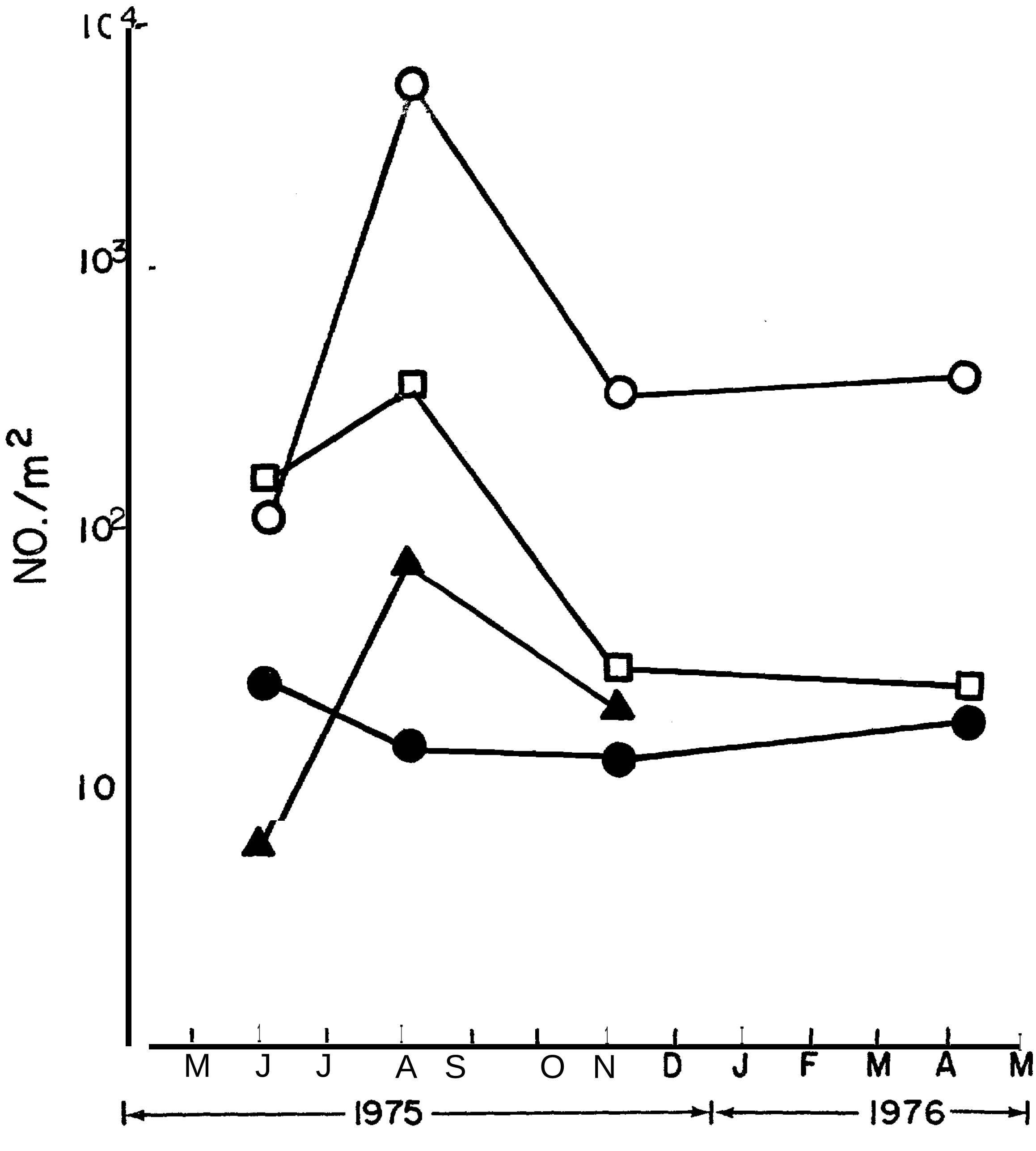


Figure 10. The average abundance of the copepod, *Calanus marshallae*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

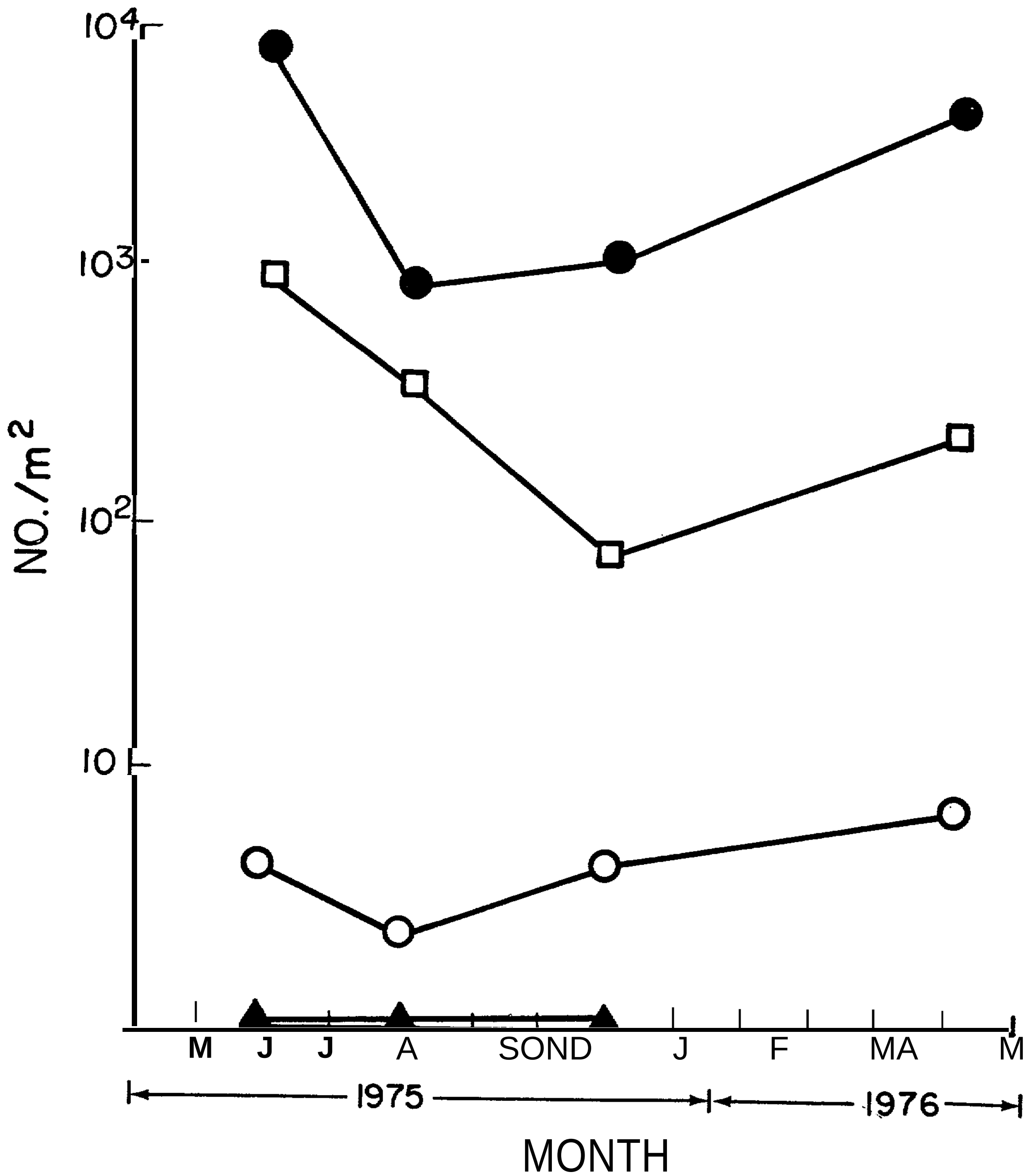


Figure 11. The average abundance of the copepod, *Calanus plumchrus*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf* open circles indicate central shelf; and triangles the northern' coastal regime.

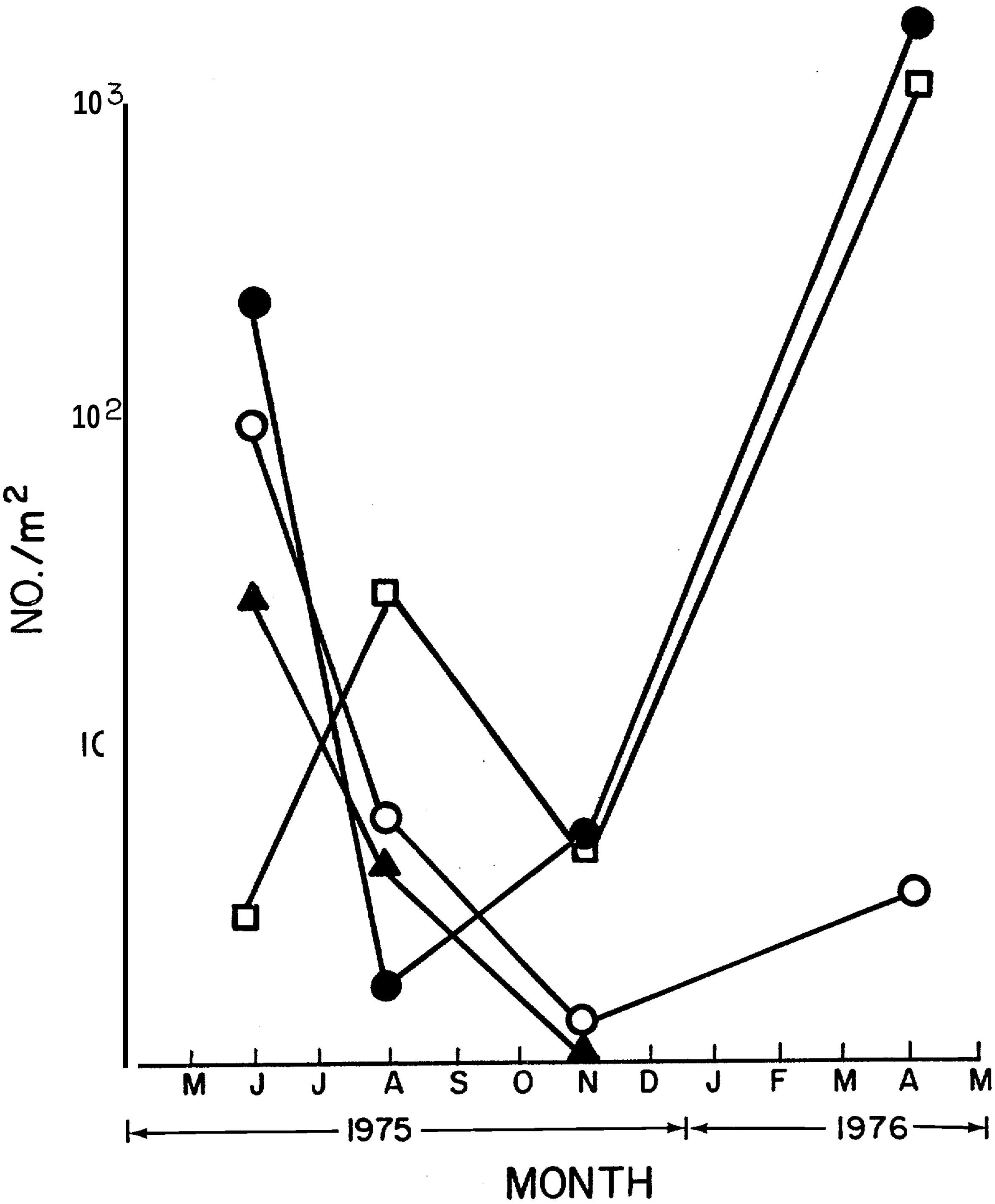


Figure 12. The average abundance of the *Calanus* spp. copepodites in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

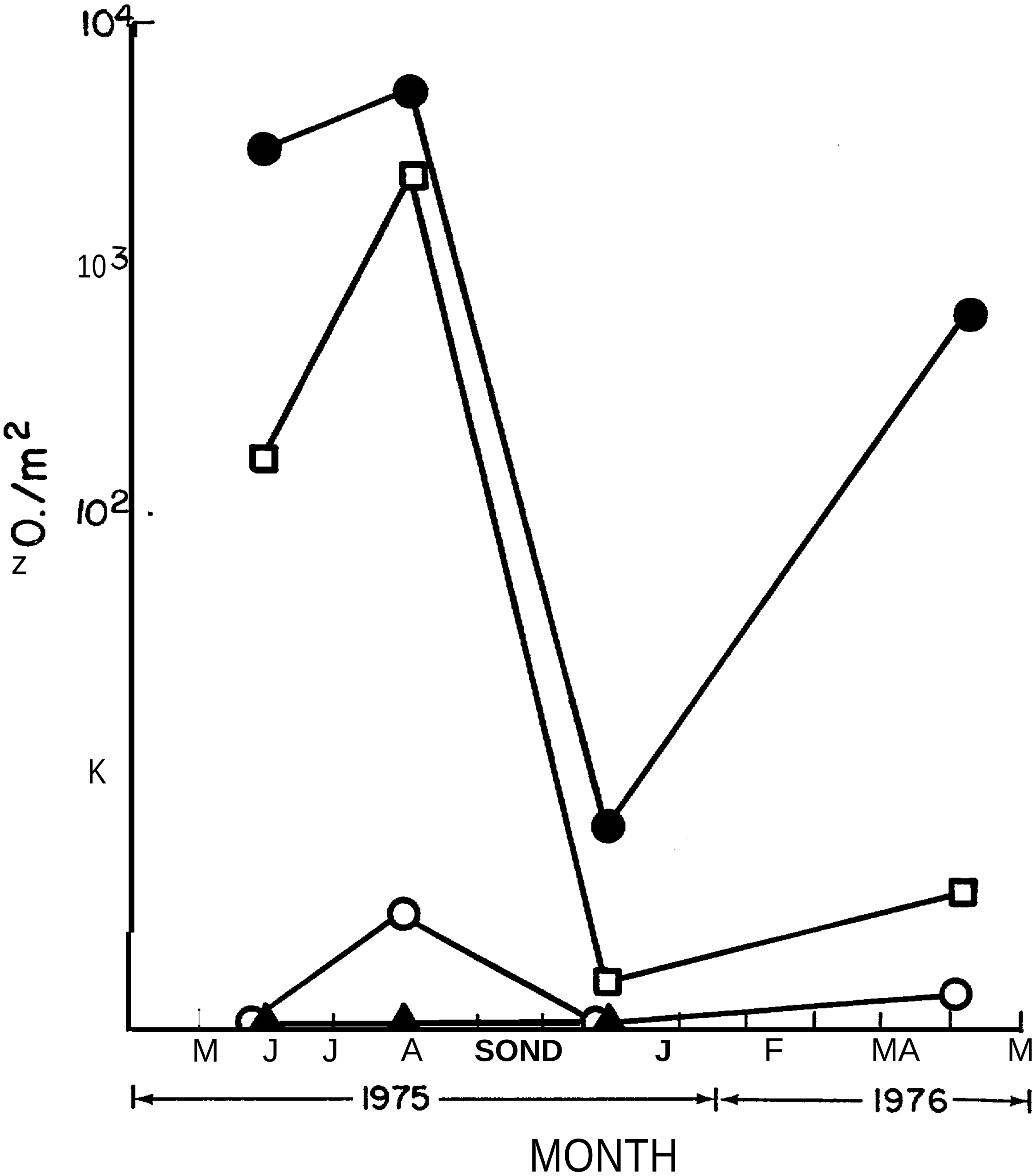


Figure 13. The average abundance of the copepod, *Eucalanus b. bungii*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

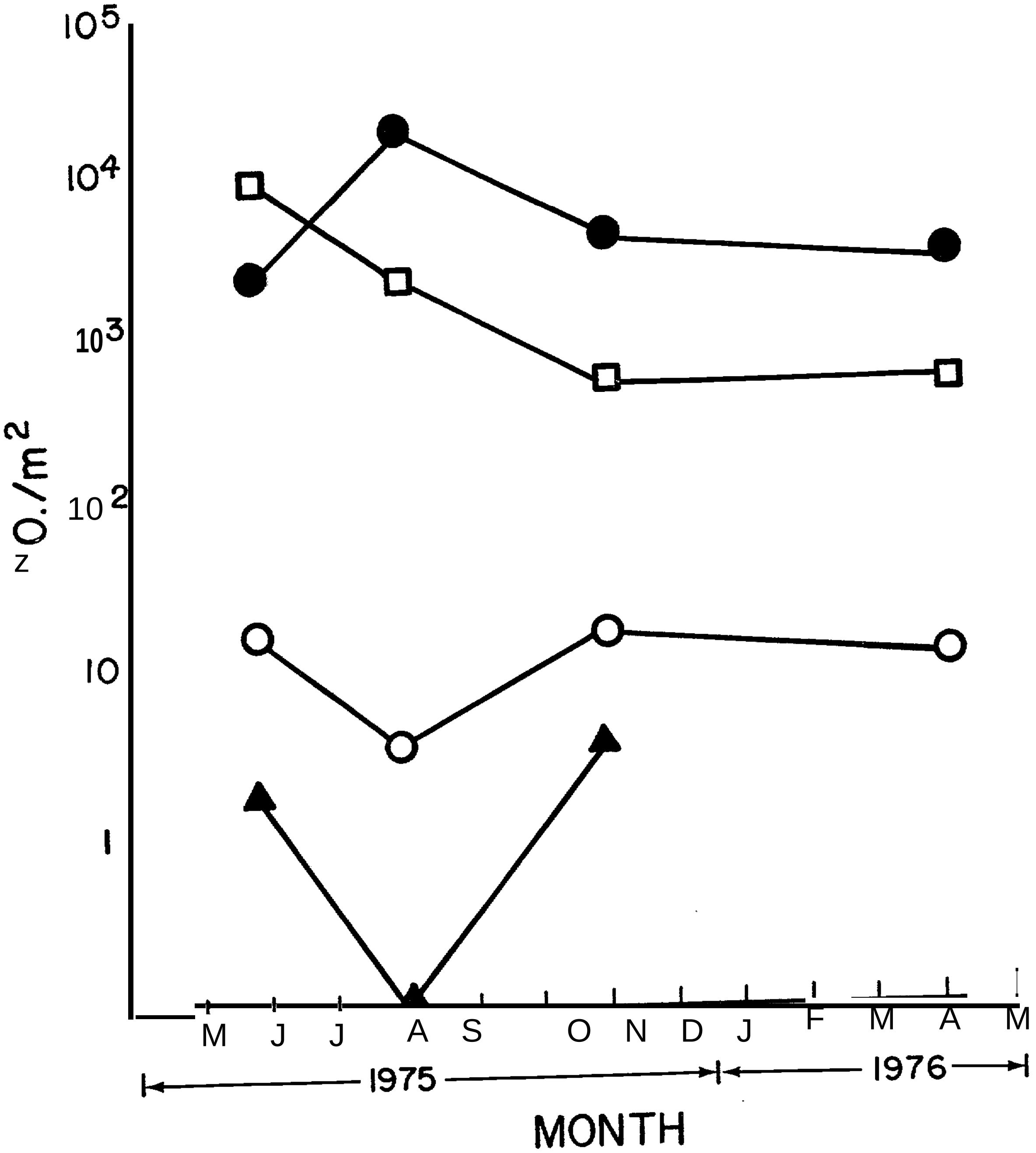


Figure 14. The average abundance of the copepod, *Metridia lucens*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

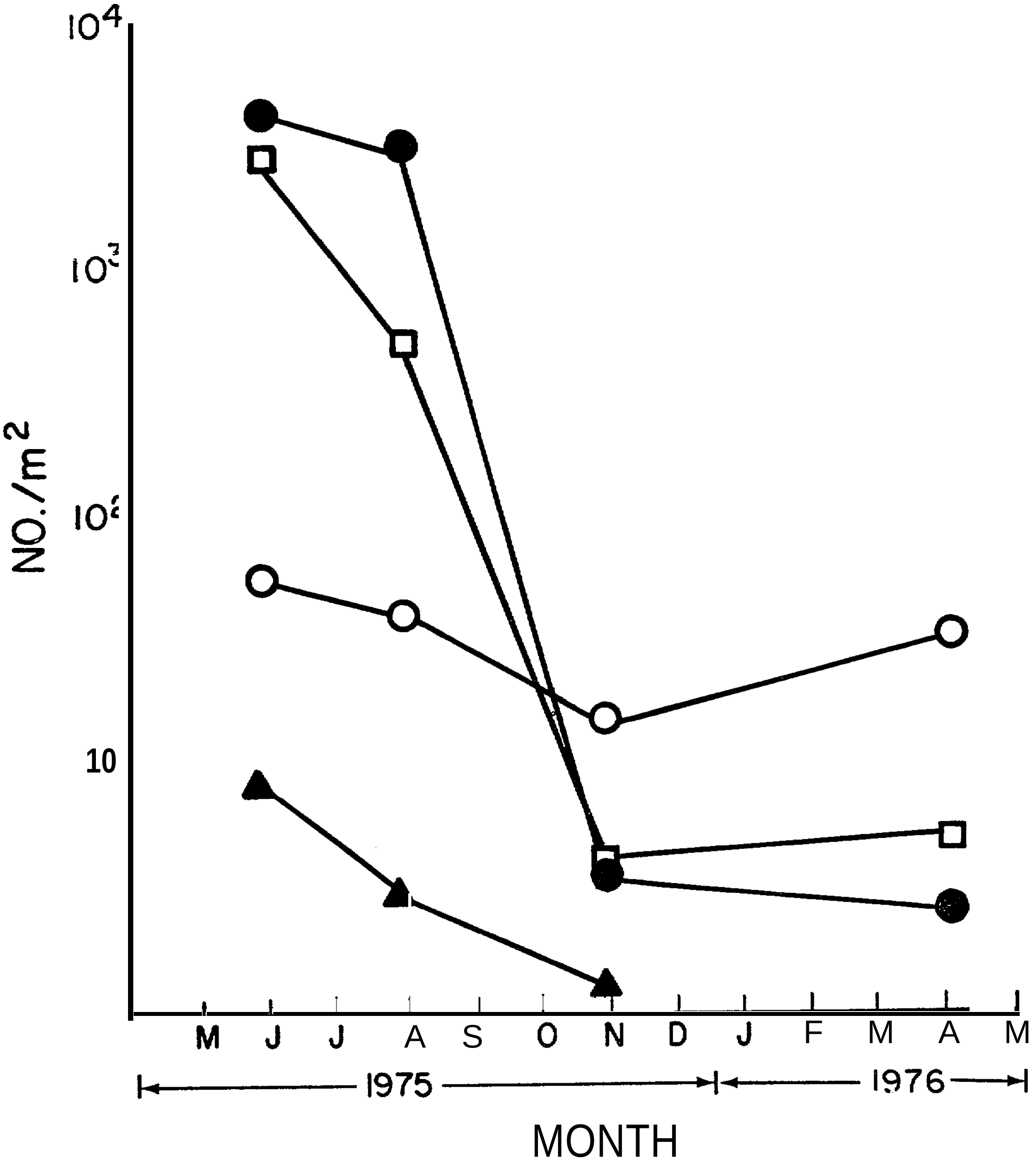


Figure 15. The average abundance of the copepod, *Oithona similis*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

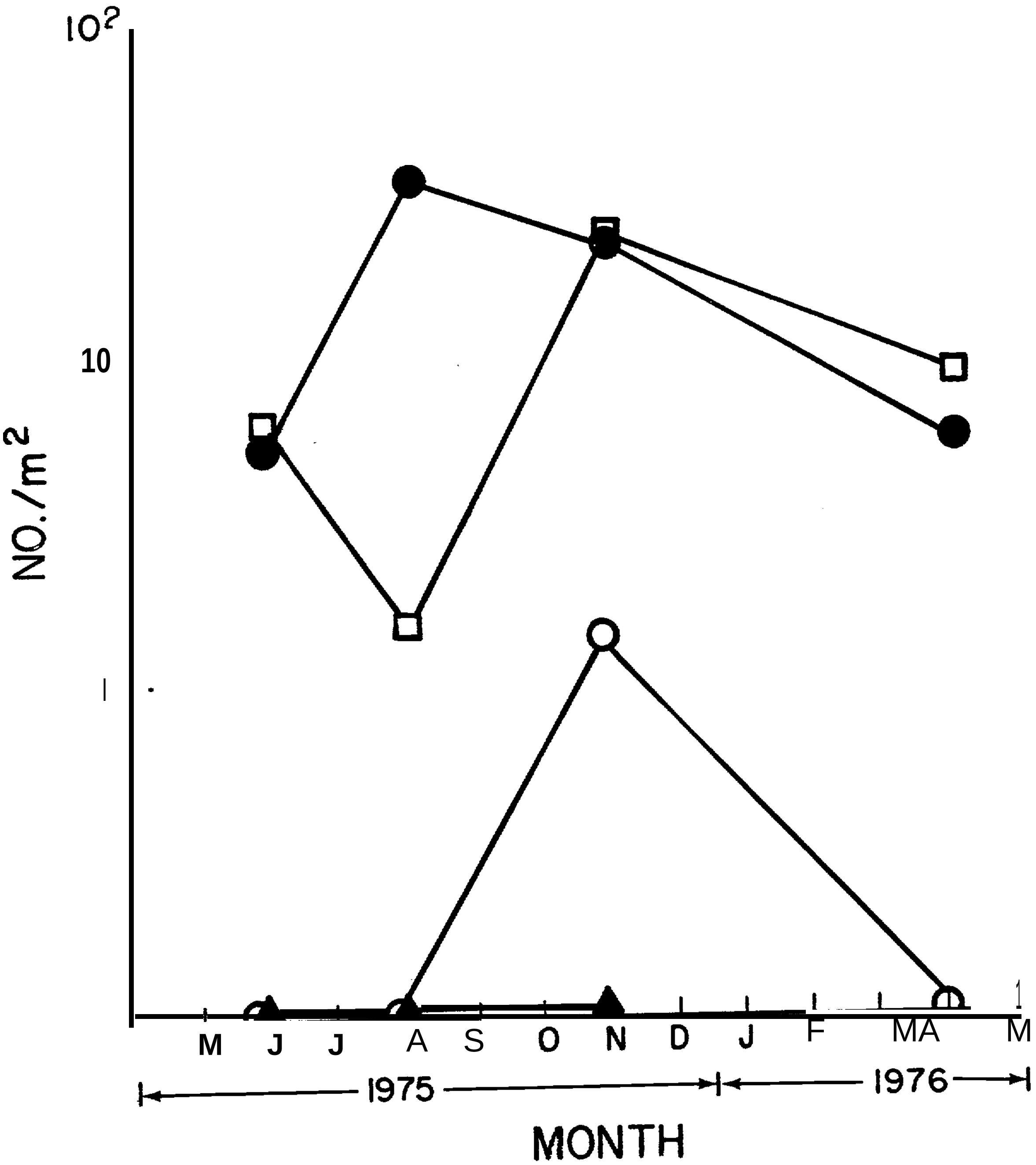


Figure 16. The average abundance of the copepod, *Oithona spinirostris*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

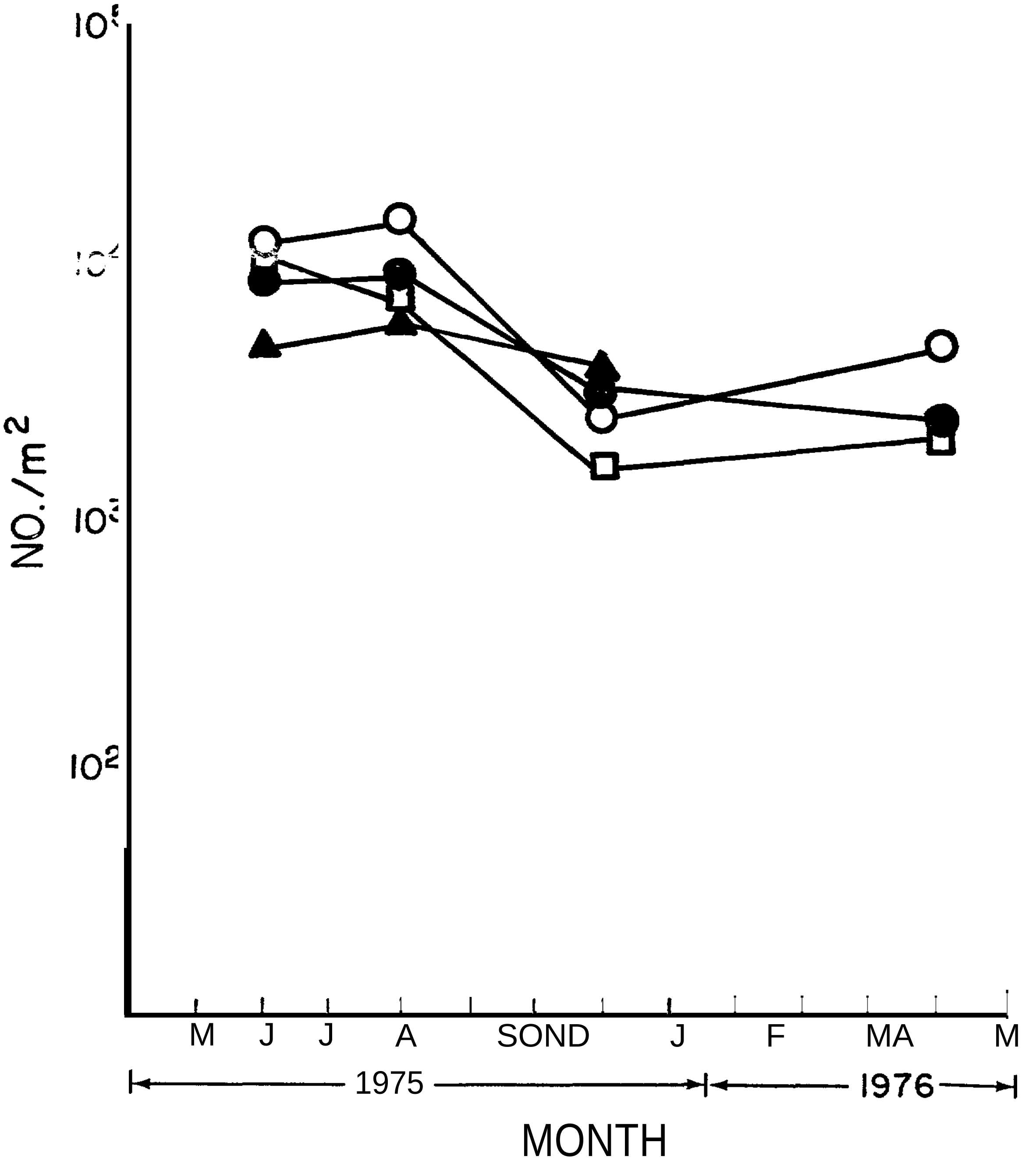


Figure 17. The average abundance of the copepod, *Pseudocalanus* spp., in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

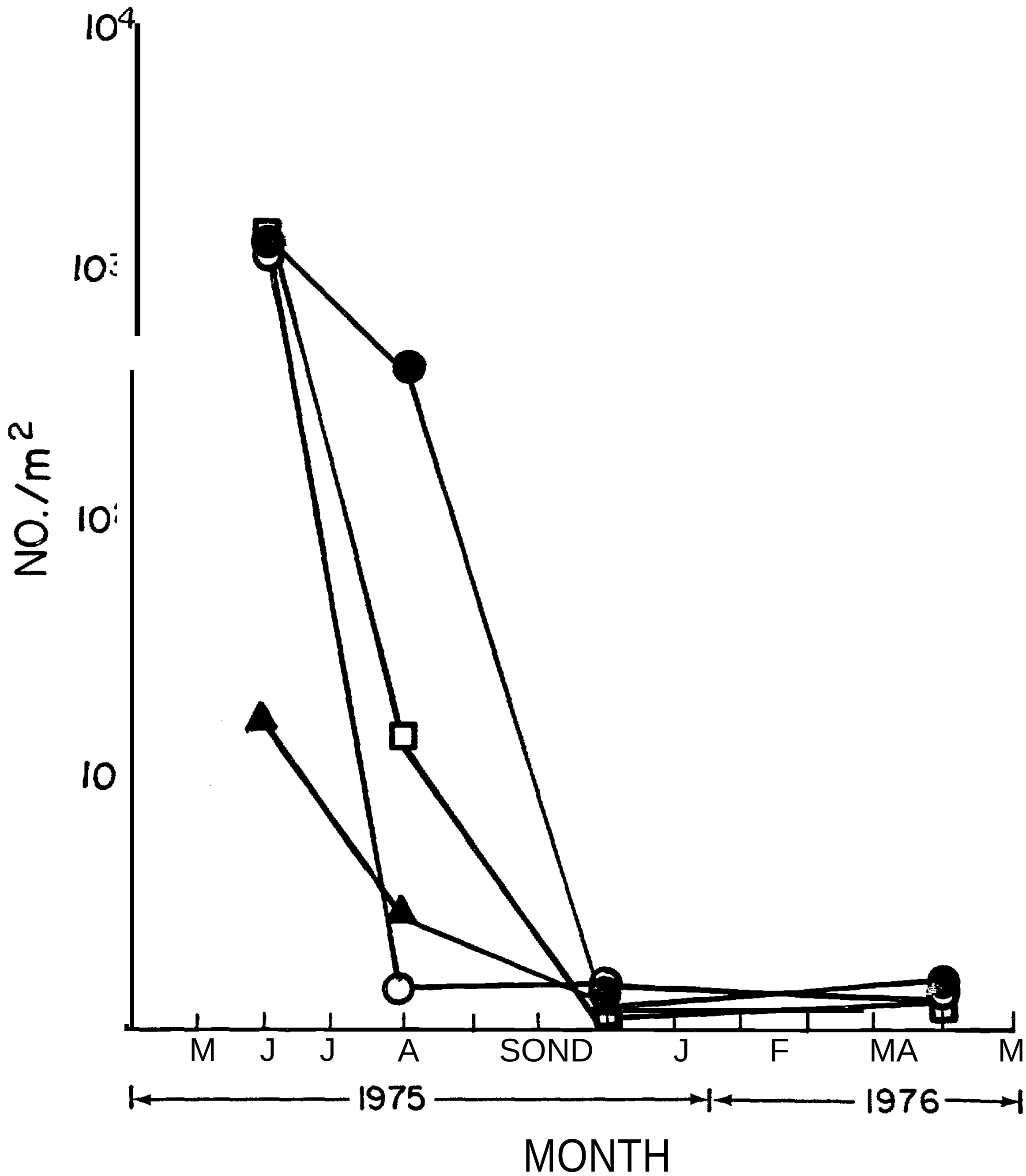


Figure 18. The average abundance of a composite of unidentified copepod nauplii in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime,

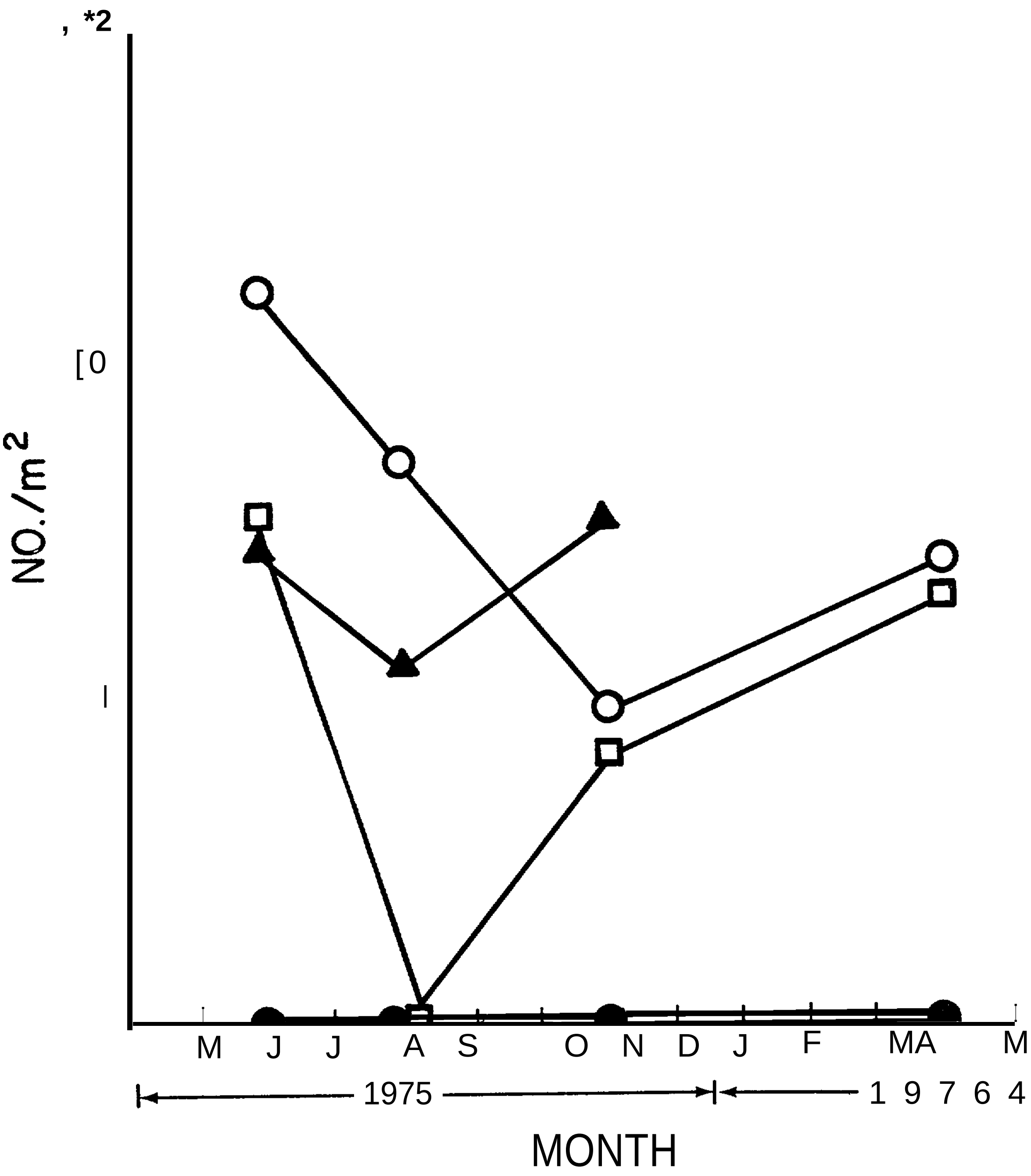


Figure 19. The average abundance of the amphipod, *Parathemisto libellula*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

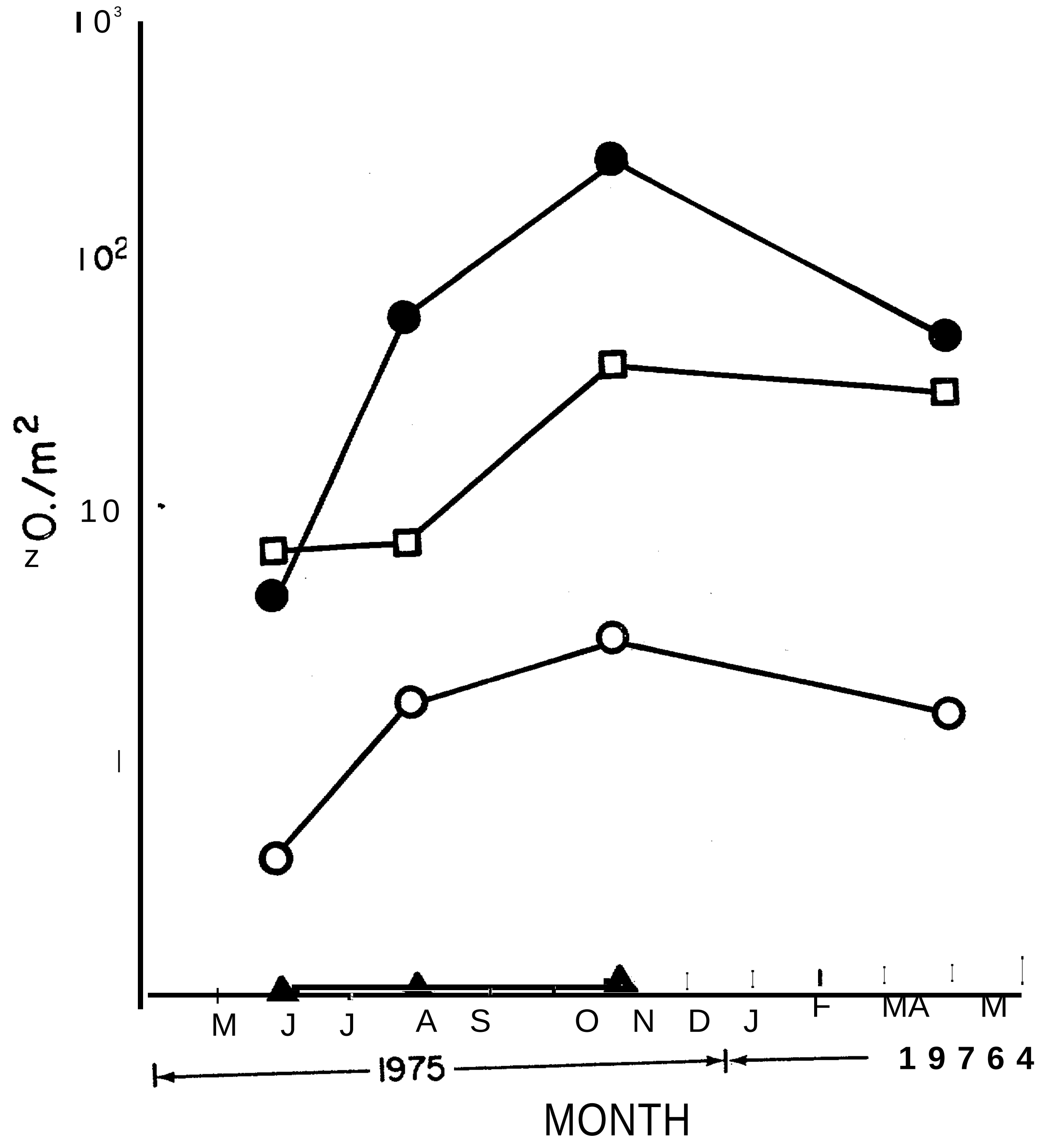


Figure 20. The average abundance of the amphipod, *Parathemisto pacifica*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

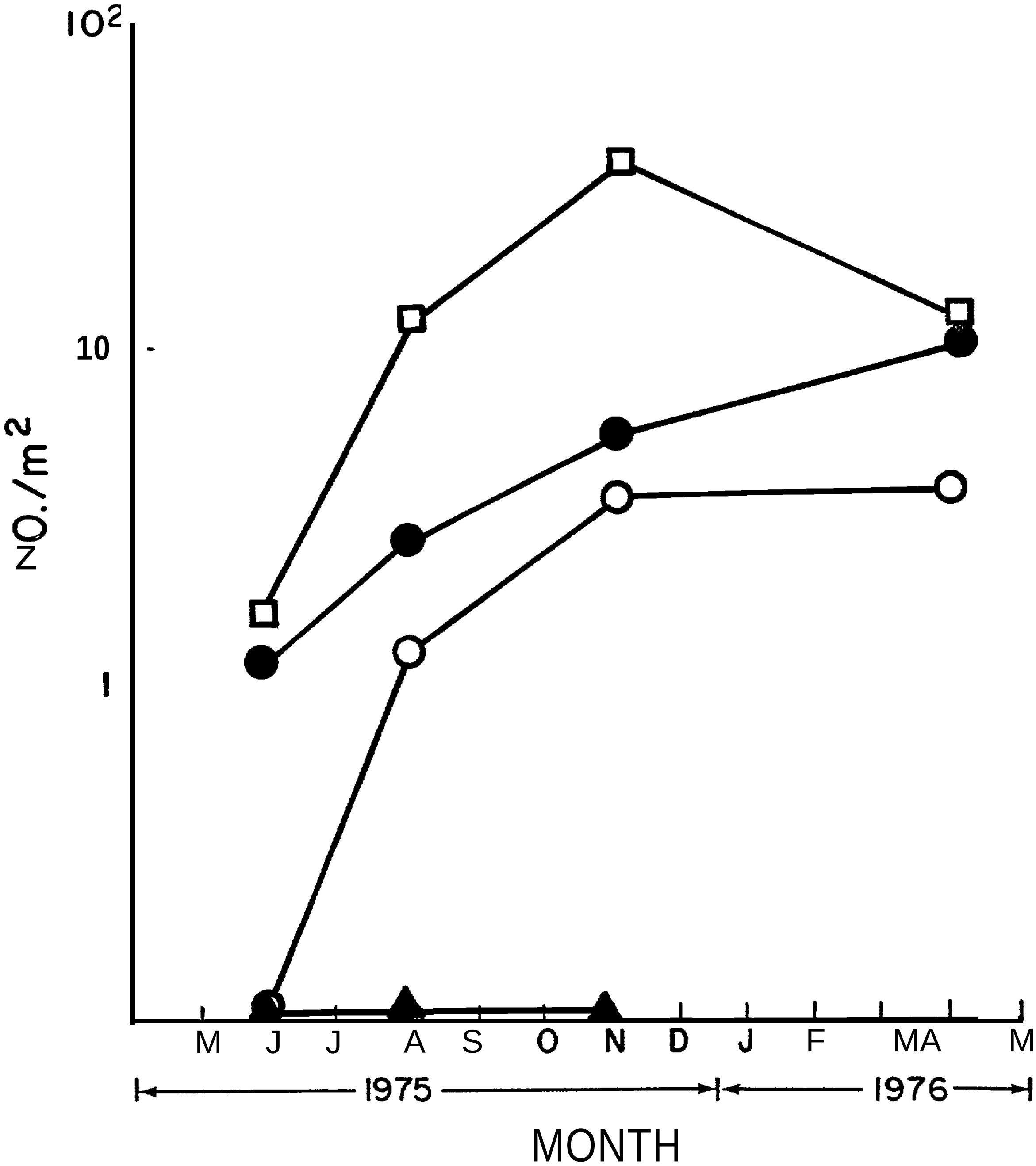


Figure 21. The average abundance of the euphausiid, *Thysanoessa inermis*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

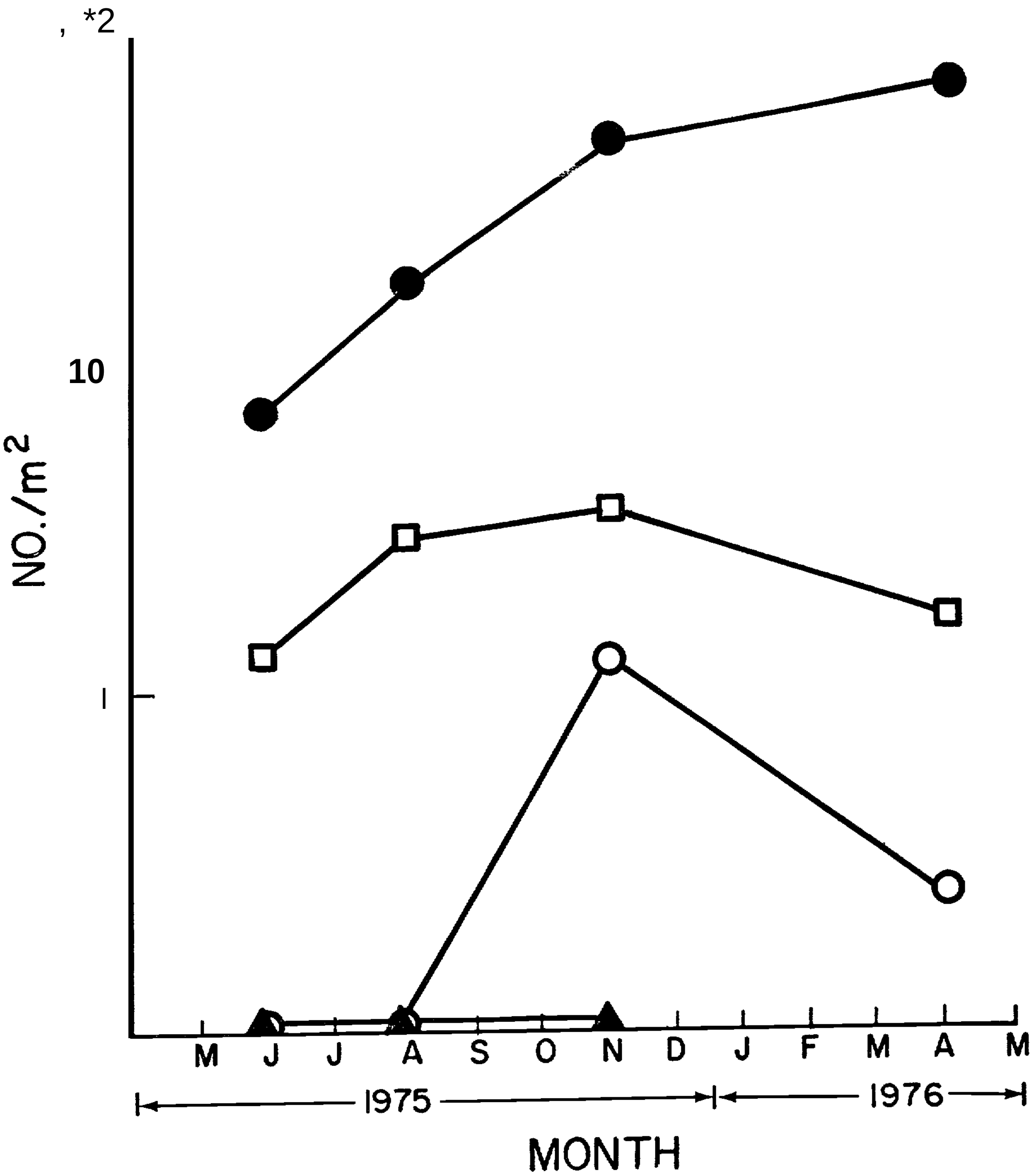


Figure 22. The average abundance of the euphausiid, *Thysanoessa longipes*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

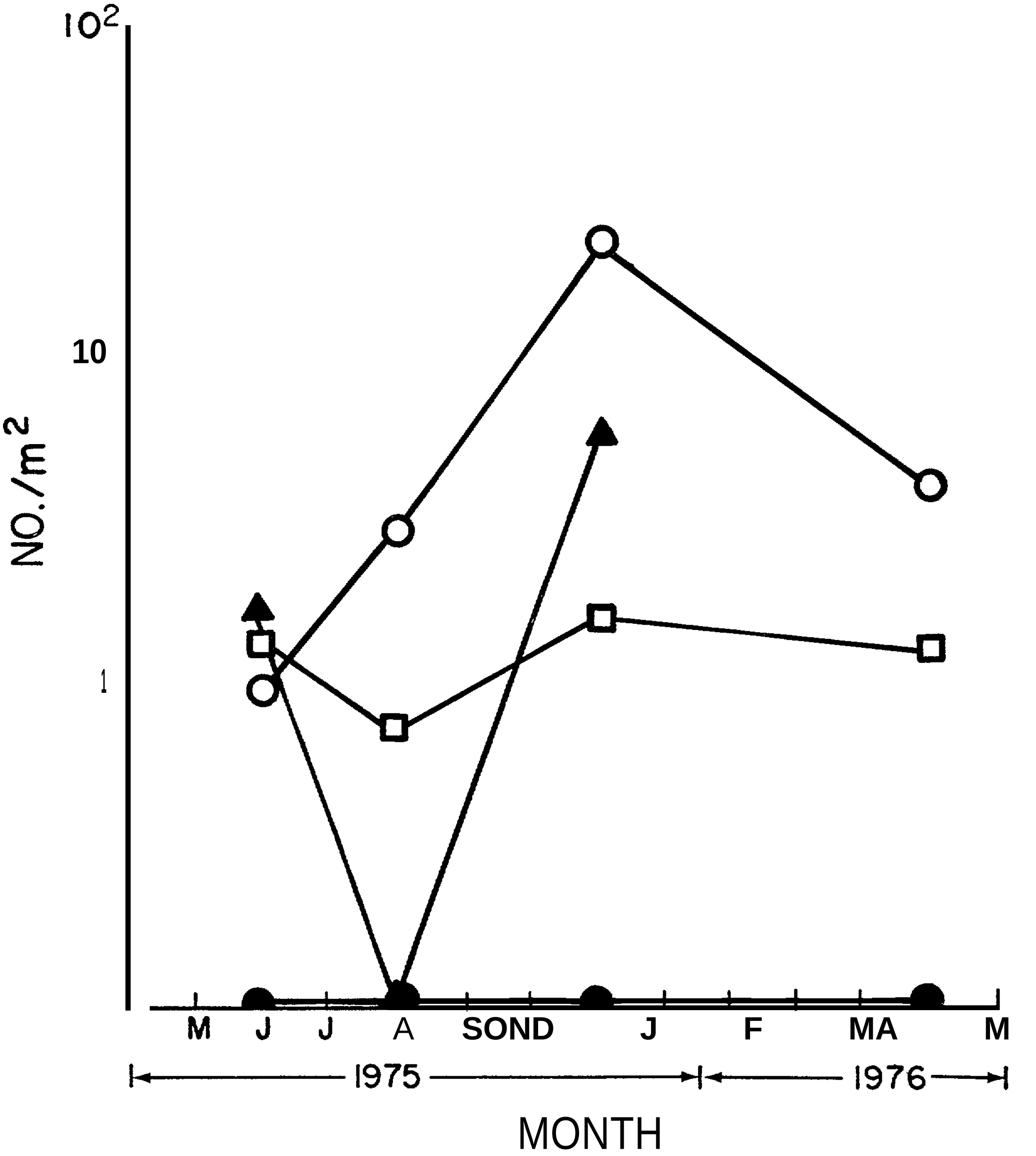


Figure 23. The average abundance of the euphausiid, *Thysanoessa raschii*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

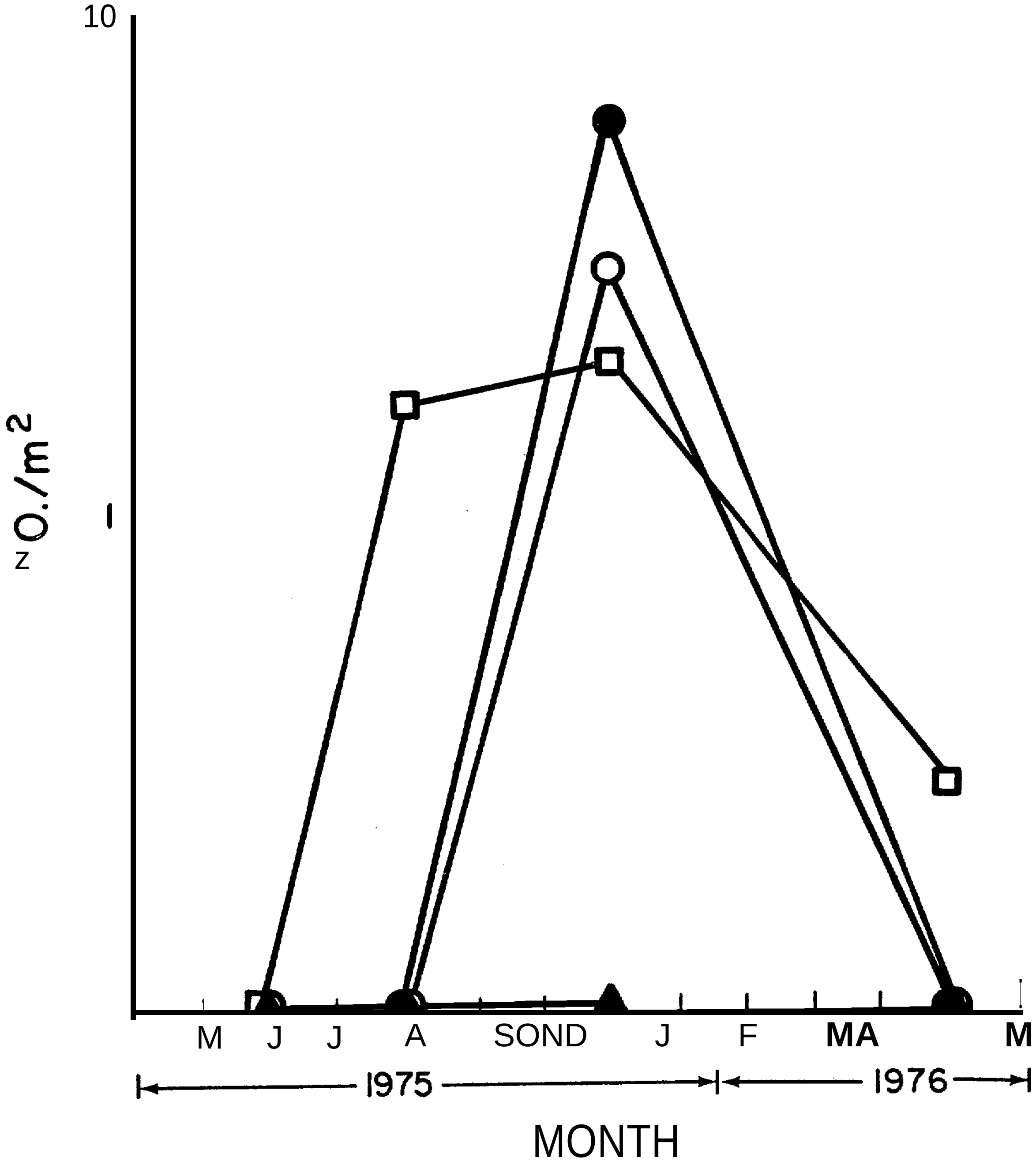


Figure 24. The average abundance of juvenile *Thysanoessa* spp., in the southeastern Bering Sea; May 1975-April 1976, Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

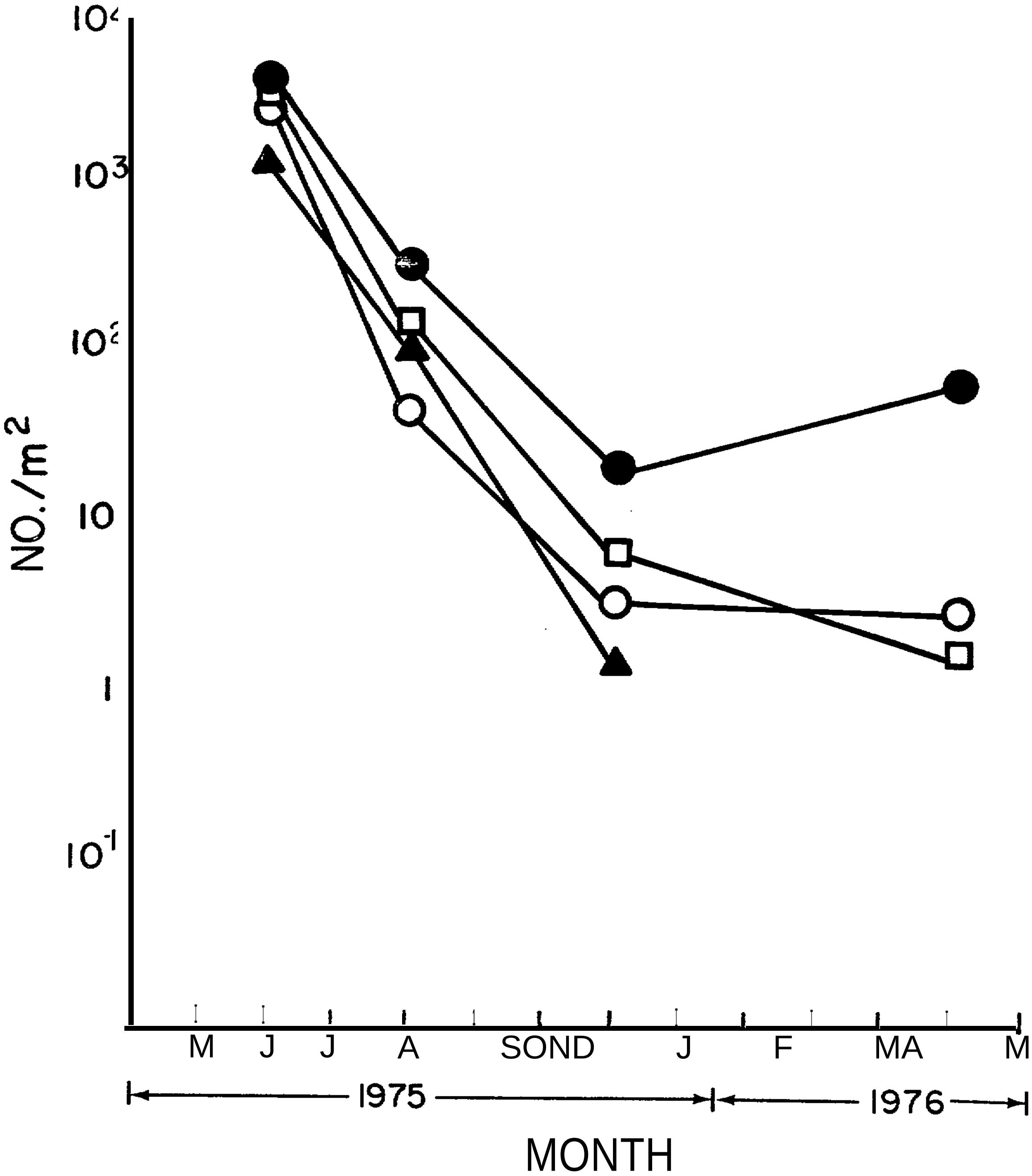


Figure 25. The average abundance of a composite of euphausiid eggs and larvae in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

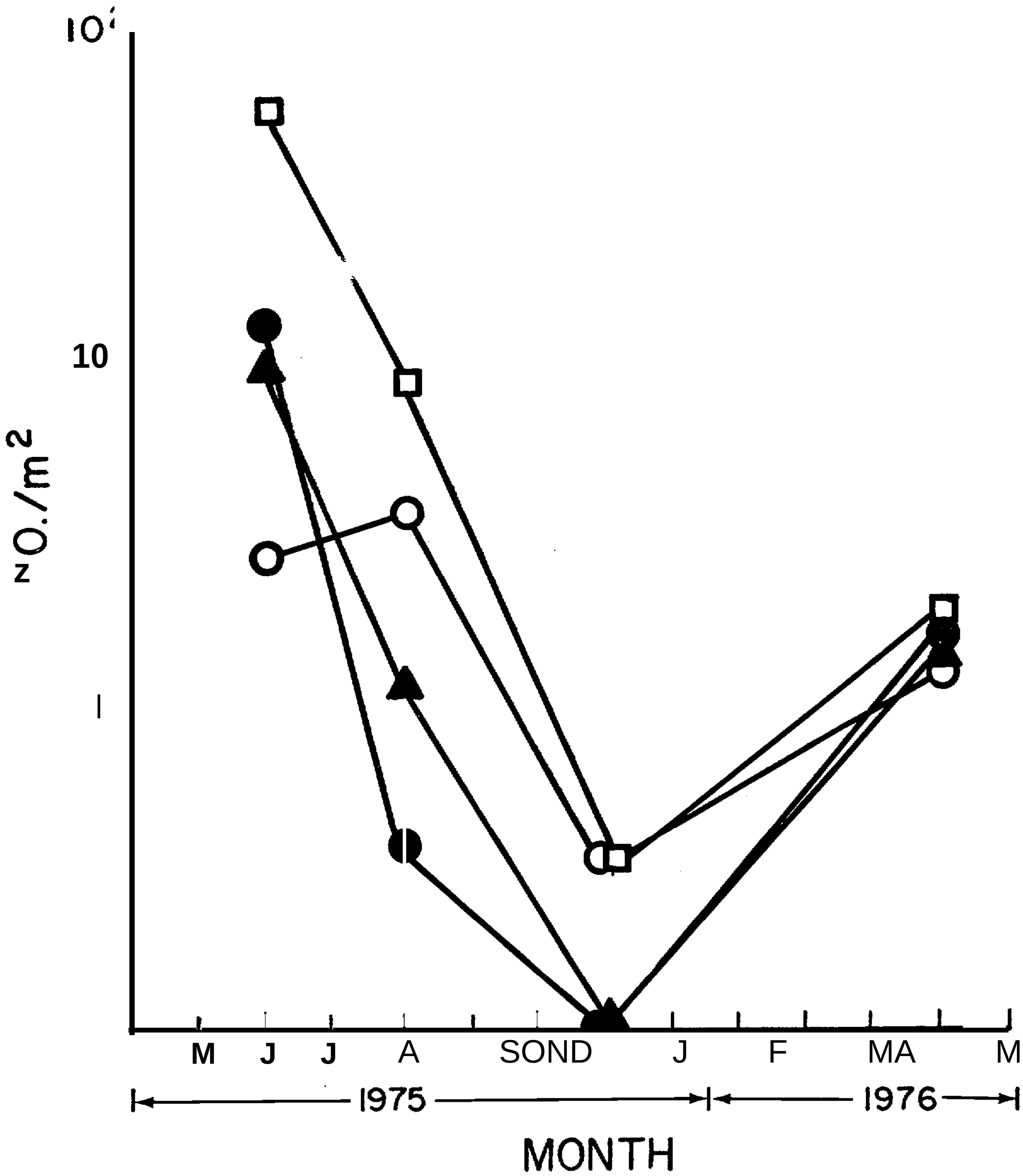


Figure 26. The average abundance of larval spider crabs, Majiidae, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

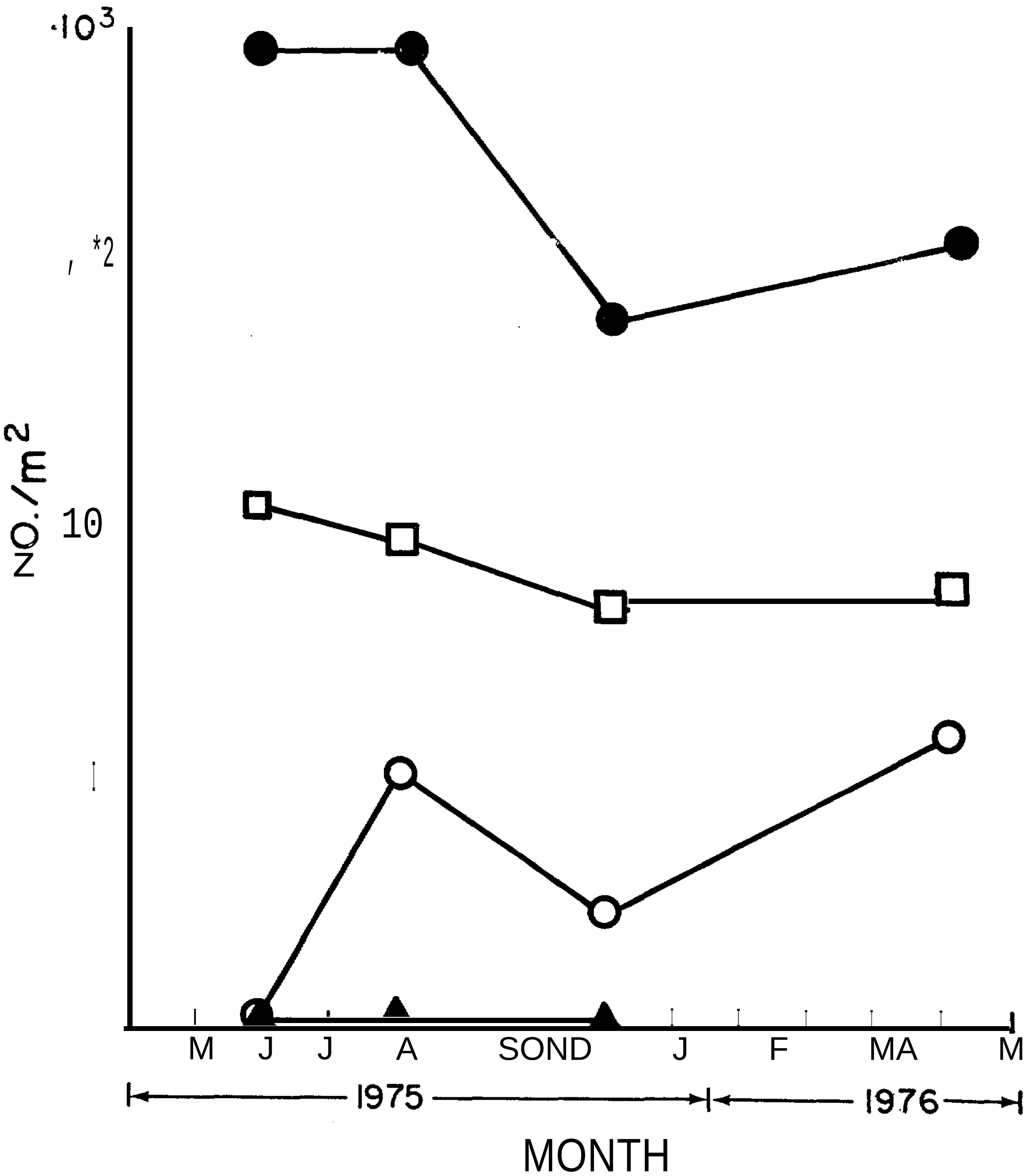


Figure 27. The average abundance of the chaetognath, *Eukrohnia hamata*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime,

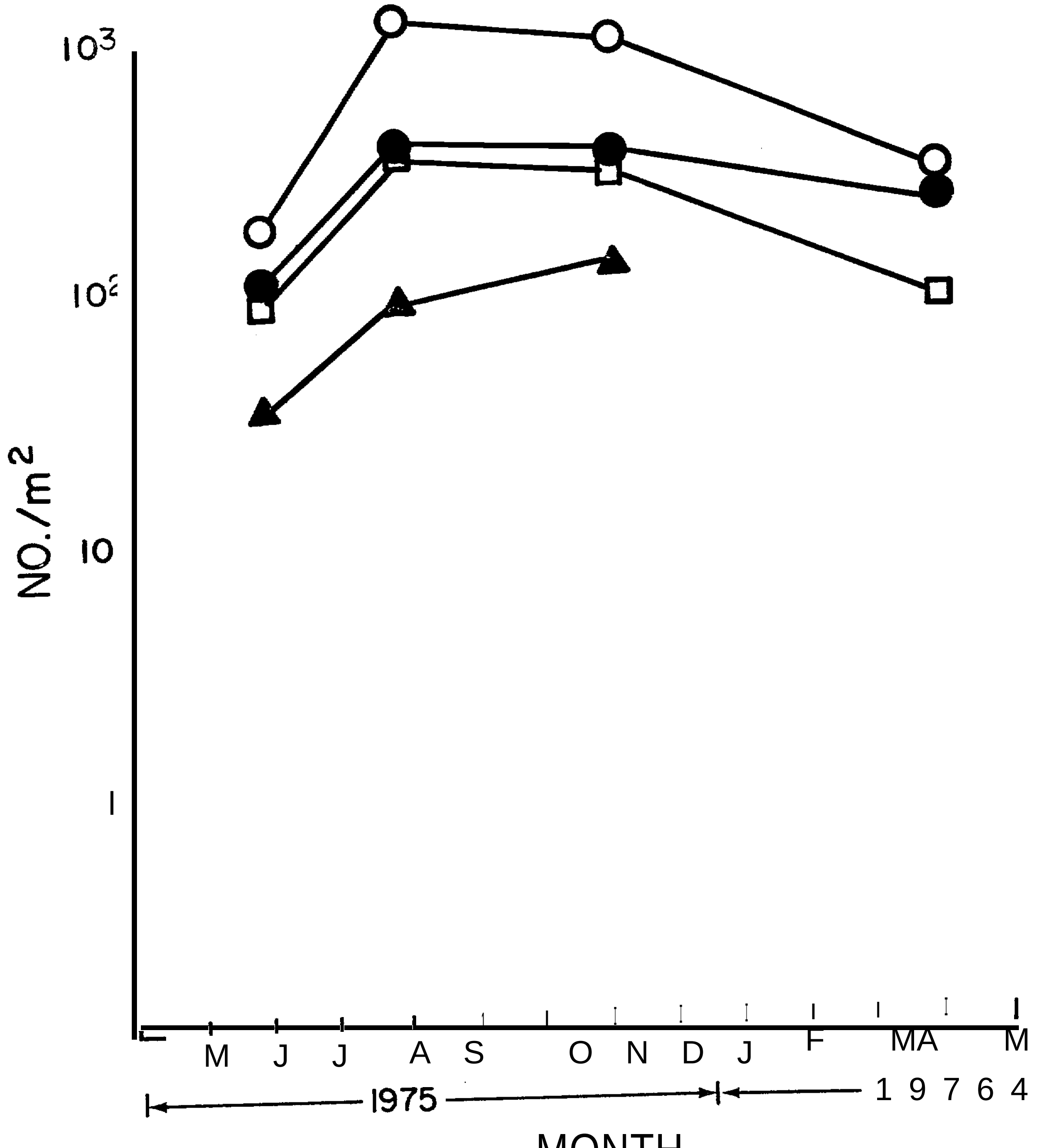


Figure 28. The average abundance of the chaetognath, *Sagitta elegans*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

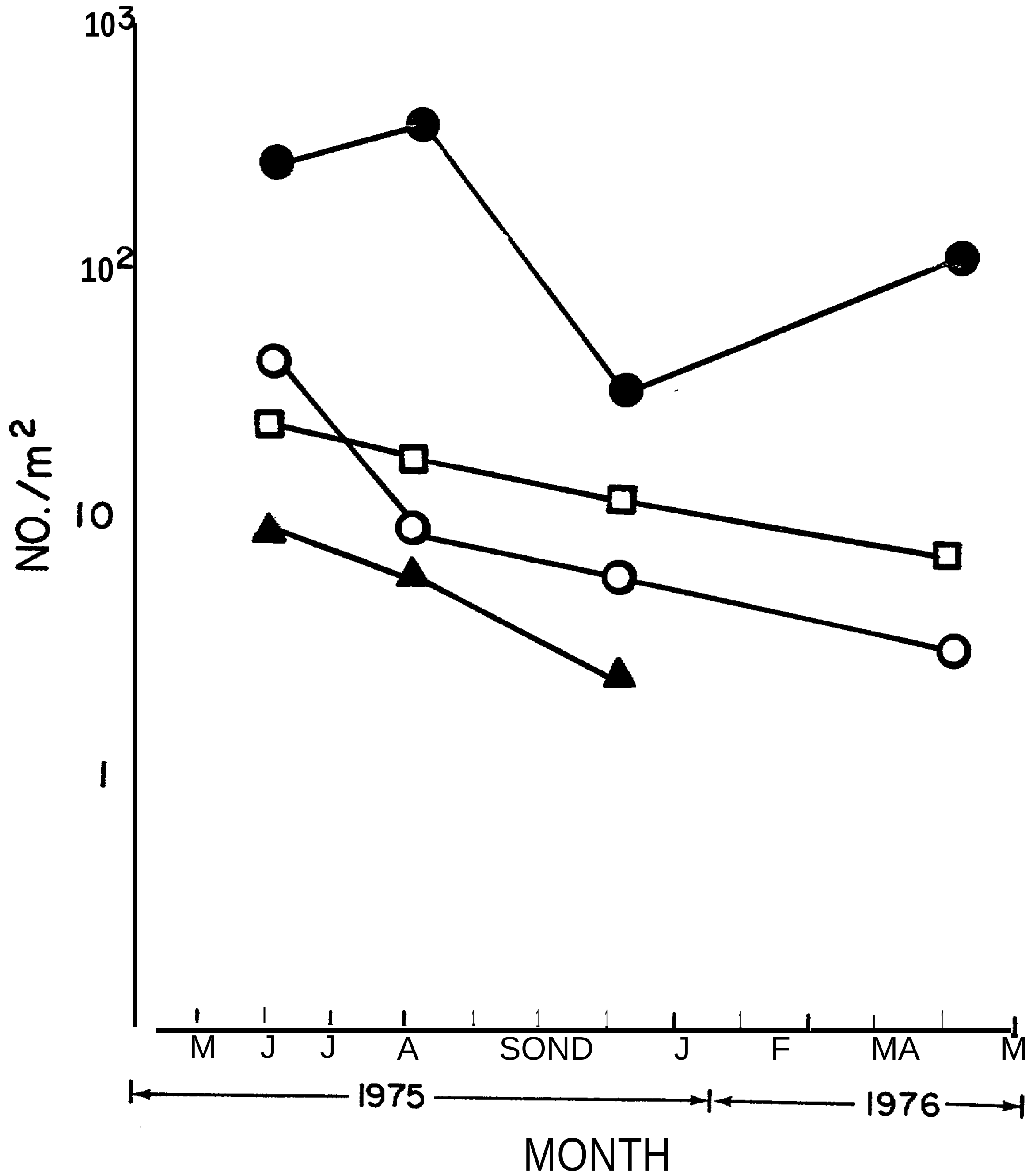


Figure 29. The average abundance of juvenile chaetognaths in the south-eastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

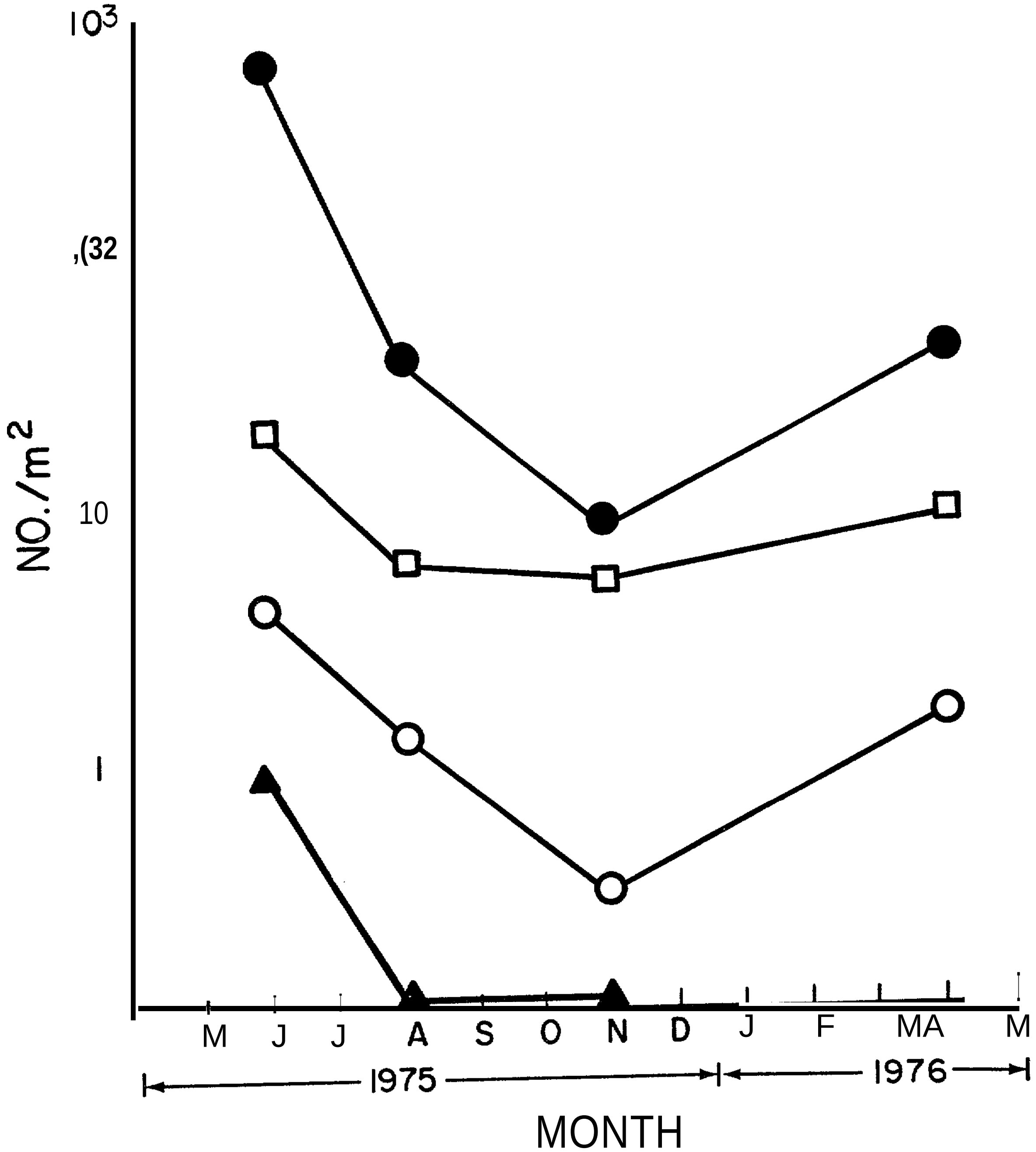


Figure 30. The average abundance of larvaceans, *Oikopleura* spp., in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

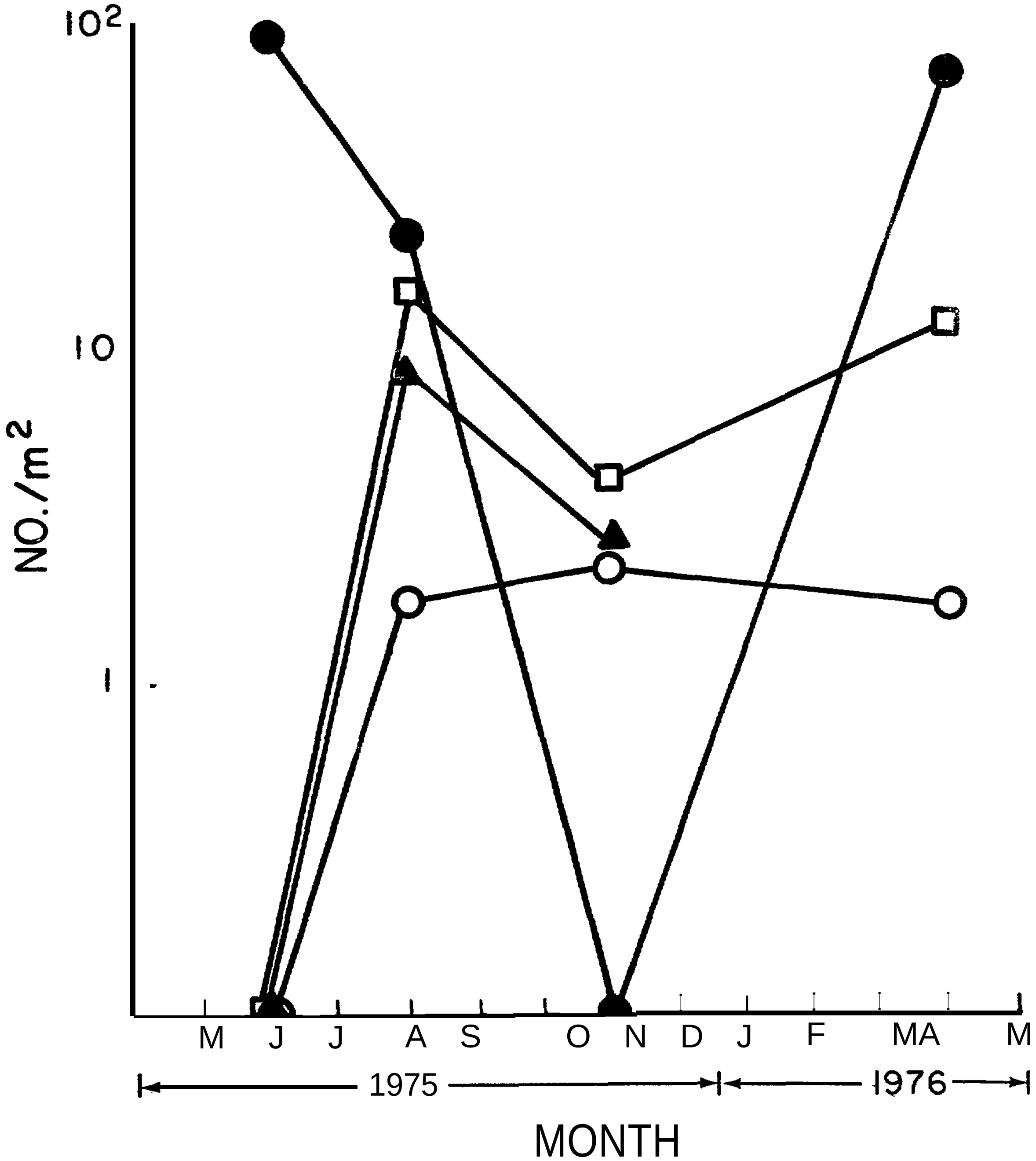


Figure 31. The average abundance of a composite of unidentified larvaceous in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

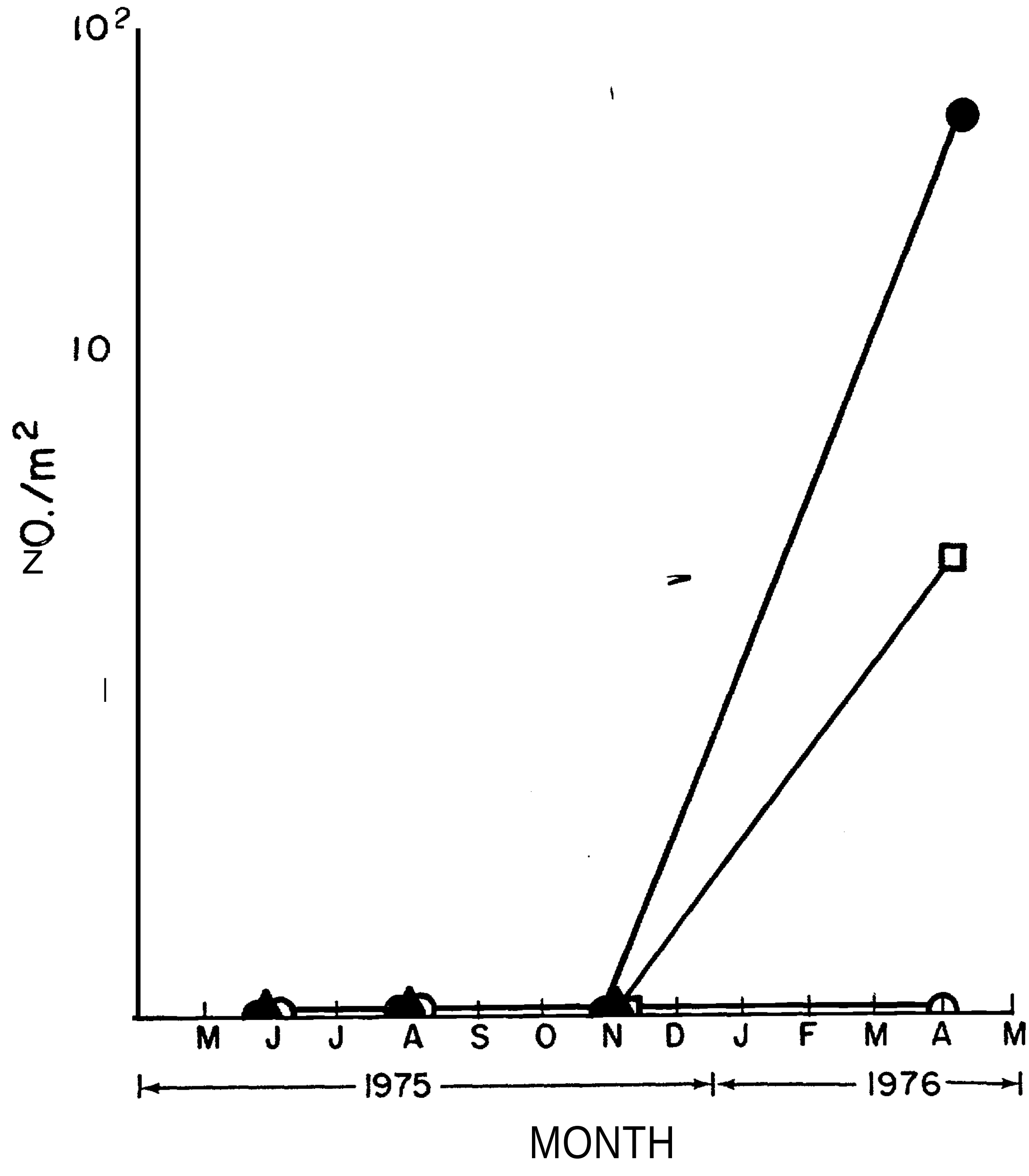


Figure 32. The average abundance of larval pollock, *Theragra chalcogramma*, in the southeastern Bering Sea; May 1975-April 1976. Darkened circles indicate the open ocean regime; squares the outer shelf; open circles indicate central shelf; and triangles the northern coastal regime.

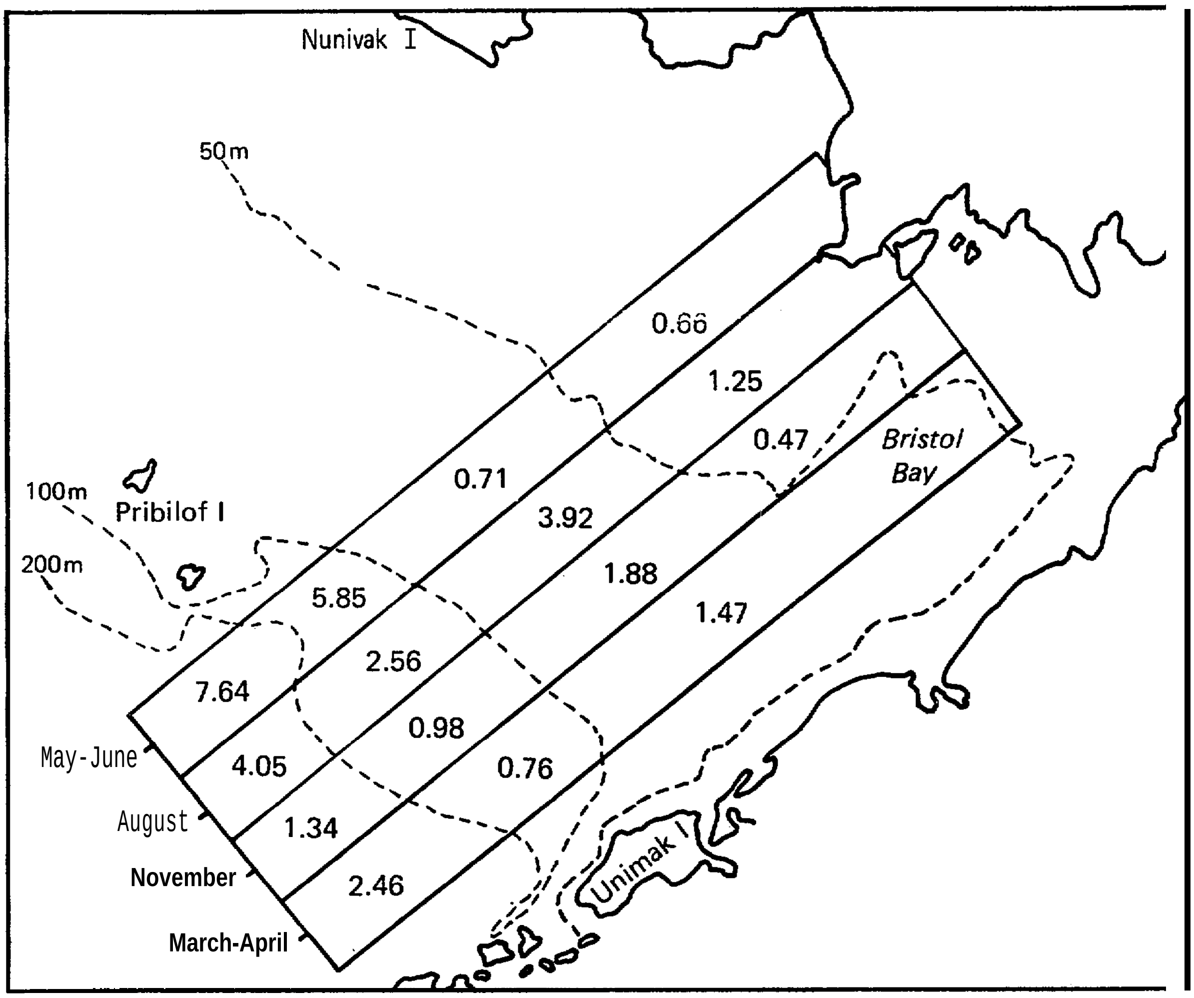


Figure 33. The average dry weight in grams per square meter of sea surface for net plankton retained by a 0.333-mesh l-m net.

TABLE V

DISTRIBUTION PATTERNS BY REGIME FOR NUMERICALLY DOMINANT ZOOPLANKTON AND MICRONEKTON GROUPS IN THE SOUTHEAST BERING SEA

A. Usually Most Abundant in the Open Ocean

| | |
|---|---|
| *Dimophyes arctica* | *Metridia lucens* |
| *Clione limacina* | *Parathemisto pacifica* |
| *Limacina helicina* | Euphausiid (eggs and larvae) |
| *Conchoecia* spp. | *Thysanoessa longipes* |
| *Calanus cristatus* | *Eukrohnia hamata* |
| *C. plumchrus* | Chaetognath (juveniles) |
| *Eucalanus b. bungii* | *Oikopleura* spp. |
| Larvacea (juveniles) | *Theragra chalcogramma* |

B. Usually Most Abundant in the Outer Shelf

*Oithona spinirostris*
*Thysanoessa inermis*
Majiidae (larvae)

C. Usually Most Abundant in the Central Shelf

| | |
|---|---|
| *Calanus glacialis* | *Parathemisto libellula* |
| *C. marshallae* | *Thysanoessa raschii* |
| *Pleudocalanus* spp. | *Sagitta elegans* |

D. Usually Most Abundant in the Northern Coastal Area

*Acartia longiremis*

E. No Consistant Regime Affinity

| | |
|---|---|
| *Aglantha digitale* | *Thysanoessa* spp. (juveniles) |
| *Calanus* spp. (juveniles) | *T. spinifera* |
| Copepod nauplii | *Oithona similis* |

F. Absent in the Northern Coastal Regime

| | |
|---|---|
| *Dimophyes arctica* | *Parathemisto pacifica* |
| *Clione limacina* | *Thysanoessa inermis* |
| *Calanus cristatus* | *T. longipes* |
| *C. plumchrus* | *T.* spp. (juveniles) |
| *Eucalanus b. bungii* | *Eukrohnia hamata* |
| *Oithona spinirostris* | *Theragra chalcogramma* |

Of the entire dominant group, only the copepod *Acartia longiremis* seemed to prefer the northern coastal regime. In fact, twelve categories were completely absent from this shallow water at all times of the year. This result is not interpreted to suggest that the coastal zone is a biological desert, but rather that forms originating in deeper water are not successful in populating this regime.

Average dry weight as $g/m^2$ pooling all cruises, ranges from 3.87 in the open ocean to 2.54 in the outer shelf, down to 2.00 in the central shelf, and finally to 0.79 in the coastal zone shallower than 50 m.

However, when this data is normalized to estimates per unit volume ($mg/m^3$) by accounting for an average depth fished in each regime (200 m, 150 m, 75 m, 25 m), the pattern is somewhat reversed such that the coastal area exhibits about 32, the central shelf 27, the outer shelf 17, and the open ocean 19. Expressed in this manner the various regimes differ in biomass per unit volume by less than a factor of 2.0. There is reason to suspect that suspended sediment in the nearshore collections may have biased these weights slightly high.

Within and among the spatial regimes most populations exhibited a strong seasonal component associated with annual reproduction or migration into and/or away from the area. Those categories which were obvious composites of early life history stages [i.e. juvenile *Calanus* spp., copepod nauplii, euphausiid eggs, larvae, and juveniles, spider crab larvae (Majiidae), immature chaetognaths, and larval fish *(Theragra chalcogramma)*] are examples of this phenomena. Pooling dry weight valves ($g/m^2$) for all regimes within each cruise, the average seasonal variation over the year ranges from a high of 3.72 in May-June, to 1.17 in November.

The copepods *Calanus cristatus*, *Calanus plumchrus*, and *Eucalanus b. bungii* which overwinter in the north Pacific as stage V copepodites well below the surface, were expected to reflect this ontogenetic behavior in their seasonal patterns of abundance in the upper 200 m. *Calanus cristatus* was absent from catches in November, and *Eucalanus* was much reduced in number in accord with the seasonal displacement (Figs. 8, 13). Surprisingly, *Calanus plumchrus* did not leave the upper 200 m as had been expected but held through the season with only minor variations in number (Fig. 11).

## 6.3 Statistical Studies

Estimates of within-regime variability by cruise were used to compute confidence intervals for single samples and for the average number of samples obtained per regime (n=9). As stated previously, it had been the intention of the field program to generate no fewer than 10 observation per stratum so that real differences exceeding about a factor of 5.0 could be discerned. In fact, confidence intervals (P=0.05) calculated using individual mean-square error values for each category ranged from 6.26 to 1.55 for geometric means with nine observations (Table VI). This indicates that in general all differences between means which exceed about a factor of 6 are real although the level of precision is much better than that for some categories. Differences associated with mean-square-error values calculated from the two configurations (3 cruises by 4 regimes; 4 cruises by 3 regimes) are considered negligible.

TABLE VI

CONFIDENCE INTERVALS FOR SINGLE SAMPLES AND GEOMETRIC MEANS
($P = 0.05$)

| Taxonomic Category | Confidence Interval: 3 cruises x 4 regimes, n = 1 | 3 cruises x 4 regimes, n = 9 | 4 cruises x 3 regimes, n = 1 | 4 cruises x 3 regimes, n = 9 |
|---|---|---|---|---|
| Cnidaria | | | | |
| Hydrozoa | | | | |
| *Aglantha digitale* | 43.60 | 3.52 | 51.56 | 3.72 |
| *Dimophyes arctica* | 29.86 | 3.10 | 16.65 | 2.55 |
| Mollusca | | | | |
| Pteropoda | | | | |
| *Clione limacina* | 20.71 | 2.74 | 15.10 | 2.47 |
| *Limacina helicina* | 31.98 | 3.16 | 29.88 | 3.10 |
| Crustacea | | | | |
| Ostracoda | | | | |
| *Conchoecia* spp. | 168.69 | 5.53 | 141.24 | 5.21 |
| Copepoda | | | | |
| *Acartia longiremis* | 24.90 | 2.92 | 48.29 | 3.64 |
| *Calanus cristatus* | 159.40 | 5.42 | 124.38 | 4.99 |
| *C. glacialis* | 216.37 | 6.00 | 142.27 | 5.22 |
| *c. marshallae* | 235.73 | 6.18 | 176.73 | 5.61 |
| *C. plumchrus* | 66.54 | 4.05 | 70.30 | 4.13 |
| *C.* spp. (juveniles) | 196.83 | 5.83 | 123.69 | 4.98 |
| *Eucalanus b. bungii* | 41.02 | 3.45 | 57.21 | 3.85 |
| *Metridia lucens* | 66.47 | 4.05 | 74.61 | 4.21 |
| *Oithona similis* | 130.64 | 5.07 | 141.42 | 5.21 |
| *O. spinirostris* | 68.18 | 4.05 | 71.94 | 4.16 |
| *Pseudocalanus* spp. | 4.68 | 1.67 | 3.72 | 1.55 |
| Nauplii (composite) | 89.99 | 4.48 | 50.48 | 3.70 |
| Amphipoda | | | | |
| *Parathemisto libellula* | 12.57 | 2.32 | 16.67 | 2.55 |
| *P. pacifica* | 20.57 | 2.74 | 16.55 | 2.54 |
| Euphausiacea | | | | |
| *Thysanoessa inermis* | 19.19 | 2.68 | 22.80 | 2.84 |
| *T. Longipes* | 17.99 | 2.62 | 15.91 | 2.52 |
| *T. raschii* | 10.72 | 2.21 | 6.93 | 1.91 |
| *T. spinifera* | 5.32 | 1.75 | 6.63 | 1.88 |
| *T.* spp. (juveniles) | 31.57 | 3.16 | 32.47 | 3.19 |
| T. spp. (eggs and larvae) | 24.80 | 2.92 | 16.24 | 2.53 |

TABLE VI

CONTINUED

| Taxonomic Category | Confidence Interval: 3 cruises x 4 regimes n = 1 | 3 cruises x 4 regimes n = 9 | 4 cruises x 3 regimes n = 1 | 4 cruises x 3 regimes n = 9 |
|---|---|---|---|---|
| Crustacea (cent'd) | | | | |
| Decapoda | | | | |
| Majiidae (composite) | 13.62 | 2.39 | 12.99 | 2.35 |
| Chaetognatha | | | | |
| *Eukrohnia hamata* | 20.96 | 2.76 | 20.02 | 2.72 |
| *Sagitta elegans* | 11.93 | 2.28 | 4.87 | 1.69 |
| Composite (juveniles) | 98.09 | 4.61 | 59.79 | 3.91 |
| Chordata | | | | |
| Larvacea | | | | |
| *Oikopleura* spp. | 133.44 | 5.11 | 97.87 | 4.60 |
| Composite | 254.90 | 6.26 | 133.35 | 5.11 |
| Teleostei | | | | |
| *Theragra chalcogramma* | | | 19.27 | 2.68 |
| DRY WEIGHT (composite) | 4.22 | 1.62 | 3.86 | 1.57 |

## VII. DISCUSSION AND SYNTHESIS

Implicit in the effort to survey and "characterize" the shelf environments of Alaska was the worry about possible detrimental effects associated with the development and eventual exploitation of non-renewable resource fields in these areas. Studies were initiated to gather and synthesize data that could be used to modify lease-area nominations and sale schedules so that so-called "critical habitat" might be protected. Surveys of the unobtrusive pelagic flora and fauna (phyto- and zooplankton) were prompted by the need to understand in greater detail specific aspects of organic matter transfer processes in the water column overlying the shelf in the southeastern Bering Sea, acknowledged internationally as the location of one of the most productive commercial fisheries in the world. It was argued that since the majority of populations at all trophic levels are dependent upon the plankton communities for their survival, either directly or indirectly, specific regions or times of the year that are "biologically active" should be documented and described. This study was undertaken to provide some of that information.

It is not surprising that many of the numerically dominant species sampled in the upper 200 meters of the southeastern Bering Sea are also reported as dominant and ecologically important in the northwestern Pacific, the northern Gulf of Alaska and the western Bering Sea (Minoda, 1971; Cooney, 1975; LeBrasseur, 1965). The general counter-clockwise surface circulation provides a near shelf and coastal "river in the sea" which carries plankton populations to the north from the subarctic current around the periphery of the northern Gulf where the Alaska Stream then moves them westward along the Aleutian Chain and eventually into the Bering Sea. This biological continuity was observed over the shelf south of Hinchinbrook Entrance to Prince

William Sound in the northern Gulf of Alaska where the species composition was found to be nearly identical to that reported at the Canadian offshore weather station P some 800 nautical miles upstream (Cooney, 1975). The numerically common copepods *Calanus cristatus*, *Calanus plumchrus*, *Eucalonus b. bungi*, *Metridia lucens*, and *Pseudocalanus* spp., the amphipod *Parathemisto pacifica*, the chaetognath *Eukrohnia hamata* and *Sagitta elegans*, and the pteropods *Clione limacina* and *Limacina helicina* are all major constituents of the holoplankton in the shelf waters between station P and the Pribilof Islands.

The major significance of this continuity is in the process of recruitment at any location along the path of this generalized current system. Of potentially greater importance is the question of how the shelf plankton community composition and the relative abundance of species compares with that found in deeper adjacent ocean waters. Many of the numerically dominant species undergo extensive ontogenetic migrations associated with overwintering and reproduction. These populations move to deep water, 500-1000 m, in late summer and early fall where some (the interzonal copepods *Calanus cristatus*, *Calanus plumchrus*, and *Eucalanus b. bungii*) reproduce. This being the case, those shelf environments influenced most directly by adjacent oceanic water exhibit strong seasonal fluctuation in the composition of the dominant animal plankters. This phenomenon was clearly observed in the northern Gulf of Alaska (Cooney, 1975).

In the southeastern Bering Sea, the seasonal distributions of these same copepods are similar with the striking exception that *Calanus plumchrus* was present at all times in the upper 200 m over both deep water and the shelf. This behavior is not consistent with the general description of the reproductive cycle in this specie sampled elsewhere.

The more widespread distribution patterns of the oceanic species provides a biological clue to the influence of oceanic waters on the shelf of the southeastern Bering Sea. As was noted (Table V), a large percentage of dominant plankters were absent at all times from water shallower than 50 m in the northern coastal regime. This was not the case in the northern Gulf of Alaska, where oceanic species occured regularly in the coastal water particularly during the spring and summer months. It is quite probable that freshwater entering Bristol Bay directly and from the Kuskokwim River somwhat to the north freshens the nearshore regime beyond the tolerances of the oceanic species. The euryhaline copepods *Acartia longiremis* and *Pseudocalmus* spp. occur there without apparent difficulty.

Takenouti and Ohtani (1974) describe three major water masses for this area: (1) a relatively saline (32 to 33°/00) source from the Alaska Stream via Unimak Pass and the deep Bering Sea Basin. At its coldest this water is always relatively warm (3° to 4°C); (2) relatively stable resident shelf water of slightly lower salinity (32.0 ± 0.50/..) which is strongly stratified in summer. The deeper water below the seasonal thermocline is consistently the coldest found over the shelf (-1° to +2°C); and (3) a coastal water of lowest salinity (<31.6°/00) indicating the direct influence of freshwater runnoff. The circulation within and the interaction between these water masses is extremely complex (Coachman and Charnell, 1977) .

In an effort to determine how this physical partitioning of the shelf environment could effect the distribution and abundance of animal plankton and micronekton, a series of stations was occupied in August 1975 from deepwater landward up the axis of Briston Bay (see Appendix I, Fig. 9-11;

Table II, Appendix III). Sixty-six taxonomic categories were reported for open ocean collections, with 43, 41, and 40 occurring in the outer shelf, central shelf and coastal regimes. However, only 10 species in the coastal area were also found in the deeper water indicating a somewhat unique near-shore community. When the abundance of several common taxa were examined along this transect, it was apparent that for most, the distributions either terminated or exhibited some marked decrease in abundance in the area of stations 72 and 82. Only *Sagitta elegans* seemed unaffected.

An examination of CTD data taken at this time indicates that a remarkable decrease in temperature at depth was encountered somewhere between station 62 and 72 (see Appendix III). Water below 38 m at the deeper station (62) averaged about 4°C while at location 72, the temperature at this depth and below fell to 1.3°C. I suggest this strong "thermal barrier" was responsible for excluding many of the oceanic species from waters landward of this feature.

Cooney (1977; Appendix II) reported that while the seasonal ice-edge seemed to have little effect on the distribution of plankton and micronekton, inverse thermal stratification associated with ice-cooled water did in fact influence the community. A relatively low diversity and sparse assemblage was found in regions where the cold underice water mass extended to the bottom (depths <80 m). At locations somewhat deeper, the community abundance and diversity increased markedly presumably due to the inclusion of organisms living in the *warmer* near-bottom oceanic water. This stratification of the population was examined more closely during the spring of 1977 and will be reported in September, 1978. The fact that remnants of this cold underice water mass persist as a thermal band along the shelf during late spring, summer, and early fall, means that many oceanic species which would normally invade this region are probably excluded by extremely low temperatures. During the warmer season, a landward community of more neritic species develops in the absence of the typical oceanic assemblages.

The notion of "critical" periods or habitats relative to plankton assemblages probably applies most appropriately to the temporary or meroplanktonic forms, such as the eggs and larvae of fishes and shellfishes. This entire region is one of great commercial importance particularly for the harvest of walleye pollock, king and snow crabs, and other demersal fin-fishes (Low, 1975).

The zoea and megalops of spider crabs of which *Chionoecetes* spp. the snow crab is probably dominant, and larval pollock were censused in this study (Figs. 26, 32). While crab larvae were collected in all areas and seasons, the pollock was restricted to the early spring, and open ocean and outer shelf regions. This "window" seemingly has the characteristics of both critical timing and location with regard to the survival of this species. I suspect that had sufficient volumes of water been sampled, a larger number of fishes with similar critical periods would have been reported.

The much more complex question of the overall productivity of this region of the Bering Sea is being examined critically by the National Science Foundation, Office of Polar Programs ecosystem study, PROBES. Now in its third funding season, this multidisciplinary effort has focussed its attention on walleye pollock, an abundant commercial species which utilizes both the pelagic and near-bottom realms of the outer shelf and open ocean. Although the annual production of organic matter in this region is not unusually high (range 85-589 g $C/m^2$), the system seemingly favors an above average production at higher trophic levels both in the water column and on the seabed. The mechanics of this process are now understudy. It may be that a combination of physical factors related to water stability and cold temperature formed by seasonal sea ice, together with a low diversity at higher levels provides the means to distribute the annual primary production very efficiently to consumers. Nishiyama (1975) describes two relatively simple food chains for the southeastern Bering Sea based on work conducted by Mito (1974): (1) a pelagic chain beginning with the euphausiid genus *Thysanoessa* → walleye pollock pacific cod, turbot, halibut, and blackcod; and (2) a benthic chain with the pink shrimp *Pandalus borealis* → flathead and rock sole. I suspect these notions are over simplifications to some degree although both euphausiids and pollock occur in the diets of most species of large fishes, seabirds and marine mammals, suggesting this system is relatively more simple than some.

Cooney (1976; see Appendix I) speculated that much (perhaps more than 50%) of the organic matter produced over the shelf is not harvested by grazers in the watercolumn but rather sinks to the seabed. Exceptional standing stocks of benthic deposit and suspension feeders in the outer shelf regime testify to the availability of ample food. In fact, the very noticable "blooms" observed in this region during late spring probably result more from an uncoupling of grazing pressure related to the size of the algal chains forming at this time than to light or nutrient availability. This hypothesis was to have been examined during the FY 78 field season. However, budget restrictions eliminated further field work. The PROBES scientific effort this year will address this notion in the framework of a systems study.

## VIII. CONCLUSIONS

1. The animal plankton and micronekton communities of the southeastern Bering Sea are similar in their composition and relative dominance structure to assemblages reported for the north Pacific, the northern Gulf of Alaska, and the northwestern Pacific Ocean.

2. The distribution of taxa within and between specific bathymetric regimes is related to the physical structure of the shelf water masses and the biology of the major species. A very cold-water remnant associated with winter cooling and the presence of seasonal sea ice seemingly blocks the penetration of many oceanic species into the central shelf and coastal waters during the spring and summer. The coastal regime freshened by runoff, annually develops a neretic fauna that can be identified in coastal areas further to the north.

3. Seasonality in the plankton community is associated with ontogenetic migration and responses to the annual production of organic matter. Interzonal copepods, with the exception of *Calamus plumchrus*, leave the shelf in the fall and reappear in late winter and early spring.

4. The notion of "critical habitat" or "critical. season" seems to apply most clearly to members of the temporary plankton community i.e., commercial species. Walleye pollock (*Theragra chalcogramma*) survives its planktonic early life history during a narrow time window in the spring in waters of the open ocean and outer shelf In respect to this species the area and timing are critical.

# IX. IMPLICATIONS OF CONCLUSIONS

Since the major motivation for this study was in relation to offshore oil development, I feel obliged to comment on the ramifications of the conclusions in this regard. It must be noted that although the results suggest some specific continuity of populations with time and location, they in fact only represent discrete observations at four times during one year. However, given this qualification, I feel the major time and space patterns as well as seasonal changes in species composition are portrayed representatively in this study. Further details of ecological interaction will require a more careful examination of specific hypotheses.

## *9.1* Scientific Merit

In my view this study is scientifically sound and reports some new facts concerning the distribution and abundance patterns of zooplankton and micronekton in the southeastern Bering Sea. Because observations were obtained as early as March and as late as November, some information is now available to evaluate the effect of the seasonal ice pack on the unobtrusive fauna of the region. The ice itself seems to be of little consequence, but the process of freezing, "and the effect of the pack on the underice water mass does appear to define some apparently real biological boundaries for most of the oceanic species. A more thorough examination of this hypothesis will be reported in September, 1978.

While in itself, a simple reconnaissance of the animal plankton and micronekton communities is not particularly noteworthy, the information obtained by this project will now allow other more sophisticated studies to be undertaken. The PROBES investigation was able to move quickly into specific hypothesis testing because much of the basic information was available on standing stocks, levels of seasonal variability, and relationships to oceanic factors. Many aspects of this study will be submitted to scholarly journals for publication in the marine sciences.

## 9.2 Relations to OCS Petroleum Development

The specific implications of this study will not be understood until the petroleum chemists and laboratory biologists are able to more fully describe the effects of fossil fuels on representatives of wild plankton populations. This horrendous, perhaps impossible task, will presumably rank the relative sensitivities of the most "ecologically important" species, and their life history stages, so that a new category of "susceptible" organisms may be identified. Coupled with information concerning food dependencies at higher trophic levels, and the specifics of seasonal distributions, a model of probable affects could then be developed which would address in some way, the problem of impact. It is my understanding that the Environmental Assessment of the Alaskan Continental Shelf and associated research studies are moving in this direction.

This study reveals that there is nothing particularly unusual about the animal plankton and micronekton communities in the southeastern Bering Sea. As mentioned previously, the species composition and seasonal variations are similar to those described for other areas in the north Pacific Ocean. What is not clearly known, is how these populations exploit their environment in this region and are in turn utilized by other members of the community. I surmise that the major food items occurring in the diets of plankton feeding birds, marine mammals and fishes will be the same dominant species as reported here. This means that although nearly 200 species can be found, only 20 or 30 are tropically important at the lowest consumer levels in maintaining the large populations which feed upon them. From an ecological vantage point, this result indicates that most of the organic carbon utilized by pelagic grazers passes through relatively few but abundant subpopulations which sustain the rest of the system. While this may be biologically efficient, it could become critical if these sustaining populations were adversely affected in any longterm way. This statement is not meant as a "red flag" but rather an interpretation of a biological mechanism which appears efficient but relatively simple in terms of redundance. However, since the coastal shelf areas tend to be influenced by relatively steady current flow, any localized effects would soon be absorbed by mixing and advection.

## X. FUTURE STUDIES

Research planned but not implemented for FY 78 included experimental measures of the process of organic matter transfer. There is increasing evidence that much of the organic carbon produced in any coastal bloom is not directly utilized, but rather sinks to the seabed or is advected away from a region. This partitioning of the water column productivity must be understood if the balance and production associated with both the pelagic and benthic systems is to be described in predictive terms. Also, if petroleum from accidental spills or catastrophes enters the *system* and mixes with a bloom, there would seem to be a probability that incorporation might occur which would then feed into both the pelagic and benthic trophic structure. This eventually should be examined experimentally in the laboratory or with controlled releases at sea.

At the very least, future studies in the southeastern Bering Sea should develop models of the trophic relationships between the obvious higher trophic levels (fishes, birds, and mammals) and the dominant zooplankton and micronekton reported here.

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APPENDIX I

ZOOPLANKTON AND MICRONEKTON STUDIES IN THE
BERING - CHUKCHI/BEAUFORT SEAS
1976

(Published in Environmental Assessment of Alaskan Continental Shelf, Principal Investigators Annual Reports for the year ending March 1976, Vol. 7, pp. 95-158)

APPENDIX II

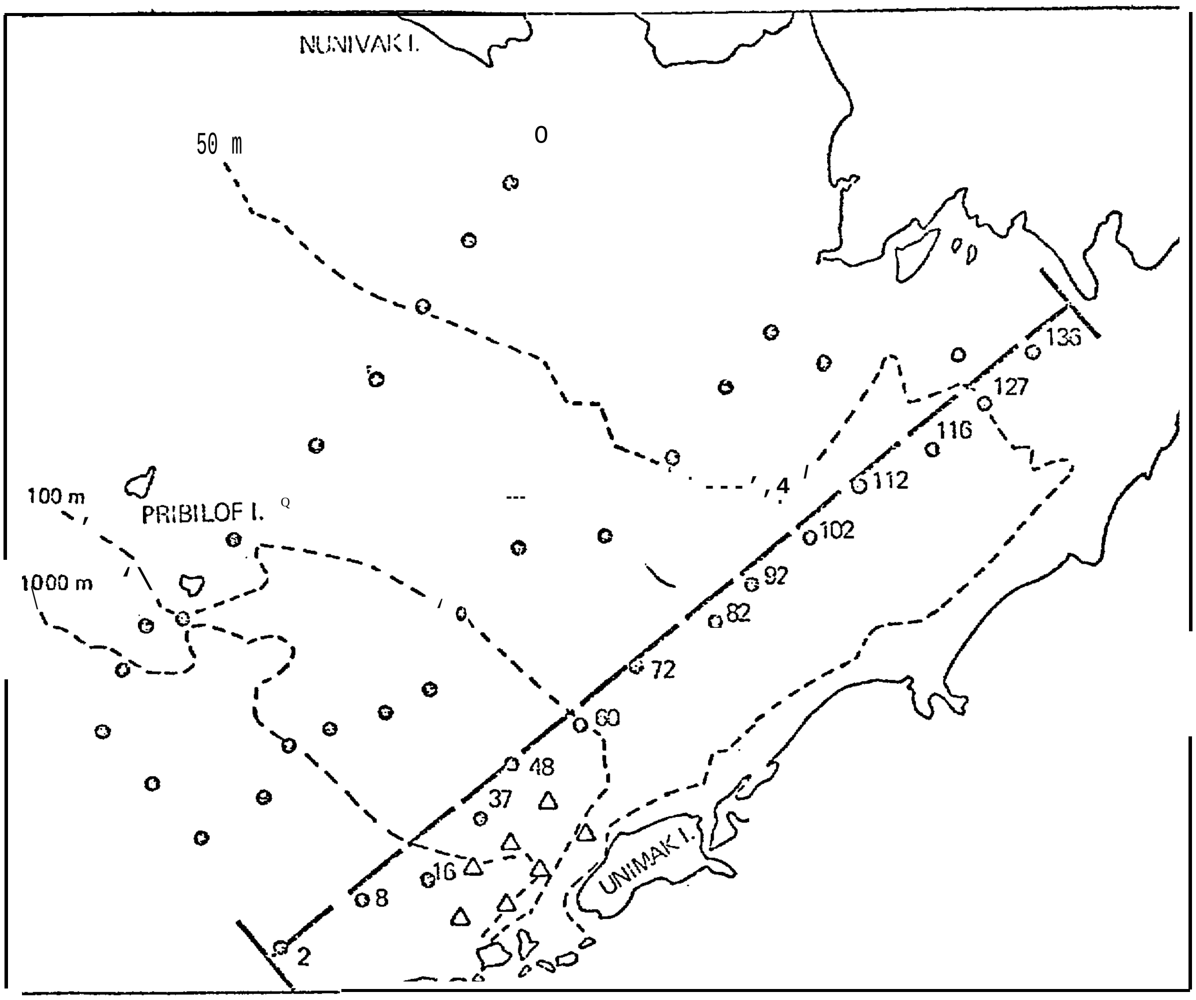
# ZOOPLANKTON AND MICRONEKTON STUDIES IN THE BERING - CHUKCHI/BEAUFORT SEAS 1977

(Published in Environmental Assessment of Alaskan Continental Shelf, Principal Investigators Annual Reports for the year ending March 1977, Vol. X, pp. 275-363)

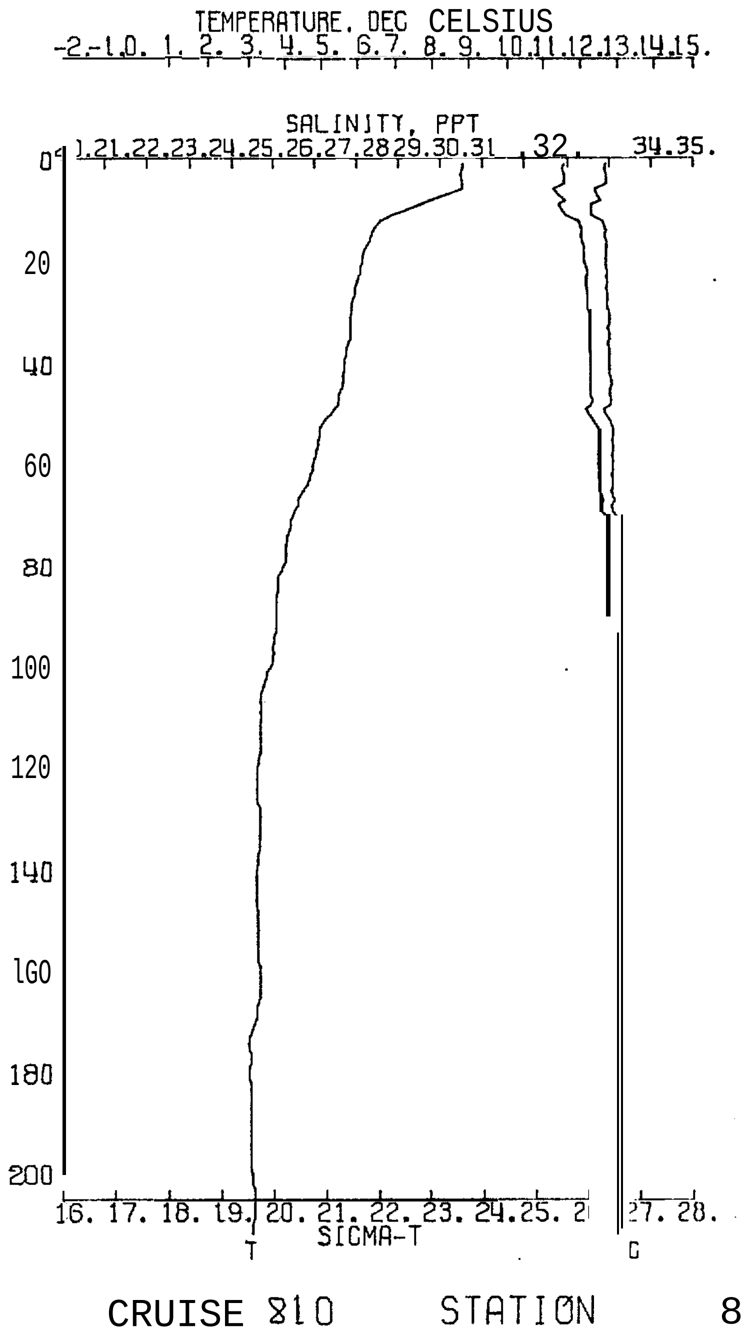
APPENDIX III

FOURTEEN STD PROFILES TAKEN ABOARD THE NOAA VESSEL *DISCOVERER*
AUGUST 1975

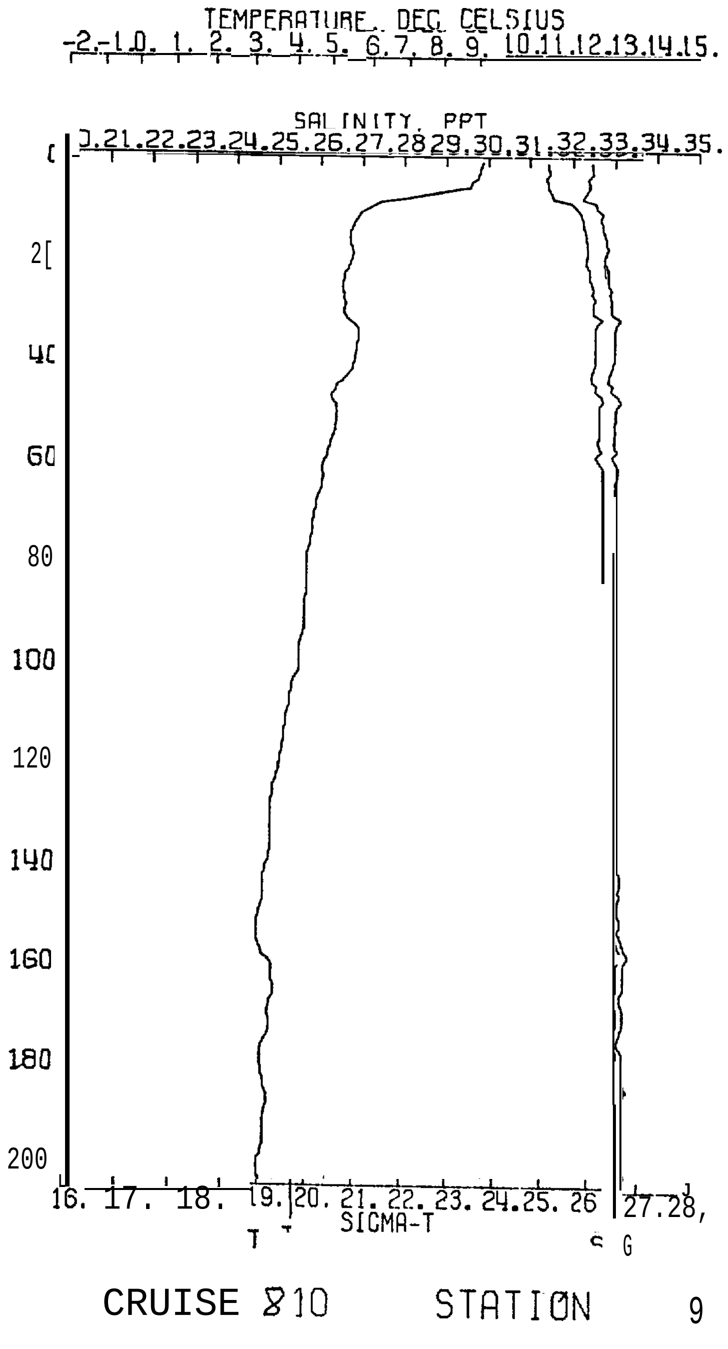
(from Appendix I, Figure 9, transect details)



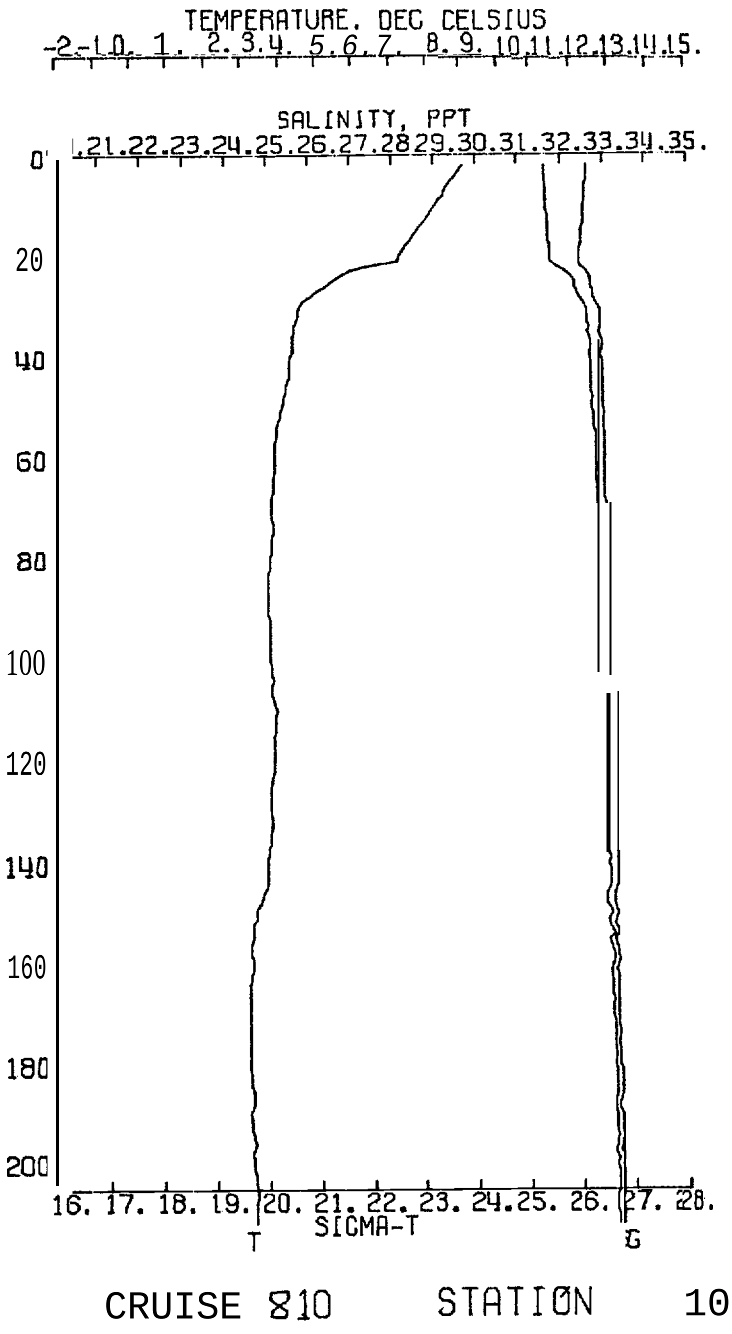

August 1975, cross-shelf transect. Numbers refer to oceanographic station name.



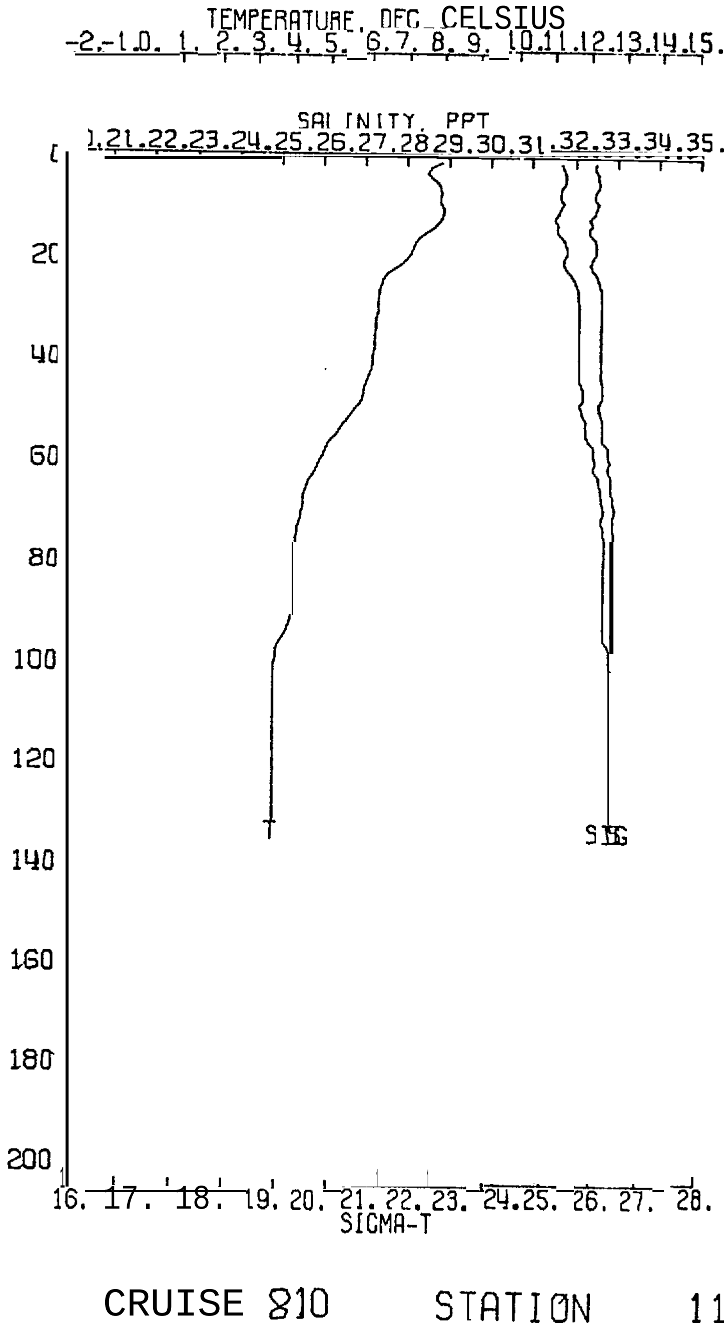

Appendix 111 - Figure 1. Plankton station 2 (*Discoverer* 810, station 8), STD profile.



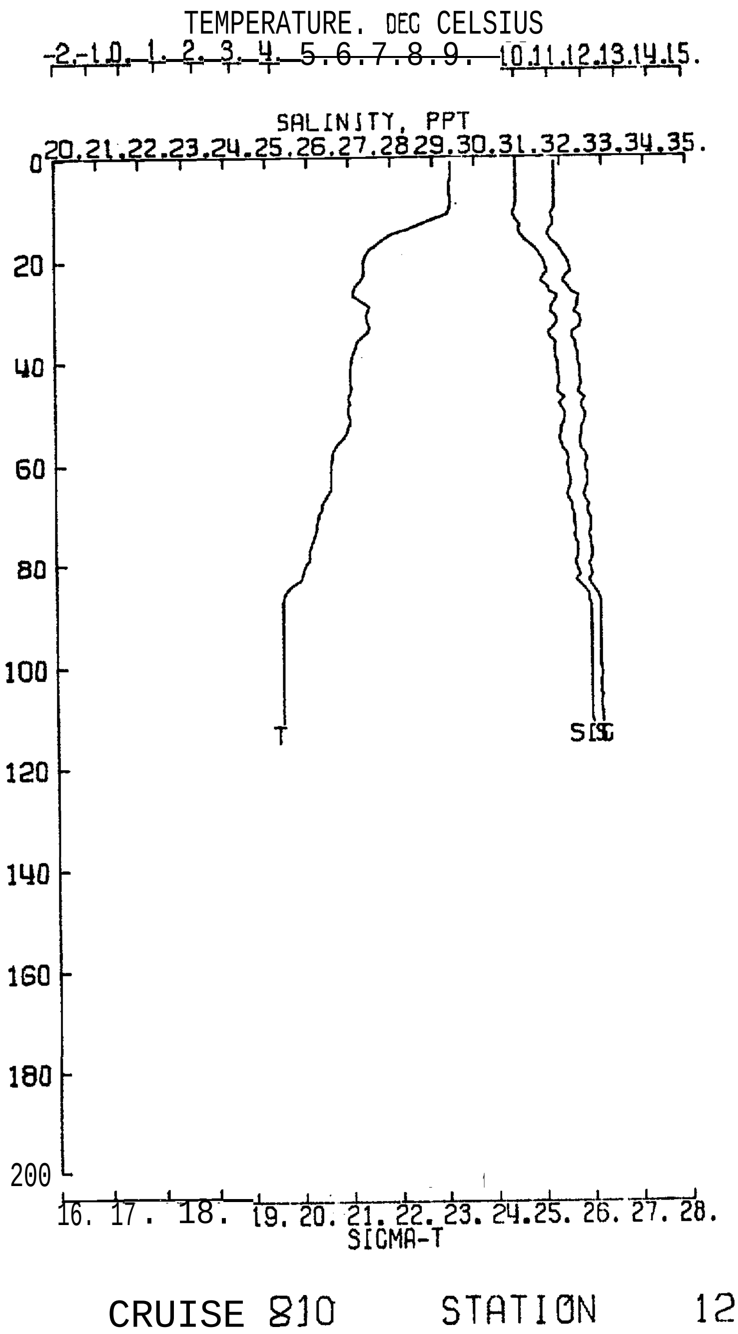

Appendix III - Figure 2. Plankton station 8 (*Discoverer* 810, station 9), STD profile.



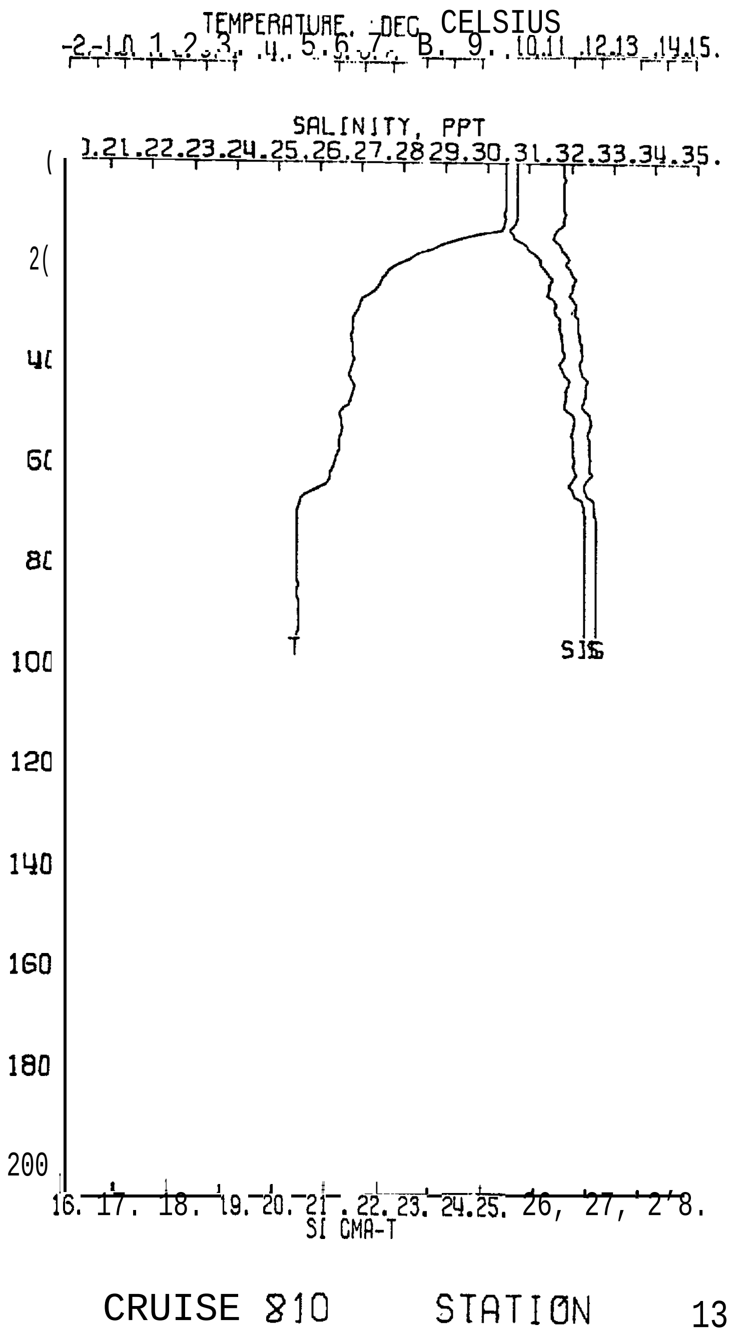

Appendix III' -Figure 3. Plankton station 16 (*Discoverer* 810, station 10), STD profile.



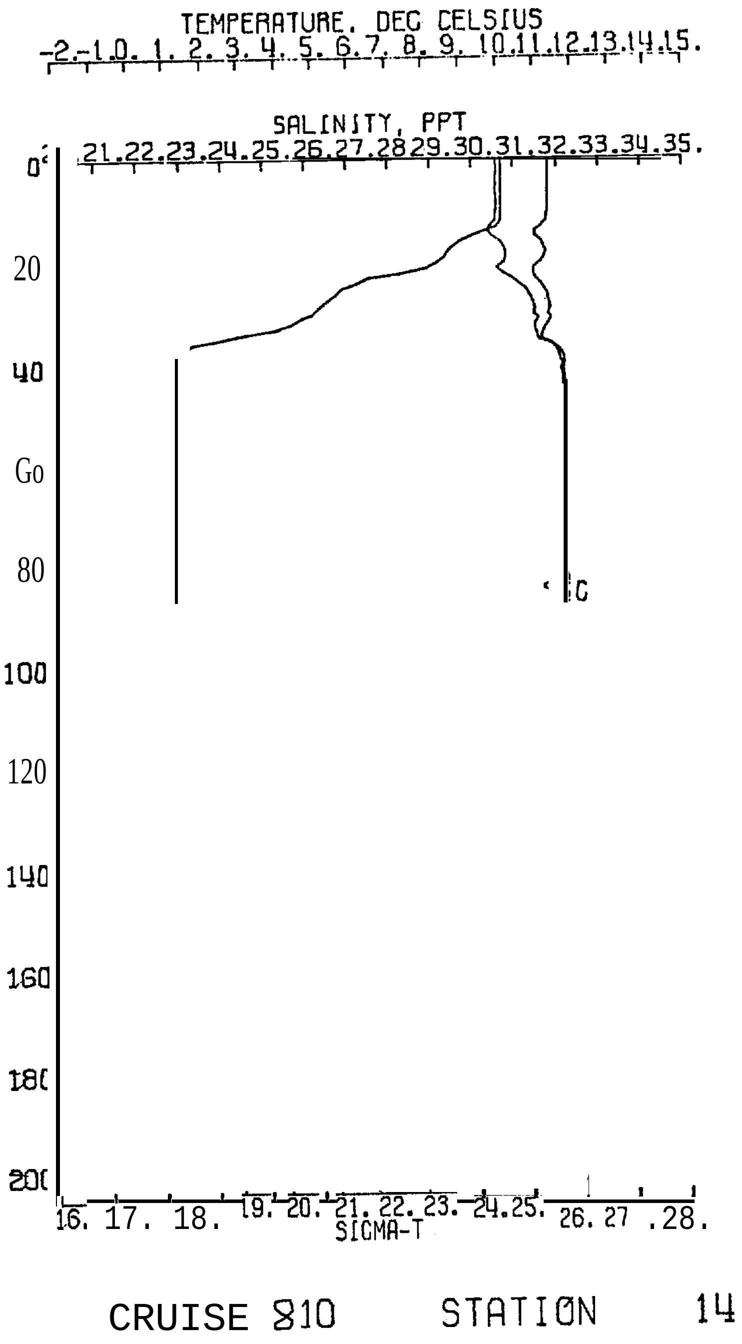

Appendix III - Figure 4. Plankton station 37 (*Discoverer* 810, station 11), STD profile.



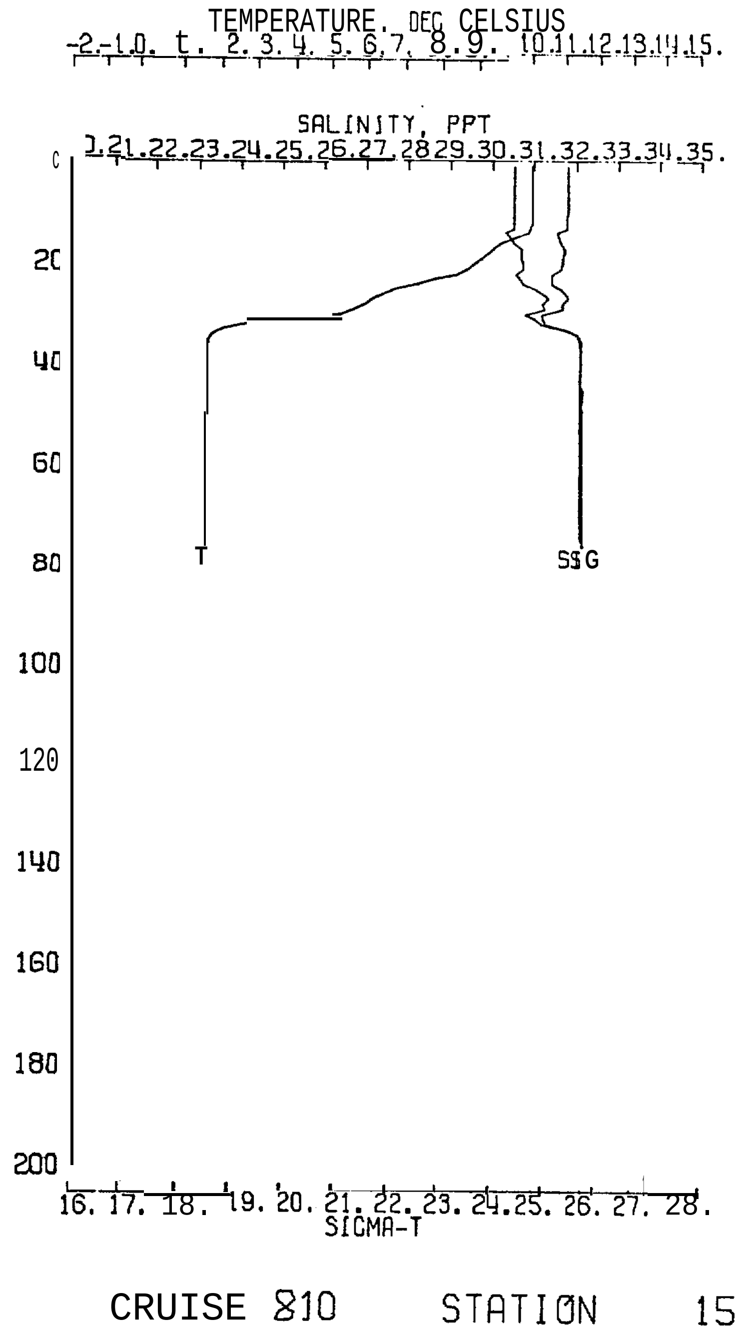

Appendix III - Figure 5. Plankton station 48 (*Discoverer* **810,** station 12'), STD profile.



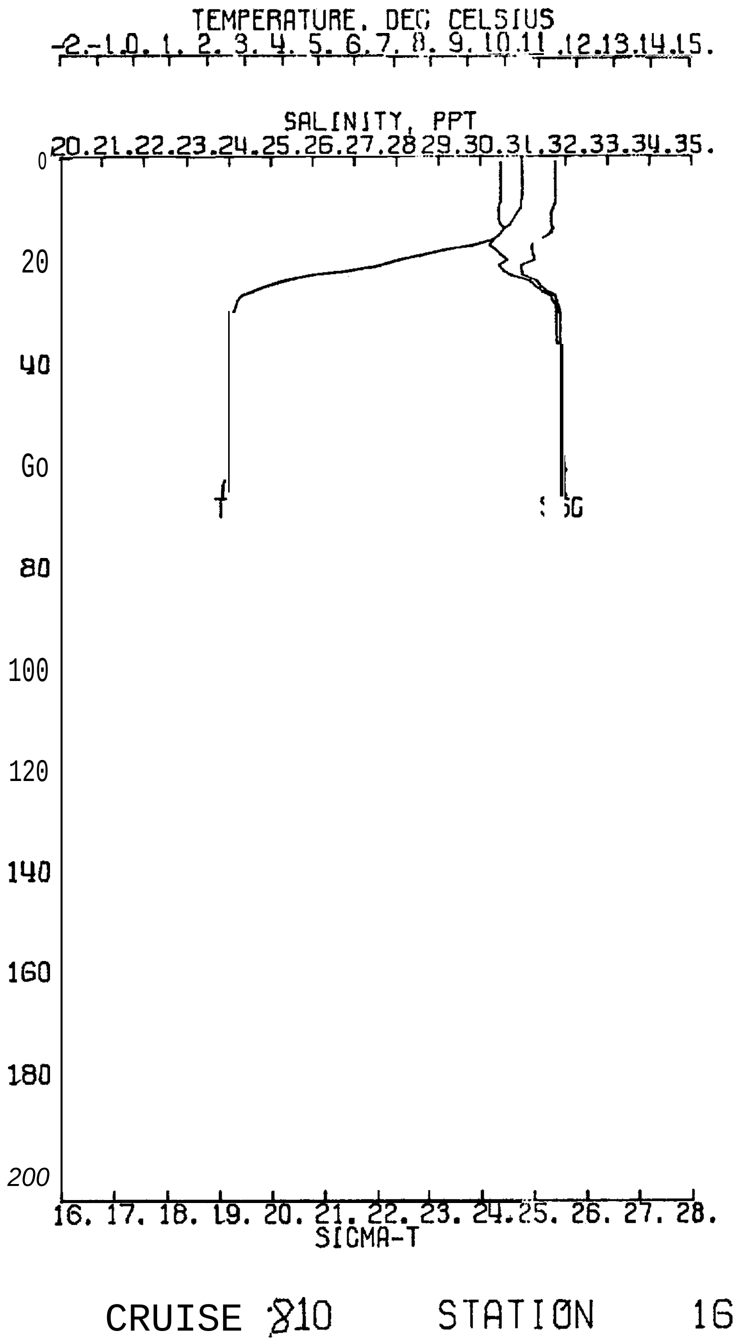

Appendix III - Figure 6. Plankton station 60 (*Discoverer* 810, station 13), STD profile.



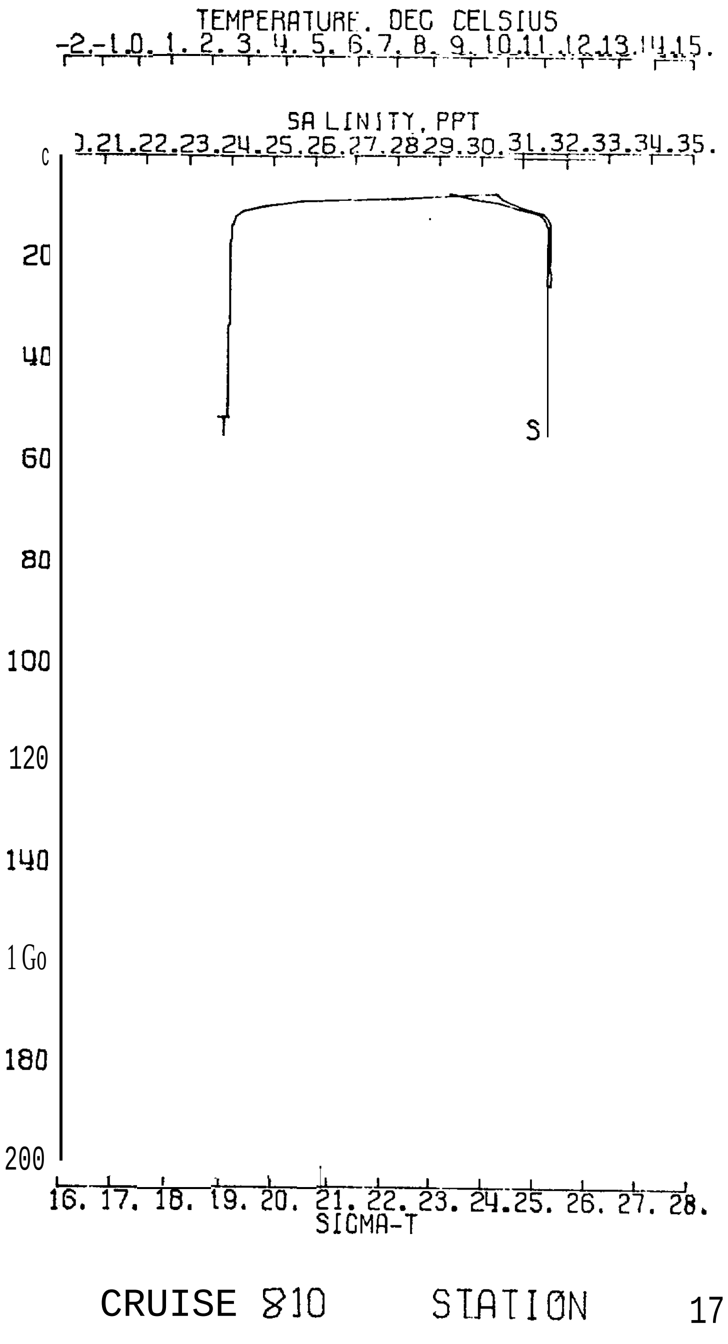

Appendix III - **Figure** 7. Plankton station 72 (*Discoverer* 810, **station** 14), STD profile.



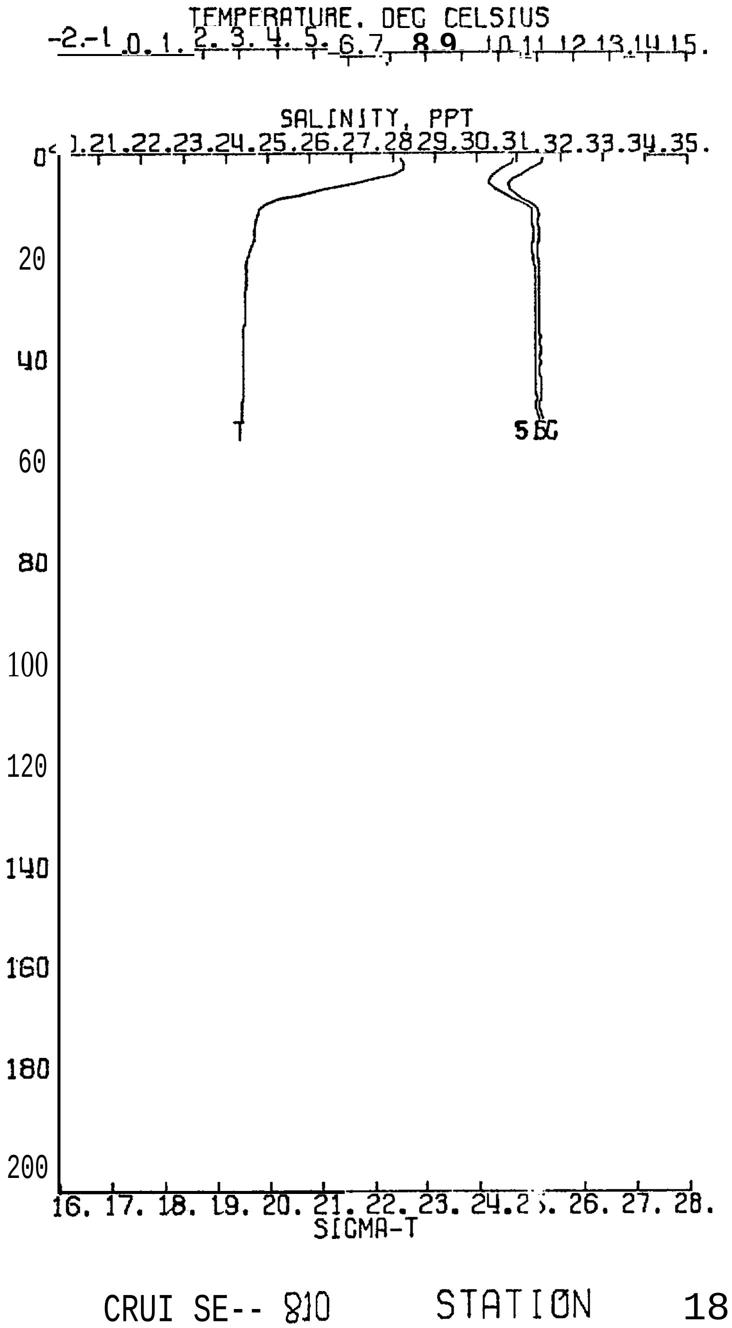

Appendix III - **Figure** 8. Plankton station 82 (*Discoverer 810,* station 15), **STD profile.**



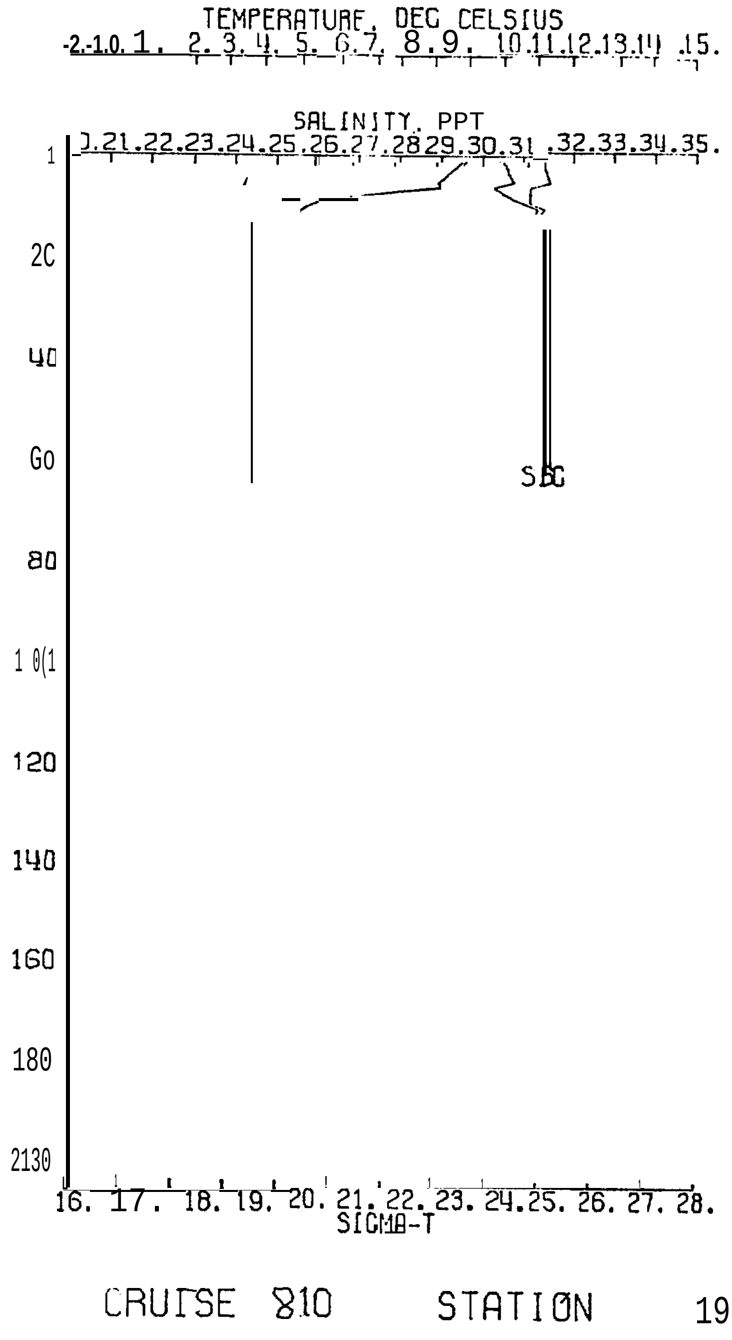

Appendix III - Figure 9. Plankton station 92 (*Discoverer* 810, station 16), STD profile.



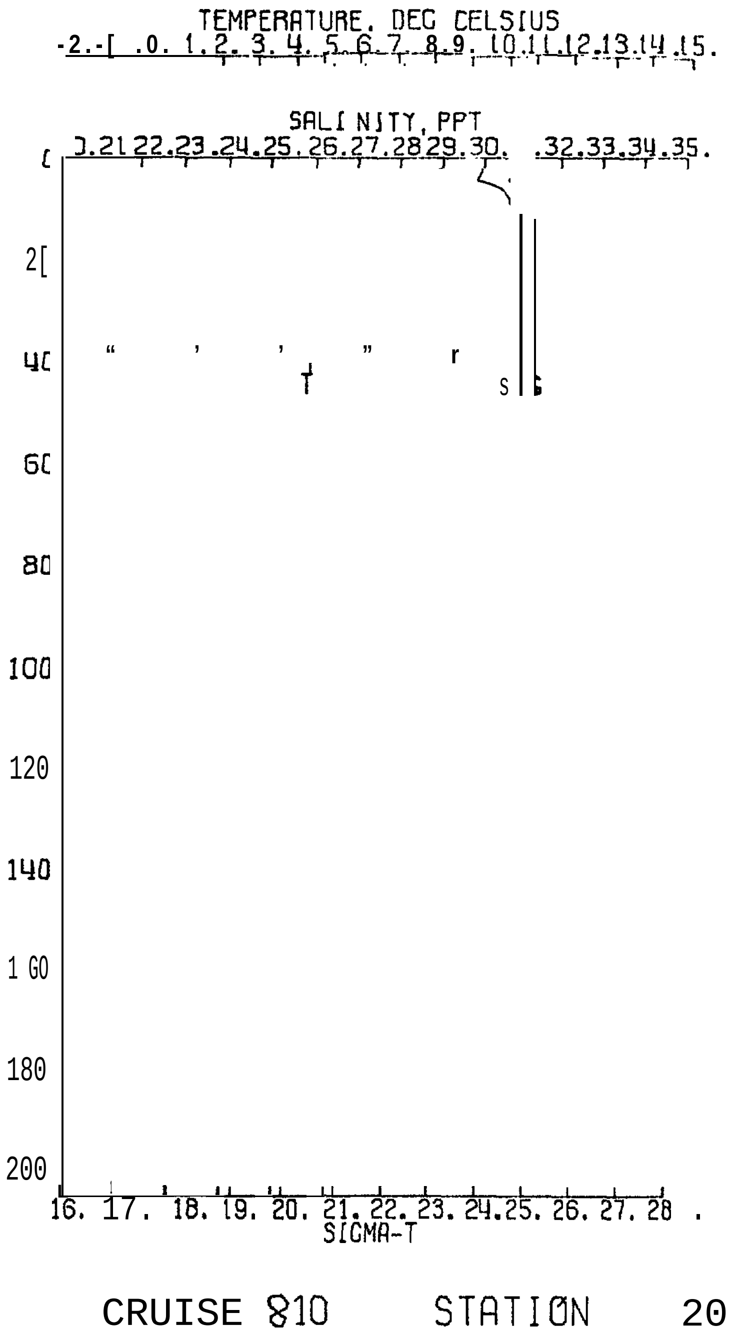

Appendix III - Figure 10. Plankton station 102 (*Discoverer* 810, Station 17), STD profile.



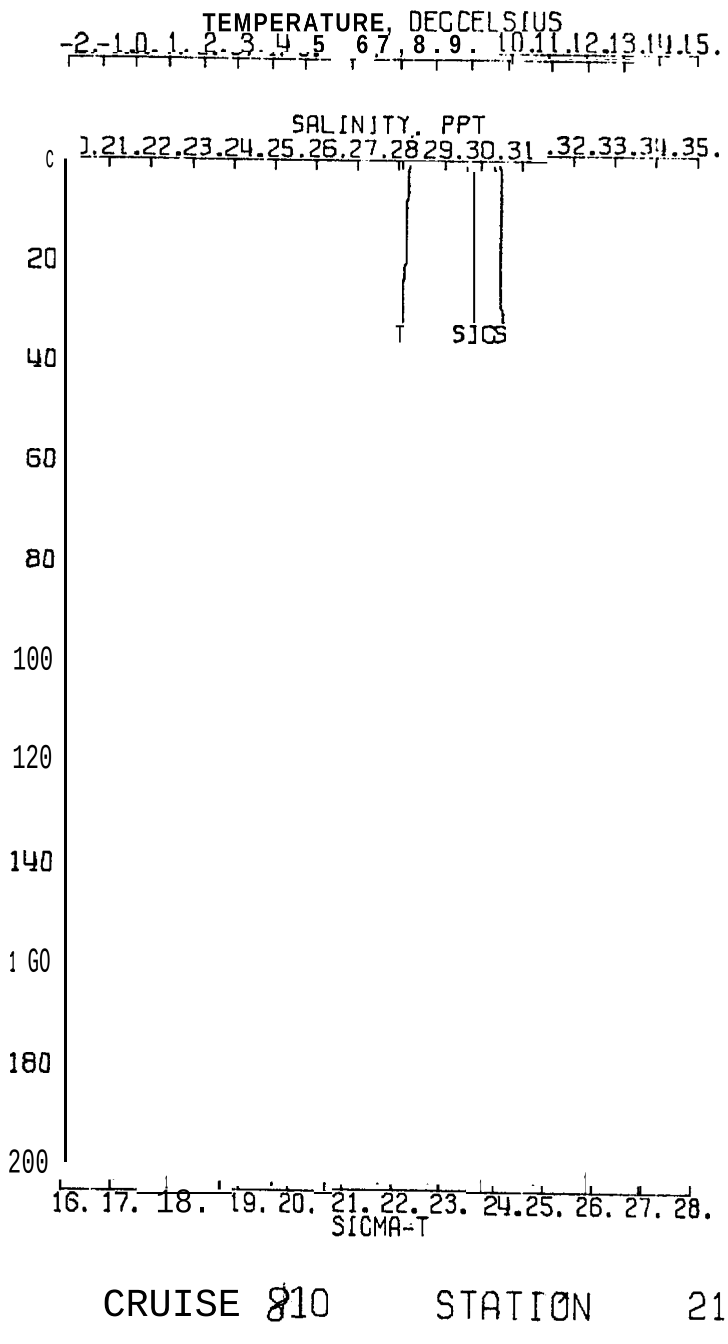

Appendix III - Figure 11. Plankton station 112 (*Discoverer* 810, station 18), STD profile.




Appendix III - Figure 12. Plankton station 116 (*Discoverer* 810, station 19), **STD** profile.




Appendix III - Figure 13, Plankton station 127 (*Discoverer* 810, station 20), STD profile.




Appendix III - Figure 14. Plankton station 136 (*Discoverer* 810, station 21), STD profile.