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Seasonal Plankton Composition of the Nearshore Zone off Kodiak Island, Alaska:

Summary of Field Operations
Fall 1977–Spring 1979
and
Preliminary Results of
Fall 1977 and Spring 1978 Cruises.

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NOTICE

SEASONAL PLANKTON COMPOSITION OF THE NEARSHORE ZONE OFF KODIAK ISLAND, ALASKA: SUMMARY OF FIELD OPERATIONS FALL 1977-SPRING 1979 AND PRELIMINARY RESULTS OF FALL 1977 AND SPRING 1978 CRUISES

by

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I. Summary of Objectives, Conclusions and Implication with Respect to OCS Oil and Gas Development

A field program was designed to elucidate the distribution in time and space of the zooplankton (both holo- and meroplankton) of continental shelf waters contiguous to Kodiak Island. These planktonic forms are of vital importance to the marine food web of the area, not only as food for higher trophic levels, but because most finfish and shellfish of the area spend critical early parts of their life histories as members of the plankton community. Prior to this study, virtually nothing was known about the specific composition and abundance of the zooplankton community, nor was the seasonal occurrence and areal distribution of larval forms of species contributing to the fisheries of the area known. With the knowledge of these distributions, the effects of chronic or catastrophic impacts of mineral development can be evaluated. Certain areas and seasons may be more critical than others to the success of year classes as they pass through their planktonic phase.

II. Introduction

A. General Nature and Scope of Study

The general approach to our objectives is to sample plankton in Kodiak Island shelf waters using a centric-systematic sampling grid during seasonal cruises. Biological sampling at each station includes surface ichthyoneuston tows, integrated oblique bongo tows from near bottom to the surface and, at selected stations, discrete depth Tucker tows. Associated environmental data are collected. Such sampling enables us to identify dominant taxa, their distribution in time and space, relations between nearshore, mid-shelf and slope fauna, and to assess the influence of bathymetric and oceanographic features of the region on the distribution of organisms.

B. Specific Objectives

Our overall objectives are to determine the seasonal composition, distribution, and apparent abundance of marine organisms of ecological or economic importance and to investigate relations among these parameters and environmental conditions with emphasis on ichthyoplankton and meroplankton.

Specifically, the objectives are: (1) determine seasonal composition, distribution, and apparent abundance of major life-stages of selected planktonic taxa, including fish eggs and larvae, larvae of shrimp and crab, and euphausiids; (2) examine observed biological distributions in relation to bathymetry and available hydrographic data; and (3) compare the distribution of planktonic organisms in nearshore, mid-shelf, and slope waters.

C. Relevance to Problems of Petroleum Development

There are significant gaps in knowledge of the temporal and spatial changes in the composition of planktonic organisms of ecological or economic importance in the Kodiak Island shelf area. Of critical need in attempts to evaluate the potential impact of mineral development on the early life history of important components of the marine ecosystem is the evaluation of what species are where, in what abundance, and at what time of the year during their egg and larval stages. Evaluation of the food web, through coordination with marine mammal and bird studies and other relevant programs, may well indicate critical times or areas where contamination could severely impact upper trophic level production and year class success of species that are subjects of fisheries.

We are finding that many species are neustonic, that is, they occur in the upper few centimeters of the water column, during some of their early life history stages. This area is particularly vulnerable to contamination since most oil floats at the sea surface and disperse widely from the site of a spill. Laboratory studies are showing the extreme sensitivity of early life history stages to oil and its components (e.g. Strusaker et al., 1974; Mironov, 1969). Thus the importance of knowing the seasonal and spatial distribution of the meroplankton in waters around Kodiak Island by species is obvious.

III. Current State of Knowledge

Very little was known about the seasonal composition of plankton in waters contiguous to Kodiak Island prior to initiation of the present OCSEAP sponsored studies. Although several wide-ranging plankton sampling cruises have been conducted by a number of organizations, both foreign and domestic, few have concentrated on studies in the Kodiak Island region. A brief historical account of studies pertinent to the Kodiak Island archipelago follows:

The International Pacific Halibut Commission conducted ichthyoplankton sampling in the Gulf of Alaska from 1926-34 (Thompson and Van Cleve, 1936). Their station grid included a number of stations in the Kodiak Island area. These authors reported only the occurrence of Pacific halibut (Hippoglossus stenolepis) eggs and larvae in their plankton samples.

Halibut eggs were found southeast of Cape Chiniak, but the majority of halibut eggs were distributed east of 150°W, where sampling was more intense. Early larvae of the halibut were distributed offshore on the southeast side of Kodiak Island and late-larvae were apparently carried inshore to the western end of Kodiak Island and northwest of Trinity Islands (Thompson and Van Cleve, 1936).

In 1955, a multi-nation cooperative study of the North Pacific Ocean, called NORPAC, was conducted (Anon., 1960). Multi-discipline cruises by three nations (United States, Canada, and Japan) were conducted aboard 19 research vessels from 14 institutions. Only the RV Brown Bear (University of Washington) sampled waters near Kodiak Island. The Brown Bear sampled ten stations from the southwest end of Kodiak Island northeastward and through Shelikof Straits using a Clark-Bumpus sampler. Detailed data, however, were not reported.

The Fisheries Research Board of Canada collected zooplankton samples in the Northeast Pacific Ocean, north of 45°N and west to 160°W, from 1956-1964. During these years only a few stations were occupied over slope waters near Kodiak Island. LeBrasseur (MS 1965) reported the results of vertical tows made with NORPAC nets from these cruises. He included figures showing wet weight (g/1000 m^3) of total zooplankton, copepods, euphausiids, amphipods, chaetognaths, and pteropods for all years surveyed. For 1962 and 1963 he included figures depicting size and number of three species of copepods, three euphausiids, one pteropod and one chaetognath.

LeBrasseur (MS 1970) reported on the identification of fish larvae collected during these surveys in 1956-59. Rockfishes (Scorpaenidae) and searchers (Bathymasteridae) were the dominant forms found in waters near Kodiak.

Broad scale exploratory plankton sampling was conducted in the North Pacific Ocean from 1956-1977 by the Faculty of Fisheries, Hokkaido University, Japan (Anon., 1978). Only a few stations were sampled in waters near Kodiak Island and, other than station data, results were not routinely reported.

Aron (1962) reported the results of wide-scale surveys of midwater plankton and nekton in the North Pacific Ocean conducted by the University of

Washington in 1957 and 1958. Again, only a few stations were sampled in the vicinity of Kodiak Island.

In the early 1960's, Soviet researchers conducted plankton surveys directed at Pacific ocean perch (Sebastes alutus) off Kodiak Island. Lisovenko (1964) described the catches of rockfish larvae (assumed to be S. alutus). According to this author, Sebastes larvae were found over the slope in the Yakutat, Kodiak, Shumagin, and Unimak areas at concentrations up to 120 per m^2 in April and May over depths of 200-700 m; other species of fish larvae collected during these surveys were not reported.

In April and May 1972, the NWAFC conducted a multi-discipline survey in waters contiguous to Kodiak Island. Ichthyoplankton composition was reported by Dunn and Naplin (MS 1974). Twenty-three kinds of fish larvae and 12 kinds of fish eggs were captured.

Pollock eggs (Theragra chalcogramma), which accounted for 97.2% of all fish eggs captured, were most abundant just west of Kodiak Island (near 56°30'N, 156°20'W). The largest catch of pollock eggs was 104,645 per $10m^2$ of sea surface. Eggs of flathead sole (Hippoglossoides elassodon) occurred at 31 stations, primarily inside the 200 meter contour. Rex sole (Glyptocephalus zachirus) eggs occurred at eight stations between the 200 - 2,000 m isobath.

Pollock were also the predominant larvae, constituting 62% of the total catch. They occurred at 21 stations scattered throughout shelf and slope waters; the largest catch (standardized catch of 12,118 per $10m^2$ of sea surface) occurred southwest of the Trinity Islands (at 55°51'N, 154°56'W) over 327 m of water.

Sand lance (Ammodytes hexapterus) larvae accounted for 11.3% of the total catch, followed by sculpins (Cottidae) 7.5%, and rock sole (Lepidopsetta bilineata) 6.9%.

The results of physical oceanography studies from this cruise were reported by Ingraham and Fisk (1973), Ingraham and Hastings (1974), Favorite et al. (MS 1975), and Favorite and Ingraham (1977). Surface nutrient concentrations were discussed by Sanborn (MS 1973); the occurrence and distribution of monstrillid copepods by Threlkeld (MS 1973, 1977).

Gosho (MS 1977) took plankton samples in certain estuaries of Kodiak Island while studying the food habits of juvenile pink salmon. Harris and Hart (MS 1977) studied the pelagic and nearshore fishes in three bays (Ugak, Kaiugnak, Alitak) on the east and south coasts of Kodiak Island (OCSEAP RU 485 final report). Their sampling equipment (tow net, herring trawl, beach seine and try net) had mesh sizes too large to sample ichthyoplankton quantitatively. They reported, however, the occurrence of "larval" fishes when captured. Based on length frequency data, the dominant larvae captured were hexagrammids (greenling) and cottids (sculpins).

IV. Study Area

The study area is about 68,000 km^2 and encompasses the continental shelf off Kodiak Island from approximately the 40 m contour to the 2,000 m contour (Figures 1-6). Stations extend from Portlock Bank on the east to Trinity Islands on the west. Albatross Bank and Kiliuda and Chiniak Trough lie within the sampling area.

V. Sources, Methods and Rationale of Data Collection

A series of five offshore research cruises to sample zooplankton of the Kodiak shelf have been conducted in this program (Table 1).

A pattern of stations was laid out in the continental shelf area off Kodiak Island (Figs.1-6). The pattern was modified from a stratified centric design to a systematic centric design after the first two cruises, but the areal coverage remained basically the same. Some planned stations were deleted on specific cruises due to inclement weather and other operational difficulties. During periods of inclement weather some stations designated by RU553 in the bays of Kodiak Island were occupied.

Plankton was collected at each station, using several types of nets and towing schemes to investigate depth distribution and diel migrations as well as large scale areal distribution. Field sampling was conducted in general accordance with standard MARMAP procedures (Smith and Richardson, 1977), so these data will be comparable with others collected in other programs.

The use of Sameoto neuston samplers allows identification of the near surface components of the plankton. The use of an integrated tow (60-cm bongo nets) allows estimation of biomass and determination of areal distribution of organisms. Discrete depth sampling (Tucker trawl) enables identification of which strata organisms occupy and allows investigation of diel migrations. Replicate tows were made at selected stations to assess sampling variability. Additionally, diel studies were made at locations where large catches of ichthyoplankton occurred. At those stations, a surface neuston tow and multiple Tucker trawl tows were made every other hour for at least 24 hours.

To assess the importance of inshore areas to recruitment of shrimp and crab larvae, zooplankton was sampled bi-weekly in four bay systems along the southern and eastern shores of Kodiak and Afognak Islands (see RU553). Initially, five stations were located in the central and inner portions of Izhut, Kalsin, Kiliuda and Kaiugnak Bays. Three additional stations were added to the Izhut and Kiliuda station patterns to increase sampling density in the inner portions of these bays.

All stations were sampled during each two-week survey period, including 24-hour diel observations at one of the stations in both Izhut and Kiliuda Bays. The station sampling pattern and diel observations were expected to indicate spatial occurrence and vertical migration, respectively, of decapod larvae. Diel sampling was also expected to identify changes in species diversity and abundance, by depth zone and time of day. The most seaward stations sampled during the inshore surveys corresponded with nearshore sampling locations of the offshore plankton surveys.

Plankton samples were preserved in 5% Formalin buffered with sodium tetraborate and returned to shore for processing. The settled volume of each sample was determined (Kramer et al., 1972). All fish eggs and larvae (i.e., samples are not split) were sorted out of the neuston, 0.505 mm bongo and one-meter Tucker trawl. Fish eggs and larvae were identified to lowest taxa, counted (abundant taxa were measured), and life history stage noted. Zooplankton from the 0.333 mm bongo nets, after volumes were determined, were sorted to major categories (e.g., class, phyla, or order) from an aliquot of the total (ca 500 organisms) and enumerated. A separate subsample was taken to yield an aliquot containing approximately 200 adult euphausiids which were identified to species, enumerated, lengths measured, and wet weights (Weibe et al., 1975) determined. Samples from the 0.505 mm Tucker trawl were subsampled for ca 200 euphausiids which were handled as above. An additional subsample of about 500 organisms was taken for separation of shrimp (Natantia) and decapod crab (Reptantia) larvae. Additional subsampling as necessary was conducted by the Kodiak Laboratory, NWAFC, to provide adequate numbers of decapod larvae for analysis.

Selected bulk samples (i.e. that portion remaining after removal of the 500 organism aliquot) were examined further. Either subsamples containing a minimum of 500 Natantia were obtained or all Natantia and Reptantia were removed from the bulk samples. The resulting shrimp and crab larvae were also identified to lowest taxonomic classification-life stage development and enumerated.

Analyses of the cruise data are in progress now. Similar analyses are performed on all of the taxonomic groups investigated under this program (e.g. ichthyoplankton, shrimp and crab larvae, and euphausiids); however, priority will be given to thorough analysis of ichthyoplankton and shrimp and crab larval data.

Geographic analysis consists of plotting species distribution on charts of the area. Isolines of abundance for species of interest on a logarithmic scale are plotted on the charts. Biomass is expressed as numbers per 10 m^2 of surface area for each station. For abundant species of interest, biomass estimates for entire cruises or portions thereof are derived by calculating the areas represented by each station and summing the biomasses at the stations of interest.

As hydrographic data become available, their distribution are plotted and compared with that of biomass plots of plankton species.

Comparisons of the geographic, bathymetric, and hydrographic distribution of plankton biomass on a seasonal basis are made by comparing the several cruises with each other. Species lists, rank orders of abundance, and size or stage distributions are compared. The importance of each season to the reproduction of economically and ecologically important species in the area is evaluated by examining the abundance of their larval stages on a seasonal basis.

An analysis of the community structure of the zooplankton of the area will employ a variety of numerical classification techniques. These analyses allow statements concerning the co-occurrence of species which may in some way (e.g., competition for food) influence the distribution and survival of each other.

Discrete depth tows with the neuston net and the Tucker trawl allow comparisons of densities at various depths on a diel cycle. Experiments are designed so that, with transformation (e.g., $\log_{10} x + 1$), a factorial analysis of variance can be performed -- the factors being depth, time of day, species, and replicates.

VI. Results

The offshore survey of plankton of the Kodiak area has consisted of five cruises (Table 1). The cruise tracks and station locations are shown in Figures 1-6. Collections have been made as described above, and analyses are now in progress.

The following section will describe in a preliminary manner results obtained so far for the hydrography, sea bed drifters, ichthyoplankton, and invertebrate zooplankton from the Fall 1977 and Spring 1978 cruises. Additional detail is provided for the decapod larvae combining results of the inshore survey (RU553) with those of the offshore survey. Comparison between seasons, nets, and areas are made as appropriate. Analysis of data from the Spring cruise collected east of 150^{o}W are incomplete and not shown on the figures. Changes of scale of abundance are noted in figure legends.

HYDROGRAPHY

Fall, 1977

Circulation and hydrography near Kodiak Island in September-November, 1977, was discussed by Schumacher et al. (In Press). We use these data herein because of CTD failures during our cruise 4MF77.

Surface temperatures in October - November, 1977 ranged from only 7^{o}-8^{o}C in the area covered by our cruise track (Figure 7). Water over the banks was relatively cool at 7^{o}C and water of this temperature extended out over the slope. Water to the northeast was warmer than to the southwest, but observations in the latter area were made 2 to 3 weeks later than those to the west (Schumacher, et al., In Press). Surface salinity increased uniformly with distance from shore ranging from 31.5‰ nearshore to 32.5‰ in slope waters (Figure 8). Temperatures at 50 m (Figure 9) indicated relatively warm 7^{o}C water over banks with a sharp decrease to 5^{o} or 6^{o}C off the slope. Salinity at 50 m (Figure 10) increased from inshore to offshore. Bottom (or 200 m) temperatures decreased uniformly from 7^{o}C over banks inshore to 4.0^{o}C over slope waters (Figure 11). Bottom (or 200 m) salinity increased from 32‰ over banks to 33.5‰ over slope waters (Figure 12). Tongue of relatively high salinity (33‰) extended into Kiliuda, Chiniak, and Stevenson Troughs.

Schumacher et al. (In Press) discussed the general oceanographic conditions observed in the fall, 1977. The observed transport in the Alaskan Stream off Kodiak Island was approximately 12 x 10^{6} m^{3} s^{-1}. They noted that weak southwestward flow extended onto the continental shelf and found gyre-like features present in the troughs. These authors found essentially homogenous water over banks.

Spring, 1978

Our observations during the Spring Cruise (March 28 - April 20, 1978) showed 4.0^{o}C water over North Albatross Bank (Figure 13) and over South Albatross Bank and the Trinity Islands. Temperatures of 4.5^{o}C covered portions of Kiliuda Trough and Middle Albatross Bank. A pocket of 5.0^{o}C water covered portions of Portlock Bank and Stevenson Trough. Surface salinities (Figure 14) were 32.2‰ nearshore with the 32.4‰ contour extending from near the shelf break over South Albatross Bank to shore over Middle Albatross Bank, thence southeasterly over Northern Albatross Bank. The 32.6‰ contour essentially followed the 2000 m contour. Temperature and salinity at 50 m were essentially the same as surface measurements. Bottom (or 200 m) temperature (Figure 15) contours indicated that the 5°C isotherm roughly paralleled the 200 m contour; colder (<4°C) water covered portions of North Albatross Bank and the Trinity Island flats. Bottom (or 200 m) salinity contours (Figure 16) indicated low salinity (<32.4‰) waters encompassing much of the nearshore zone to mid-shelf. Less saline (<32.4‰) water also covered North Albatross Bank. The 33.2‰ isotherm generally coincided with the slope break.

Schumacher et al. (1978) discussed hydrographic conditions over the Kodiak Island shelf region from March 2-10, 1977. Our observations taken the following year from March 28-April 20, 1978 parallel those of Schumacher, et al. (1978). They found two subsurface cores of warm saline water, one near the shelf break and one extending northwestward from the shelf break into Amatuli Trough. The 5.0°C bottom (or 200 m) isotherm in 1977 paralleled the shelf break; water warmer than 5.0°C (bottom or 200 m depth) enveloped parts of Stevenson Trough and Portlock Bank. A tongue of higher salinity (>33.0‰) water at bottom (or 200 m) extended into Stevenson Trough.

SEA-BED DRIFTER RECOVERIES

A total of 3,536 sea-bed drifters was released at 16 points during the five cruises (Table 1). Recoveries to date total 32, or 1 percent, from releases made in November, 1977 through November, 1978. Drifters generally were recovered inshore from their release locations, although some variability is evident (Figure 17). Recoveries from releases made in the entrance to Stevenson Trough were made at the head of the trough. Recoveries from releases made over middle Albatross Bank generally were made in Kiliuda Trough, northwest of the point of release. Other recoveries were in Kaiugnak Bay from releases made just outside the entrance of the bay.

ICHTHYOPLANKTON

From the Fall, 1977 and Spring, 1978 cruises we see that eggs and larvae of fishes form a diverse community in the Kodiak area. Eggs and/or larvae of 26 taxa occurred five or more times in a particular life history stage-gear-net combination (Table 2). Many taxa cannot be identified at the species level, due to inadequate descriptions of early life history stages. In the following section the distribution and abundance of several taxa is discussed in relation to the two seasons, differences in neuston and bongo catches, and areas of occurrence and abundance.

Mallotus villosus (Capelin)

Capelin larvae were widely distributed in Fall as shown in bongo net catches (Figure 18). They seemed to be most abundant close to shore. This is to be expected since the adults spawn intertidally on beaches in Fall (Hart, 1973). A few larvae were taken at widely scattered locations in the neuston net in Fall (Figure 18). In Spring, they were more abundant in the neuston net than in the bongo (Figure 19). They were also not as close to shore as they were in Fall. This apparently results from a change to more neustonic habits as the larvae grow, since those in Spring were larger than those in Fall.

Theragra chalcogramma (Walleye pollock)

Pollock eggs were taken in both bongo and neuston nets in both Fall and Spring (Figures 20-21). In both seasons the areas of occurrence were similar in both nets; however, the bongo catches seemed to show a little more detail. In Fall most eggs were nearshore, concentrated in two areas - off Marmot Bay and off Sitkalidak Island. A few were also taken in the neuston net offshore over the troughs. In Spring the distribution was broader which may in part reflect the larger area sampled at that time. Most were taken south of Kiliuda Bay with the highest abundances in the southeast part of Shelikof Strait. It appears that their distribution extended beyond our survey area to the south and west. Again, as in Fall, a few were also caught offshore at widely scattered stations.

Hexagrammos I (Greenling)

The larvae we designate Hexagrammos I are probably Hexagrammos decagrammus (Kelp greenling), but precise identification awaits further analysis. In the Fall small larvae of this greenling were taken in neuston tows and their distribution was centered over Kiliuda Trough where they extended from nearshore to the edge of the shelf (Figure 22). Some were also over Middle Albatross Bank. By Spring, larvae were taken in the neuston collections throughout the study area (Figure 23). They appeared most abundant over Middle Albatross Bank, although concentrations occurred in several other areas. Some were also taken in the bongo net in Spring, occurring in areas of high abundance as indicated by neuston collections (Figure 23).

Hexagrammos stelleri (Whitespotted greenling)

In Fall, whitespotted greenling were taken in the neuston net at nearly every station, and they also occurred at scattered stations in the bongo catches (Figure 24). They were abundant at nearshore as well as offshore stations. However, they were absent at a few of the most shoreward stations. In Spring they occurred in neuston collections, at stations widely spread over the survey area (Figure 25). They also occurred in areas that were not sampled in Fall. The widest area of distribution was over Southern Albatross Bank.

Pleurogrammos monopterygius (Atka mackerel)

Atka mackerel larvae were taken in Fall and Spring, primarily in the neuston net (Figures 26-27). In Fall they were abundant over Kiliuda Trough and occurred at scattered stations to the north. A few were taken in the bongo tows over Kiliuda Trough in Fall. In Spring they were present over Northern and Middle Albatross Banks. They were also present at two stations just east of Shelikof Strait, south of Kodiak Island. Most occurred over the middle of the shelf.

Hemilepidotus sp. (Irish lords)

Several species of Irish lords may be represented by larvae in our collections. Work is continuing on distinguishing these larvae. Some of the irregularities in geographic patterns may be the result of overlapping occurrences of more than one species. In Fall these larvae were taken in nearly every tow of both the bongo and neuston net (Figure 28). They were fairly evenly distributed over the study area, but did show areas of increased abundance near the edge of the shelf off Kiliuda and Chiniak Troughs. In Spring they were more widespread but not as evenly distributed (Figure 29). Several areas of abundance were seen, and the bongo and neuston catches show dissimilar patterns of distribution.

Ammodytes hexapterus (Pacific sand lance)

Sand lance larvae were taken in bongo and neuston net tows in Spring (Figure 30). They appear much more widespread in bongo catches, where they were taken mostly over the inner half of the shelf and to the south of Kodiak Island. They were abundant nearshore south of Kodiak Island, between it and Trinity Islands. They were also taken at isolated stations offshore.

Hippoglossoides elassodon (Flathead sole)

Eggs of flathead sole were taken in a relatively small area in neuston and bongo net tows in Spring (Figure 31). They were all associated with water over troughs. Most were over Kiliuda Trough, while some also occurred over Chiniak and Sitkalidak Troughs.

INVERTEBRATE ZOOPLANKTON

The following is a report of the horizontal and seasonal distributions and abundances of major zooplankton taxa and euphausiid species. These results are based on catches from the bongo nets. Bongo nets were towed at nearly every station on each cruise. Too few Tucker trawl samples were collected during the Fall cruise to allow adequate inter-cruise comparisons for that sampling method. The bongo nets also sampled the entire water column on every tow. This eliminated the need to consider diel changes in the vertical distribution of animals as a source variable and enabled data to be combined regardless of the time collected.

The contour plots (Figures 33 to 43) illustrate representative distributions of some zooplankton taxa. These plots are typical of the variations of distributions found in the area studied.

Seasonal patterns of abundance and occurrence of different zooplankton taxa are shown in Tables 3 and 4. Comparisons in these tables were based on 43 stations from each cruise whose locations and bathymetry were similar (Figure 32). If taxa were not caught at the stations examined for seasonal comparisons but were present at other stations or in the Tucker trawl samples, their presence was indicated in Tables 3 and 4. Abundance is presented as the log of the number of individuals caught per $10m^2$ per station. This will be used throughout the following discussion. Cruises will be referred to as either Fall (Cruise 4MF77) or Spring (Cruise 4DI78).

The taxa are listed below as two groups - the major zooplankton taxa and Euphausiacea species. Life history stages are not determined for major taxa except Cirripedia, Gastropoda, Echinodermata, and Euphausiacea. Cirripedia larvae were examined because of their high abundance during parts of the year. Euphausiid larvae and juveniles were examined because of their ecological and economical importance to the area.

Major Zooplankton Taxa

As expected, the Copepoda were the dominant zooplankton in the area. Cnidarians, pteropods, amphipods, chaetognaths, and larvaceans occured at $\geq$70% of the stations and occurred more frequently in the Fall than Spring. These same taxa also tended to be more abundant than others. Taxa that occurred at less than 5% of the stations (Tables 3 and 4), were Siphonophora, Mollusca, Heteropoda, Mysidacea, and Thaliacea. The taxa below are discussed in order of greatest to least percent occurrence.

Copepoda (Figure 34)

Copepoda occurred at all stations examined. Generally the abundance of copepods was evenly distributed over the shelf with no apparent change between Spring and Fall. A preliminary investigation of the data from Fall showed 45 species were captured. All were in the copepodid stage of development (Bruce Wing, personal communication). This is consistent with the findings that Calanus hyperboreas near Maine do not become adults until late fall or early winter (Conover, 1965).

Cnidaria (Figure 33)

Cnidaria were abundant and occurred at all the stations in Fall. In Spring, only a 70% occurrence was found as well as a decrease in abundance. In Fall Cnidaria were evenly distributed over the shelf, but in Spring there were areas of low or no occurrence. A particularly noticeable area of low abundance was the area north of the Trinity Islands. The Fall cruise did not sample this area, so it is not known if this low abundance in the Spring was a seasonal event.

Chaetognatha

Chaetognaths occurred at more stations in Fall than in Spring, 95% and 79%, respectively. Absences occurred on the Spring cruise at nearshore stations, particularly in the Stevenson Entrance area. Average abundance was 2.2-2.3/10m^2/Station (log value) and did not vary seasonally.

Amphipoda

Amphipods occurred more often in the Fall than Spring, but the abundance remained at 2.2-2.3/$10m^2$/Station for both cruises. There was no apparent pattern of distribution except that the highest number of zero occurrences occurred in the Kiliuda Trough and Southern Albatross Bank areas.

Larvacea

The percent occurrence of larvaceans was nearly the same with no pattern of absences for both cruises. The average abundance per station was the same. However, greater numbers of animals (7/$10m^2$/Station) were encountered over Southern Albatross Bank than in other areas during Spring. The abundance on the Fall cruise was evenly distributed.

Pteropoda

There was an 84% occurrence of pteropods in the Fall compared to a 63% occurrence in Spring. However, there were slightly more animals per station in Spring (2.3/$10m^2$/Station) than Fall (2.1/$10m^2$/Station). Absences appeared randomly distributed over the sampling area for both cruises. But the southern Albatross Bank - Kiliuda Trough area supported higher abundances per station (approx. 3/$10m^2$/Station) than elsewhere (2/$10m^2$/Station).

Cirripedia nauplii and cypris developmental stages (Figures 35 and 36)

Cirripedia nauplii were most prominent during Spring based on percent occurrence and average abundance (Table 3). In general, the highest concentrations were found nearshore, but very low concentrations were also found nearshore in adjacent areas. Concentrations of 4/$10m^2$/Station were also found toward the outer edge of the shelf over Southern Albatross Bank. Cirripedia were much less abundant (1.5 compared to 3.3/$10m^2$/Station) in the Fall and occurred at 16% fewer stations.

Cirripedia cypris (a later developmental stage) was much more prominent in the Fall than Spring. There was a 70% occurrence in the Fall compared to a 26% occurrence in Spring. Abundance per station, however, remained nearly equal for the two cruises. In Spring most cirripedia cypris were located from Kaiugnak Bay seaward over Southern Albatross Bank. Cirripedia cypris were more evenly distributed over the shelf during the Fall cruise but with a noticeable absence of animals in the Kiliuda and Stevenson Trough areas.

Caution must be applied when interpreting data on these larval stages, especially during the Spring spawning period. For example, note the absence of nauplii in the outer Chiniak Trough - Northern Albatross Bank area. These stations were sampled earlier in the cruise than stations to the south. Higher concentrations of nauplii may have spread to early stations very soon after they were sampled. The few cypris caught during the Spring cruise further suggest we were trawling very near the initial spawning period when rapid changes in both occurrence and abundance of cirripedia larval stages occur.

However, the pattern for the Fall cruise (Figure 35, top) suggests that the middle and southern area of the shelf may be more productive as shown by the concentrations of nauplii caught in these areas and not to the north.

Annelida

Annelids occurred at more stations in Fall but were less abundant per station than in Spring. During both periods they were evenly distributed over the shelf.

Cladocera

Cladocera also occurred at more stations in Fall than Spring (35% versus 7%). The number of animals caught per station remained nearly equal for the two cruises. In Spring cladocerans only occurred over Southern Albatross Bank but this pattern changed by Fall when cladocerans mostly occurred at nearshore stations of the survey area.

Ostracoda

The percent occurrence and abundance per station of ostracods were nearly equal between cruises. Generally, higher abundances were found at the outer edge of the shelf during both cruises but no apparent pattern of distribution over the shelf was evident.

Isopoda

Isopods were more than twice as evident during the Fall than Spring. Abundance was also slightly higher during Fall (1.8 versus 1.6/10m^2/Station). The pattern of isopod distribution was very different between Spring and Fall. During Spring isopods generally occurred northward from Northern Albatross Bank. In Fall most isopods were found to the south of Middle Albatross Bank.

Other Zooplankton Taxa

Ctenophores were more abundant in Fall than Spring. They occurred at less than 10% of the stations and were low in abundance. During the Fall cruise they were evenly distributed along the shelf but more prominent at the nearshore stations.

Gastropod larvae were found at 42% of the stations in Spring and not at all during Fall. There was no apparent pattern in their distribution.

Cumaceans also did not occur in Fall and they occurred at only 9% of the stations in Spring. However, their abundance at these stations averaged 4.8/10m^2/Station.

Echinoderm larvae occurred in Fall but not Spring. Their low abundance in Fall suggests that peak spawning for the Echinodermata occurs sometime between the dates of our two cruises.

Other major taxa that were captured but never very much in evidence were the Siphonophora, Heteropoda, Mysidacea, and Thaliacea.

Euphausiacea

Euphausiids were very abundant near Kodiak Island in the area surveyed. Four species dominated: Thysanoessa inermis, Thysanoessa spinifera, Euphausia pacifica, and Thysanoessa longipes. Other species rarely caught were Stylocheiron sp., Tessarabrachion occulatus, and Thysanoessa raschii. Because euphausiids are important food sources for the marine mammals, fish, and birds of the area, contour plots of the four relatively abundant species are included (Figure 39 to 42) and discussed below. Also included are contour plots of euphausiid larvae and juveniles.

Euphausiacea developmental stages (Figures 37 and 38)

Euphausiid larvae and juveniles were less abundant and occurred at fewer stations in Spring than Fall. In the Spring the highest concentrations of larvae were found at nearshore stations. These stations were sampled later in the cruise but the concentrations caught early in the cruise at Marmot Flats and east of Northern Albatross Bank show that there was some earlier spawning. Juveniles were also found during the Spring cruise, but may be from last year's season (Ponomareva, 1963). Juveniles occurred at many stations in Spring but in very low abundance (.8/10m^2/ Station). By Fall both juvenile and larval euphausiids occurred throughout the area and both showed increased abundance.

Thysanoessa inermis (Figure 39)

Thysanoessa inermis occurred at more stations in Spring than Fall (58% versus 33%), but the average catch per station remained nearly equal. The distribution of T. inermis during both cruises was overdispersed. Areas of high concentrations of animals were similar for the two cruises with both nearshore and offshore concentrations.

Thysanoessa spinifera (Figure 40)

Thysanoessa spinifera was the second most abundant euphausiid species in the area. They occurred with an average abundance of 1.5/10m^2/Station. Both the average number and percent occurrence of T. spinifera were nearly equal for Spring and Fall. T. spinifera appeared to occupy the same areas as T. inermis - particularly the area near the edge of the shelf over Kiliuda Trough.

Euphausia pacifica (Figure 41)

Euphausia pacifica was present in very low numbers during Spring, and animals were mostly located along the outer edge of the Kodiak shelf. In Fall greater numbers were found over the shelf, particularly over the inner area of Northern Albatross Bank and Stevenson Trough.

Thysanoessa longipes (Figure 42)

Thysanoessa longipes occurred with equal frequency during the two cruises but was more abundant on the average during Fall. *T. longipes* appeared only as a fringe member of the shelf ecosystem and was found most abundant near the outer edges of the shelf in areas greater than 100 fm. This pattern was evident on both cruises.

In summary, it appears that euphausiids spawn as early as mid-March in the area of the Kodiak Shelf. This concurs with Ponomareva (1963) who found euphausiids in the Sea of Japan spawned in March. The larvae are probably those of *T. inermis* and *T. spinifera*. These are the two dominant euphausiid species on the shelf, and the larval distributions were roughly parallel to those of *T. inermis* and *T. spinifera* in Spring.

The average abundance of euphausiids found was approximately 50 individuals/ $10m^2$ of the two dominant species. This is similar to numbers reported by Frost and McCrone (1979) at Stations P and Q (50^oN, long. 145^oW and 51^oN, long. 137^oW, respectively). Frost and McCrone (1979) towed their nets from 500 m to the surface and the dominant euphausiid in their tows was *Euphausia pacifica*. The shallow waters of the Kodiak shelf appear to support a much more dense euphausiid population than the nearest oceanic area studied.

SHRIMP AND CRAB LARVAE

Several species of decapod crustaceans are of considerable economic or ecological importance in the Kodiak area (Table 5).

Population diversity

Representatives of the families Hippolytidae, Majidae, Pinnotheridae and Paguridae were the most frequently occurring decapods, with the Hippolytidae and Paguridae having the highest incidence of occurrence. Other less frequently occurring families were Crangonidae, Ateleyclidae, Cancridae, Lithodidae and Pandalidae.

Comparisons of crab (Reptantia) and shrimp (Natantia) abundance within samples indicate some localized concentrations of larvae exist. Figure 43 shows the offshore distributions of crab and shrimp larvae during Spring. The major part of a given sample appeared to be either Reptantia or Natantia larvae.

Species composition generally did not vary between study areas or between bays within the inshore study area. Table 6 lists important decapods and their occurrence in each of the study areas as determined by their presence or absence in all samples examined to date.

Temporal distribution

In general, densities of crab and shrimp larvae appeared lowest during the early winter and spring months, and increased through the summer, with the highest densities occurring during late June and July. It appears that larval abundance of both taxonomic groups (Reptantia and Natantia) coincides temporally.

Table 7 indicates the time of occurrence and stage of development of important decapods in the study areas as exhibited by their presence in samples.

Although March-April initiation of sampling was thought to be sufficiently early in the season to determine the time of larval release, this was not the situation for some species. *Chionoecetes bairdi* and some species of the family Crangonidae were present in stages 2 through megalops forms in the earliest (March-April) samples. No stage 1 *C. bairdi* were encountered in the early samples; however, they were present in late April samples. Other species such as *Cancer gracilis*, *C. magister*, and members of family Pinnotheridae were not encountered until after mid-April. A protracted larval release is suggested for most species because stage 1 larvae were encountered throughout the survey time period (March-August).

It appears that with certain species, there may be a temporal variation in the time of larvae release between the inshore and offshore study areas. For example, stage 1 Pinnotheridae occurred inshore as early as mid-April, whereas initial offshore occurrence was not until late June.

Spatial distribution

Most decapod species of principal interest were found in both study areas (inshore and offshore). *Pandalus hypsinotus* and *P. platyceros* were only encountered in the offshore and inshore study areas, respectively. Additionally, *P. montagui tridens* only occurred in samples collected from one of the bays within the inshore study area.

Initial examination of neuston samples indicates that megalops of *Chionoecetes bairdi* are highly mobile and can occur in the upper layers of the water column. This species was frequently encountered in neuston samples.

Diel sampling

Day-night samples indicate that species diversity varied by depth. This variability also appears to change with time. For example, during daylight hours in Izhut bay, the highest species diversity occurred in the depth range of 50-70 meters while during hours of darkness, the highest diversity occurred higher in the water column (i.e. 30-50 meters).

Decapod larvae abundance also changed with time and depth. During the day, the highest abundance occurred in deeper water layers (50-70 m) while at night, abundance increased in shallower zones (30-50 m).

Aliquot subsamples

Aliquot subsamples do not appear to provide the total diversity and relative abundance of species and life history stages. These subsamples only appear to indicate the presence of those species that are the most abundant within a given bulk sample.

VII. Discussion

From these preliminary results, it appears that we have in hand plankton samples adequate to describe the major seasonal features of plankton distribution in the Kodiak area with respect to hydrography, bathymetry and interspecies relationships. The analysis to date of the first two cruises shows that the area harbors a diverse plankton community, with complex relations between the measured parameters. More detailed interpretation of these data await processing of samples from the later cruises.

Although analysis of shrimp and crab larval data has not been completed, preliminary findings indicate that:

There appears to be no difference in species diversity between the inshore and offshore study areas; however, inshore abundance in various bays appears to be higher than levels present in the offshore study area. Whether this species diversity-abundance information indicates separate inshore-offshore stocks or a single overall population cannot be determined at this time. Investigations of larval transport mechanics may provide insight into decapod population dispersal in the Kodiak Island region. If inshore and offshore stocks are related, do offshore larval populations result from inshore concentrations dispersing seaward or, are inshore concentrations a result of shoreward decapod larval transport from offshore areas?

Series of repetitive sampling at 1 location indicated substantial variability in numbers of organisms and the dominance of one species group or another. There was a strong tendency for decapods within a sample to be mostly crab or shrimp. Samples obtained during diel sampling suggest that larval populations are not randomly distributed within an area, but rather, form concentrations or clumps that are predominantly one taxonomic group or another.

Several families formed the majority of decapod organisms in the samples examined to date. Although the study areas support commercial crab and shrimp fisheries, larvae of economically important species were encountered in low abundance. It is not known whether this low larval abundance reflects depressed stock conditions or results from low sampling density.

Three families of crab (Pinnotheridae, Paguridae, and Majidae) and two families of shrimp (Hippolytidae and Crangonidae) represent the most frequently occurring decapod larvae. The abundance of these larvae, relative to larvae of economically important decapods, differs from a comparative abundance of the adult forms. This may reflect high mortality rates during early life stages for the families mentioned above.

Survey data suggests a sequential occurrence of species in the study areas. Data from samples collected later in the year indicate that members of family Pinnotheridae and Cancer gracilis (Cancridae) replace organisms from families Paguridae, Hippolytidae, and Crangonidae in density and frequency of occurrence.

There is evidence to suggest that larval release of some decapods may occur earlier than mid-March. This early release may be a normal occurrence or a result from mild winter conditions accelerating egg development. Additionally, it appears that larval release of decapods may not occur during a limited time span, but rather may be protracted throughout the year.

VIII. Conclusions

From our study thus far the following tentative conclusions can be drawn with regard to the plankton community off Kodiak Island and our survey of it:

General

The study area contains a diverse plankton assemblage, with complex patterns of distribution.

Ichthyoplankton

Several taxa show high abundances in waters over troughs in the area. Capelin larvae in Spring, 1978, were concentrated over Kiliuda Trough, South Albatross Bank and northwest of the Trinity Islands. Pollock eggs also were more abundant in the general area from Kiliuda Trough to west of the Trinity Islands. Greenling (*Hexagrammos* Type I) were centered over Kiliuda Trough in the Fall, 1977, but were widely dispersed in the Spring, 1978. Atka mackerel larvae also were found mainly over Kiliuda Trough in the Fall, but during Spring were primarily over Northern and Middle Albatross Banks. Flathead sole eggs were found mainly over Kiliuda Trough during Spring.

Some early life history stages of fishes in Kodiak Island waters are neustonic. Examples are greenling (*Hexagrammos* Type I; *H. stelleri*); Atka mackerel; and certain sculpins (e.g. some *Hemilepidotus* sp.). Other taxa occur deeper in the water column, such as capelin, sand lance and some sculpins.

Invertebrate Zooplankton

There is a higher abundance of zooplankton on the Kodiak shelf in the Fall compared to early Spring.

The most abundant taxa in the area were cnidarians, pteropods, amphipods, chaetognaths, and larvaceans, and euphausiids. Copepods, as expected, were the most abundant group.

Siphonophores, heteropods, mysids, and thaliaceans were present but with very low occurrence.

All species of copepods were in the copepodid developmental stage during Fall.

Thysanoessa inermis and *spinifera* tended to occur in patches over the shelf.

Euphausia pacifica and *Thysanoessa longipes* are most abundant near the outer fringe of the Kodiak shelf.

Euphausiids probably start spawning in early March and continue throughout the summer and early fall.

Euphausiid juveniles from the previous year's season are found in early Spring.

Shrimp and Crab Larvae

Until final analysis of data has been completed, results are inconclusive. However, certain tentative conclusions can be made at this time:

Time of occurrence of decapod larvae concides between inshore and offshore areas for the Kodiak Island region.

Several families form the majority of the decapod larvae population.

Relative abundance of most decapods is a function of time. The highest densities of larvae usually occur during midsummer months.

Decapod larvae populations in both inshore and offshore study areas have the same basic species composition.

The sample aliquots may not provide adequate species representation within samples.

IX. Needs for further study

The overall patterns of seasonal occurrences of zooplankton of the Kodiak shelf are being derived from the present collections. Further studies on annual variations in distribution are needed before the patterns can be well understood. The present study was not designed to investigate small scale distributions on a horizontal or vertical basis. Such studies are important if the impact of such things as local spills of oil on zooplankton are to be evaluated properly. Comparisons of the shelf around Kodiak to the shelf elsewhere with respect to the early life history of species with broad distribution needs to be made in order to understand the relative importance of various shelf areas to these species.

Preliminary analysis of decapod larval sample data shows a need for further study with regard to: (1) decapod larvae transport mechanics, (2) stratification of larvae by depth, (3) localized concentrations or clumping behavior, (4) diel migration of larval decapods within the water column, and (5) early periods of larval release.

An intensive study of one particular bay system within the inshore study area would shed further light on the questions listed above as well as provide data useful in assessing the magnitude of larval decapod populations for the entire nearshore region.

X. Summary of January-March 1979 Quarter

Activities to date are on schedule with respect to the milestone chart (Table 8).

A. Field Activities

Offshore

a. The fifth quarterly offshore cruise was conducted aboard the FRS Miller Freeman from February 13 - March 11, 1979.

1. Field Party:

Name	Affiliation	Role
Kenneth Waldron	NWAFC	Chief Scientist
Ann Matarese	NWAFC	Biologist
Donald Fisk	NWAFC	Physical Science Technician
Martha Siemroth-Peters	NWAFC	Biological Technician
Gary Shigenaka	NWAFC	Biological Technician

2. Methods:
At each grid station a surface neuston tow was made for 10 minutes utilizing a Sameoto sampler to sample ichthyoneuston. A double-oblique bongo tow was next made from near bottom to the surface to sample ichthyo- and zooplankton. At selected stations a Tucker trawl was used to sample discrete strata. A CTD cast was made at each station. Sea-bed drifters were released at 16 locations.

3. Sample Collection Localities
The station plan is illustrated in Figure 5. A total of 88 regular grid stations was occupied.

4. Data Collected and Analyzed:

(a) Number of samples collected:

	89	neuston samples
	179	bongo samples (88 each 0.505 and 0.333 mm mesh)
	74	Tucker trawl samples
Total	339	

A total of 88 CTD measurements was taken and 768 sea-bed drifters were released.

(b) Number and types of analyses:

Samples collected during the Freeman cruise have been sent to the contractor for sorting.

b. Inshore

The 12th cruise of the R/V Commando was conducted by RU553 from March 1 through March 20, 1979. Details of that cruise will be reported by RU553. Aliquots of crab and shrimp larvae from samples collected by RU553 will be identified by RU551.

B. Laboratory Activities

1. Scientific group (all analyses except for those of crab and shrimp are conducted at the Seattle laboratory):

Name	Affiliation	Role
Jean Dunn	NWAFC	Co-principal investigator
Arthur Kendall	NWAFC	Co-principal investigator
Robert Wolotira	NWAFC*	Co-principal investigator
Langdon Quetin	NWAFC	Biological Oceanographer
John Bowerman	NWAFC*	Fisheries Biologist
Ann Matarese	NWAFC	Fisheries Biologist
Beverly Vinter	NWAFC	Ichthyoplankton Specialist
Jay Clark	NWAFC	Biological Technician
Don Fisk	NWAFC	Physical Science Technician
Eric Monk	NWAFC*	Biological Technician
Bernie Goiney	NWAFC	Biological Technician

* Kodiak Laboratory

2. Methods:

Fish eggs and larvae were identified by microscopic examination using standard procedures of larval fish taxonomy. Fish eggs and larvae were measured by means of a calibrated ocular micrometer.

Aliquots of zooplankton from the 0.333 mm mesh bongo net were identified by the sorting contractor to phylum, class, or order, as appropriate, except for euphausiids which were identified to species. Euphausiids from the Tucker trawl were also identified by the sorting contractor.

Crab and shrimp larvae were identified to species and life history stage.

3. Sample Collection Localities:

Ichthyoplankton samples presently being identified were collected during the fall 1978 cruise (R/V Wecoma 78-1). The station grid is shown in Figure 4.

Zooplankton data from this cruise have been received from the sorting contractor.

4. Data Analyzed:

a. Discoverer cruise (4DI78) - Spring 1978

The tape of the ichthyo- and zooplankton data and ancillary information from the spring 1978 cruise will be forwarded to OCSEAP shortly.

b. Miller Freeman cruise 78-2 - Summer 1978.

Identification of ichthyoplankton samples was completed. Station, ichthyo- and zooplankton data were entered into our data management system.

c. Wecoma cruise 78-1 - Fall 1978.

Identification of ichthyoplankton samples from this cruise has begun. Zooplankton have been sorted from aliquots from 98 bongo (0.333 mm mesh) samples and aliquots of euphausiids from 100 Tucker trawl samples have been identified.

d. Shrimp and crab larvae.

Through this quarter, the shrimp-crab portions of approximately 2500 aliquots have been shipped to the Kodiak Facility. Of these, 1968 have undergone detailed sorts to the lowest possible taxonomic-life history stage classification. Additionally, all crab and shrimp larvae were removed from 14 bulk samples (i.e. that portion of the plankton sample remaining after the removal of the 500-organism aliquot) so that an evaluation of levels of precision for the aliquot portion could be examined.

Species diversity comparisons between aliquots and bulk samples were also investigated. Four of the 14 above-mentioned bulk samples were sorted to lowest possible taxonomic levels.

Information recorded during the sorts and counts of aliquots and bulk samples included:

(1) total number of all organisms per bulk sample

(2) total number of decapods per bulk sample and aliquot

(3) numbers of crab and shrimp per species and life stage per bulk sample and aliquot.

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XI. Auxiliary Material

A. References Cited

Anonymous. 1960. Oceanic observations of the Pacific 1955: The NORPAC Atlas. Univ. Calif. Press and Univ. Tokyo Press, 532 p.

Anonymous. 1978. The "Oshoro Maru" cruise 65 to the Bering Sea and the Bristol Bay in June-August 1977. Data Rec. Oceanogr. Obs. Expl. Fish., Hokkaido Univ. 21: 1-79.

Aron, W. 1962. The distribution of animals in the eastern North Pacific and its relationship to physical and chemical conditions. J. Fish. Res. Bd. Canada 19: 271-314.

Conover, R.G. 1965. Notes on the molting cycle, development of sexual characters, and sex ratio in Calanus hyperboreas. Crustaceana, 8: 308-320.

Dunn, J.R. and N.A. Naplin. MS 1974. Fish eggs and larvae collected from waters adjacent to Kodiak, Island, Alaska, during April and May 1972. MARMAP Rep. No. 12, NWAFC, 61 p.

Favorite, F., W.J. Ingraham, Jr., and D.M. Fisk. MS 1975. Environmental conditions near Portlock and Albatross Banks (Gulf of Alaska), May 1972.

Favorite, F. and W.J. Ingraham, Jr. 1977. On flow in the Northwestern Gulf of Alaska, May 1972. J. Oceanogr. Soc. Japan 33(2): 67-81.

Frost, B.W. and L.E. McCrone, 1979. Vertical distribution, diel vertical migration, and abundance of some mesopelagic fishes in the eastern subartic Pacific Ocean in summer. Fish. Bull. 76(4): 751-770.

Gosho, M.E. MS 1977. The food and feeding habits of juvenile pink salmon in the estuaries of Kodiak Island, Alaska. MS Thesis, Univ. Washington, Seattle, 87 p.

Harris, C.K. and A.C. Hartt. MS 1977. Assessment of pelagic and near shore fish in three bays on the east and south coasts of Kodiak Island, Alaska. Final Rep. OCSEAP RU485, 190 p.

Hart, J.S. 1973. Pacific fishes of Canada. Bull. Fish. Res. Bd. Canada, No. 180, 740 p.

LeBrasseur, R.J. MS 1965. Biomass atlas of net zooplankton in the northeastern Pacific Ocean, 1956-1964. Fish. Res. Bd. Canada, Manuscr. Rep. Series (Oceanogr. and Limnol.), No. 201, 294 p.

LeBrasseur, R. MS 1970. Larval fish species collected in zooplankton samples from the northeastern Pacific Ocean 1956-1959. Fish. Res. Bd. Canada, Tech. Rep. No. 175, 47 p.

Lisovenko, L.A. 1964. Distribution of larval Pacific ocean perch (Sebastodes alutus G.) in the Gulf of Alaska. (Transl. in Soviet Fish. Inves. N.E. Pacific, Part III, 217-225).

Mironov, O.G. 1969. The development of some Black Sea fishes in sea water polluted by petroleum products. J. Ichthyol (English transl. of Voprosy Ikhtiologii) 9: 919-922.

Ponomareva, L.A. 1963. Euphausiids of the North Pacific-their distribution and ecology. Akad. Nauk SSSR Inst. Okeanol. (Translated by Israel Program Sci. Transl., Jerusalem 1966, IPST cat. no. 1368, 154 p.).

Sanborn, H.R. MS 1973. Surface nutrient concentrations near Kodiak Island, Alaska. April to June, 1972. MARMAP Survey I Rep. No. 11, NWAFC, 20 p.

Schumacher, J.D., R.K. Reed, M. Grigsby, D. Dreves (In Press). Circulation and hydrography near Kodiak Island, September to November, 1977. NOAA Tech. Rep. ERL.

Schumacher, J.D., R. Sillcox, D. Dreves, and R.D. Muench. 1978. Winter circulation and hydrography over the continental shelf of the Northwest Gulf of Alaska. NOAA Tech. Rep. ERL404-PMEL31, 16 p.

Smith, P.E. and S.L. Richardson. 1977. Standard techniques for pelagic fish egg and larva surveys. Food Agri. Organ. Fish. Tech. Paper No. 175, 100 p.

Struhsaker, J.W., M.B. Eldridge and T. Echeverria. 1974. Effects of benzene (a water-soluble component of crude oil) on eggs and larvae of Pacific herring and northern anchovey, IN: F.J. Vernberg and W.B. Vernberg (Eds.), Pollution and physiology of marine organisms, Academic Press, New York, 253-284.

Thompson, W.F. and R. VanCleve. 1936. Life history of the Pacific halibut. (2) Distribution and early life history. Int. Fish. Comm. Rep. 9, 184 p.

Threlkeld, S.T. MS1973. The occurrence and distribution of five species of Monstrillidae (Copepoda: Monstrilloida) from near Kodiak, Alaska. MARMAP Survey I Rep. No. 7, NWAFC, 23 p.

Threlkeld, S.T. 1977. The distribution of five species of Monstrillidae (Copepoda: Monstrilloida) near Kodiak Island, Alaska. Crustaceana, 32(3): 225-228.

Weibe, P.H., S. Body, and J.L. Cox. 1975. Relationships between zooplankton displacement volume, wet weight, dry weight, and carbon. Fish. Bull. 73(4): 777-786.

Table 1.--Number of plankton samples collected and other associated measurements made on OCSEAP cruises October 1977 - March 1979.

Cruise No.	Vessel	Cruise	Cruise Dates	Number Stations Occupied	Number of samples by gear type: Neuston 0.505	Bongo 0.505	Bongo 0.333	Tucker 0.505	IKMT	Number Samples Collected	CTD Casts	XBT Probes	Seabed Drifters Released
1	*Miller Freeman*	4MF77	31 Oct-14 Nov 1977	61	83	59	59	168	0	369	40	31	400
2	*Discoverer*	4DI78	28 Mar-20 Apr 1978	89	111	85	85	138	56	475	117	0	800
3	*Miller Freeman*	2MF78	19 Jun-9 July 1978	91	111	89	89	176	40	505	106	0	800
4	*Wecoma*	1WE78	25 Oct-17 Nov 1978	94	101	98	98	100	0	397	97	0	768
5	*Miller Freeman*	1MF79	13 Feb-11 Mar 1979	88	89	88	88	74	0	339	88	0	768

Table 2.--Vertebrate taxa collected at least five times in a stage-gear-net combination from the Fall 1977 and Spring 1978 plankton cruises off Kodiak Island.

		Fall 1977				Spring 1978			
Taxon	Stage	Neuston	Bongo	Tucker 1	Tucker 2	Neuston	Bongo	Tucker 1	Tucker 2
No fish present	n.a.					X			
unidentified	larva						X		X
unidentified A	egg					X			
Mallotus villosus	larva	X	X	X	X	X			
Leuroglossus schmidti	egg		X	X					
Leuroglossus schmidti	larva							X	
Protomyctophum thompsoni	larva		X	X					
Stenobrachius leucopsarus	larva						X	X	X
Stenobrachius leucopsarus	juvenile						X		
Theragra chalcogramma	egg	X	X			X	X	X	X
Theragra chalcogramma	larva						X	X	X
Hexagrammidae	larva					X			
Hexagrammos sp.	larva	X				X			
Hexagrammos D	larva	X							
Hexagrammos E	larva	X							
Hexagrammos I	larva	X				X	X	X	X
Hexagrammos stelleri	larva	X	X		X	X			
Pleurogrammos monopterygius	larva	X	X			X			
Cottidae	larva						X	X	X
Gymnocanthus A	larva						X	X	X
Hemilepidotus sp.	larva	X	X	X	X	X	X	X	X
Myoxocephalus B	larva						X	X	X
Myoxocephalus G	larva						X		X
Cyclopteridae	larva						X		X
Stichaeidae	larva						X	X	X
Chirolophis polyactocephalus	larva					X			
Lumpenus sagitta	larva						X	X	X
Lyconectes aleutensis	larva					X			X
Ammodytes hexapterus	larva					X	X	X	X
Pleuronectidae	egg					X	X	X	X
Atheresthes stomias	larva						X	X	X
Hippoglossoides elassodon	egg					X	X	X	X
Lepidopsetta bilineata	larva						X	X	X

Table 3.--Seasonal comparison of major invertebrate zooplankton from cruises 4MF77 (Fall) and 4DI78 (Spring). Occurrence is the number of stations at which a group was represented. Percent occurrence is based on 43 stations analyzed from each cruise. Average abundance is expressed as log $N/10m^2$/station.

		4MF77 (Fall)			4DI78 (Spring)		
Taxonomic Group	Stage	Occurrences (# of Sta.)	Occurrence (% of Sta.)	Ave. No. (Log $N/10m^2$/Sta)	Occurrences (# of Sta.)	Occurrence (% of Sta.)	Ave. No. (Log $N/10m^2$/Sta)
Cnidaria		43	100	2.8	30	70	2.3
Hydrozoa siphonophora		-	-	-	1	2	2
Ctenophora		9	21	1.2	1	2	1
Annelida		26	61	1.7	10	23	2
Mollusca		0	-	-	2	5	2
Gastropoda	Larva	0	-	-	18	42	2.3
Heteropoda		0	-	-	1	2	1
Pteropoda		36	84	2.1	27	63	2.3
Cladocera		15	35	1.9	3	7	2
Cumacea		0			4	9	4.8
Ostracoda		20	47	2.0	18	42	2.1
Copepoda		43	100	4.2	43	100	4.3
Cirripedia	Nauplius	18	42	1.5	25	58	3.3
Cirripedia	Cypris	30	70	2.3	11	26	2.4
Mysidacea		3	7	1.3	-	-	-
Isopoda		17	40	1.8	7	16	1.6
Amphipoda		39	91	2.8	30	70	2
Echinodermata	Larva	8	19	1.0	-	-	-
Chaetognatha		41	95	2.3	34	79	2.2
Thaliacea		2	5	2.0			
Larvacea		40	93	2.9	38	88	2.9

Table 4.--Seasonal comparison of Euphausiacea from cruises 4MF77 (Fall) and 4DI78 (Spring). Occurrence is the number of stations at which a group was represented. Percent occurrence is based on 43 stations analyzed from each cruise. Average abundance is expressed as log $N/10m^2$/station.

		4MF77 (Fall)			4DI78 (Spring)		
Taxonomic Group	Stage	Occurrences (# of Sta.)	Occurrence (% of Sta.)	Ave. No. (Log $N/10m^2$/Sta)	Occurrences (# of Sta.)	Occurrence (% of Sta.)	Ave. No. (Log $N/10m^2$/Sta)
Euphausiacea	Larva	42	98	2.9	17	40	2.4
Euphausiacea	Juv.	43	100	2.8	31	72	.8
Euphausia pacifica	Adult	16	37	1.4	8	19	.1
Stylocheiron sp.	Adult	1	2	1.0	1/	-	-
Tessarabrachion oculatus	Adult	2	5	1.5	2	5	1
Thysanoessa inermis	Adult	14	33	1.7	25	58	1.5
T. longipes	Adult	5	12	1.2	6	14	.5
T. raschii	Adult	3	7	1.0	3	7	0
T. spinifera	Adult	15	35	1.4	16	37	1.6

1/ Occurred in bongo net tows but not at stations used for seasonal comparison

Table 5.--Decapod crustaceans of principal interest in the Kodiak Island region.

Species of Present or Potential Commercial Importance

Scientific name	Common name
Pandalopsis dispar	Sidestripe shrimp
Pandalus borealis	Pink shrimp
P. goniurus	Humpback shrimp
P. hypsinotus	Coonstripe shrimp
P. platyceros	Spot shrimp
P. stenolepis	- -
Paralithodes camtschatica	Red King crab
Cancer magister	Dungeness crab
Chionoecetes bairdi	Snow crab

Species (or Familes) of High Abundance or Potential Ecological Importance

Family or scientific name	Common name
Family Crangonidae	Sand shrimp
Family Hippolytidae	Hippolytid shrimp
Pandalus montagui tridens	- -
Family Paguridae	Hermit crab
Telmessus cheiragonus	Arthopod crab
Cancer gracilis	Cancer crab
Family Pinnotheridae	Pea crab

Table 6.--Occurrence (X) of larvae of crab and shrimp species of principal interest in inshore and offshore areas examined during plankton surveys of the Kodiak Island area, October, 1977 - August, 1978.[1/]

	Inshore[2/]				Offshore
	Z	C	L	G	
Shrimps					
Family Crangonidae	X		X	X	X
Family Hippolytidae	X	X	X	X	X
Pandalopsis dispar	X				X
Pandalus borealis	X	X	X	X	X
P. goniurus	X	X	X		X
P. hypsinotus					X
P. montagui tridens		X		X	
P. platyceros	X				
P. stenolepis	X		X	X	X
Crabs					
Paralithodes camtschatica	X	X	X	X	X
Family Paguridae	X	X	X	X	X
Telmessus cheiragonus	X	X		X	X
Cancer magister			X	X	X
Cancer gracilis			X	X	X
Family Pinnotheridae	X	X	X	X	X
Chionoecetes bairdi	X	X	X	X	X

1/ Inshore Surveys--March-August, 1978; Offshore Surveys--October-November, 1977; March-April, 1978; June-July,1978.

2/ Z = Izhut Bay
C = Chiniak-Kalsin Bay
L = Kiliuda Bay
G = Kaiugnak Bay

Table 7.--Time of occurrence of larval shrimp and crab by taxa and life history stage in inshore and offshore areas of Kodiak Island. Broken lines indicate the projected occurrence of species based on absence of life stages from samples. All stages are zoea unless otherwise indicated.

SPECIES OR FAMILY	INSHORE MONTH (J F M A M J J A S)	OFFSHORE MONTH (J F M A M J J A S)
Family Crangonidae	stages 1 - 5	stages 1 - juvenile
Family Hippolytidae	stages 1 - 5	stages 1 - 6
Pandalopsis dispar	stage 1 ?	stage 1
Pandalus borealis	stages 1 - 6	stages 1 - 5
Pandalus goniurus	stage 1 ?	? stage 5
Pandalus hypsinotus	not captured	stage 1?
Pandalus platyceros	stage 1 ?	not captured
Pandalus stenolepis	? stages 1 - juvenile ?	stages 1 - 5
Pandalus montagui tridens	? stage 1 ?	not captured
Paralithodes camtschatica	? stages 1 - 4 ?	stages 1 - glaucothe
Family Paguridae	stages 1 - glaucothe	stages 1 - glaucothe
Telmessus cheiragonus	? stages 1 - 4 ?	stages 1 - megalops
Cancer magister	stage 1	stages 1 - 2 ?
Cancer gracilis	stage 1	stages 1 - 2 ?
Family Pinnotheridae	stages 1 - 2 ?	stages 1 - 3 ?
Chionoecetes bairdi	? stages 1 - 2	? stages 1 - megalops

Table 8.--Major milestone or activity chart
for RU 551

MILESTONE CHART

| - Start

△ - Planned Completion Date

▲ - Actual Completion Date
(to be used on quarterly updates)

RU # 551 PI: Dunn, Kendall, Wolotira

Major Milestones: Reporting, and other significant contractual requirements; periods of field work; workshops; etc.

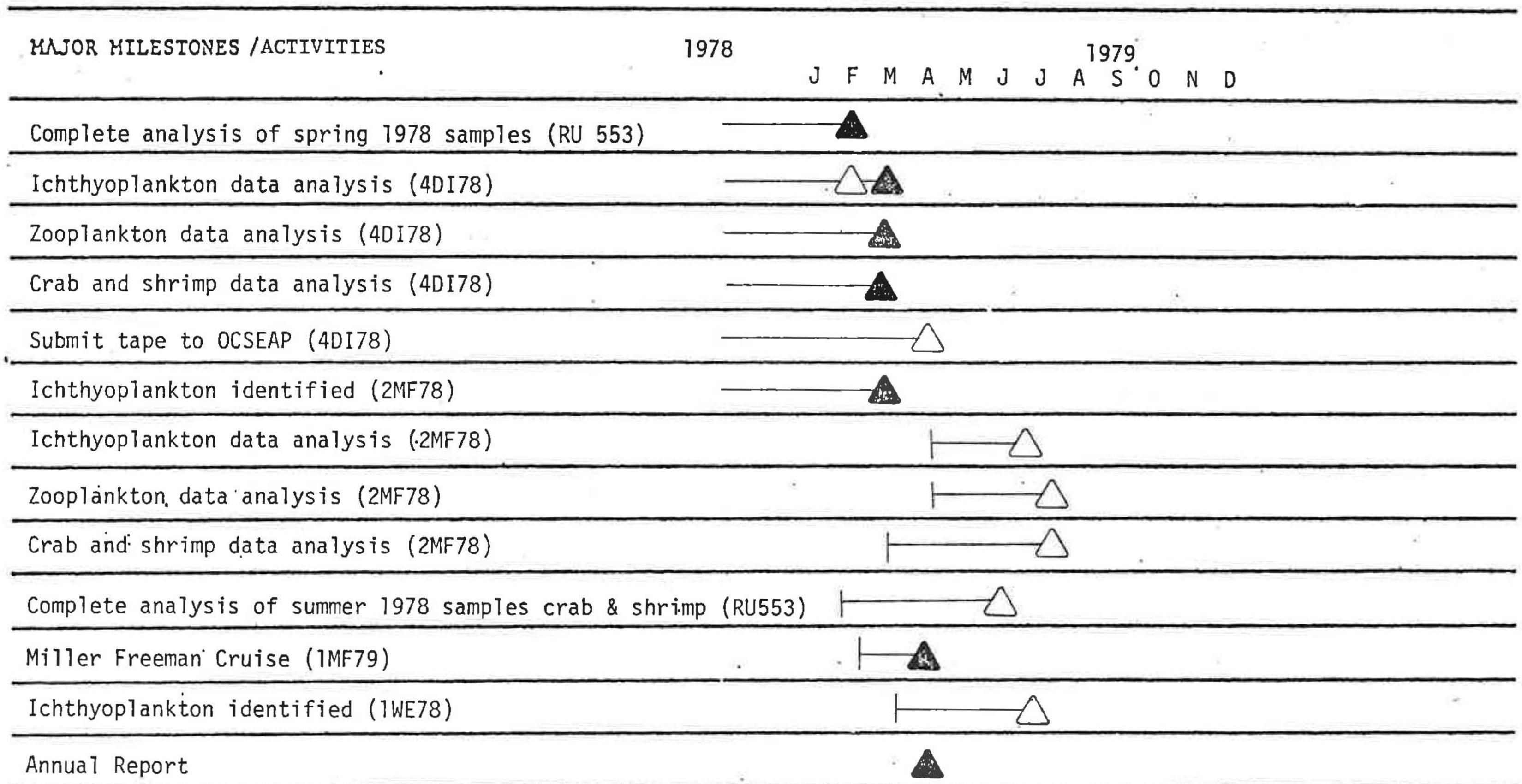


Table 8.(contd)--Major milestone or activity chart for RU 551

MILESTONE CHART

|- Start

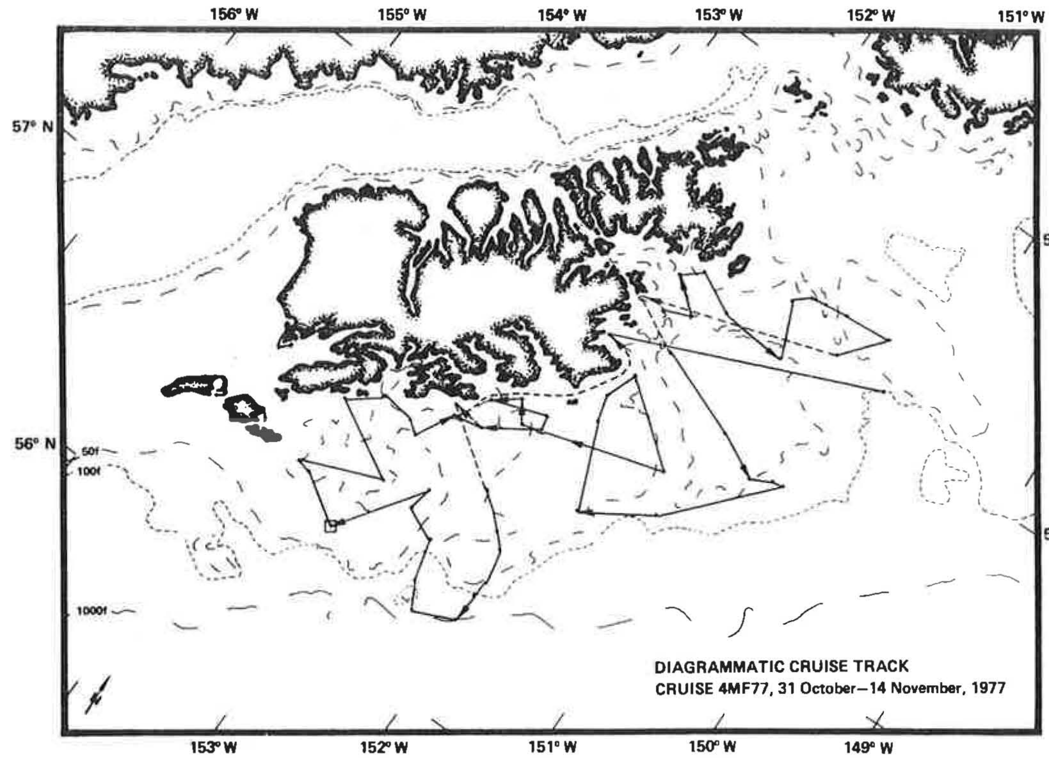
△- Planned Completion Date

▲- Actual Completion Date (to be used on quarterly updates)

RU # 551 PI: Dunn, Kendall, Wolotira

Major Milestones: Reporting, and other significant contractual requirements; periods of field work; workshops; etc.

MAJOR MILESTONES/ACTIVITIES	1978	1979 J	F	M	A	M	J	J	A	S	O	N	D
Ichthyoplankton data analysis (1WE78)							|—	—	△				
Submit tape to OCSEAP (2MF78)							△						
Zooplankton data analysis (1WE78)					|—	—	—	△					
Crab and shrimp data analysis (1WE78)					|—	—	—	—	△				
Complete analysis fall 1978 crab & shrimp samples (RU553)					|—	—	—	—	△				
Submit tape to OCSEAP (1WE78)									△				
Ichthyoplankton identified (1MF79)								|—	—	—	△		
Ichthyoplankton data analysis (1MF79)											|—	—	△
Zooplankton data analysis (1MF79)										|—	—	—	△
Crab and shrimp data analysis (1WE78)									|—	—	—	—	△
Submit quarterly report (Synthesize first four cruises)											△		
Complete analysis winter 1979 crab & shrimp samples (RU553)											|—	—	△
Submit Tape to OCSEAP (1MF79)													△
Final Report													△



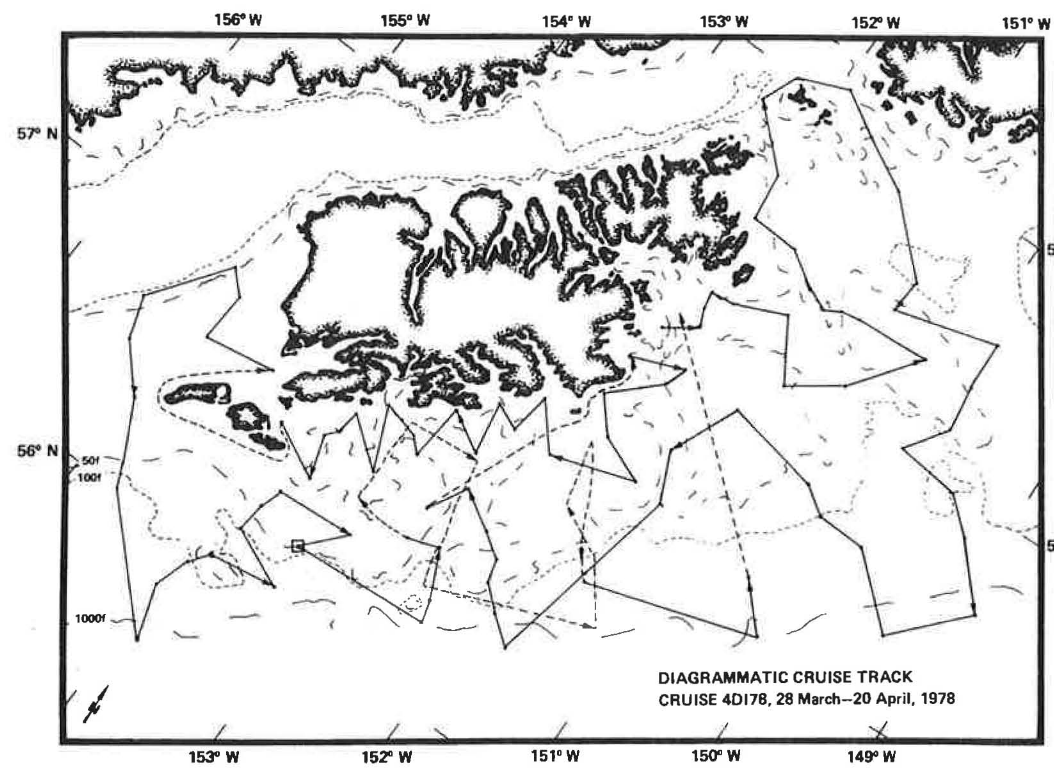
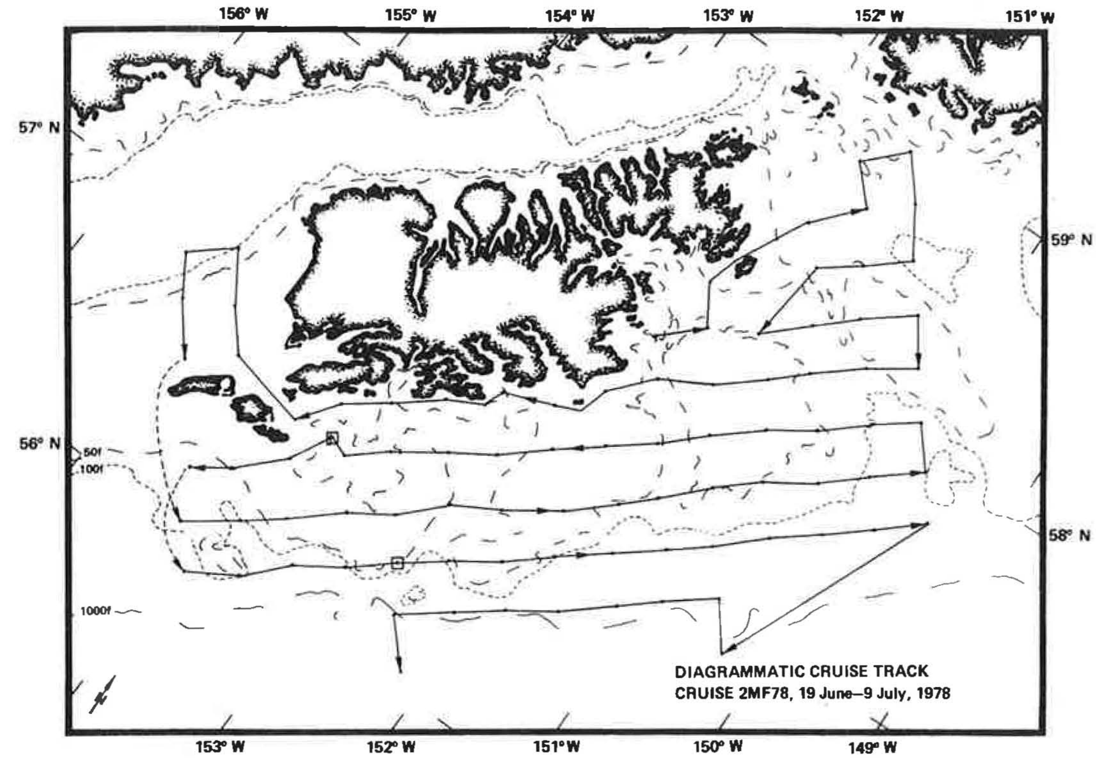


Figure 1.--Cruise track, Fall, 1977
Figure 2.--Cruise track, Spring, 1978



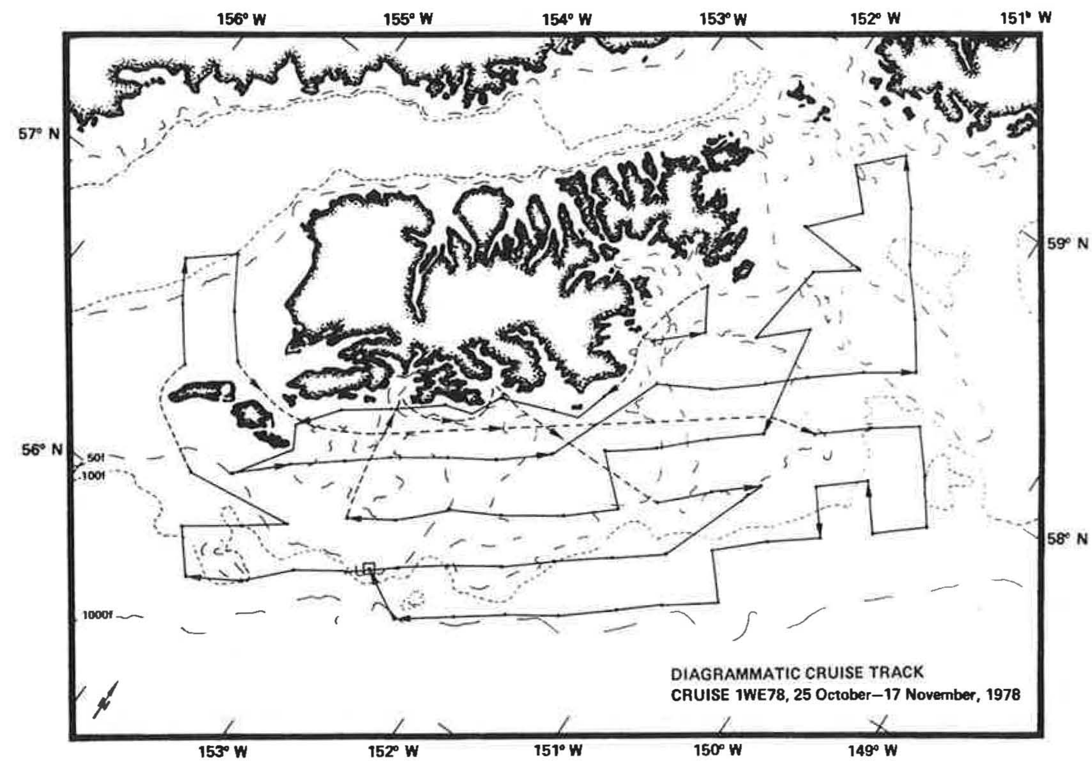
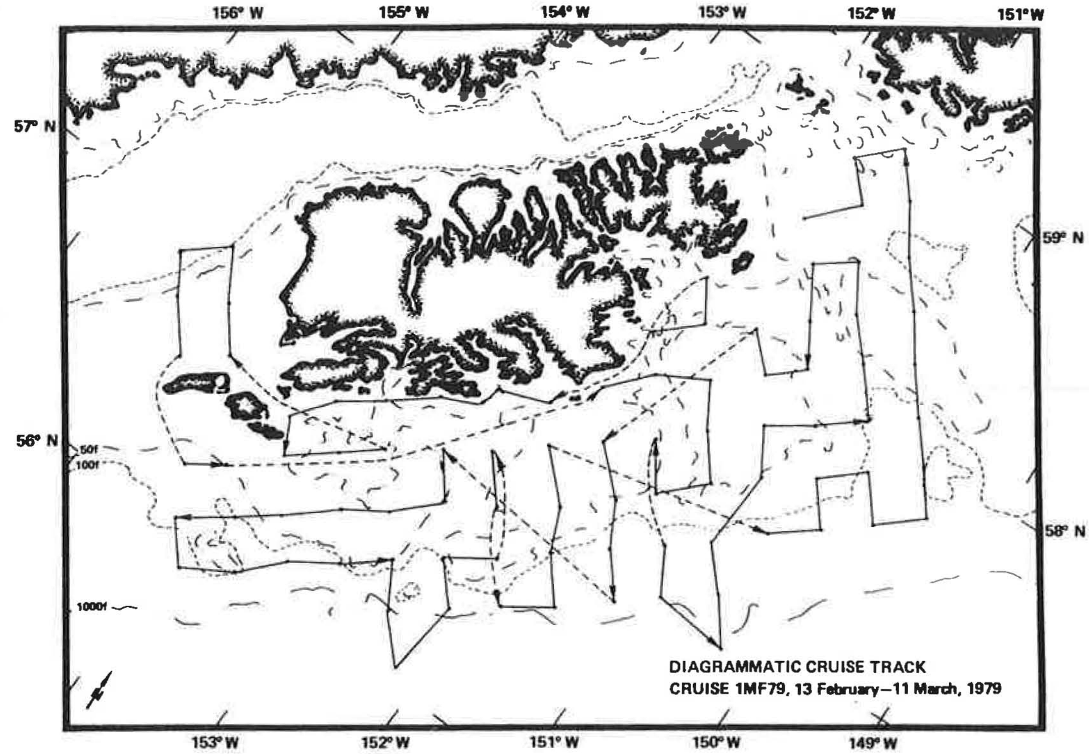


Figure 3.--Cruise track, Summer, 1978
Figure 4.--Cruise track, Fall, 1978



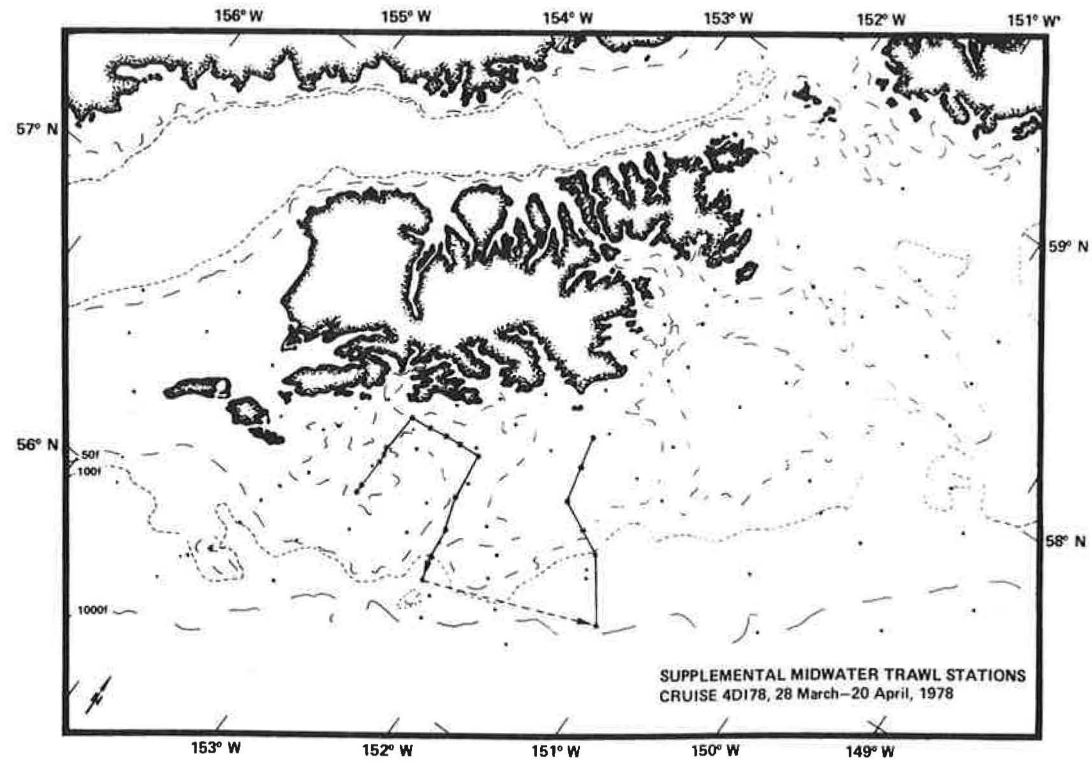
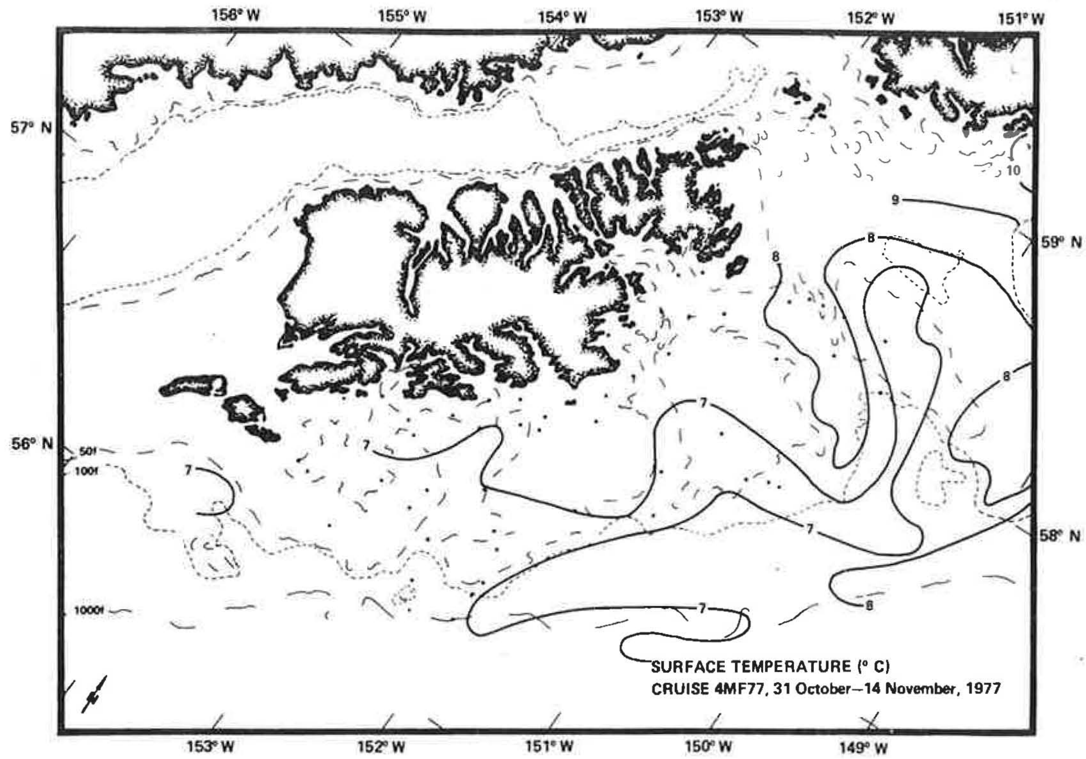


Figure 5.--Cruise track, Winter, 1979
Figure 6.--Supplemental midwater trawl stations, Spring, 1978



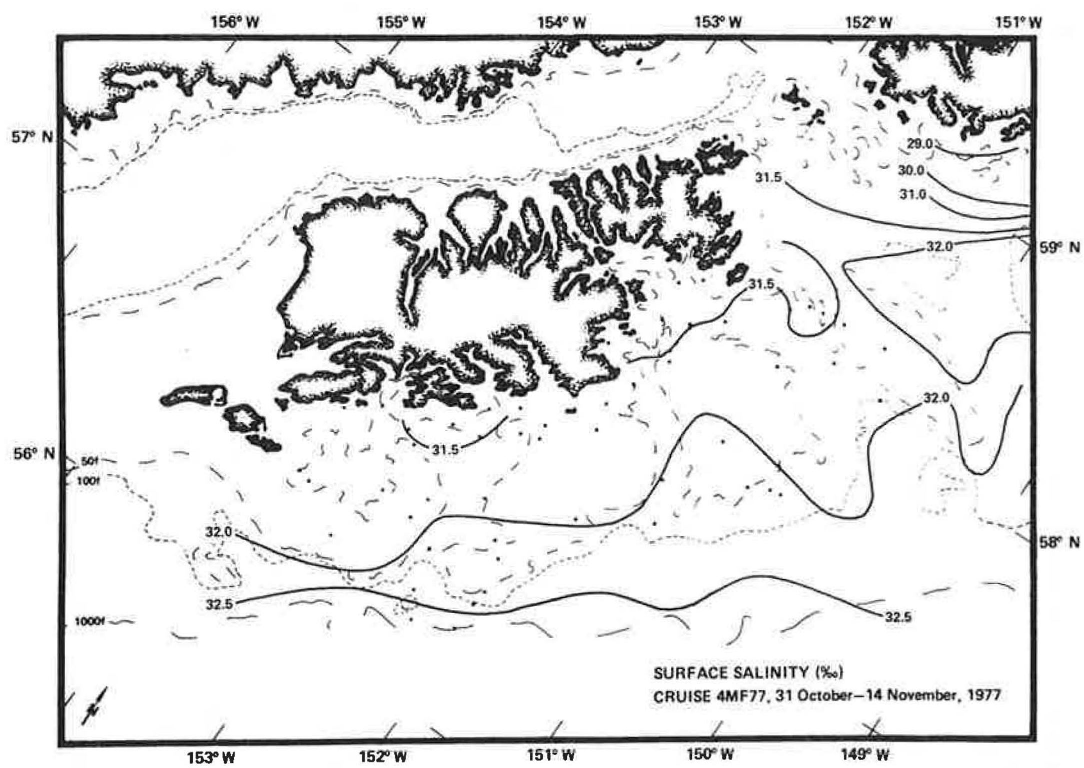
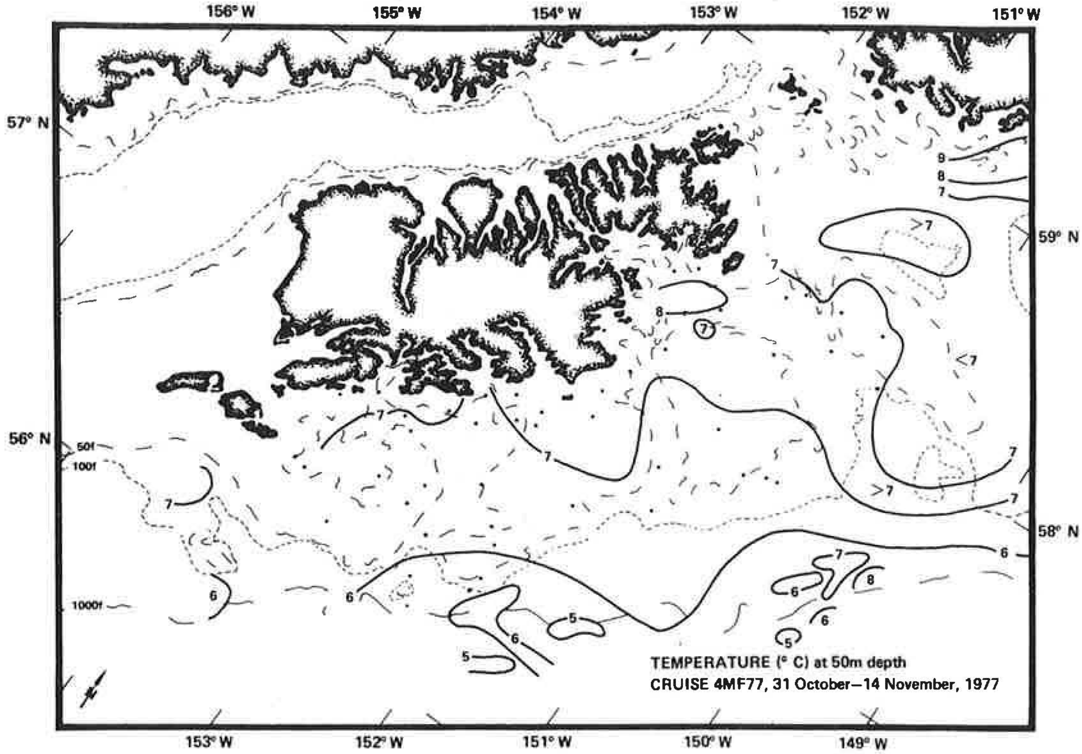


Figure 7.--Surface temperature (^{o}C), Fall, 1977 (Data from Schumacher, et al., In Press.)

Figure 8.--Surface salinity (‰), Fall, 1977 (Data from Schumacher, et al., In Press.)



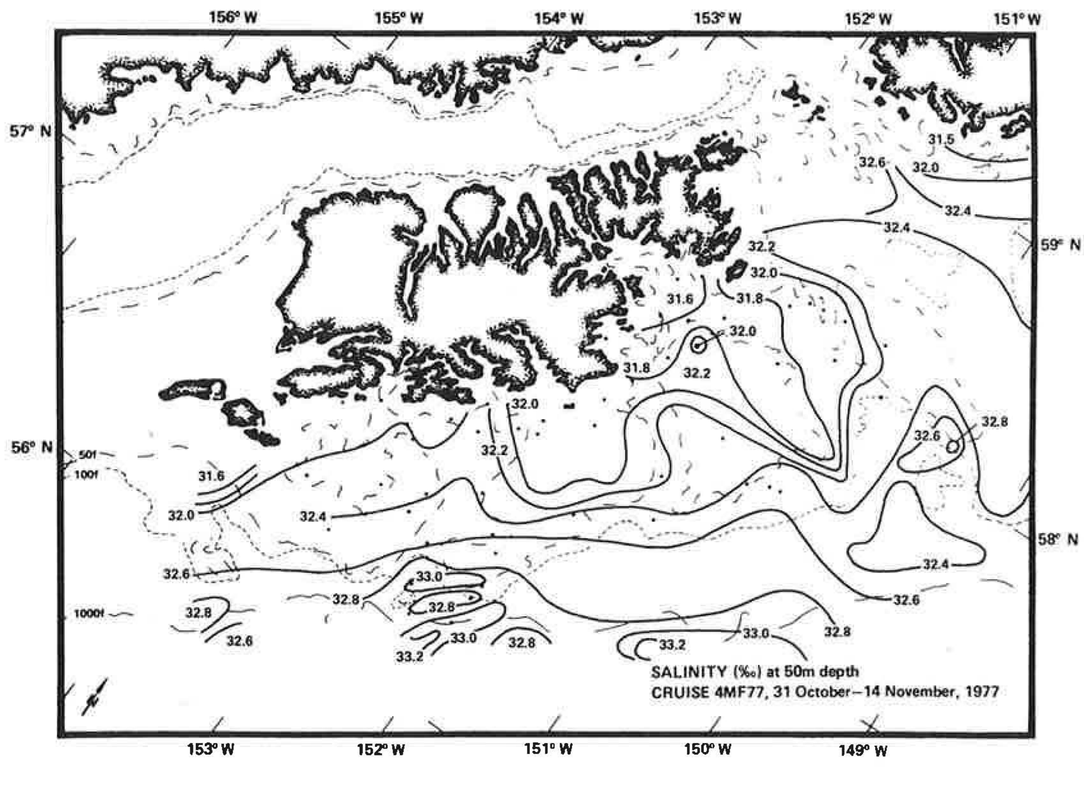
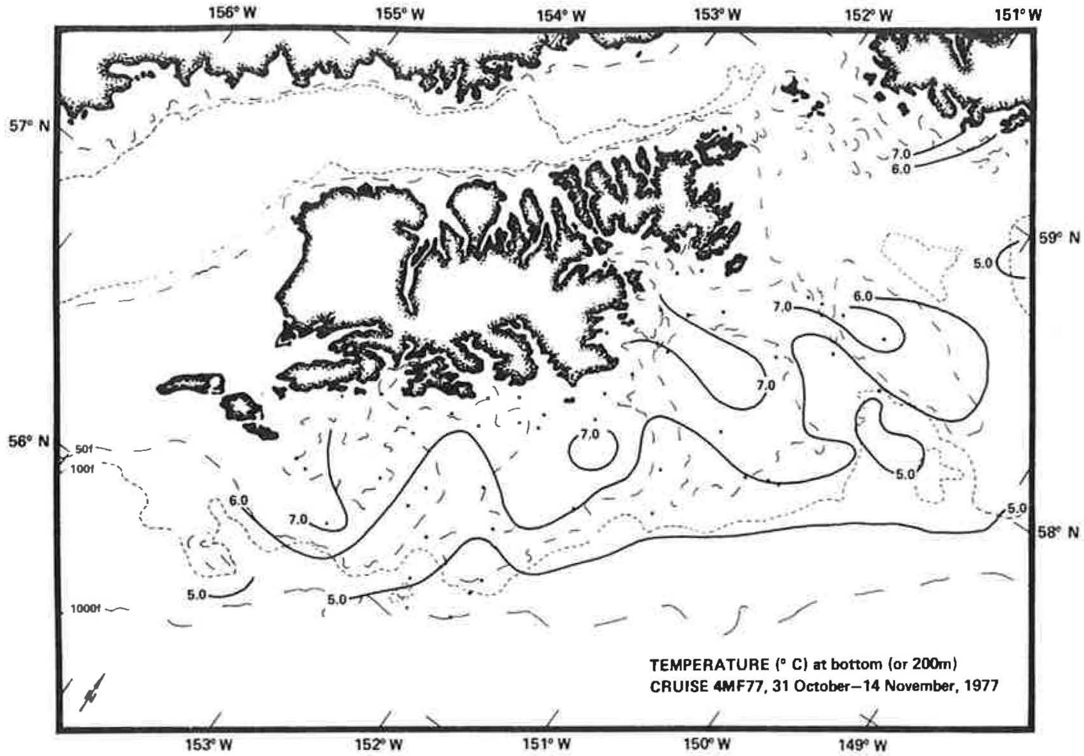


Figure 9.--Temperature (^{o}C) at 50 m depth, Fall, 1977 (Data from Schumacher, et al., In Press.)

Figure 10.--Salinity (‰) at 50 m depth, Fall, 1977 (Data from Schumacher, et al., In Press.)



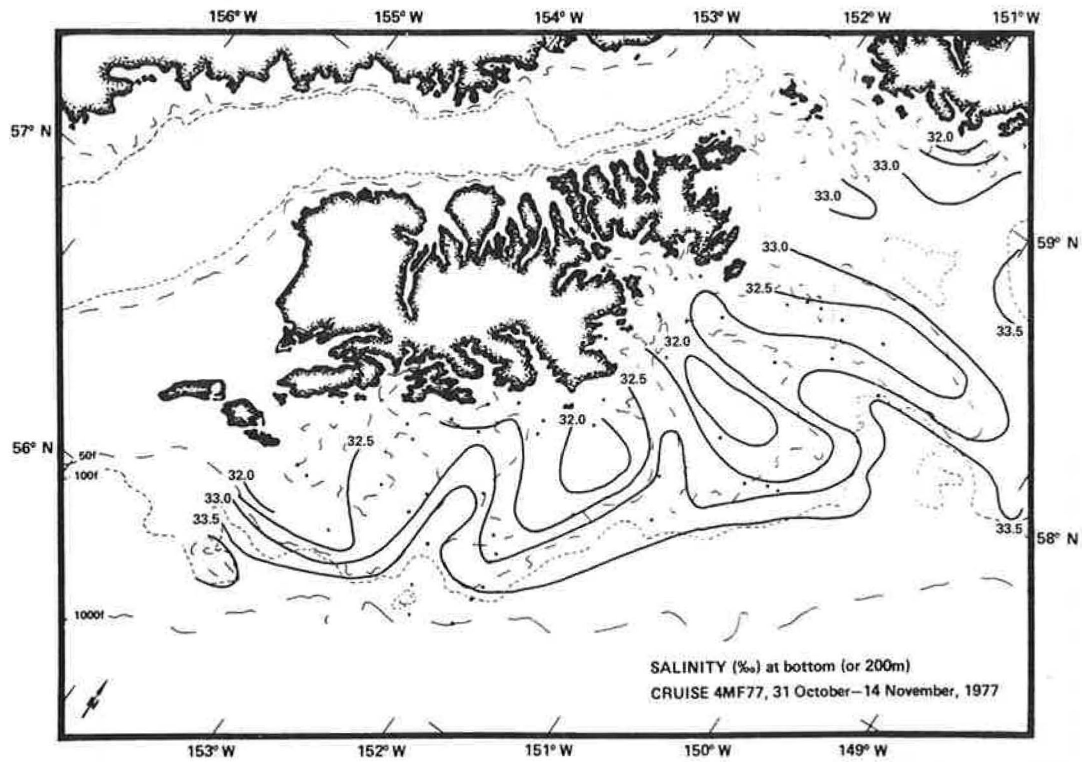
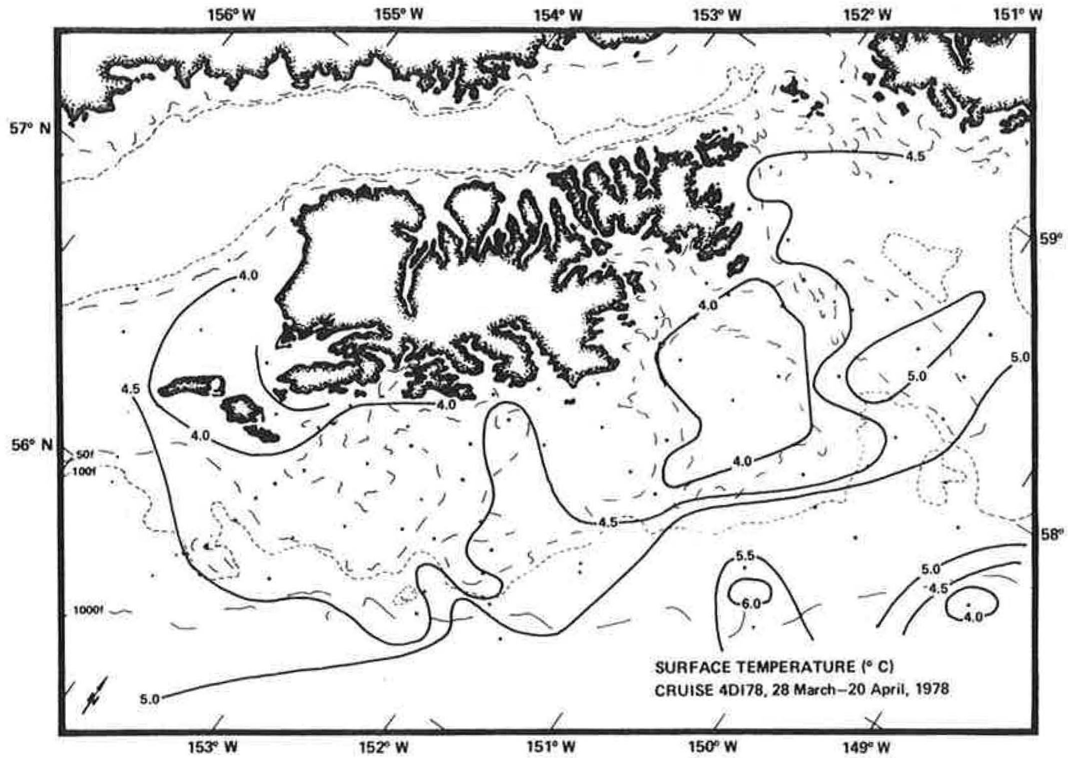


Figure 11.--Temperature (°C) at bottom (or 200 m), Fall, 1977 (Data from Schumacher, et al., In Press.)

Figure 12.--Salinity (‰) at bottom (or 200 m), Fall, 1977 (Data from Schumacher, et al., In Press.)



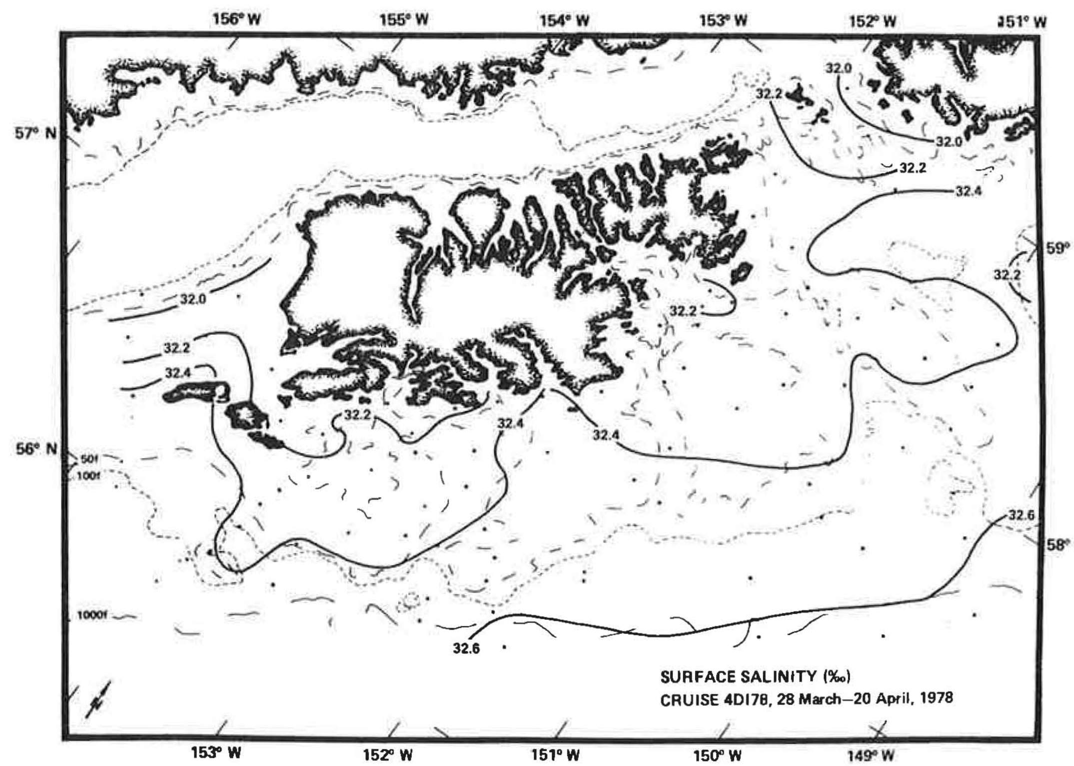
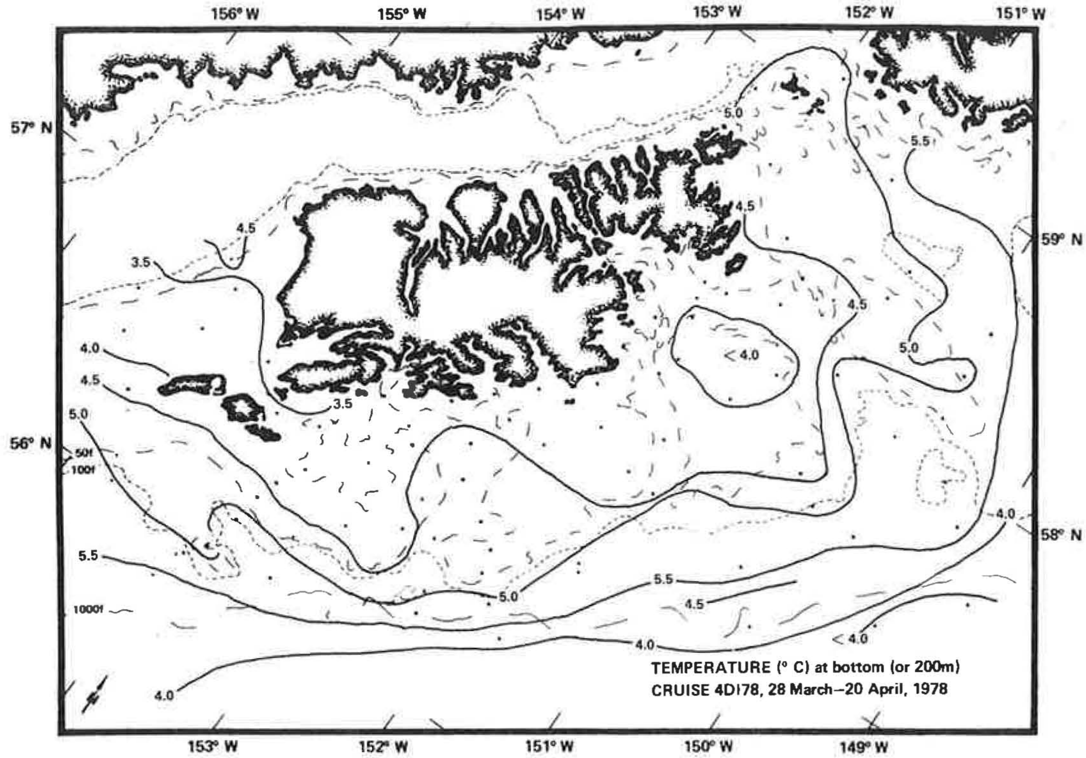


Figure 13.--Surface temperature (°C), Spring, 1978
Figure 14.--Surface salinity (‰), Spring 1978



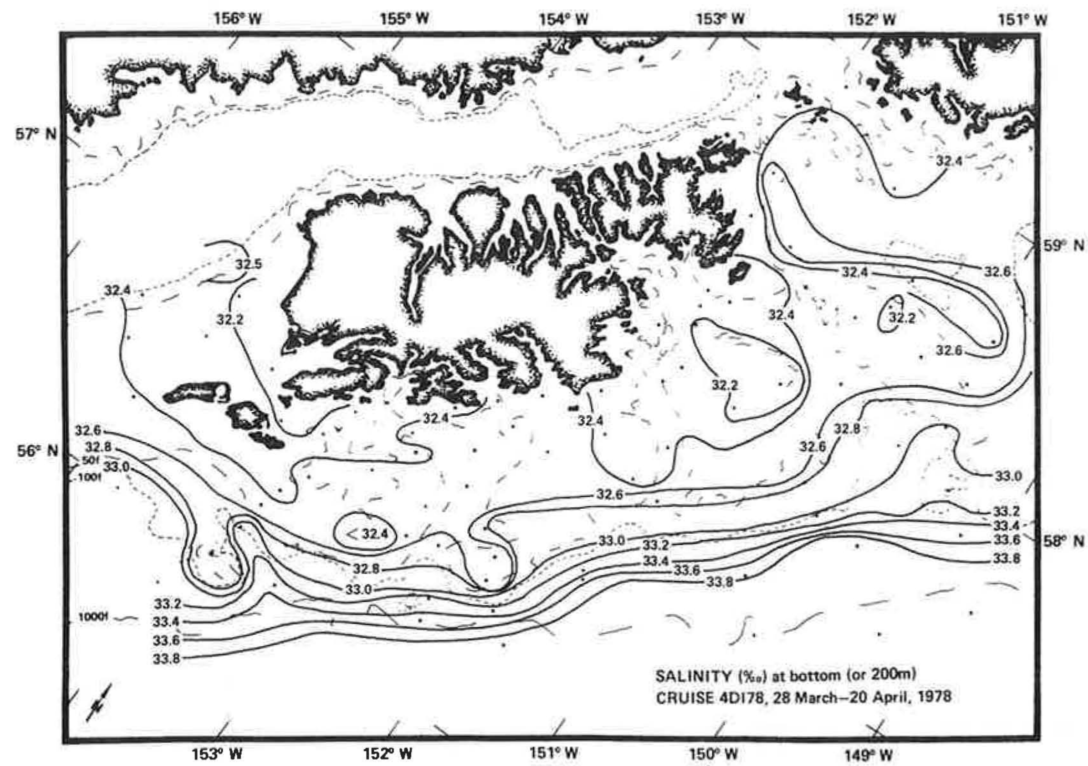


Figure 15.--Temperature (^{o}C) at bottom (or 200 m), Spring, 1978
Figure 16.--Salinity (‰) at bottom (or 200 m), Spring, 1978

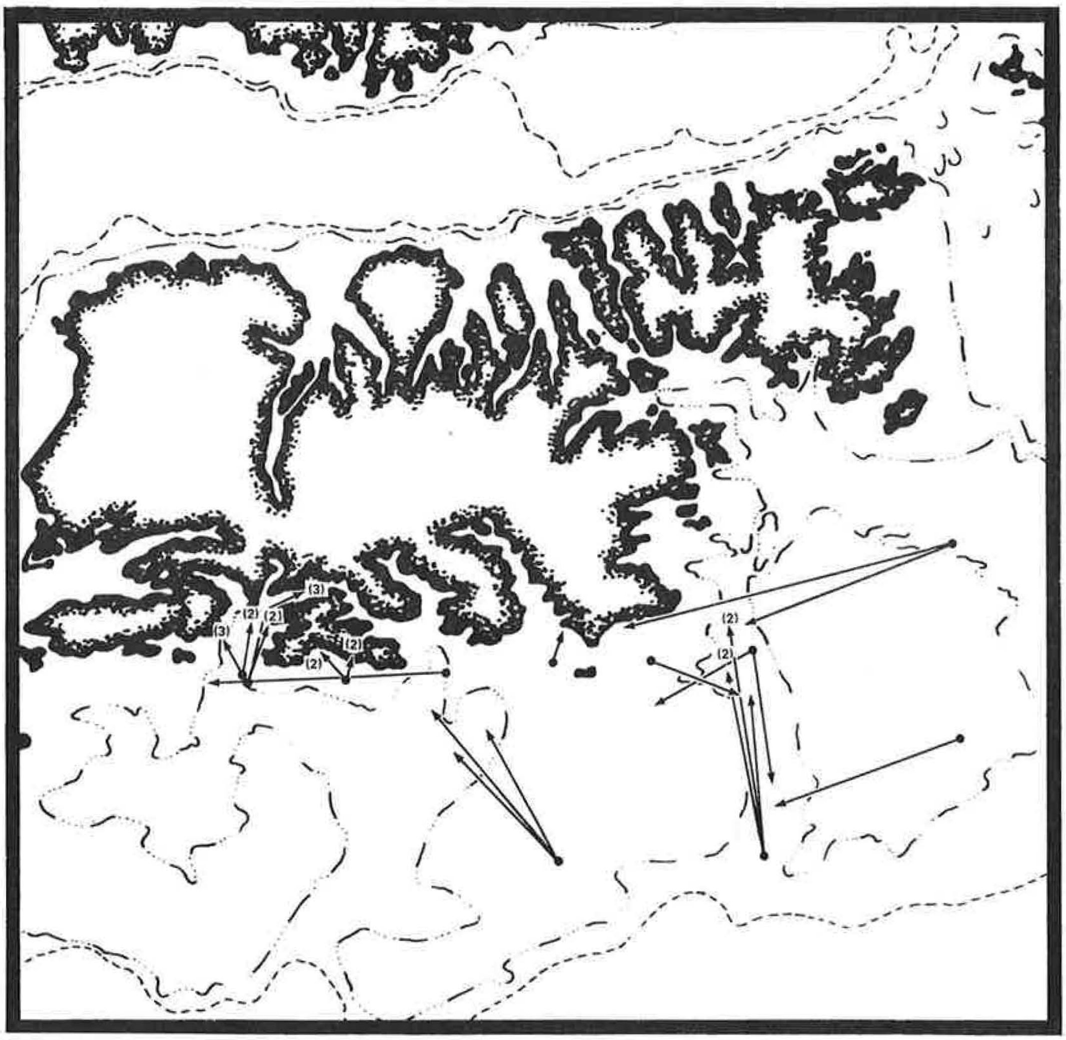


Figure 17.--Sea bed drifter recoveries from releases made in November, 1977 through November, 1978

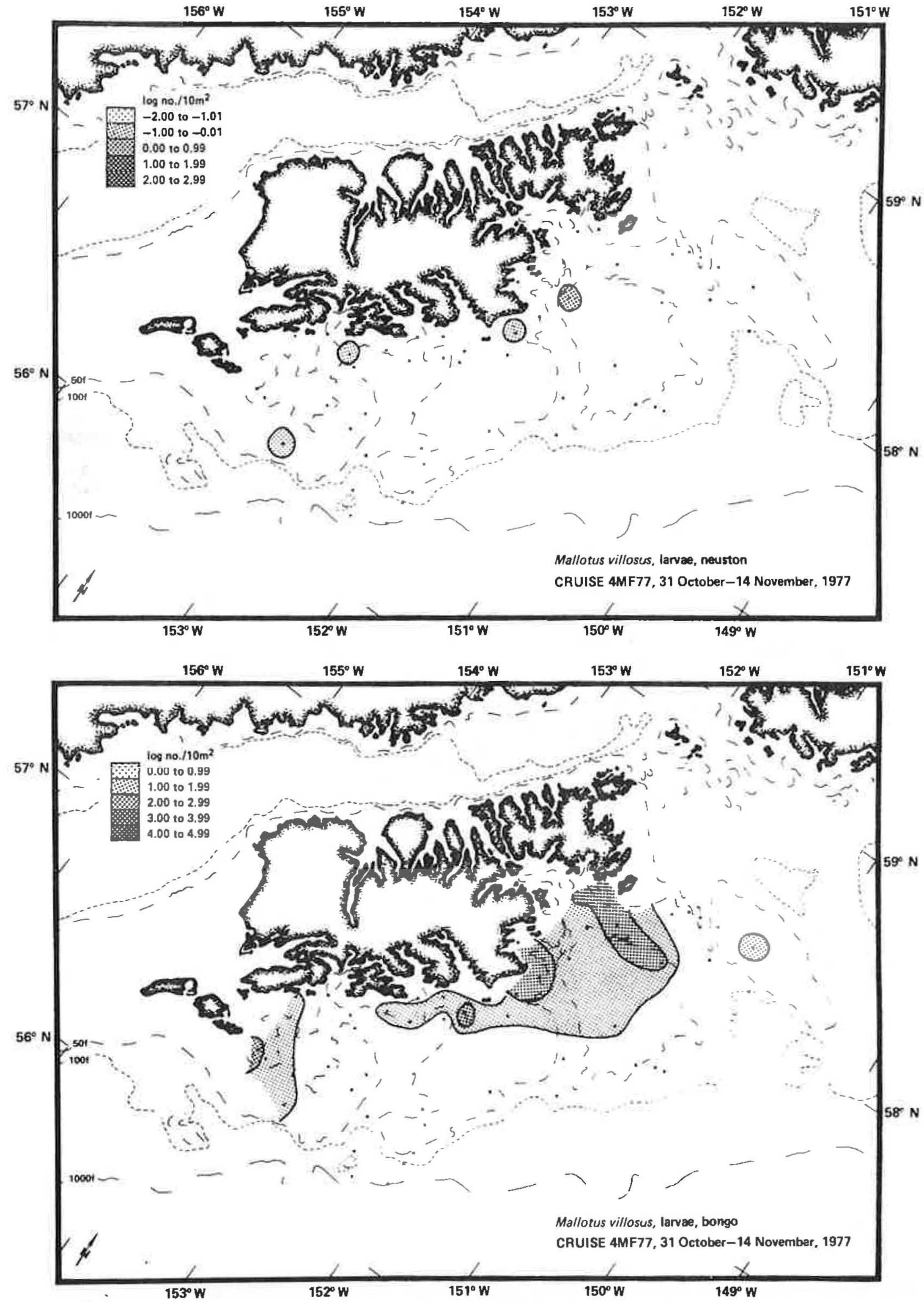


Figure 18.--Distribution and abundance of Mallotus villosus larvae in neuston (top) and bongo (bottom) tows from the Fall cruise.

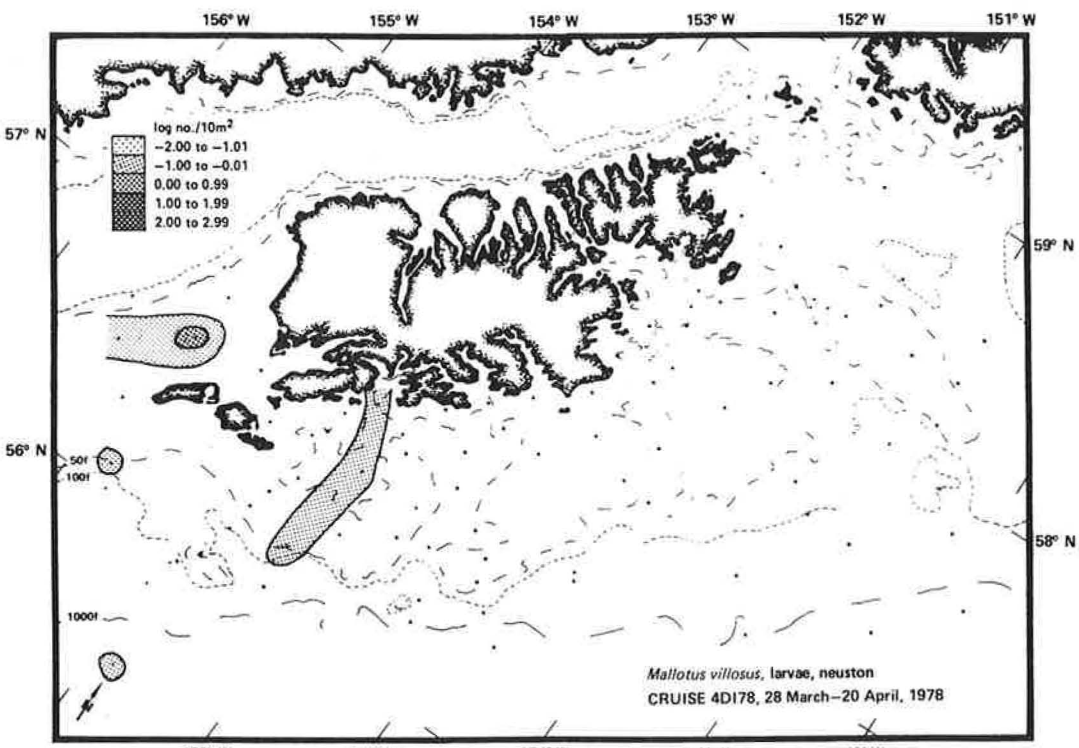


Figure 19.--Distribution and abundance of Mallotus villosus larvae in neuston tows from the Spring cruise.

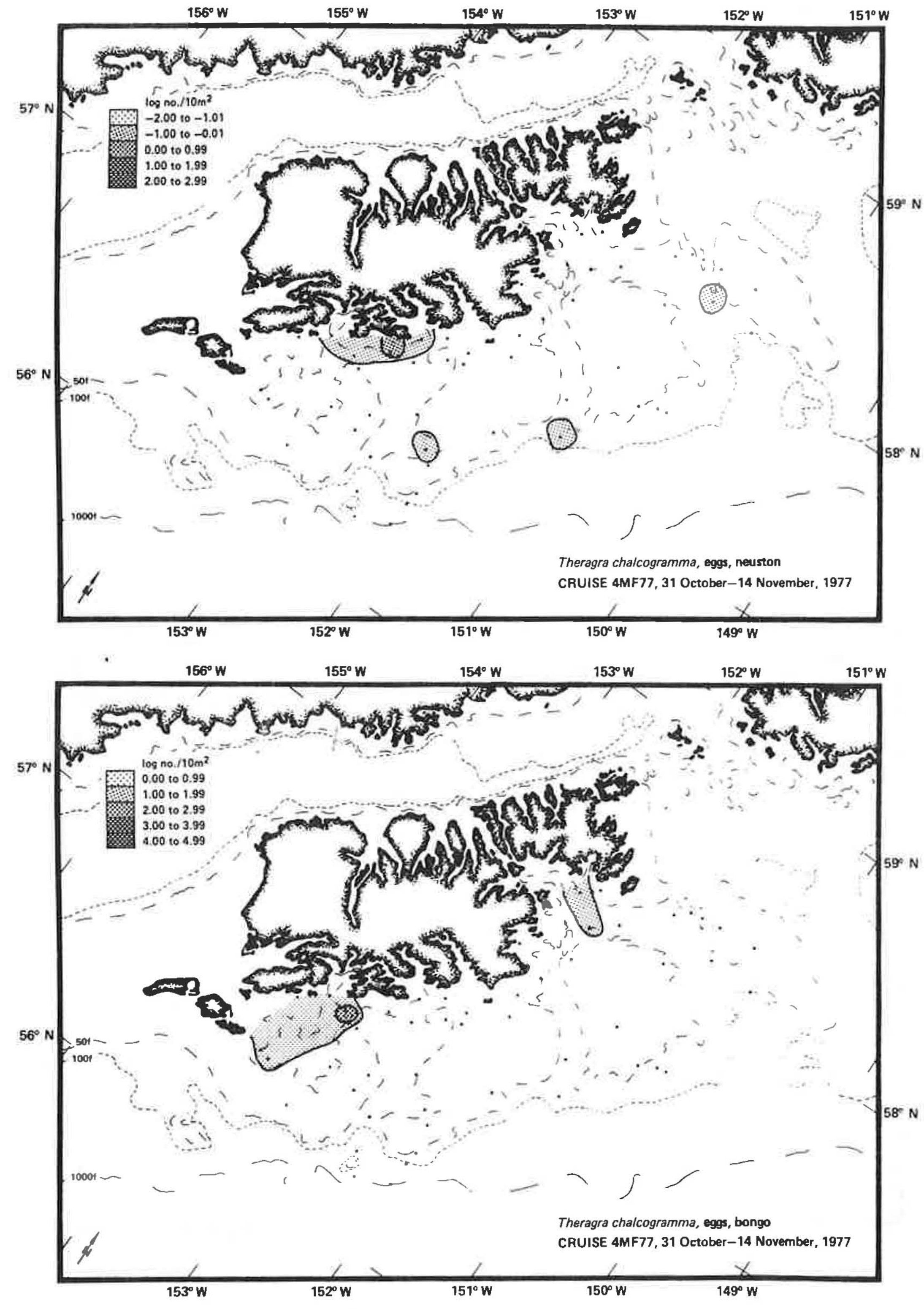


Figure 20.--Distribution and abundance of Theragra chalcogramma eggs in neuston (top) and bongo (bottom) tows from the Fall cruise.

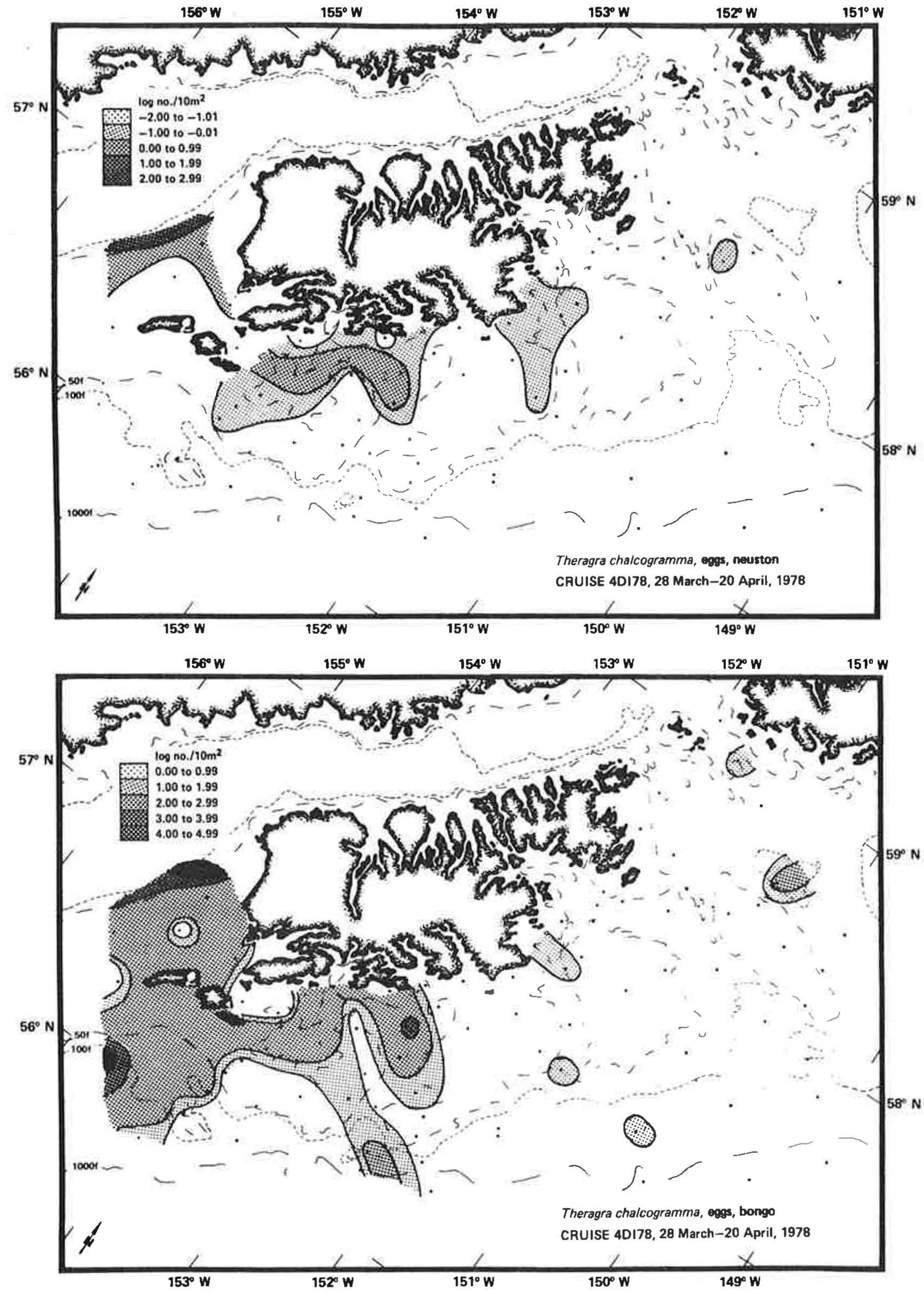


Figure 21.--Distribution and abundance of Theragra chalcogramma eggs in neuston (top) and bongo (bottom) tows from the Spring cruise.

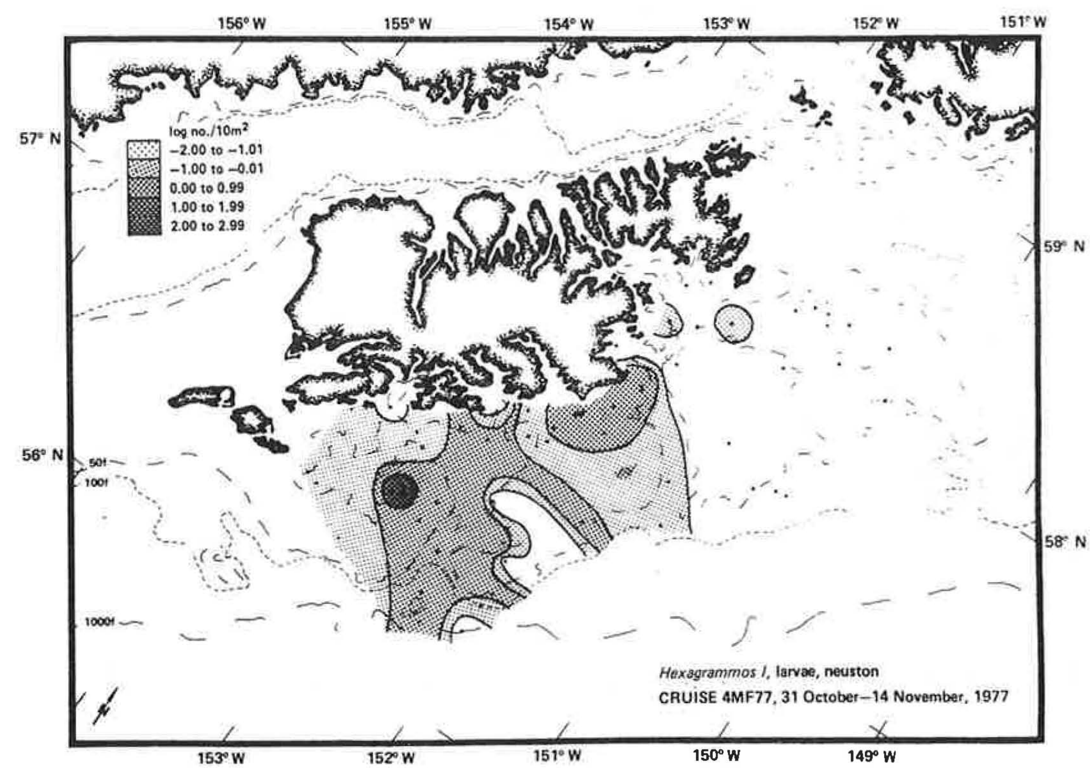
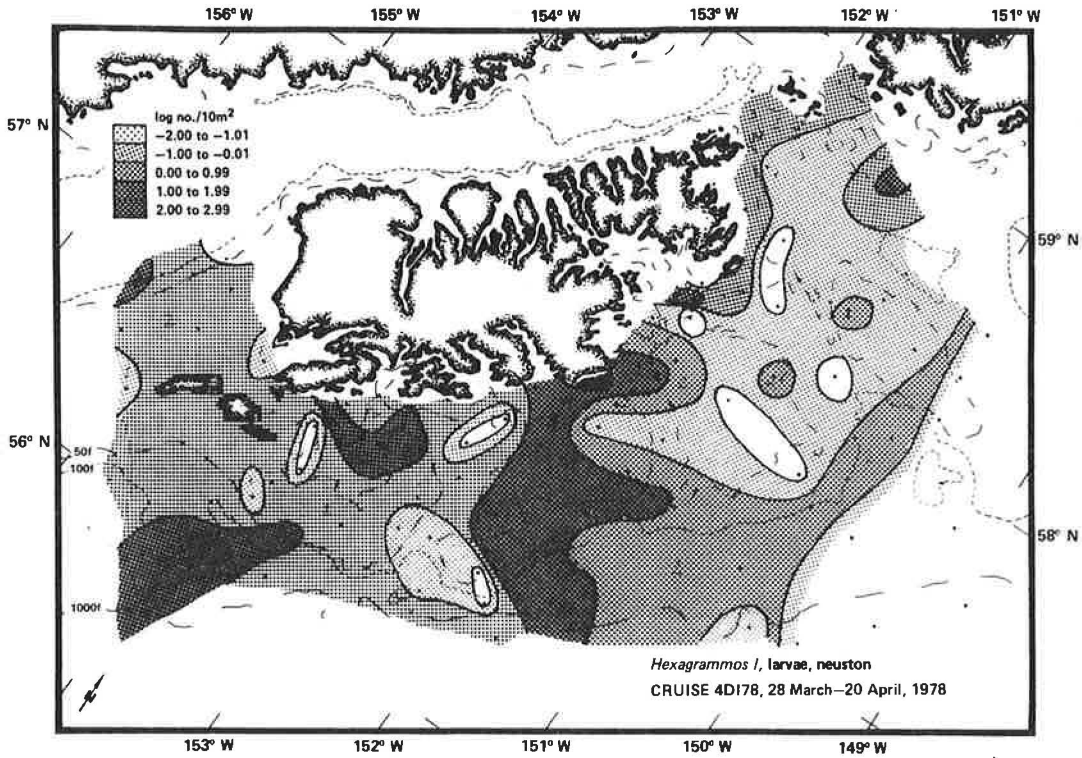


Figure 22 --Distribution and abundance of Hexagrammos I larvae in neuston tows from the Fall cruise.



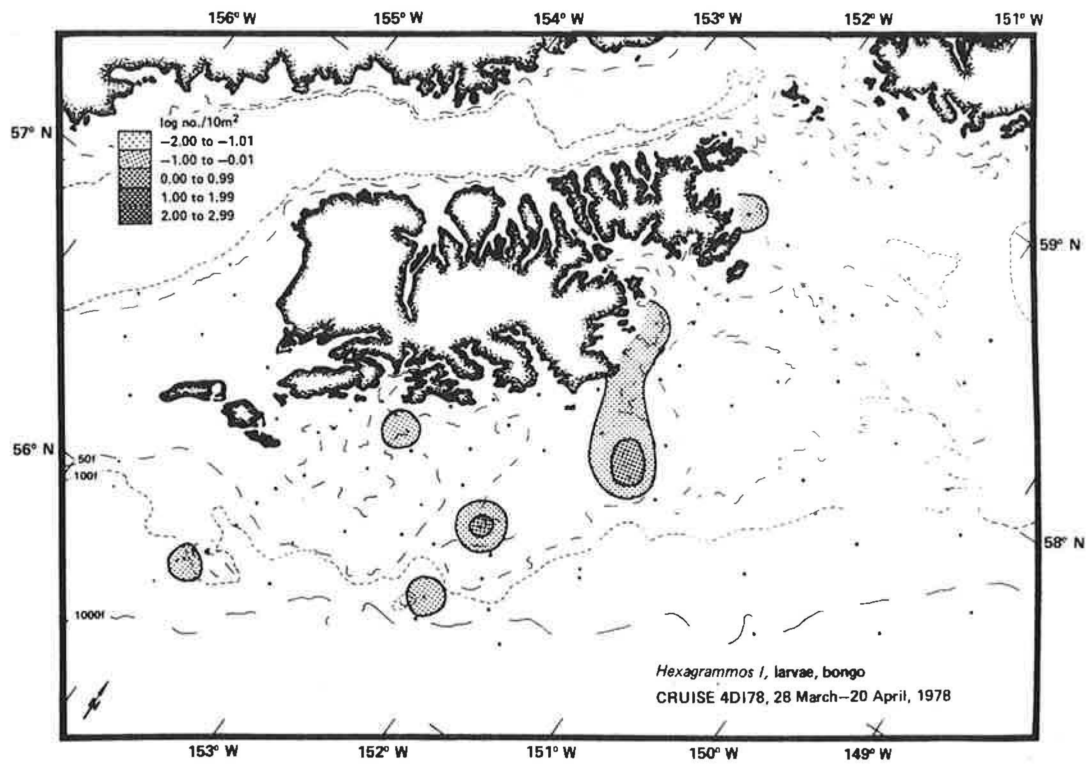


Figure 23.--Distribution and abundance of Hexagrammos I larvae in neuston (top) and bongo (bottom) tows from the Spring cruise.

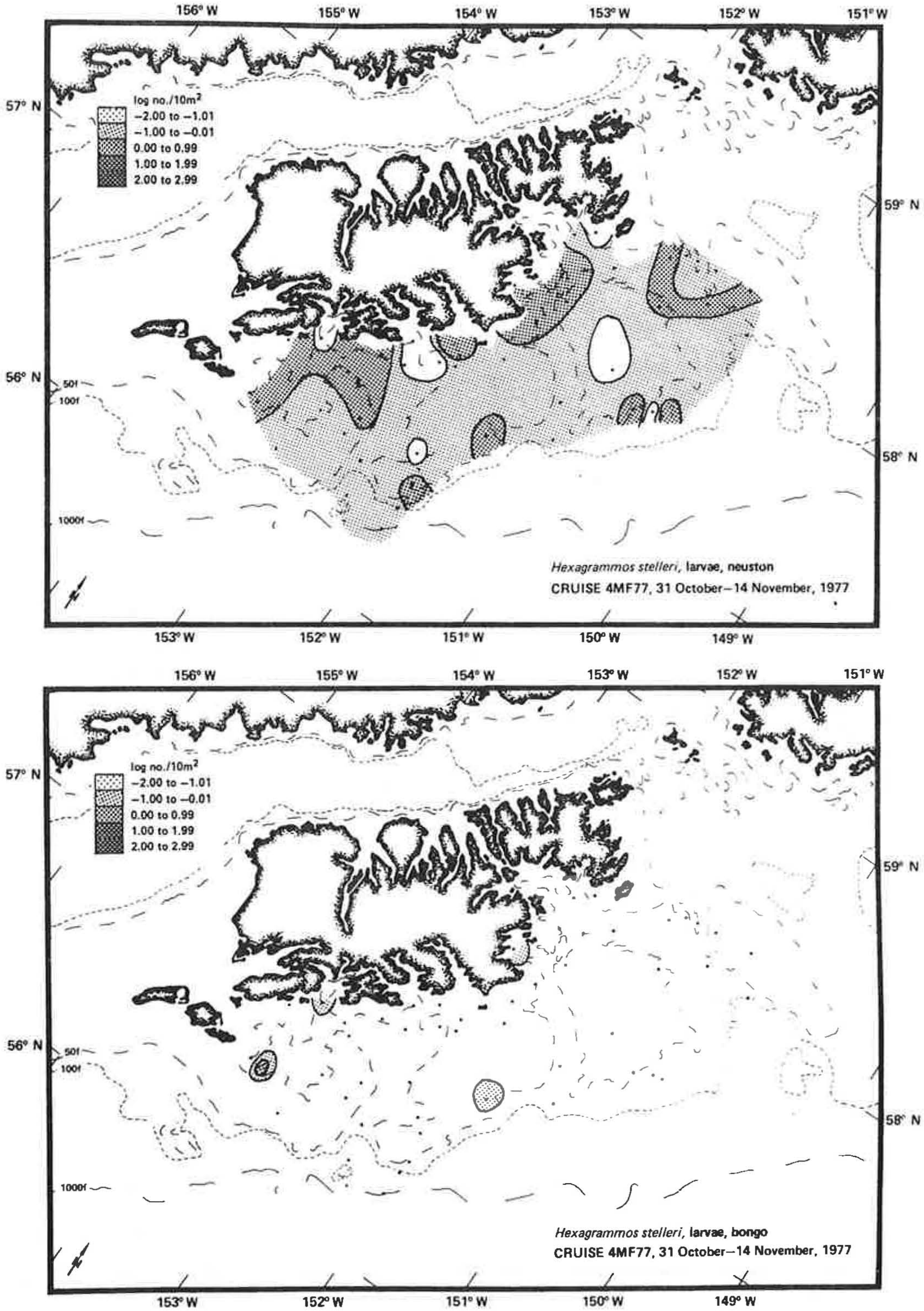


Figure 24.--Distribution and abundance of Hexagrammos stelleri larvae in neuston (top) and bongo (bottom) tows from the Fall cruise.

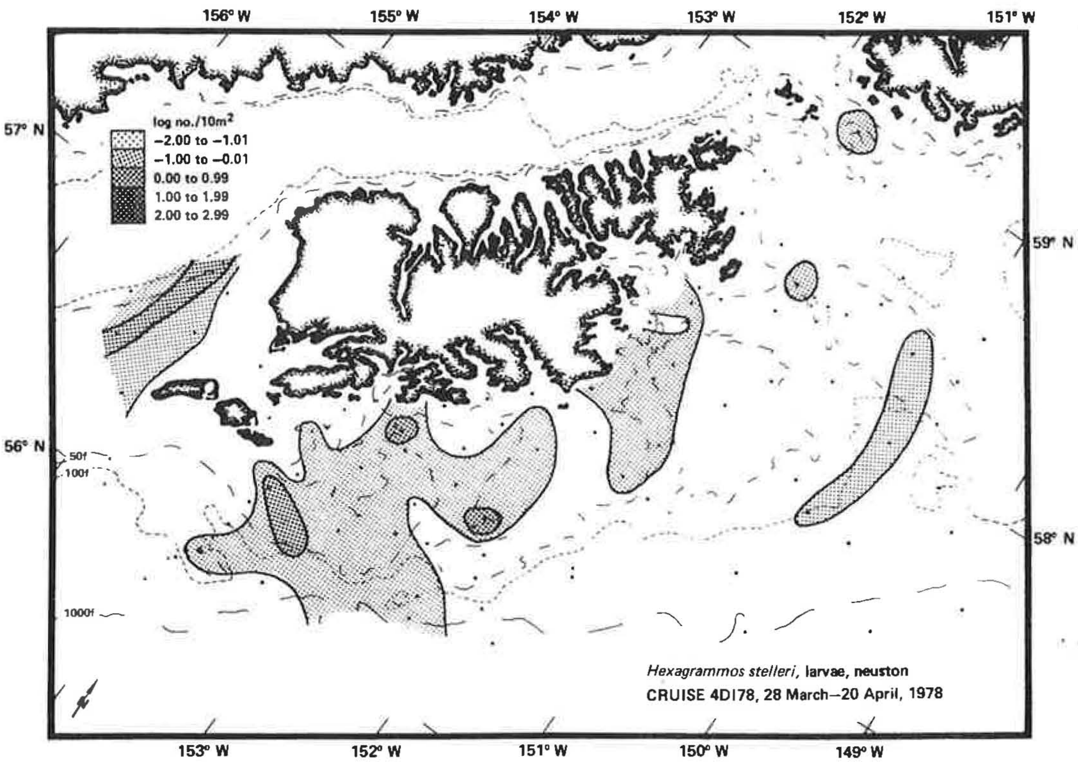


Figure 25.--Distribution and abundance of Hexagrammos stelleri larvae in neuston tows from the Spring cruise.

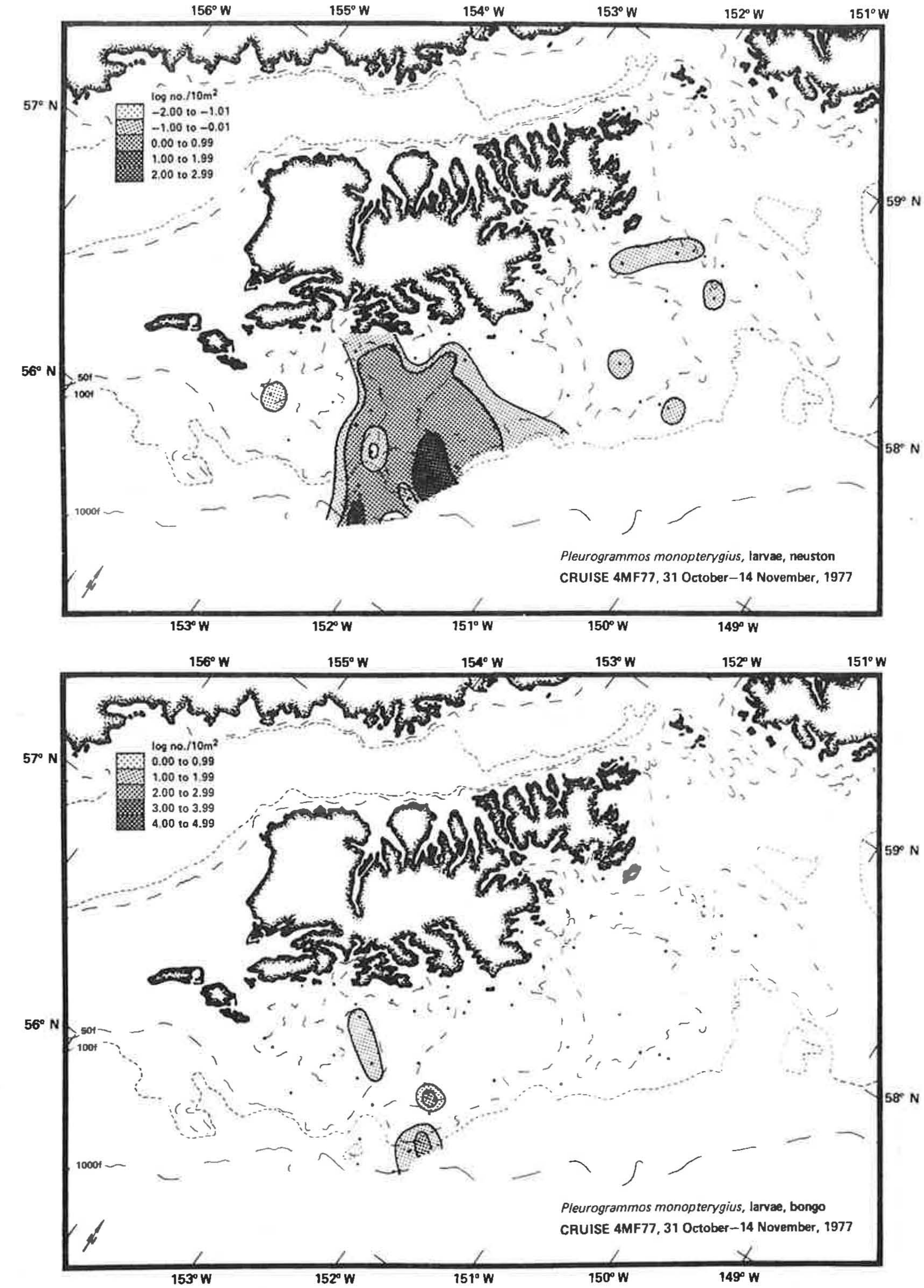


Figure 26.--Distribution and abundance of Pleurogrammos monopterygius larvae in neuston (top) and bongo (bottom) tows from the Fall cruise.

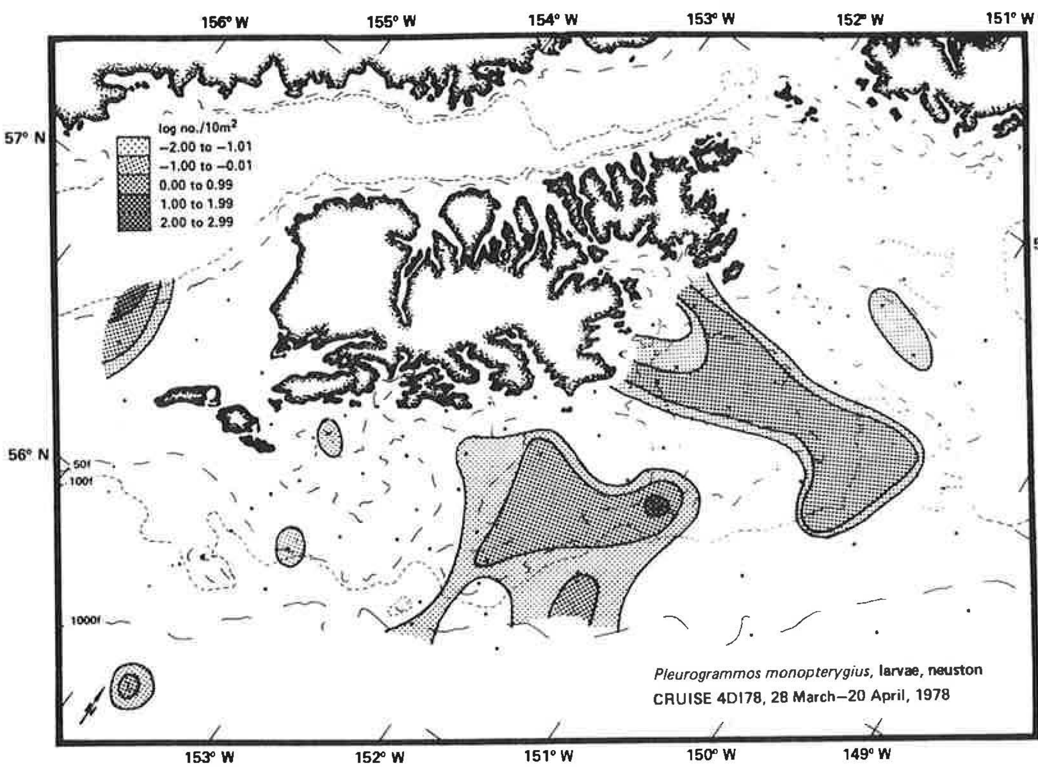
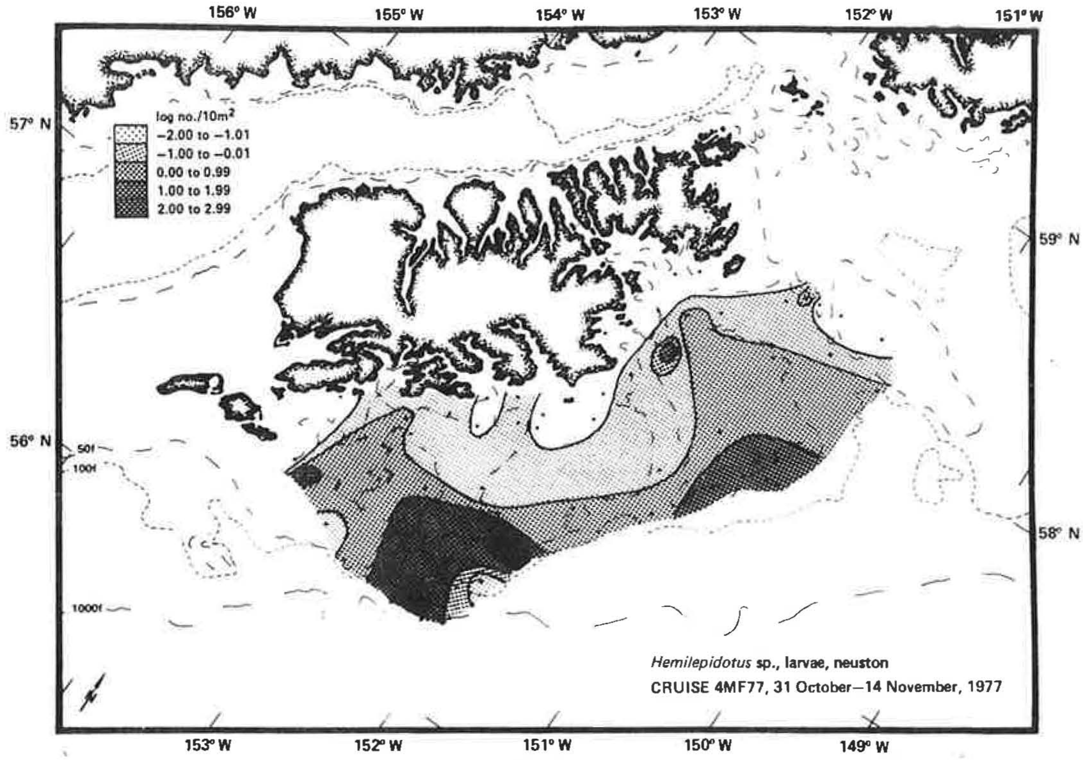


Figure 27.--Distribution and abundance of Pleurogrammos monopterygius larvae in the neuston net from the Spring cruise.



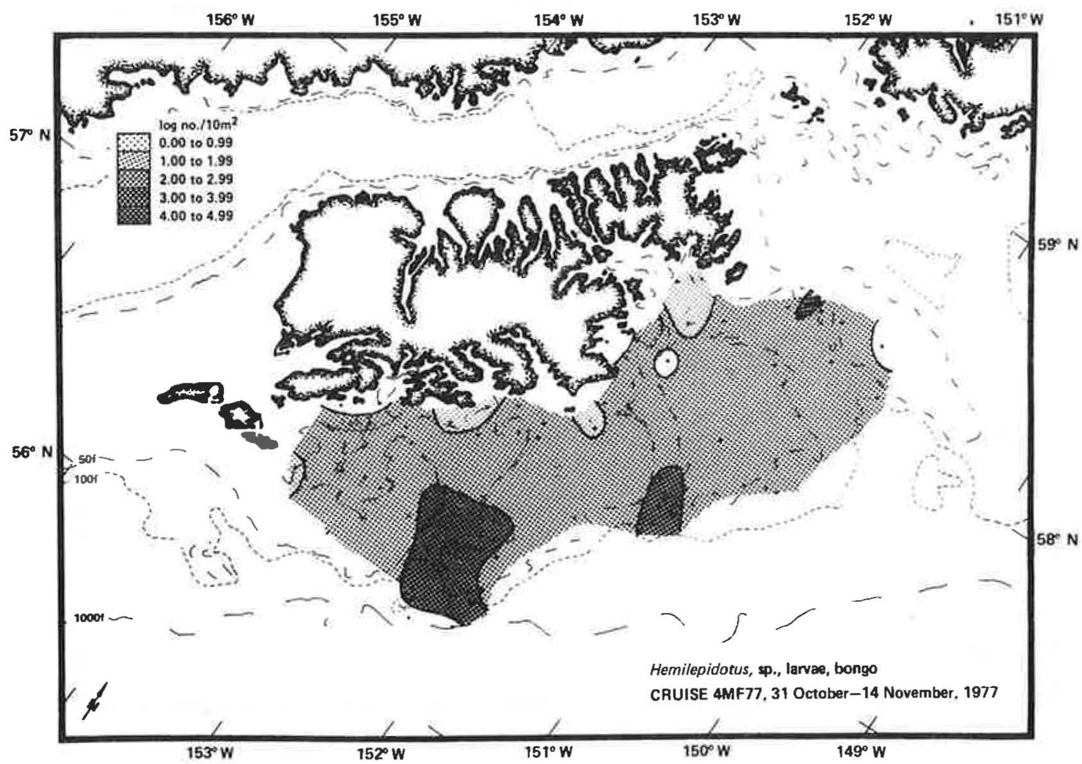


Figure 28.--Distribution and abundance of Hemilepidotus sp. larvae in neuston (top) and bongo (bottom) tows from the Fall cruise.

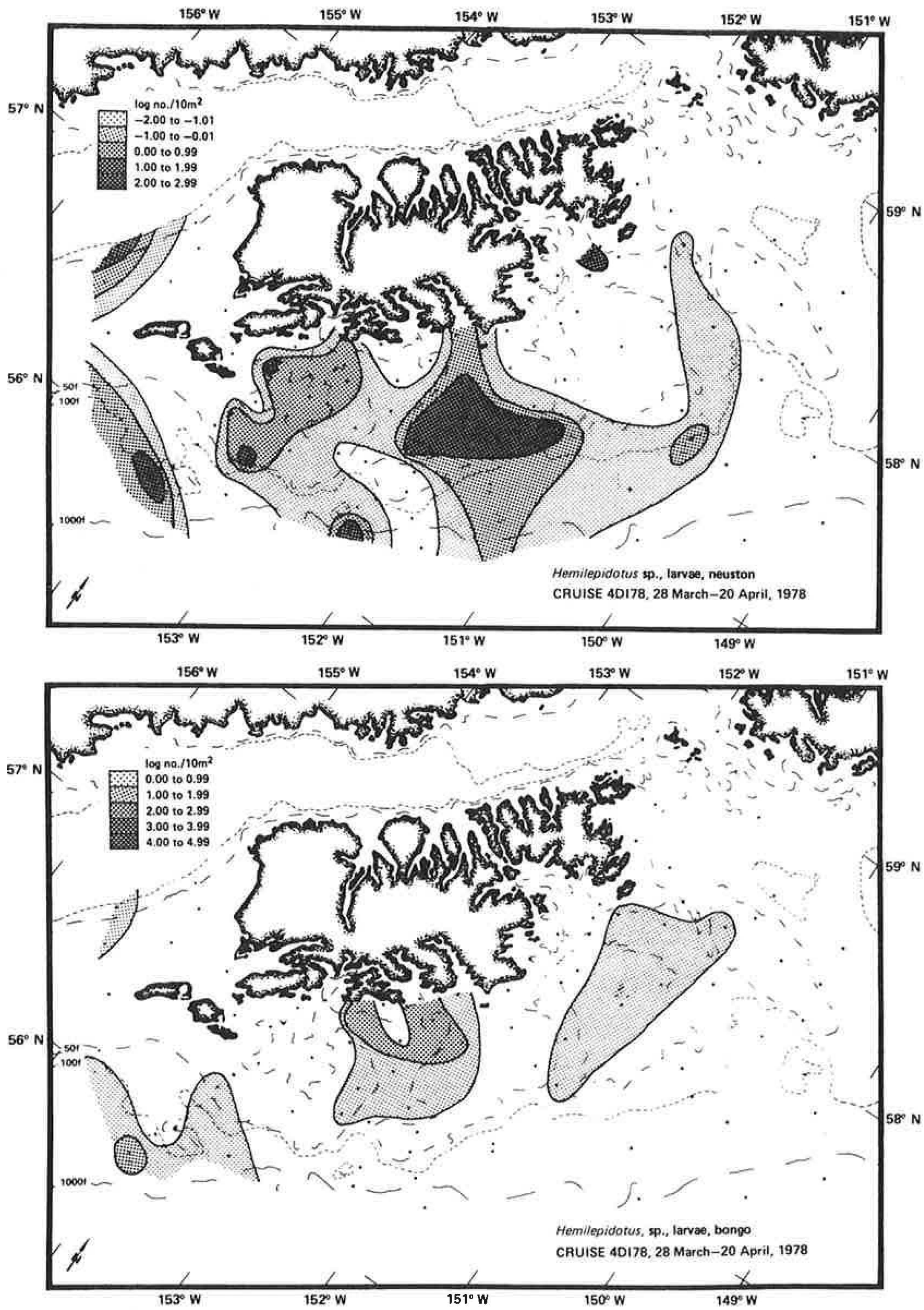


Figure 29.--Distribution and abundance of <u>Hemilepidotus</u> sp. larvae in neuston (top) and bongo (bottom) tows from the Spring cruise.

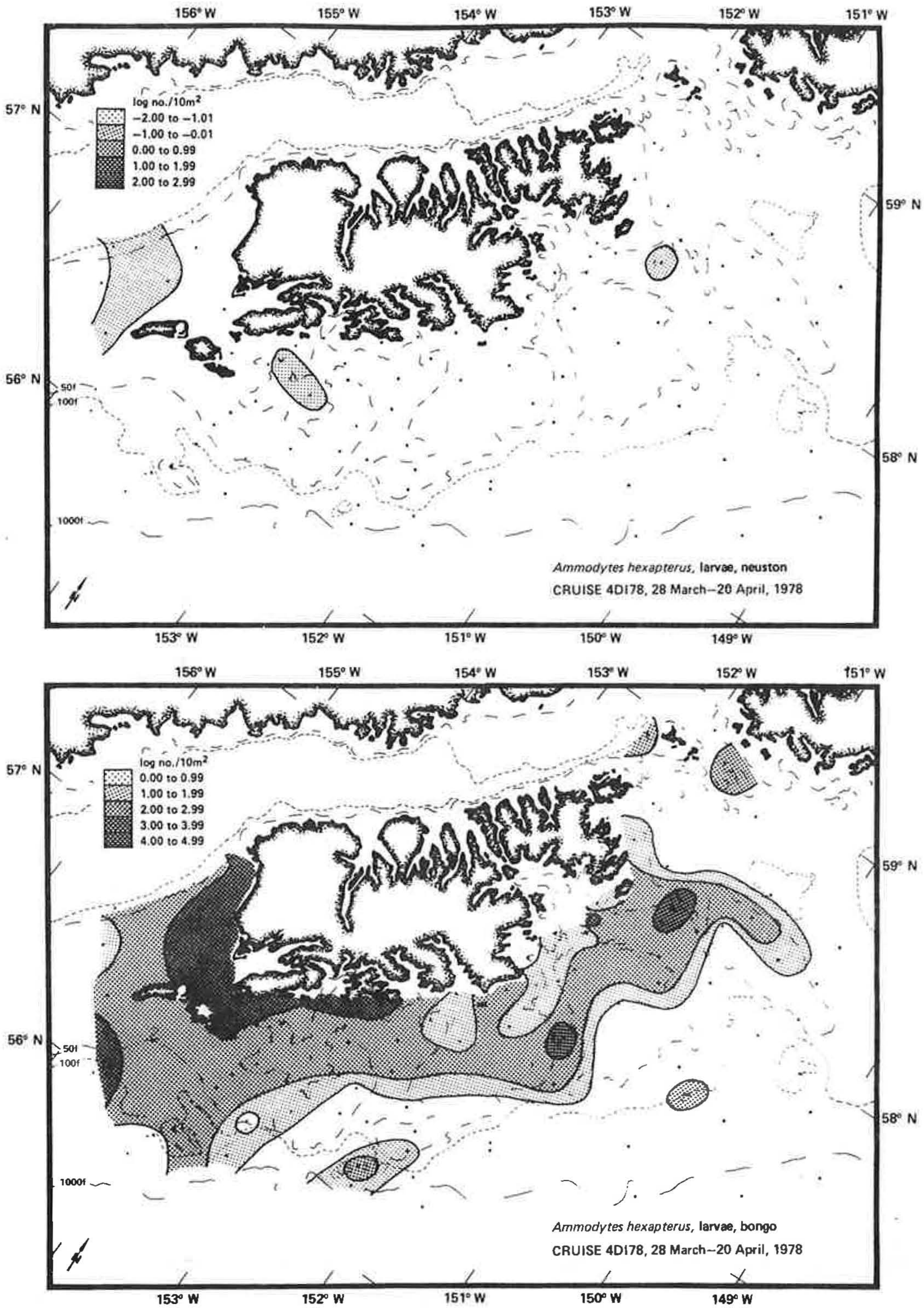


Figure 30.--Distribution and abundance of Ammodytes hexapterus larvae in neuston (top) and bongo (bottom) tows from the Spring cruise.

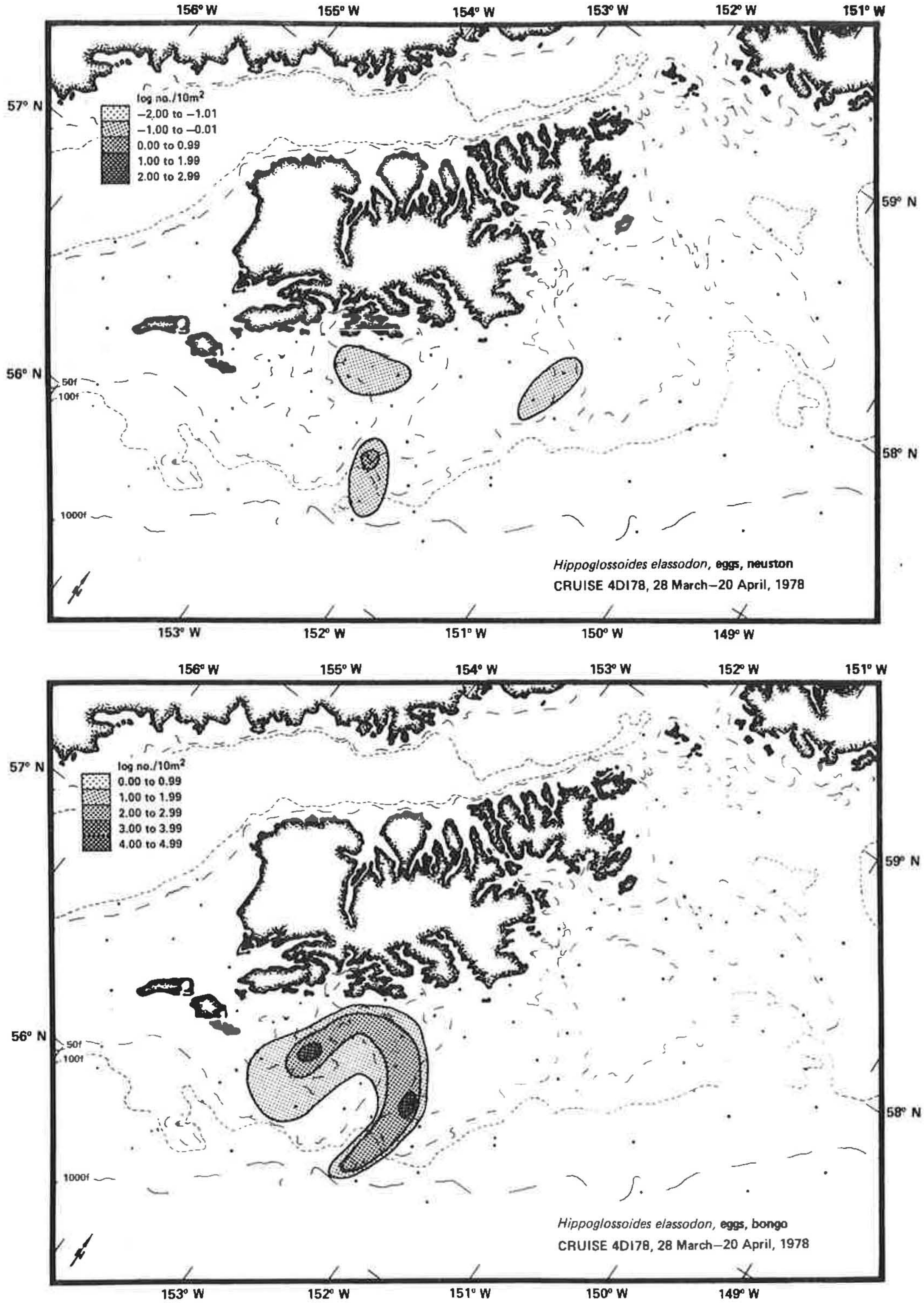
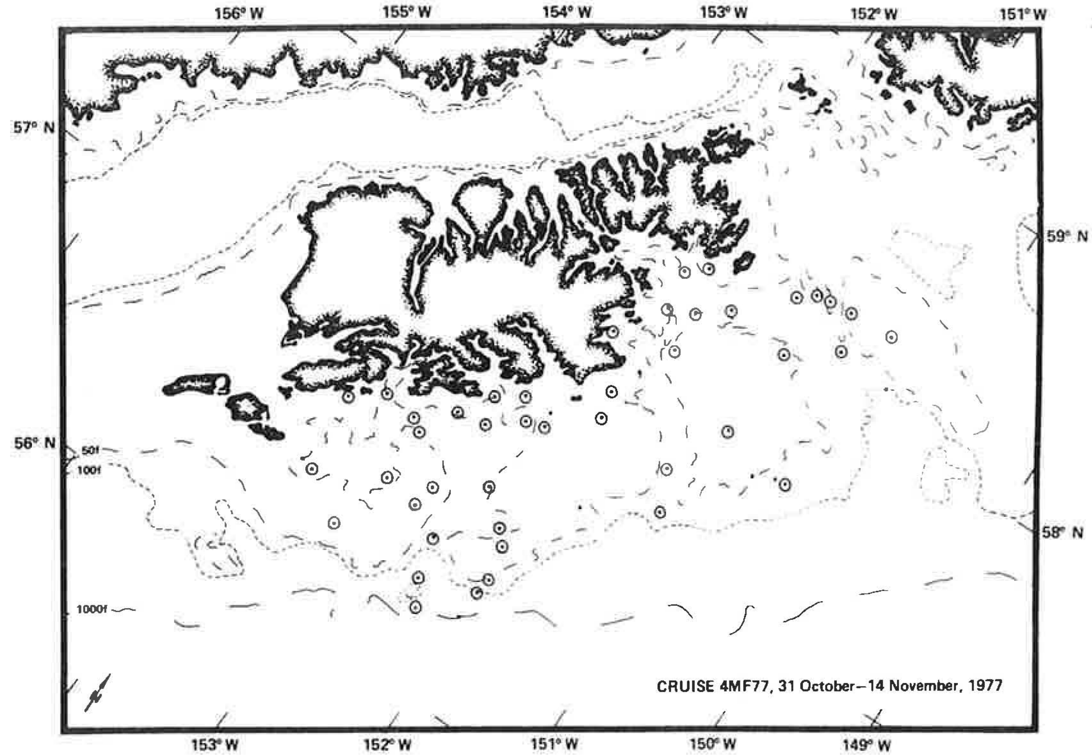


Figure 31.--Distribution and abundance of <u>Hippoglossoides elassodon</u> eggs in neuston (top) and bongo (bottom) tows from the Spring cruise.



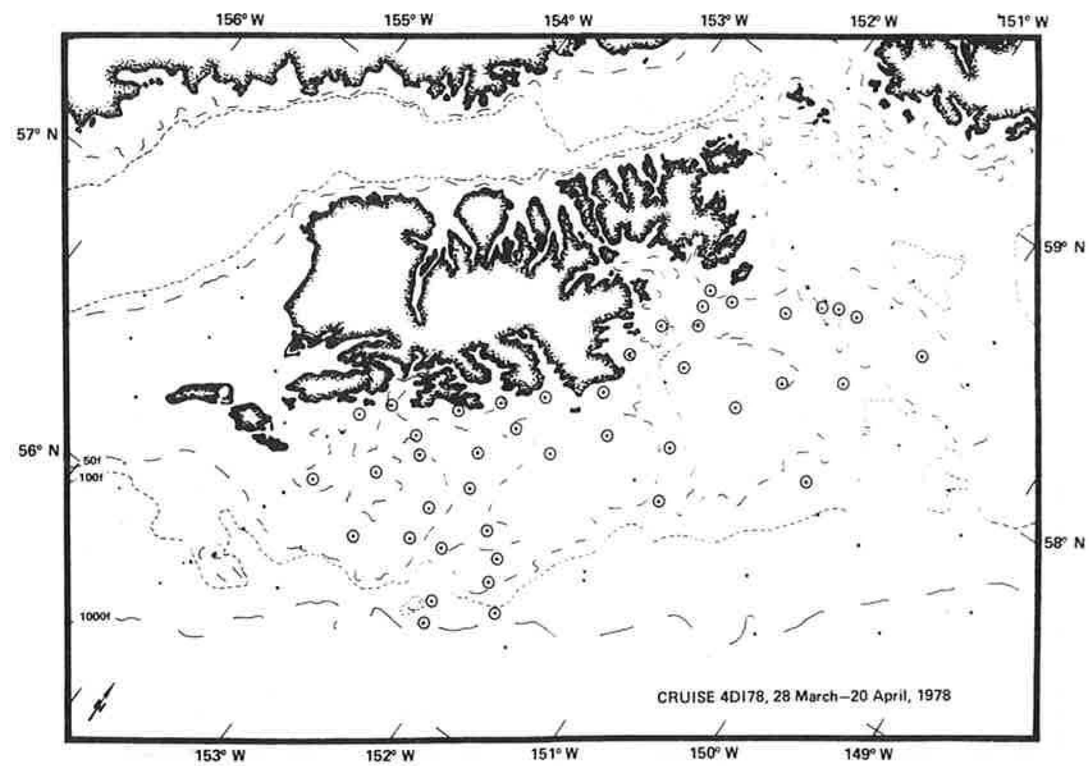
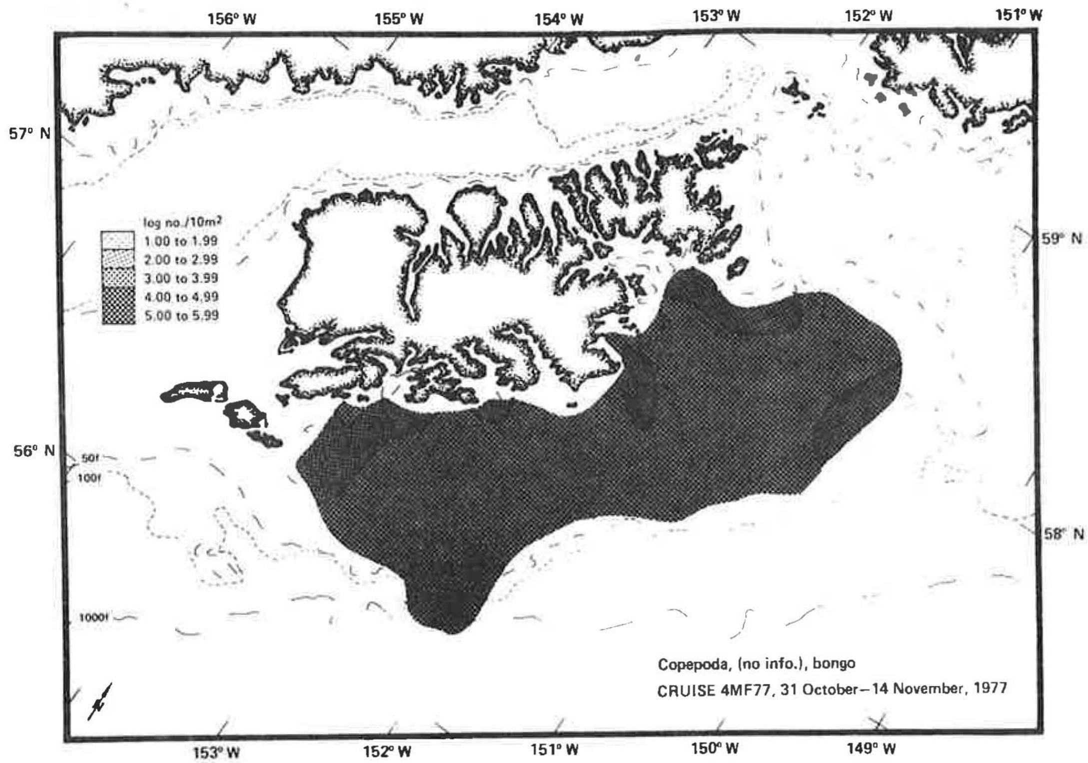


Figure 32.--Station locations used during the Fall (top) and Spring (bottom) to compare the seasonal occurrence and abundance of zooplankton (Tables 3 and 4) near Kodiak Island.



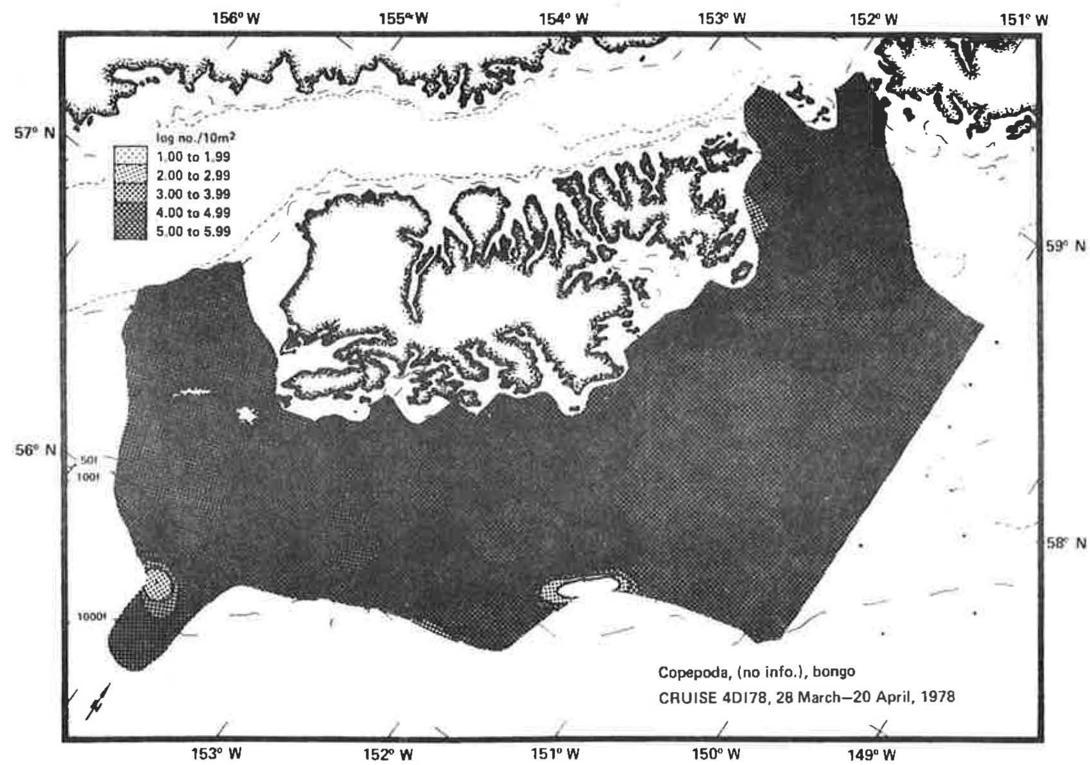


Figure 33 --Distribution and abundance of Copepoda during the Fall (top) and Spring (bottom) from bongo net samples.

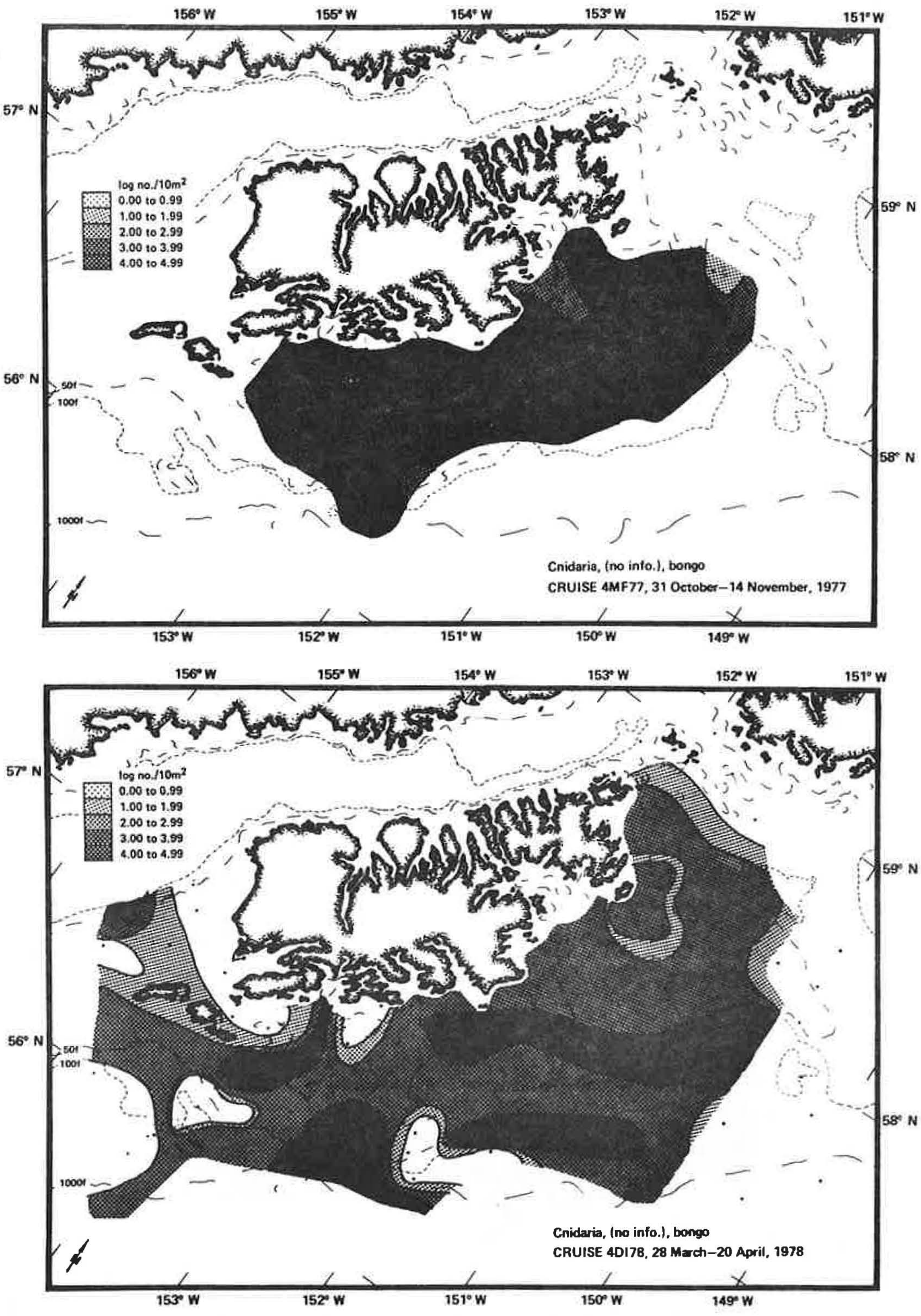


Figure 34.--Distribution and abundance of Cnidaria during the Fall (top) and Spring (bottom) from bongo net samples.

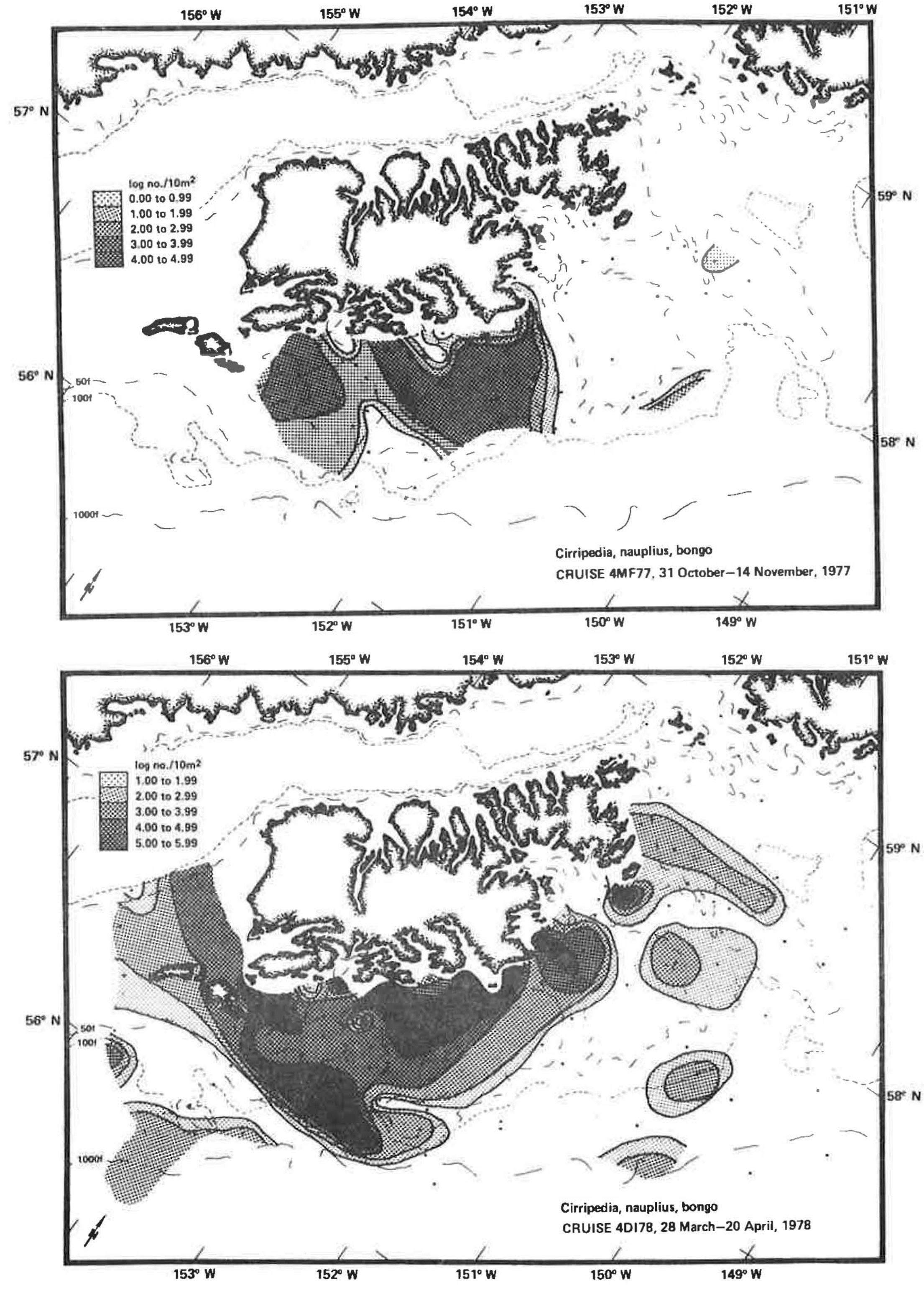
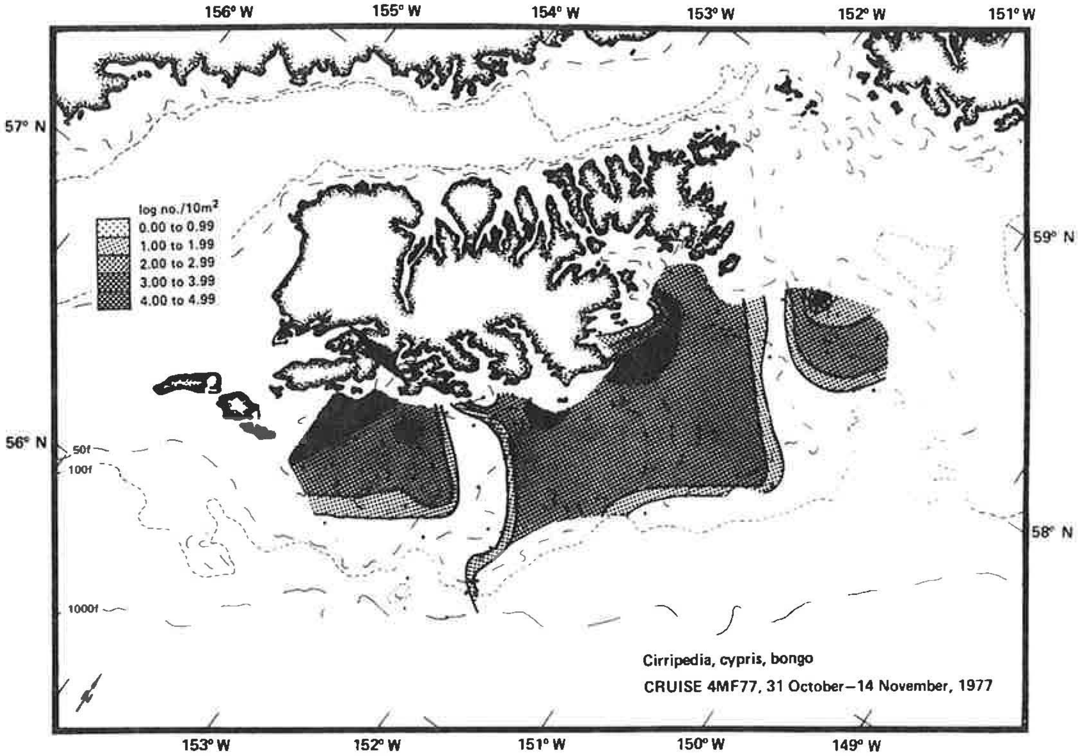


Figure 35.--Distribution and abundance of Cirripedia nauplii during the Fall (top) and Spring (bottom) from bongo net samples.



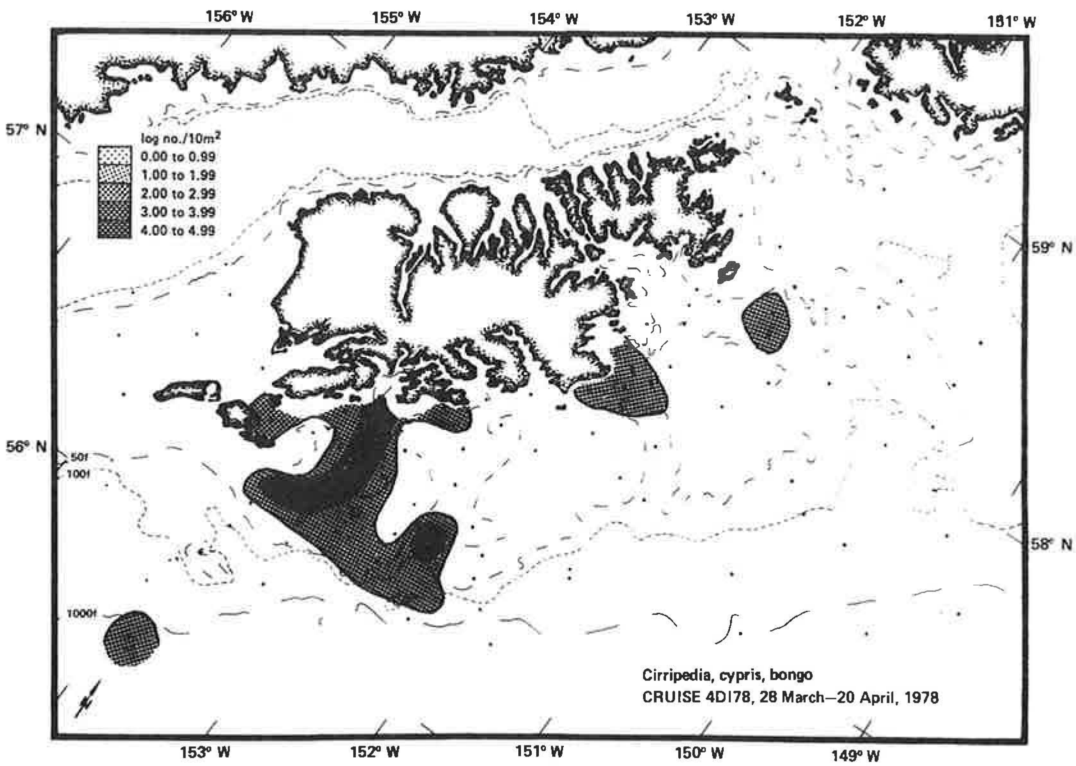


Figure 36.--Distribution and abundance of Cirripedia cypris during the Fall (top) and Spring (bottom) from bongo net samples.

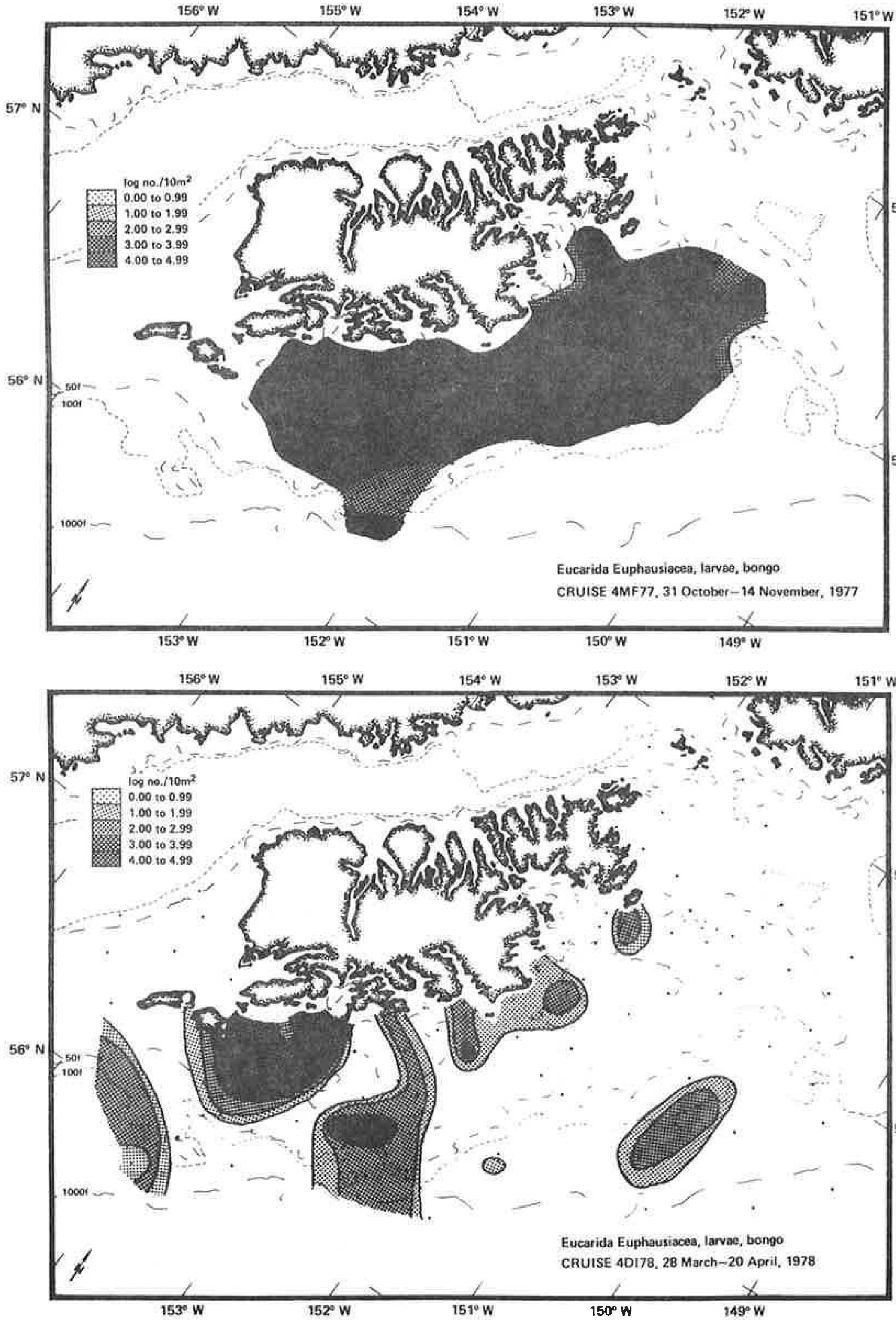


Figure 37.--Distribution and abundance of Euphausiacea larvae during the Fall (top) and Spring (bottom) from bongo net samples.

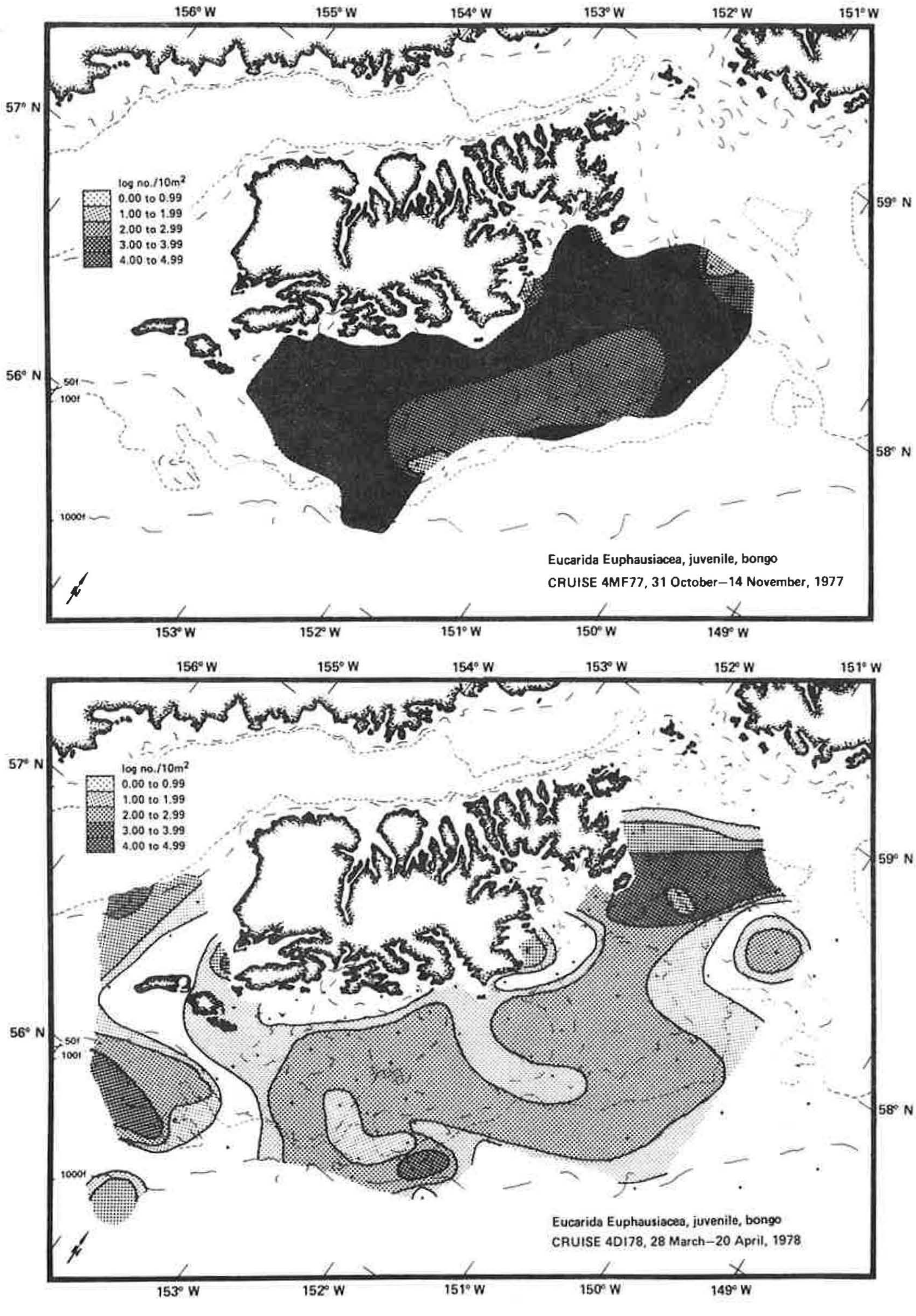


Figure 38.--Distribution and abundance of Euphausiacea juveniles during the Fall (top) and Spring (bottom) from bongo net samples.

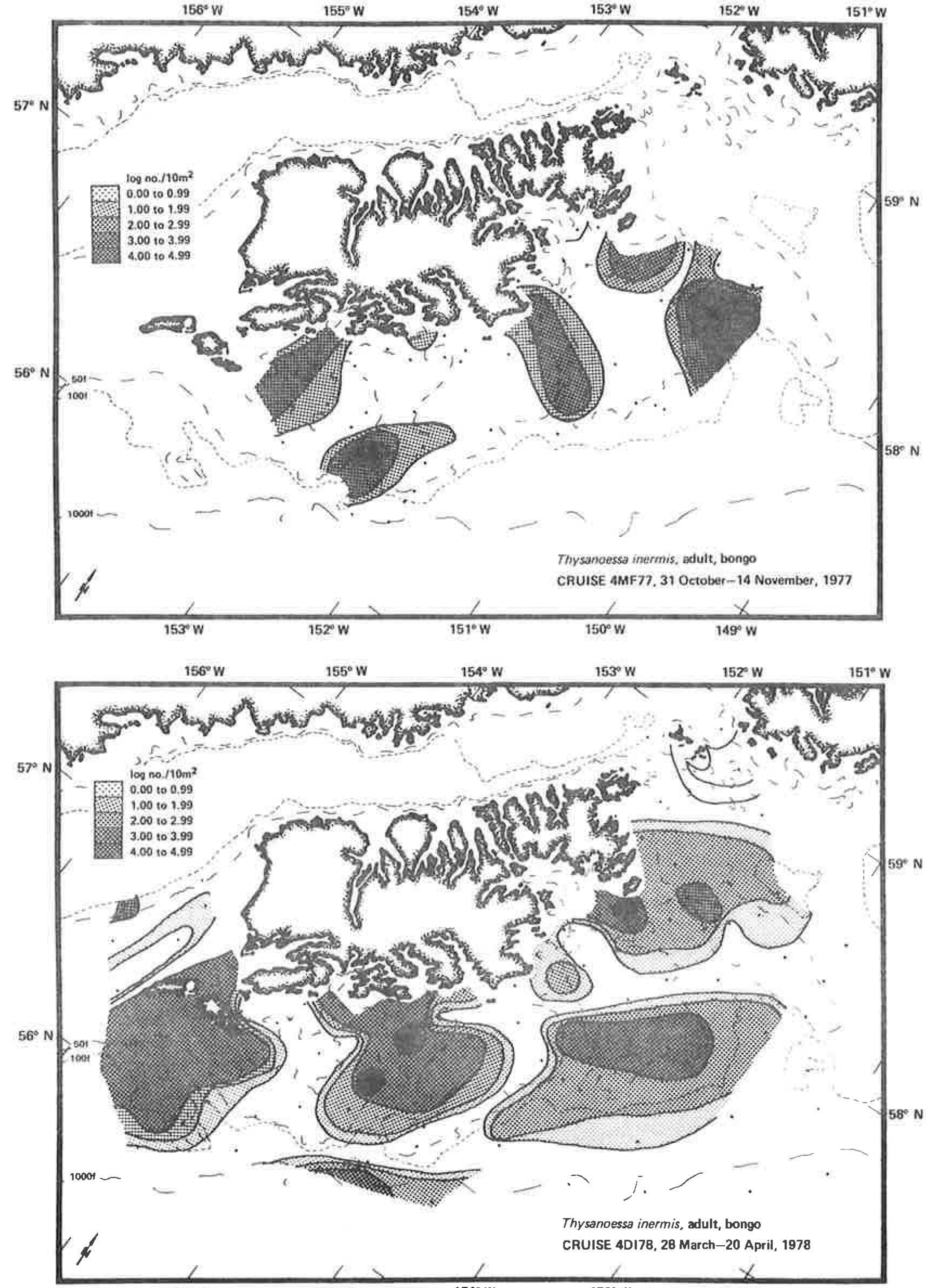


Figure 39.--Distribution and abundance of Thysanoessa inermis during the Fall (top) and Spring (bottom) from bongo net samples.

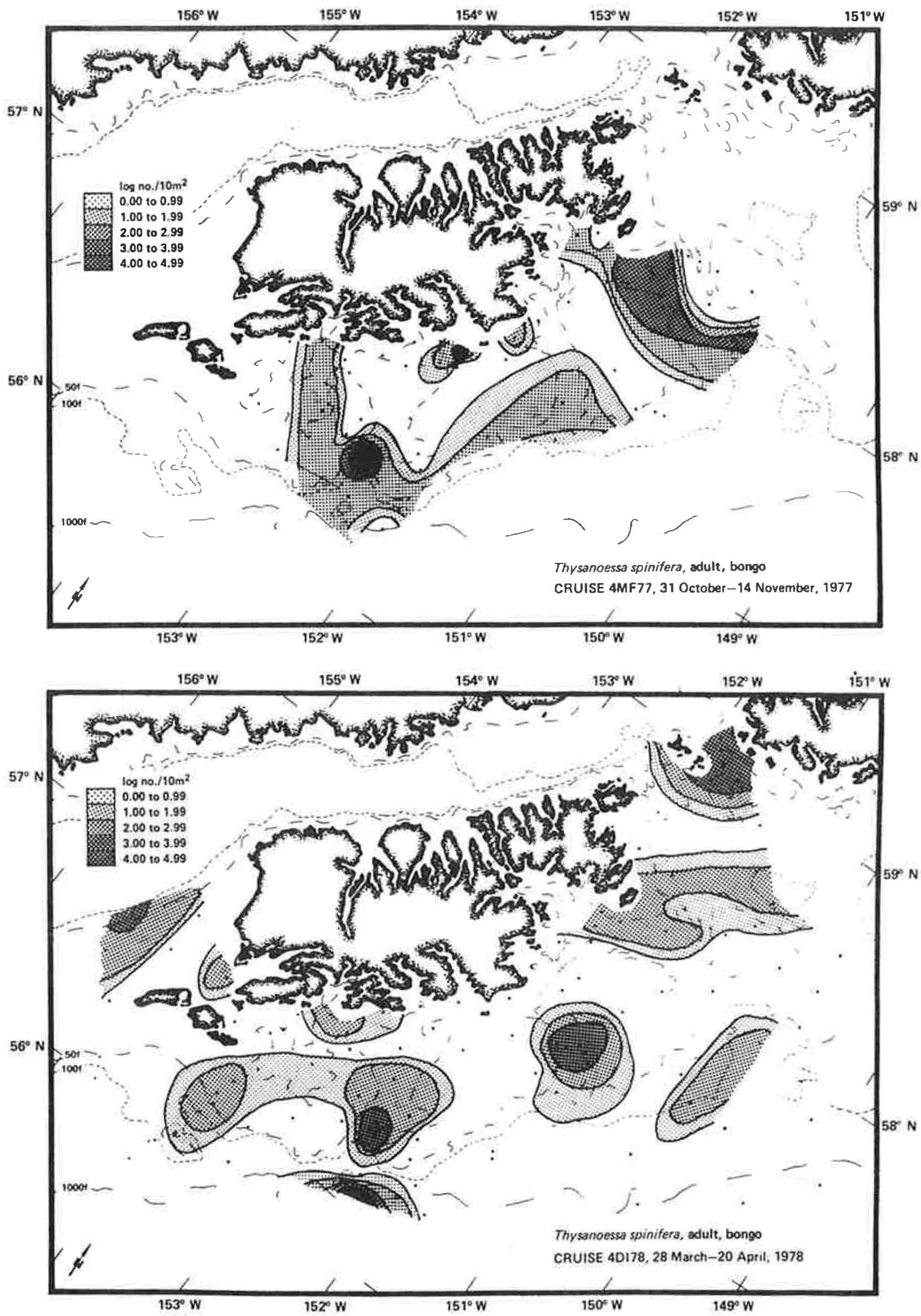


Figure 40.--Distribution and abundance of Thysanoessa spinifera during the Fall (top) and Spring (bottom) from bongo net samples.

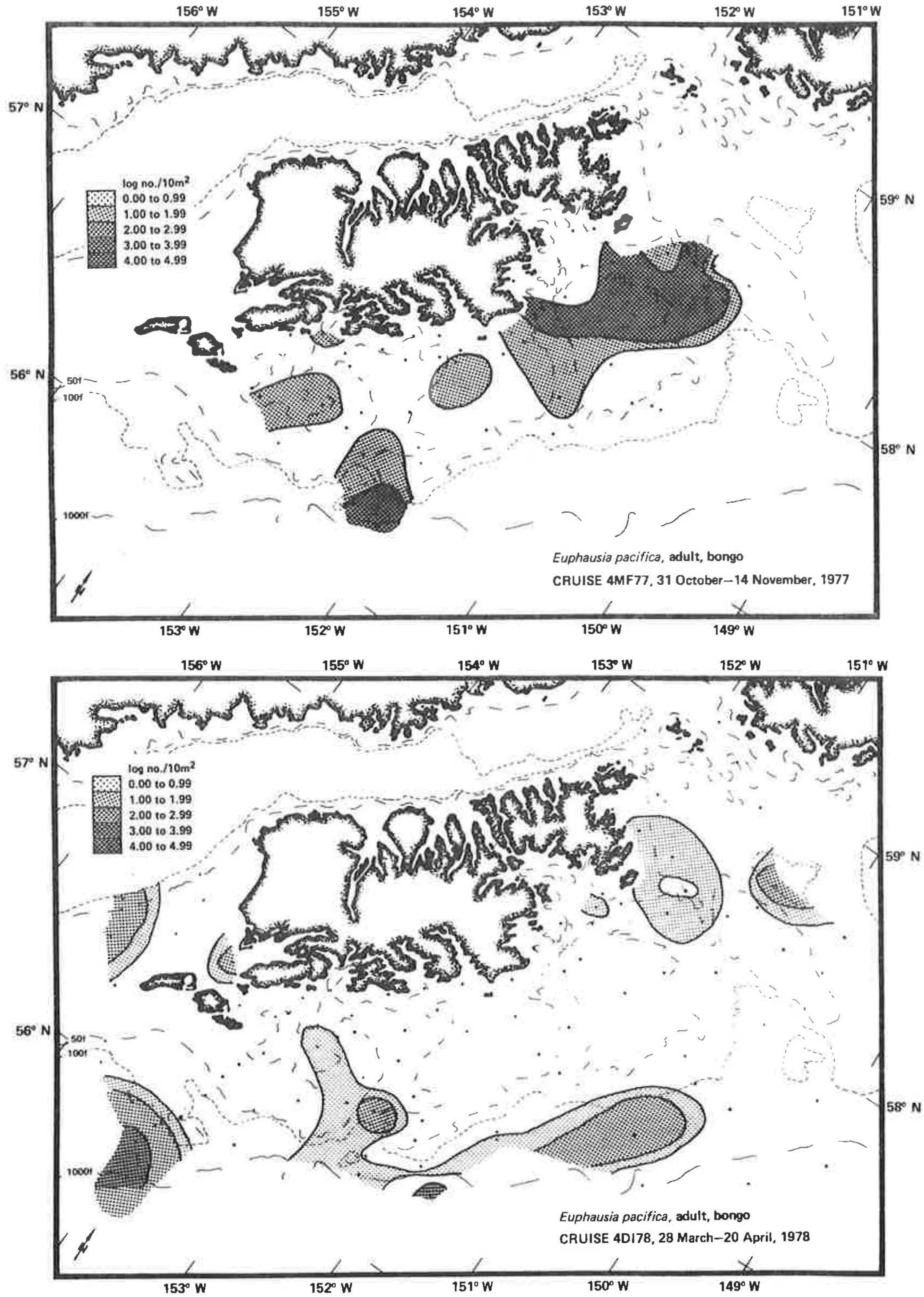
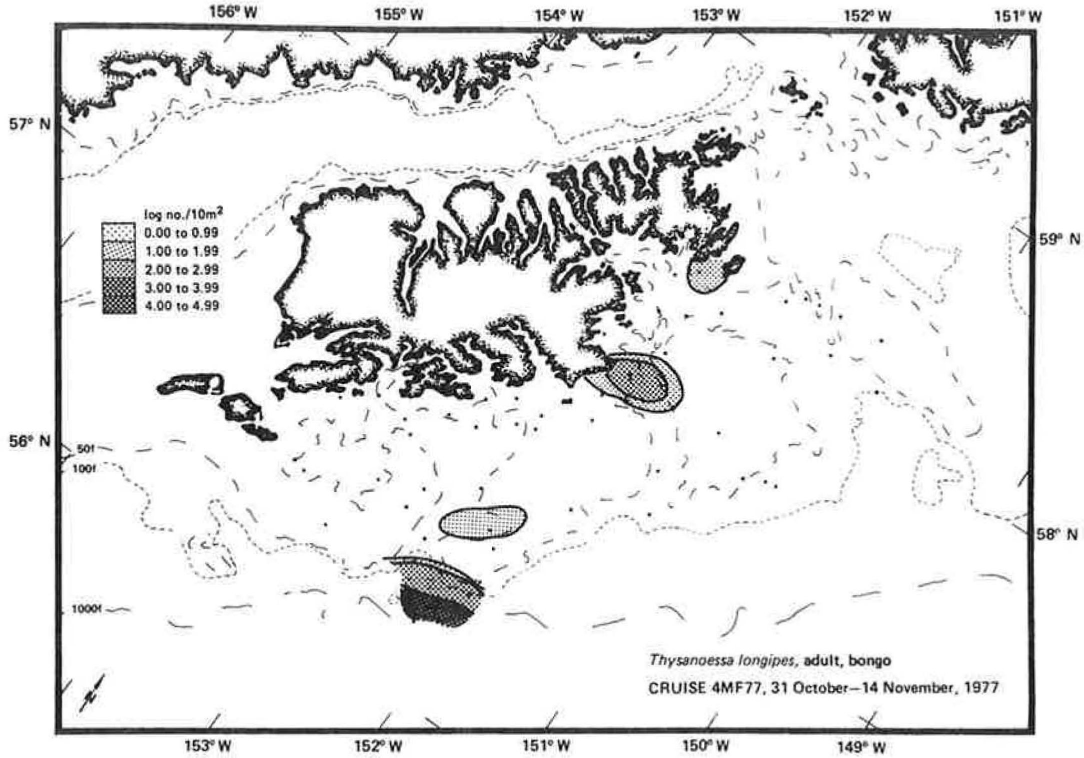


Figure 41.--Distribution and abundance of Euphausia pacifica during the Fall (top) and Spring (bottom) from bongo net samples.



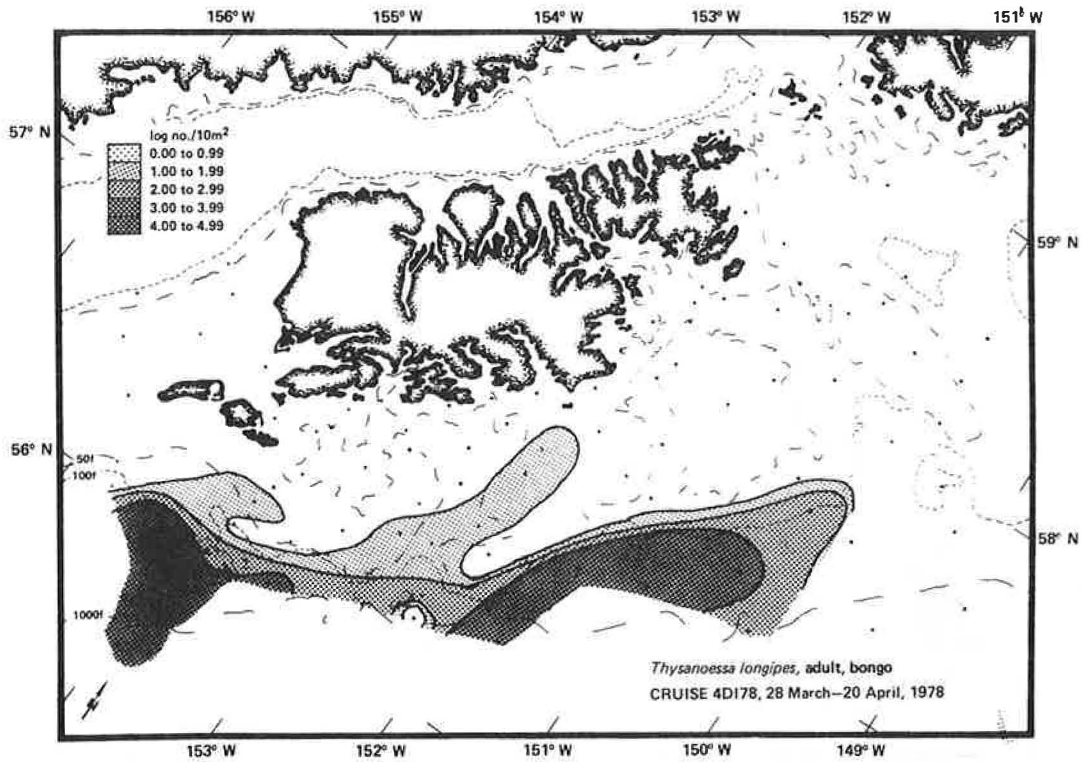


Figure 42.--Distribution and abundance of Thysanoessa longipes during the Fall (top) and Spring (bottom) from bongo net samples.

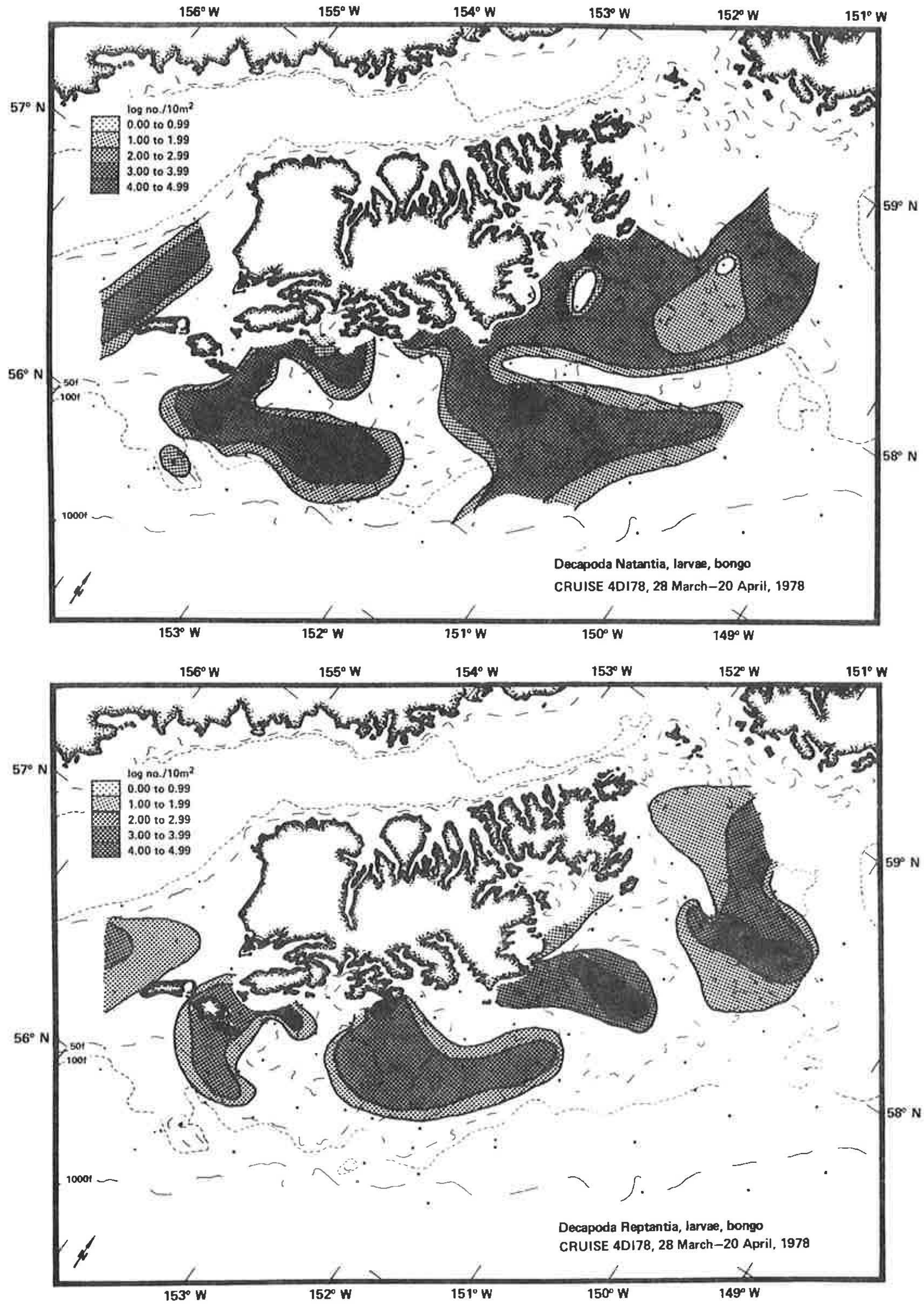


Figure 43.--Distribution and abundance of Decapoda Natantia larvae (top) and Decapoda Reptantia larvae (bottom) during the Spring from bongo net samples.